UNIVERSITY OF DEUSTO

Causal Modelling to Quantitatively Analyse People's Everyday Decisions Regarding Energy Consumption and Their Reactions to Interventions

Doctoral thesis presented by

ARMANDO AGUAYO MENDOZA

Within the PhD programme in

ENGINEERING FOR THE INFORMATION SOCIETY AND SUSTAINABLE DEVELOPMENT

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With a smile, I dedicate this work to those who are no longer with me, to the lives of those who accompany me and whom I love deeply, and to all those in whom I find a source of human and professional inspiration.

Abstract

The goal of this research is to mitigate the effects of climate change by refining energy systems modelling (ESM) to obtain a more nuanced description of demand drivers, with a specific focus on residential energy consumption. The approach involves several key strategies: applying novel causal models to dissect human decision-making processes in energy consumption, particularly in the areas of mobility, flexibility, building (heating and cooling), and appliance use; developing innovative methods for forecasting energy loads and assessing the impact of policy changes; and deepening understanding of household energy consumption patterns, with an emphasis on factors influencing behavioural changes toward energy-efficient practices.

The WHY project, which has generated essential information on factors affecting household investment decisions in the current energy transition context, is a central element of this effort. Using a scenario-based methodology adapted from the Delphi method, the project has gathered expertise on future energy transition scenarios in four key areas. Through a unique co-creation activity, based on self-determination theory, 32 determinants of investment decision-making were identified and systematically categorised into a taxonomy of 32 factors. This taxonomy was tested through a survey of more than 1,700 people in the EU and Latin America to determine how these determinants are distributed across the target population.

In addition, a cross-sectoral survey was conducted, validating archetypes and prioritising factors within the energy transition, using fictitious scenarios. This survey played a key role in characterising the archetypes of the European population and identifying behavioural clusters, thus enriching our understanding of investment archetypes. Advanced AI techniques, such as clustering and Monte Carlo simulations, were employed to discern deterministic clusters, leading to the emergence of new archetypes, such as "the activist". These clusters, representing various investment profiles, were further detailed through "person descriptions," which facilitated a deeper understanding of decision-making behaviours and underlying needs. The results, including the datasets, have been made public.

The final stage of this research was to generate causal models for each investment profile, using the stages of change of the Transtheoretical Model (TTM) to categorize each determinant. Directed Acyclic Graphs (DAGs) were used to conceptualise the causal relationships between the influencing factors, providing essential information for shaping energy policies. These DAGs enable targeted interventions on priority factors, thus streamlining decision-making processes. As a result, they form the basis for developing customised intervention strategies tailored to various types of individuals and residents in different sectors, paving the way for effective and sustainable energy transition initiatives.

Keywords: Causal modelling, Modelling human behaviour, Intervention-based strategy, Expert knowledge, Energy transition, Energy consumption, Energy efficiency.

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- Figures used to represent Europe and Latin America are AI-generated elements
- Figures of Causal diagrams were created with www.drawio.com

Executive Summary

The energy transition depends fundamentally on actions and decisions in households. Homeowners or renters often deviate from rational decision-making models, suggesting that the classic archetype of the "resource man"—an individual who is assumed to make decisions purely based on rational economic calculations—is not an accurate representation. Consequently, traditional models of decision-making, which presuppose an always rational actor who makes decisions on economic bases, are not apt to capture the nuances of domestic behaviour. Since energy transition investment decisions are similarly influenced by these complex behavioural patterns, it is clear that a novel approach is needed. Such an approach must employ different optics to understand and encourage household engagement in the energy transition, taking into account the diversity of motivations and behaviours that drive household decisions.

The potential of artificial intelligence (AI) as a solution for modelling behaviour is the subject of considerable debate. Although traditional AI methods have demonstrated their ability to capture behavioural patterns under stable conditions, their viability is seriously in question in interventional situations. This limitation is due to the fact that AI algorithms, particularly those based on machine learning, are often trained on historical data that do not account for dynamic changes following interventions. As a result, models may lack the adaptive capacity needed to reliably predict behaviours in environments altered by policy changes, economic incentives, or other forms of intervention. It is therefore crucial to explore advanced AI methodologies that can address the complexities and evolving nature of human behaviour in response to interventions, ensuring that AI remains a valuable tool in the field of behavioural prediction and analysis.

Research question: How can causal diagrams be utilized as a modelling technique to accurately analyze household energy consumption patterns and the impact of policy interventions, and how can these insights be scaled to inform macro-level energy policies across the European Union?.

This research question addresses several key issues: utilizing causal modeling techniques to analyze energy consumption decisions and responses to interventions, understanding household energy consumption patterns (including what services are used, when, how much energy they consume, and why), and assessing the impact of specific policy interventions (such as taxes on excessive energy consumption and energy efficiency labels). Expert knowledge and causal diagrams can significantly enhance the development of tools to scale these findings to inform energy policies at national and EU levels, ensuring that results are open source and accessible for wider impact and application.

This study advocates for the use of Causal Modelling as a sophisticated alternative in scenarios where traditional methods fall short. Causal Models, which can be seen as a generalization of Structural Equation Models, pivot away from purely data-driven approaches, instead integrating Expert Knowledge into their framework. This incorporation not only renders them falsifiable and identifiable but also ensures their robustness in prediction, even under conditions of intervention. Additionally, Causal Models afford the generation of counterfactuals, facilitating a deeper understanding of "what might have been" had different decisions been made. A salient advantage of these models is their inherent explainability; they are constructed in a manner that is both accessible and understandable to a broader audience, thereby demystifying the complexities typically associated with Artificial Intelligence (AI) and Machine Learning (ML) techniques.

All of the aforementioned provide policymakers with a tool to create energy policies that are specifically tailored to the target population (section 12.5). Additionally, it allows for the prediction of the potential impact these policies will have on the intended audience, Thereby supporting the a posteriori development of strategies to mitigate the effects of climate change. The chapter on *designing an intervention strategy* (Chapter 12) promotes energy transition in EU households by modelling household behaviours and investment decisions. It emphasizes the importance of understanding household archetypes. It suggests tailored policy-based interventions based on surveys and socio-economic data to achieve effective energy transition strategies (section 12.5).

Initially, the study focuses on retrieving causal knowledge through work with expert panels (Part I). The focus is on addressing the nuances of the current energy transition, particularly in aspects such as mobility, flexibility, construction and the use of household appliances. This analysis is qualitative and will provide policymakers with a tool for designing energy policies tailored to the specific needs and behaviours of this population. By estimating the impact of policy changes on this target group, the project aims to improve public engagement in energy policy changes, thus facilitating a more effective and participatory energy transition.

In parallel, the project broadens its scope to include the Latin American population. This inclusion adds a valuable cross-cultural dimension to the research, allowing two important aspects; first, the validation, through another context (Latin America) of the methodology developed in this research for the extraction of human expert knowledge and; second, the comparison and contrast with the European population. This dual approach ensures a robust and versatile understanding of household energy use, decision-making processes and responses to policy interventions in diverse cultural contexts.

Both strands of the study—causal knowledge building in Europe and causal modelling in Latin America—converge to meet the overall objective of improving energy demand modelling. By adopting a qualitative analysis approach and using advanced causal modelling techniques, this study aims to provide a comprehensive understanding of household energy consumption patterns and to develop innovative methods for short- and long-term energy load forecasting.

The methodology used in this study, termed **CausalDec** (Chapter 2, was designed to uncover the factors influencing household decision-making in the energy transition and consists of seven phases grouped into two key conceptual components: the *acquisition of expert knowledge* (phases 1 to 5) and *causal modelling* (phases 5 to 7). These components, brought together in phase 5, work together to provide a comprehensive analysis of decision-making processes.

The methodology *CausalDec* is outlined as follows:

- **Literature Review**: Establishing a foundational understanding of existing knowledge and gaps.

First part: Retrieving Expert Knowledge

- *Phase 0* - **Defining Topics**: Concentrating on Buildings, Mobility, Flexibility, and Appliances within the energy transition.
- *Phase 1* - **Designing Fictional Scenarios:** Outlining key residential sector aspects contributing to the energy transition.
- *Phase 2* - **Identifying Key Factors**: Pinpointing specific determinants influencing investment decisions in family units.
- *Phase 3* - **Coding**: Employing inter-rater reliability analysis through expert panels, each focusing on a different energy aspect.

- *Phase 4* - **Taxonomy Development**: Creating a glossary of determinants based on socio-psychological needs theory.

First part: Retrieving Expert Knowledge

- *Phase 5* - **Archetype Crafting**: Developing household-level decision-maker archetypes.
- *Phase 6* - **Cross-Sectorial Survey**: Conducting surveys to validate or discover new archetypes.
- *Phase 7* - **Causal Modelling**: Selecting critical determinants for each archetype and developing causal diagrams.

This methodology represents a holistic and multi-dimensional approach, integrating various techniques and perspectives to thoroughly analyze and understand the dynamics of household energy decision-making. The first part—*Acquisition of Expert Knowledge*—encompasses phases 1 to 5 and involves the acquisition of expertise in four key aspects of the energy transition (CausalDec - Part I). Through structured interviews, surveys and methods such as the Delphi technique, the aim is to collect and synthesise expert opinions on the factors affecting household energy decisions. This step is crucial to ground the analysis in real-world experience, thus providing a solid basis for understanding the intricacies of how households make energy-related decisions. The second part—*Causal modelling*—encompasses phases 5 to 7 and focuses on the creation of Causal graphs to illustrate the relationships between factors that influence household energy decisions, identified through expert knowledge (CausalDec - Part II). This step uses Directed Acyclic Graphs (DAGs). By clarifying these cause-effect relationships, it allows researchers to estimate how political, technological and social changes might affect household energy behaviours.

The **validation method** employed in this study takes advantage of triangulation to ensure the validity and credibility of the findings (Chapter

11). This approach includes three distinct but complementary types of triangulation: (i) *interdisciplinary triangulation*, which integrates perspectives from different academic disciplines to enrich the analysis; (ii) *methodological triangulation*, which involves the use of multiple research methods or data sources to verify findings; and (iii) *collaborative triangulation*, which relies on collaboration between researchers from diverse backgrounds to interpret data. Together, these triangulation strategies provide a robust framework for validating research findings, increasing their reliability and depth.

The **validation of the CausalDec methodology** involved applying and replicating the approach in a new context, moving from a European to a Latin American perspective. This validation method made it possible to examine the adaptability and relevance of the CausalDec methodology in different cultural and geographical contexts and to assess the robustness of the CausalDec approach, demonstrating its effectiveness and reliability beyond its initial European context, which is also a principle of the causal modelling technique. This cross-regional application underlines the potential of the methodology for wider application in the study of household decision-making in the global energy transition.

This research outlines a multidimensional strategy encompassing several **key outcomes** obtained through the conduct of the phases of the CausalDec methodology:

In **Phase 0**—Defining Topics—was set out to analyse household energy consumption patterns. This analysis is essential to understand and reduce residential greenhouse gas emissions, focusing on the following four **key aspects**:

- **Mobility**: The project examines factors influencing the use of Electric Vehicles (EV), micro-mobility, and public transport. It emphasizes the significant role of human habits and psychological factors in commuting choices, providing insights for policymakers to encourage sustainable mobility.

- **Flexibility**: The study looks at the impact of individual and collective behaviours on the adoption of domestic energy storage systems and participation in Local Flexibility Markets (LFM). Social practices related to energy use timing and flexibility are analyzed for their effects on demand and supply in LFMs.
- **Building**: The project explores how occupants' use of heating, cooling, ventilation, and lighting affects a building's energy consumption. Strategies like eco-feedback, social interaction, and gamification are evaluated for their effectiveness in influencing occupant behaviour.
- **Everyday Appliances**: The research underlines the critical role of human behaviour in the energy consumption of everyday appliances. It underscores the importance of understanding and influencing occupant behaviour to drive energy efficiency in various settings, including industrial environments.

Section 3.1.1 includes a detailed description of these energy aspects.

The assembly of an **expert panel** is a crucial component of this study, outlining its crucial role in providing a comprehensive and expert perspective on the energy issues explored. In Phase 0—*Definition of the topics of interest*—expert panels were strategically formed with a diverse composition, incorporating experts from technical, social, economic, psychological and end-user backgrounds (section 3.1.2). This diversity ensures a broad spectrum of ideas, leading to more comprehensive and substantive conclusions. The importance of the panel is reinforced by its multidisciplinary nature, which facilitates a nuanced understanding of complex issues by including experts from various fields within the energy sector. The multi-sectoral representation introduces a wide range of professional experiences and viewpoints, which are essential to address sector-specific challenges and opportunities. The inclusion of international diversity broadens the debate with global perspectives, making the findings relevant in different cultural contexts. In addition, the gender balance within the panel fosters inclusiveness, ensuring that diverse experiences and perspectives are taken into account for a comprehensive and unbiased analysis. Thus, the panel of experts serves as a cornerstone of the research, using their varied and wide-ranging expertise to provide in-depth analysis and informed recommendations, significantly enriching the research.

Five future **scenarios of the energy transition**—focusing on mobility, flexibility, building, and appliances—were designed in Phase 1 (sections 4.3.1, 4.3.2, 4.3.3, 4.3.4). Based on theoretical frameworks, these scenarios indicate that internal factors such as personal beliefs, values, and environmental concerns are key motivators for individuals to alter their daily habits and decrease their carbon and energy footprint domestically. Detailed descriptions of these scenarios can be found in Chapter 4.

Based on contributions from panels of experts in each of the energy aspects, a **Common Glossary** (Table 7.1) and the two-level 32-Factor **Taxonomy** (Fig F.1) were developed, standing as key outcomes of the research. This glossary systematically details psychological needs and behavioural factors, providing a detailed and qualitative understanding of what drives human behaviour, especially in the context of the energy transition in European households. It includes universal psychological needs such as autonomy, relatedness, and competence (rooted in self-determination theory), along with additional needs like stimulation, meaning, security, and financial security—the latter being an integral part of Maslow's hierarchy of needs.

The 32-factor taxonomy, presented in two layers, graphically delineates these psychological needs and their associated determinants at a lower level, providing a clear visual representation of the complex interplay between various factors influencing decision-making processes in the residential sector. It underscores the intricate web of motivations driving household energy choices and behaviours, crucial for designing effective energy transition strategies. This two-tiered taxonomy, covering nine psychological needs and 32 determinants, offers a robust framework for understanding and influencing the behavioural aspects vital to the energy transition.

Both the common glossary and the two-level taxonomy are essential tools for policymakers and energy specialists, as they provide deep insights into human behaviour in relation to energy consumption and pave the way for tailor-made interventions. Furthermore, these tools underline the critical importance of citizen participation in shaping and implementing energy policy changes. By understanding the psychological needs and behavioural factors detailed in the taxonomy and glossary, policymakers can design strategies that resonate with citizens' values and motivations, thereby encouraging greater public support and participation in the energy transition (see chapter 12). In addition, these resources can help develop counterfactual scenarios that allow stakeholders to explore alternative futures and assess the potential impacts of different policy options and societal actions.

- This research—based on expert knowledge—has established eight distinctive **European archetypes** or Investment profiles—Early Adopter, Uninterested, Homo Economicus, Fearful, Stubborn, Influencer, Careful, Activist—each encompassing different patterns of behaviour and reactions to changes in the energy policy (Chapter 8). They are based on a comprehensive consolidation of expert knowledge and constitute an important phase of the *CausalDec* methodology, which includes causal modelling using *Directed Acyclic Graphs* (DAGs).

The taxonomy is strongly relevant for identifying and developing archetypes related to European **investment profiles**. By outlining a comprehensive list of psychological needs and behavioural factors, the taxonomy provides a structured framework for understanding the underlying motivations and behaviours of decision-makers in the context of energy investments. This detailed knowledge facilitates the segmentation of decision-makers into distinct archetypes, each characterised by specific behavioural patterns, motivations and attributes observed during the investment decision-making process.

The archetypes, drawn from the taxonomy, represent various profiles of decision-makers, providing a nuanced understanding of the various approaches and thought processes that influence their investment decisions. This understanding is crucial for developing strategies and interventions that are tailored to the unique thinking and priorities of different types of investors, thereby fostering more informed and strategic investment decisions (section 12.5).

Further, the process of identifying these archetypes involves empirical mapping of these archetypes, through a **cross-sectoral survey** (chapter 9), provides a snapshot of population behaviour. This step is essential for creating validated investment profiles that reflect real-life behaviours and preferences of European residents concerning energy transition initiatives.

The survey aims to characterise the European population with respect to a predefined taxonomy, facilitating the identification of behavioural groups and validating existing archetypes."This was essential both to confirm initial archetypes and to discover new investment profiles, such as " *The Energy Poor*" and "*The Climate Denier*" (section 9.4). The use of cross-sector surveys allowed for a broad, cost-effective, and timely assessment of the population, capturing a snapshot of current trends and behaviours relevant to the energy transition. The survey design, based on future scenarios and socioeconomic variables, was crucial for collecting detailed data on the determinants influencing energy-related investment decision-making (appendix H). Participants rated the importance of 32 factors when considering investments in various scenarios, such as flexible markets or energy conservation. This approach enabled a data-driven analysis in which clustering techniques such as K-means and self-organizing maps (SOM) identified groups with shared values. The result was twofold: a rich open-access dataset (Borges et al., 2022c) and validation of archetypes (Aguayo-Mendoza et al., 2024), reinforcing the relevance of the taxonomy for describing the impact of human behaviour on the energy transition and informing policymaking.

The relevance of the taxonomy in developing these archetypes lies in its ability to provide a detailed and systematic understanding of the factors influencing investment decisions by the European population; which is essential for designing tailored policy interventions. By shaping **Latin American archetypes** and their clustering, mapping them against those of the European context, this research achieves a transcontinental perspective of energy behaviours.

The eight European archetypes are summarised below, and a comprehensive description and factors associated with each archetype are provided in section 8.3.

1. The Early Adopter: Driven by novelty and the latest trends, especially in technology, with a strong consideration for the environment and a desire to maintain social status.
2. The Uninterested: Comfort-oriented with minimal responsiveness to change, often following peer trends or default choices with resistance to new information.
3. The Homo Economicus: Economically motivated, making investment decisions based on profit potential, market confidence, and financial risk assessment.

4. The Fearful: Environmentally aware but hindered by fear or inertia, actions are influenced by personal safety concerns and risk aversion.
5. The Stubborn: Deeply committed to environmental causes, often acting out of a need to alleviate distress about environmental issues, with actions depending on personal ambition and resource availability.
6. The Influencer: Seeks to impact peers and is motivated by added value, whether it be monetary, authoritative, or social capital, feeling obliged to meet group expectations.
7. The Careful: prioritises well-being and security, making choices based on safety, environmental impact, and confidence in positive outcomes, with satisfaction as a key motivator.
8. The Activist: Compelled by a sense of duty to the community and pro-environmental values, this archetype takes actions that are consistent with legal norms and trusts in the sharing economy and open knowledge.

The archetypes serve as a foundational tool for causal modelling, giving policymakers and energy specialists a nuanced understanding of the causal paths in the decision-making process of diverse population sectors, and aiding in the effective transition toward sustainable energy practices.

Causal models—second part of the CausalDec methodology —enable the understanding of how to promote change through interventions in causal pathways (section E.2. The implementation of this second part of the CausalDec methodology in the context of the WHY project made it possible to delineate causal mechanisms of the decision-making process of the various European archetypes with regard to energy transition investments (section 10.5). The Trans-Theoretical Model (TTM) was used to trace the process of behavioural change in a series of distinct stages, from pre-contemplation to culmination (figs 10.8, 10.9). This non-linear model highlights the complexity of behaviour change and recognises that each type of person needs different strategies at each stage to move to action.

By integrating the 32-factor taxonomy with the TTM, the researchers created directed acyclic graphs (DAGs) for each archetype. These DAGs are visual representations of hypotheses drawn from expert panels about the causal relationships among the various factors and how they influence decision-making for each archetype. The DAGs help identify critical intervention points within the causal pathways for each archetype (figs 10.11, 10.12, 10.13, 10.14, 10.15, 10.16, 10.17, 10.18). Recognising these points allows researchers and policymakers to design targeted interventions that can effectively promote progress through the stages of behaviour change, ultimately fostering positive decision-making towards the energy transition.

Intervention-based strategy is a key tool for policymakers to tailor policies to their target population (chapter 12). This study outlines a strategy to promote the energy transition in EU households, focusing on modelling household behaviours and investment decisions relevant to this transition. In the context of the WHY project, the intervention strategy has proved to be a more adaptive and realistic approach to causal modelling compared to traditional artificial intelligence (AI) techniques, which allows for predicting behavioural patterns and understanding the responses of various archetypes of households to energy transition scenarios. The intervention-based strategy involves conducting surveys and collecting socio-economic data to identify dominant archetypes and formulate policies specifically designed for these groups, thus improving the efficiency of energy transition strategies.

This study, applied in the context of the *WHY project's use cases* (section 1.11), enables the energy transition to be accelerated. Recognising the complexity of household decisions, which go beyond the predictions of rational economic models, CausalDec proposes a new perspective that recognises the behavioural factors that motivate the various archetypes, and how these factors influence investment decisions for energy transition. It challenges the effectiveness of conventional AI in modelling behaviour, particularly for interventions, and advocates causal modelling as a preferable method. This approach, which integrates expert insights, is adaptable to context (Europe and LATAM) and produces explainable results.

For interventions to be successful, it is essential to understand the specific changes they are intended to promote, to identify the demographic group they are targeting, and to understand the variety of strategies, incentives and policy changes that prevail in different contexts. The findings provide a strategic plan for effective engagement and intervention, a crucial element in driving the energy transition towards sustainability. This includes the development of scenarios covering four critical elements of the energy transition—mobility, flexibility, building insulation and appliance use—and the construction of archetypes representing different decision-making profiles to accurately tailor engagement strategies.

The intervention strategy comprises the following steps, which are detailed in section 12.5:

1. Identify the target population.
2. Analyse the current stage of change.
3. Choose the right policy-based intervention.
4. Implement & Communicate.
5. Monitor & Iterate.
6. Engage with the community.

In the end, this study aims to create a **heuristic tool** for decision-makers to select appropriate **engagement strategies** that resonate with end-users, thereby increasing the likelihood of success in adopting the desired changes. This requires identifying the investment profiles prevalent in the target population through surveys, assuming a majority similarity to an archetype, and finding objective factors that hint at the presence of certain archetypes. The intervention strategy therefore focuses on identifying the target population, analysing their decision-making stages, choosing appropriate policy interventions, implementing and communicating these interventions effectively, monitoring and iterating the strategies as needed, and collaborating with the community to amplify the impact of these interventions.

In a word, identifying the phase of change and the predominant investment profiles within a target population is critical to shaping effective, responsive, and sustainable energy transition strategies. It allows for a more targeted and efficient approach to policy formulation and public participation, ultimately contributing to the success of energy transition efforts.

All of the above allows us to answer the research question: *How can causal diagrams be utilized as a modelling technique to accurately analyze household energy consumption patterns and the impact of policy interventions, and how can these insights be scaled to inform macro-level energy policies across the European Union?*. It can be concluded that causal diagrams are an effective tool for this purpose. They represent the cause-and-effect relationships between variables influencing household energy consumption, enabling more accurate predictions and the integration of expert knowledge. These causal diagrams help simulate different policy scenarios, providing insights into potential impacts before implementation. By transitioning from associative to causative models and employing methodologies like CausalDec, which involve expert knowledge acquisition and causal modelling, customized intervention strategies can be developed and tailored to specific household segments. This customization ensures effective and equitable policies that enhance public and stakeholder engagement. Scaling these insights to macro-level policies allows for a holistic and comprehensive approach, as evidenced by projects such as the WHY project, ultimately supporting the EU's sustainable and efficient energy transition efforts.

Contents

Acronyms

ACE Average Causal Effect.

CL Chile.
CO Colombia.

DAG Directed Acyclic Graphs.

EMS Energy Management Systems.
ESM Energy System Models.
EU European Union.

LATAM Latin America.
LEM Local Energy Market.
LFM Local Flexibility Markets.

MX México.

NAM Norm Activation Model.

POF Potential Outcome Framework.

SCM Structural Causal Models.
SCT Social Cognitive Theory.
SDT Self-determination theory.
SV El Salvador.

TMD Temporomandibular Disorders.

TPB Theory of Planned Behaviour.

TTM Transtheoretical model.

CHAPTER

1

State of the Art

1.1 Introduction

This systematic review aims to deepen the literature on the current energy transition, focusing on the understanding of human behaviour and the decision-making process, as well as the theoretical frameworks describing this process, including its motivators and barriers to energy consumption decisions. Finally, the review examines the application of causal modelling techniques to human behaviour. The scope of the review covers four key aspects of the energy transition in the European context: Mobility, Buildings, Flexibility and Appliances. Emphasis is placed on studies that contribute to the development of scalable energy policies at EU level. For this purpose, a systematic search was conducted in multiple academic databases, including: Scopus, Web of Science, Google Scholar, IEEE Xplore and relevant governmental and organisational repositories. Keywords such as Energy Transition, Human Behaviour in Energy Consumption, Theoretical Frameworks for Energy Decisions, Intention-Behaviour Gap, Mobility in Energy Transition, Energy Flexibility, Energy

Efficiency in Buildings, Household Energy Demand Modelling, Causal Modelling in Energy, Behavioural Science in Energy Policy were used. The selection process consisted of an initial screening of titles and abstracts to identify studies relevant to the research questions, followed by a full-text review of the selected articles. Inclusion criteria focused on studies published within the last 10-15 years, in peer-reviewed journals and articles that provided empirical data or substantial theoretical contributions. Studies addressing the energy transition, household energy consumption and the role of human behaviour, as well as those employing or analysing causal modelling techniques were included. Non-peer-reviewed articles or those lacking relevance to the energy transition or human behaviour were excluded. The review process included systematic data extraction and synthesis of key findings, ensuring a comprehensive understanding of the current state of play.

1.2 The Current Energy Transition

The European Union (EU) is actively engaging in a shift towards a low-carbon society by updating its regulations to boost both private and public investment in clean energy (EU, 2021; SP-Global, 2020). This effort is geared towards cutting down greenhouse gas emissions and adhering to the objectives of the Paris Agreement (UNFCC, 2015). To progress its energy objectives, the EU has implemented a range of legislative and policy changes. These include enhancing energy efficiency, supporting the use of renewable energy, and curbing CO2 emissions. The EU's approach to energy transition is all-encompassing, aimed at fostering a sustainable energy sector, promoting growth and innovation, and enhancing living standards. The transition plan includes steps to significantly reduce emissions, increase renewable energy capacity threefold, double the pace of improvements in energy efficiency, and aid the worldwide shift from fossil fuels. These efforts are aligned with the Paris Agreement's objectives, striving to keep the rise in global average temperature below 1.5 degrees Celsius and achieve climate neutrality by 2050 (UNFCC, 2015). The EU's focus in its energy transition lies in promoting renewable energy, improving energy efficiency, and advancing decarbonisation, all with the aim of addressing climate change and securing a sustainable future.

1.2.1 Progress and challenges

Although significant progress has been made, the energy transition is still moving too slowly to meet the goals of the Paris Agreement (Nations, 2022; Adib et al., 2021; Agency, 2023, 2022; Lee and Romero, 2023).

Positive developments include:

- *Rapid growth of renewable energy*: Solar and wind power have become increasingly cost-competitive, leading to substantial installations worldwide.
- *Electric vehicle adoption*: Sales of electric vehicles are rising rapidly, driven by technological advancements and government incentives.
- *Increased climate awareness*: Public and political attention to climate change has grown significantly, fostering a more supportive environment for clean energy initiatives.

However, challenges persist:

- *Insufficient pace of decarbonization*: Global greenhouse gas emissions continue to rise, despite the growing adoption of renewables.
- *Inequality and access to clean energy*: Disparities in access to clean energy exist between developed and developing countries, requiring targeted efforts to ensure a just transition.
- *People engagement*: The successful implementation of renewable energy projects, the adoption of electric vehicles, and the shift towards a low-carbon economy heavily rely on public acceptance and support.
- *Fossil fuel dependency*: Many countries remain heavily reliant on fossil fuels, hindering the transition to cleaner energy sources.

1.3 The Importance of Human Behaviour in the Key Aspects of the Current Energy Transition

Human behaviour plays a crucial role in the energy transition across the four key aspects such as mobility, flexibility, building, and appliance use, each of which has unique implications.

- **Mobility**. This aspect focuses on understanding the factors that influence the adoption and use of Electric Vehicles (EVs), micro-mobility solutions, and public transportation.It highlights how human habits and psychological factors significantly influence transportation choices. The knowledge acquired can help policymakers formulate strategies to promote sustainable mobility options.
- **Flexibility markets**. This aspect focuses on understanding the factors that influence the adoption and use of Electric Vehicles (EVs), micro-mobility solutions, and public transportation. It highlights how human habits and psychological factors significantly influence transportation choices. The knowledge acquired can help policymakers formulate strategies to promote sustainable mobility options.
- **Building**. This aspect of the study looks into how building inhabitants' use of the heating and cooling, lighting, ventilation, and heating systems impacts how much energy they use. It assesses to determine whether techniques like gamification, social engagement, and eco-feedback work to change occupant behaviour towards more energy-efficient behaviours.
- **Energy efficiency in everyday appliances**. This study emphasises how human behaviour has a major influence on how much energy appliances use. It highlights how important it is to comprehend and impact occupant behaviour in order to improve energy efficiency in a variety of contexts, including homes and workplaces.

1.3.1 **Social and Behavioral Dynamics**

Human behaviour plays a critically important role in the mobility aspects of the current energy transition in Europe. This transition is not only dependent on technological developments but is also significantly influenced by the behaviours and choices of individuals and communities. The following are a key points that highlight the importance of human behaviour in this context:

- **Energy Citizenship**: The concept of energy citizenship emphasizes the diverse behaviours of individuals in the energy transition process. It suggests that policy-making should account for this heterogeneity to effectively foster energy transitions (Schlindwein and Montalvo, 2023; Silvast and Valkenburg, 2023)
- **Behavioural Paradigm Shift**: According to research presented by the Ecologic Institute, energy transitions involve a three-pronged behavioural shift (Caiati and Pearson, 2014; Amadori and Votta, 2021):
  - High agency and ownership in engaging with new technologies.
  - Orientation towards the group and grassroots processes.
  - Long-term decision-making considerations
- **Complex Systems and Social Practices**: The transition to renewable energy sources involves complex systems where technologies and human behaviours are intertwined. Understanding and reorganizing social practices, such as mobility and energy consumption, are crucial for a successful transition (Labanca, 2017; Nassar, 2024).

In general, human behaviour is essential to reaching the goals of the energy transition, involving focused interventions and regulations that take into account the intricate interactions between social variables, habits, and preferences across these crucial energy aspects.

The following section describes in detail each of those four key energy aspects.

1.4 Theoretical Framework for Understanding Energy Consumption Decisions

This section presents the theoretical foundations on which the study of energy consumption decisions is based. It covers various theories and models relevant to understanding how individuals and households make energy consumption decisions. Key theories such as the Theory of Planned Behavior, Social Cognitive Theory, and Self-Determination Theory will be discussed to highlight the psychological and social factors that influence energy consumption decisions. This framework will serve as the basis for the methodology developed in this study (Chapter 2).

- **Theory of Planned Behavior (TPB)** (Suntornsan et al., 2022; Bosnjak et al., 2020; López-Mosquera and Sánchez, 2012). The TPB posits that behavioural intentions are influenced by attitudes, subjective norms, and perceived behavioural control. In the context of energy transition:
  - *Attitudes* reflect individuals' evaluations of energy-saving behaviours.
  - *Subjective norms* represent perceived social pressure to engage in energy-saving actions.
  - *Perceived behavioural control* relates to individuals' beliefs in their ability to implement energy-saving measures.

  TPB has been applied to explain various energy-related behaviours, including green purchasing and energy-saving practices (Appendix B, section B.5.2).
- **Social Cognitive Theory and Agency**. This theory focuses on intrinsic and extrinsic motivations (Bandura, 2001). It suggests that meeting psychological needs (autonomy, competence, relatedness) can enhance motivation for energy-saving behaviours (Appendix B, section B.4.1).
- **Self-Determination Theory**. This model proposes stages of change in behaviour adoption (Sweeney et al., 2014). It can be applied to understand how individuals progress through stages of adopting energy-efficient practices (Appendix B, section B.4.2).

- **Transtheoretical Theory**. This model proposes stages of change in behaviour adoption (Prochaska and Clemente, 1982; Prochaska et al., 2008). It can be applied to understand how individuals progress through stages of adopting energy-efficient practices (Appendix B, section B.5).
- **Pro-Environmental Behavior Theory** (Steg et al., 2014; Ghazali et al., 2019; López-Mosquera and Sánchez, 2012). This framework emphasizes the role of values, situational factors, and goals in shaping environmental behaviours. It integrates hedonic, gain, and normative goals to understand pro-environmental actions (Appendix B, section B.5.1).

Other theories contributing to modelling human behaviour in energy transition include:

- **Value-Belief-Norm Theory** (Lind et al., 2015; Hiratsuka et al., 2018): Focuses on personal norms activation through awareness of consequences.
- **Norm Activation Model** (Onwezen et al., 2013; López-Mosquera and Sánchez, 2012): Emphasizes moral obligations in shaping pro-environmental behaviours

The theories used in this study to explain and model human behaviour are detailed in Appendix B, section B.4.

1.5 Bridging the Intention-Behaviour Gap

Despite the widespread application of theories such as the Theory of Planned Behavior (TPB) and the Value-Belief-Norm (VBN) Theory to understand energy-saving behaviours, a significant gap remains in translating intentions into actual behaviours. This gap between intentions and behaviours poses a challenge in effectively promoting energy transitions. Studies indicate that even if people have strong intentions to adopt energy-efficient practices, there are several factors that prevent these intentions from turning into concrete actions. Understanding this influencing factors-such as motivational, contextual, and situational elements is crucial to designing interventions that bridge this gap and facilitate real behavioral change in energy consumption.

The following are the main gaps we identify based on the literature review:

- *Limited application to specific energy transition aspects*: While these theories have been applied to general energy-saving behaviours, there is a need for more research on their application to specific aspects like mobility choices, participation in flexibility markets, or joining energy communities.
- *Integration of multiple theoretical perspectives*: There is potential to combine these theories to create more comprehensive models for predicting energy transition behaviours.
- *Addressing the intention-behaviour gap*: More research is needed to understand factors influencing the translation of intentions into actual energy transition behaviours.
- *Incorporation of contextual factors*: There's a need for more studies on how situational elements interact with theoretical components in residential settings.
- *Longitudinal studies*: Most existing research is cross-sectional, leaving a gap in understanding how attitudes, norms, and behaviours change over time during the energy transition process.
- *Cultural and demographic considerations*: More research is needed on how these theories apply in different cultural contexts and demographic groups in residential settings.

These gaps present opportunities for future research to enhance our understanding of decision-making processes in the energy transition and develop more effective interventions for promoting sustainable energy behaviours.

1.6 Mobility

1.6.1 Sustainable Mobility Solutions

- **Adoption and Use of Electric Vehicles (EVs), Public Transport, and Micro-Mobility**: The integration of electric vehicles and other forms of sustainable transport is a key component of the energy transition. Research highlights the importance of EVs in reducing greenhouse gas emissions and the role of public transport and micro-mobility in creating efficient urban mobility systems (energy, 2023; J and H., 2023; Energy, 2019; Robert, 2017).

- Infrastructure and Policy Support for Sustainable Mobility: The European Union has implemented various policies to support sustainable mobility, including the development of EV charging infrastructure and incentives for public transport. The EU's Sustainable and Smart Mobility Strategy outlines goals for green, smart, and resilient transport systems (Council, 2018; Commission, 2023)

1.6.2 Behavioural Influences

When transport users evaluate the transport means to be used, the variety of alternatives they are likely to face during the decision-making process increases as a function of the information exchange and the factors they evaluate during the process. Several theories have been proposed to assess these decision-making processes such as the following:

- **Theory of reasoned action**, based on the relationship between attitude toward behaviour, behavioural intention and actual behaviour and subjective norm (Tu and Yang, 2019; Thompson, 2019).
- **The Theory of Planned Behaviour** includes the perceived behavioural control that dimension and describes how actual behaviour towards a specific action is an effect of behavioural intention which in turn is an immediate result of attitude towards behaviour, subjective norms and perceived behavioural control ability; when there is a correspondence between perceived behavioural control and actual behavioural control, this also exerts a direct influence on behaviour (Kaufmann, 2011; LaMorte, 2022).
- **The Technology Acceptance Model** proposes the dimensions of perceived usefulness and perceived Ease to Use to explain and predict the acceptance of new technologies. This model also explains how external factors can influence internal attitudes, beliefs and behavioural Intention (Marikyan and Papagiannidis, 2023; Nickerson, 2023; Thompson, 2019).

- **Innovation Diffusion Theory** explains how users adopt innovations, for users, new ideas, products, services or experiences are innovations. The innovative decision-making process (innovative decision-making process) can be divided into the stages of perception, persuasion, decision-making, implementation and confirmation (Rogers et al., 2019; Berwick, 2003).
- **The customer satisfaction theory** is based on the assessment of perceived service quality, customer satisfaction and behavioural intention. The relationship between satisfaction and intention reflects that those who perceive a high level of service quality are more likely to be positively satisfied and pleased (Fu and Juan, 2017; Worthington, 2021).
- **Consumer choice behaviour theory** (Economy; Geistfeld, 2099) states that consumer preference is influenced by consumer satisfaction with the available transport modes and their importance to the consumer, although individual perception and perceived suitability differ due to the socio-economic-status-of-consumer and the different intrinsic characteristics of the transport modes, which makes them neither directly observable nor measurable (latent variables).
- **The hybrid choice model**, which integrates consumer choice behaviour theory and discrete choice models to assess the impact of latent variables (perception, aptitude) on the decision-making process (Kim et al., 2014; Ben-Akiva et al., 2001).
- **The Integrated choice and latent variables model** (Vij and Walker, 2016) adds social influence to the hybrid choice model, thus defining a set of five latent variables to achieve a more accurate interpretation of the individual factors affecting transport mean choice. The variables are service environment, personal safety, modal comfort, feeling of waiting, and convenience.

The theories and behavioural models mentioned above are used to establish a theoretical framework to explore the factors that influence consumers' behaviour in their intention towards the transport means to be used.

1.6.3 Case Studies

1. Why and how do people choose a particular type of transport in their daily lives?

Over the last 20 years, improvements in public transport, planning and telecommunications systems have contributed to a significant reduction in people's preference for car travel (Ajzen, 1991a; Russo, 2019; Marikyan and Papagiannidis, 2023).

From the point of view of economics, travel is a combination of price and travel time, and users tend to compare the two and as far as possible, use the cheapest and fastest means of transport or combination of means of transport (Lopez, 2020; Ajzen, 1991a). There are other factors that may influence the choice of a particular mode of transport in our daily lives and that may lead us to use other means of transport than the car, Table 1.1 lists and describes these factors.

Table 1.1: Factors that influence the choice of a particular mode of transport, focusing on public transport and commuting habits.

Factor	Description
Combining pleasure, security and privacy	People are likely to use their cars for work, even if it takes them longer because they enjoy driving and like to be in their own protected space.
More efficient telecommunications systems	Internet and multimedia have changed the way we use our time; PT users can connect to Facebook, send messages, make phone calls or other similar activities, even the user can do the same on foot, but obviously, it is more difficult to do so if driving (of course it is forbidden).
An improved and more diverse range of public transport solutions	This refers to improvements in PT supply: rail system, tram line, metro, private hire cars, taxis; a PT system that allows people to move anywhere, almost anytime, as a result, people have started to use PT more and more. Investment in alternatives to the car can lead to a change in people's practices and aspirations regarding the use of different modes of transport.
Cycle lanes and pedestrianised cities	Urban planning and cycling have a major impact, cycling has become a mode of transport in its own right; the idea of mobility allows people to think of their daily commute as a source of physical exercise as well. Pedestrian-friendly urban planning initiatives have made walking more ergonomic.
The importance of routine	Studies and research on this topic have shown that modes of transport are not interchangeable; they offer different types of accessibility. People have a daily routine and use it to do different things, if they were to use another mode of transport, they would have to do things differently, in different places and in a different order, and this is also very important in the decision-making process and ways of thinking.
Travel as an activity in its own right	Traditionally, commuting was seen as a waste of time between activities, so people sought to minimise their time, the shorter the better, because it is simply a waste of time, but now people see their daily commute as a way of staying healthy.

2. Factors to consider when choosing the most appropriate mode of public transport

Understanding the motivations underlying transport mode choice is of utmost importance for interventions aimed at changing travel behaviour. In this sense, the theory of planned behaviour and CST are integrated in a third model with the Comprehensive

Psychological Process performed on individual transport means use decision making in order to predict intention and behaviour; this last resulting model identifies as key factors those described in Table 1.2. On the other hand, the relationship between these factors and their degree of influence on the choice of a mode of transport is illustrated in Fig A.1, which is included in Appendix A.

Table 1.2: Table of key factors to consider when choosing the most suitable mode of public transport.

Factor	Description
Intangible services	Whether it's convenient, comfortable and safe to travel by TP.
Information	Opinion about timetables, online information, station information, TP route/line information.
Cost	Opinion about the costs generated by using TP.
Satisfaction	Enjoys and/or prefers to travel by PT.
Perceived behavioural control	Can relax when travelling by PT.
Attitude	It is really difficult to stop using PT.
Subjective norms	Supportive comments from family and friends about PT use.
Habits	Travelling on PT is part of daily life.
Behavioural intention	Whether PT will be the first mode of transport in the future and willingness to use PT.
Behaviour towards public transport use	Frequency of use and willingness to travel by PT.

Additionally, based on the Consumer Choice Behaviour Theory, the Hybrid Choice Model, and the Integrated Choice and Latent Variables Model, the set of latent variables used to explain the individual factors and their degree of influence (Cronbach α) on the mode of choice of public transport (Chen and Li, 2017) are mentioned and described in Table 1.3

- **Other factors to consider when choosing the most appropriate mode of transport include the following**: travel distance, number of passengers, speed of transport/Time (time required to complete the journey based on the type of transport and routes), flexibility (operating services on fixed routes and/or pre-

Table 1.3: Latent variables influencing public transport mode choice, with Cronbach's alpha values indicating the reliability of each variable.

Variables	**Description**	Cronbach α
Service environment	Degree of cleanliness, ventilation inside the PT. Safe ascent/descent. Quality of the operator's attention. Overall satisfaction with the PT environment.	0.869
Personal safety	Emergency exit and equipment in the PT. If the dissemination of information about how to act in case of an accident, fire, earthquake, etc., is correctly carried out. General satisfaction and feeling of safety in a PT.	0.768
Modal comfort	Degree of ergonomics, comfort and entertainment (radio, internet, etc.) in the PT. Clear and correct information on PT routes and stations.	0.759
Waiting feeling	Punctuality of departure and arrival of the PT. Timely departure/arrival information on notice boards, actual waiting time is very close to the estimate shown on notice boards. Other information provided at stations is interesting.	0.742
Convenience	When the time between the place of departure and the PT station is short. Convenience to transfer to other similar transport or other modes of transport. Information at PT stations is clear.	0.696

planned schedules), efficiency, diversity of transport, reliability inter-modal points, cycleways, Pedestrian-friendly cities, the importance of routine.

- **Influence of climate on public transport use**. In general, public transport services must operate in a manner that adequately meets the needs of passengers, from daily commuting to less routine and more spontaneous trips (Tao et al., 2018). Adverse and extreme weather conditions (e.g., heavy precipitation, low temperatures and high winds) are known to have the capacity to degrade service quality (e.g., disrupting service schedules) and passenger experience (e.g., waiting times and prolonged journeys), with the potential to induce temporary and long-term declines in ridership. In this regard, In Appedix A, Fig A.2 shows the most common weather conditions and the potential to negatively influence the use of public transport, bicycle and scooter use and pedestrians.

3. Why does a person buy a certain vehicle or not?

According to Theory of Planned Behaviour (TPB) and TPB, the key factors that positively influence consumer acceptance of electric vehicles and purchase intention are the following:

- Perceived usefulness, Perceived Ease of Use, Compatibility and Personal Innovation as sources of Behavioural Attitude;
- Interpersonal Influence and External Influence are sources of Subjective Norms;
- Self-Efficacy, Enabling Conditions, and Perceived Behavioural Control as similar dimensions that consequently form a new dimension named Self-Control Ability.
- Finally, Behavioural Attitude, Subjective Norms and Self-Control Ability are considered as the sources that influence behavioural Intention or behavioural Intention towards the purchase of electric vehicles;

These elements are described in Table 1.4, while Fig 1.1, shows graphically the relationship between these factors.

Based on table 1.4, the following is confirmed (Chen and Li, 2017):

- Behavioural attitude, subjective norms and self-control ability have significantly positive impacts on behavioural intention. Specifically, self-control ability is the most influential, followed by subjective norms and attitudes towards behaviour, indicating that consumers' control over the resources needed to purchase electric vehicles has the greatest impact on behavioural intention. In addition, the opinions consumers hear from their environment also have a large impact on consumer's intention to purchase electric vehicles. In addition, consumers' environmental awareness and their acceptance of technological products are also factors that affect their behavioural intention.
- Perceived usefulness, perceived ease of use and compatibility have significantly positive impacts on behavioural attitudes. Specifically, perceived usefulness has the strongest influence, followed by perceived ease of use and perceived compatibility, indicating that when consumers believe that electric vehicles are

Table 1.4: An overview of the factors driving or slowing down the adoption of electric vehicles among consumers.

Factor	Description
Attitude towards behaviour	Consumer attitudes towards the purchase of EVs.
Perceived usefulness	Consumers' perception of the efficiency of electric vehicle functions.
Perceived ease of use	Consumers' ability to learn how electric vehicles work and use them without too much effort.
Compatibility	Consumers do not need to adapt to electric vehicles.
Personal innovation	Consumer acceptance of electric vehicles.
Subjective standards	Subjective opinions of friends, family, media, government policies and internet information about electric vehicles.
Interpersonal influence	The impact of groups with whom consumers have frequent interactions, including parents, relatives, friends and supervisors, on the purchase of electric vehicles.
External influence	The impact of media, expert opinions and other non-interpersonal information on consumers' purchase of electric vehicles.
Self-monitoring	The impact of media, expert opinions and other non-interpersonal information on consumers' purchase of electric vehicles.
Self-efficacy	Consumers' self-monitoring ability to purchase electric vehicles, including capacity, knowledge and expression of confidence.
Enabling conditions	Consumers' opportunities and resources necessary for EV purchase, i.e. support from external resources.
Perceived behavioural control	Consumer control over the opportunities and resources necessary for EV purchases.

more beneficial on an individual, environmental, or national level, or believe that it is easier and more convenient to use electric vehicles, they have a more positive attitude towards the purchase of electric vehicles. In addition, consumers think that electric vehicles are forward-looking technology products with similar driving operations and cost of use as traditional vehicles. These opinions and factors have a positive relationship with consumers' attitudes towards the purchase of electric vehicles. In contrast, personal innovation has a negative impact, showing that when consumers think that they do not under-

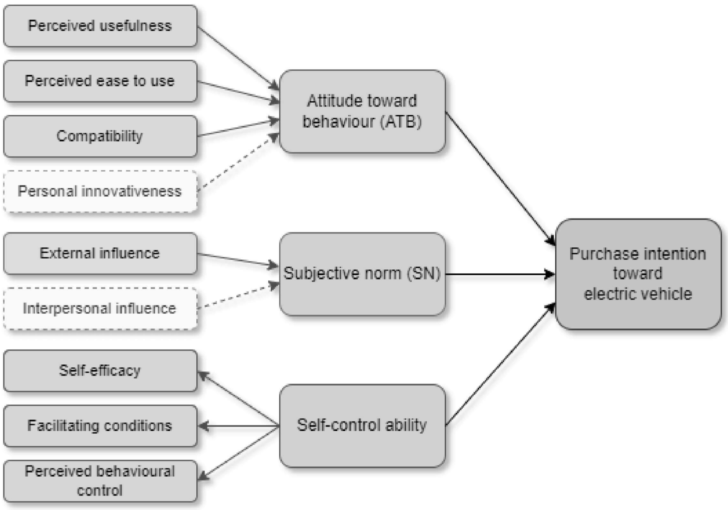

Figure 1.1: Factors that directly influence the intention to purchase electric vehicles, with behavioural attitude, subjective norm and self-control ability being the key predictors in the decision-making process.

stand electric vehicles better than those around them, they will not prioritise electric vehicles. In addition, their interest in EVs is also almost equal to that of traditional vehicles.

- Interpersonal influence negatively affects consumers' subjective norms, implying that the opinions of family, friends, peers or supervisors will not affect their attitude or behaviour towards EV purchases. External influence positively affects consumers' subjective norms, implying that, compared to the opinions of people around them, consumers are more convinced by objective information, expert opinions, and support for government policies.

4. Buying an electric vehicle

While it is fairly easy to get to most cities, getting the last mile to your final destination is not easy. The same happens on the other end of the journey (the first mile) (Toll, 2018). The last mile has found a solution in personal electric vehicles which can range from bicycles, scooters and even skateboards, all of which are electric. While it is a 1000 W electric bicycle that can go 47 km/h and is faster than almost anything else, it can still travel fast on smaller electric bicycles, electric scooters and electric skateboards.

When deciding to purchase an electric vehicle one initially thinks about a set of general factors (Camnada.Ca, 2023; Concerned-Scientists, 2018). Then an EV is selected from the three basic options: car (Concerned-Scientists, 2018), bicycle (Lopez, 2020) and scooter (Toll, 2018). In Appendix A, the Fig A.3 shows the graph of this process and the factors that are recommended to be considered and evaluated.

1.7 Flexibility

1.7.1 Concept of Energy Flexibility

Energy flexibility refers to the capacity of energy systems, especially in the context of households and local markets, to adjust their energy consumption in response to external signals, such as changes in prices or grid demands. This concept is key to balancing supply and demand, especially with the increasing integration of renewable energy sources, which are often variable and intermittent. Energy flexibility can be achieved through various technologies and systems, such as demand response programmes, smart grids and distributed energy resources (DER), which allow consumers to adjust their energy consumption dynamically. Technologies such as Internet of Things (IoT) devices, smart appliances and blockchain-based platforms for peer-to-peer energy trading are also increasingly used to improve energy flexibility. (Borges et al., 2022b; Pressmair et al., 2021; Zabaleta et al., 2020).

1.7.2 Behavioral Aspects

Consumer engagement is a critical component of energy flexibility, particularly in demand response programs where consumers adjust their energy usage in response to signals from the grid. Behavioural factors, such as the level of trust in energy providers, perceived control over energy use, and the convenience of participating in flexibility markets, significantly influence consumer participation. Successful engagement in these programs requires consumer awareness and willingness to participate, often influenced by financial incentives and environmental consciousness (Borges et al., 2022b; Kraftwerke)

Psychological factors, including perceived control, trust in technology, social norms, consumer attitudes towards technology, fear of complexity, and concerns about privacy and data security, also play a vital role in the adoption of energy flexibility measures. For instance, the reluctance to engage with smart contracts in blockchain-based energy markets can stem from legal uncertainties and a lack of understanding of the technology's benefits. Understanding these factors can help design more effective programs that encourage consumer participation (Borges et al., 2022b; Kraftwerke; year National Grid Electricity System Operator, 2020; Zabaleta et al., 2020)

1.7.3 Barries and solutions

- **Challenges to Widespread Adoption of Flexibility Measures**:
  The adoption of flexibility measures faces a number of barriers, including socio-economic, technical and legal ones. Socio-economic barriers, such as lack of consumer awareness and commitment, as well as the perceived complexity of participating in flexibility markets, can significantly hamper the uptake of these measures. Technical barriers include issues related to interoperability of devices, reliability of communication networks and integration of new technologies into existing energy systems. Legal barriers, such as the absence of regulatory frameworks to support local flexibility markets and uncertainties surrounding the use of emerging technologies such as blockchain, further complicate the deployment of flexibility measures. In addition, traditional grid infrastructure was not designed to accommodate the diverse range of technologies available today, adding another layer of complexity to the implementation of these measures. (Borges et al., 2022b; year National Grid Electricity System Operator, 2020; Zabaleta et al., 2020; Kraftwerke).

A comprehensive study was conducted to identify and categorize these barriers through a triangulation approach, which included a systematic literature review, pilot-site visits, stakeholder interactions, online surveys, workshops, and expert interviews. The study was carried out in two phases: the first phase involved identifying all relevant barriers, and the second phase focused on classifying these barriers into a taxonomy. The barriers were organized into six main themes: (1) fit to current lifestyles, (2) administration, (3) standardization, (4) trust, (5) technical, and (6) costs. This structured categorization provides a clear understanding of the challenges that need to be addressed to enhance the adoption of Local Flexibility Markets.
Each of these barriers along with those identified in the state-of-the-art were clustered in categories as can be observed in Appedix A, Fig A.4.

- **Strategies to Overcome These Barriers**:
  Solutions to these challenges involve increasing consumer awareness through education and outreach, investing in infrastructure improvements, and creating supportive regulatory frameworks. Additionally, leveraging digital platforms and technologies can simplify participation in flexibility programs and enhance consumer engagement (Pressmair et al., 2021; Zabaleta et al., 2020; IRENA, 2023).

  – **A user-centric and hybrid model**. A user-centric hybrid market model has been proposed as solution to enable the widespread adoption of Local Flexibility Markets (LFM) and Local Energy Market (LEM) in the European Union. The key parameters for characterising a new market model are identified and reviewed. The results of the applied Delphi method are presented, prioritising barriers for the widespread adoption of LEMs and LFMs, and identifying conflicts of interest in such new schemes, from the perspective of energy market participants. The findings highlight the strengths and weaknesses of the proposed market model. (ParityProject-Consortium, 2023). The local market aims to achieve three main objectives: (1) to provide flexibility services to distribution system operators (DSOs) to manage congestion and control voltage, (2) to enable small prosumers connected to the distribution grid to participate in the provision of flexibility, and (3) to facilitate flexibility through energy transactions between prosumers. The results indicate that the most important barriers for market participants, such as distribution system operators, energy retailers and aggregators, are related to standardisation, including technical standards, the lack of standardised business models and the diversity of flexibility markets (Zabaleta et al., 2020).

- **Blockchain application in P2P energy markets**. In flexible and distributed energy markets, ensuring information transparency is critical to maintaining a fair and secure market. A key aspect of these markets is the exchange of information through contracts between prosumers or intermediaries. The digitisation of these contracts through smart contracts, based on blockchain technology, is a natural progression and a critical factor for the growth of flexible and distributed markets. Blockchain technology improves the security and transparency of information flows between energy prosumers (Borges et al., 2022b; Iberdrola, 2019; Hua et al., 2022). As the energy distribution landscape has evolved from a traditional centralised structure to more distributed schemes, the complexity of interactions across multiple network levels has increased. Blockchain offers significant improvements by providing decentralised and secure communication systems within energy networks. Smart contracts, which are immutable pieces of code, play a vital role in peer-to-peer energy distribution networks, offering advantages such as accuracy, speed and security (Iberdrola, 2019; Borges et al., 2022b). Prosumers are generally positive about blockchain applications in peer-to-peer energy markets, although they express concerns about systems/algorithms and lack of regulation, which they see as the main risks (Borges et al., 2022b). In Appendix A, the Fig A.5 shows graphically the results.

1.8 Buildings

1.8.1 Energy Efficiency in Buildings: Focus on Heating and Cooling Systems

Heating and cooling systems are fundamental to the energy efficiency of buildings, as they account for a significant part of the energy consumed in residential. Efficient heating and cooling involves optimising the performance of these systems to reduce energy consumption while maintaining comfort levels. This can be achieved through a variety of strategies, such as using of high-efficiency HVAC (Heating, Ventilation, and Air Conditioning) systems, improved insulation and advanced control technologies that adjust temperatures according to occupancy and external weather conditions (Hernández, 2014; Álvaro Hermana, 2022).

1.8.2 Energy Efficiency in Buildings

- **Strategies for Improving Energy Efficiency in Residential Buildings**. Improving energy efficiency in residential buildings can be approached through several strategies, including enhancing the building envelope, upgrading insulation, installing energy-efficient windows and doors, and integrating smart technologies for monitoring and controlling energy use. These strategies are crucial for reducing energy demand and lowering greenhouse gas emissions. For example, retrofitting existing buildings with energy-efficient materials and technologies can lead to substantial energy savings (Hernández, 2014; Álvaro Hermana, 2022). Reducing the environmental impact of the building sector involves: (a) establishing strict standards for new construction; (b) encouraging the energy rehabilitation of existing buildings in areas such as lighting, air conditioning, automation and control of energy use, maintenance of installations, renovation of building envelopes or the installation of new domestic hot water systems, with zero or low greenhouse gas emissions; (c) favouring the replacement of equipment (e.g., household appliances) with more efficient ones (Álvaro Hermana, 2022). The main drivers of transforming buildings into energy hubs will be renewable energy (e.g., solar photovoltaic), energy storage, new energy consumption and control devices, the massive deployment of heat pumps, and the increasing penetration of electric mobility. Housing retrofitting will strengthen the support and protection of the most vulnerable consumers and those at risk of exclusion or energy poverty and improve the population's quality of life and health (Álvarez Pelegry et al., 2017; Zhang et al., 2022).EU initiatives promote the acceleration of the green and digital transition, including the integration of renewable energy and the renovation of buildings to improve energy efficiency and support vulnerable consumers (IRENA, 2023; EC, 2024a).

- **Towards Climate Responsive Building Design**. The Ghanaian study on bioclimatic design features provides valuable insights that can be applied to the European context, especially now that Europe is facing increasing temperatures due to climate change (UN, 2023). The research highlights how traditional building designs in hot and humid climates, such as those in Kumasi, Ghana, use elements such as outward-facing terraces, steeply pitched roofs and large, fully operable windows to enhance natural ventilation and reduce reliance on energy-intensive systems such as air conditioning (Amos-Abanyie et al., 2021). In Europe, the adoption of similar bioclimatic principles could help mitigate the effects of rising temperatures. Key strategies include optimising building orientation to minimise solar heat gain, incorporating large windows for cross-ventilation and using lightweight, thermally efficient materials. These measures can reduce the need for mechanical cooling and improve indoor thermal comfort, thereby reducing energy consumption and contributing to more sustainable building practices (Amos-Abanyie et al., 2021; Hafez et al., 2023). It is hoped that the results will spark renewed interest in building design in response to the climatic conditions of the environment and in order to reduce dependence on energy use. Simultaneously, it is hoped that they will serve as a valuable reference for contemporary architectural design practice and education (D'Agostino et al., 2024).

1.8.3 Role of Renewable Energy in Building Energy Systems

The integration ºof renewable energy sources, such as solar and wind, into building energy systems plays a key role in improving energy efficiency. These renewable sources can be used to power heating, cooling and lighting systems, significantly reducing dependence on fossil fuels. Solar panels, for example, can provide a clean and sustainable energy supply, which can be stored in batteries for use during periods of low sunlight, ensuring a constant and reliable flow of energy (Hernández, 2014; Hafez et al., 2023; Hic, 2020).

1.8.4 Occupant Behavior

- **How Occupant Behavior Influences Energy Use in Buildings**
  Occupant behaviour is a key factor influencing the energy consumption of buildings. The way people interact with heating, cooling and lighting systems can cause significant variations in energy consumption. For example, leaving lights on in unoccupied rooms, setting thermostats too high or too low, and not using energy-saving devices all contribute to higher energy consumption. Understanding these behaviours is essential for developing strategies to reduce energy consumption through behavioural interventions (Álvarez Pelegry et al., 2017; Lysandra and Amy, 2017).
  There are a number of factors that influence individual energy consumption behaviours and the role of personal practices in driving energy efficiency and sustainability. Three key determinants of energy-related actions have been identified: (1) investments in home insulation, solar panels and energy-efficient appliances; (2) conservation efforts through habit changes, such as turning off unused appliances and adjusting the temperature in the home; and (3) switching to greener electricity sources. The results reveal that the likelihood of households to invest in energy efficiency is closely related to residents' educational level, personal norms and the type and size of their residence. These factors—personal goals, knowledge, and housing characteristics—are key to encouraging energy-efficient behaviour (NMi, 2020; Liu et al., 2021).

In terms of energy efficiency, the adoption of energy conservation measures is influenced by personal norms, as well as by the type, energy label and age of the dwelling. Finally, when it comes to switching to renewable electricity sources, the decision to change supplier or to switch from one green supplier to another is mainly driven by personal norms and similar explanatory variables. These data are particularly relevant for European countries facing the need to improve household energy efficiency as part of broader climate change mitigation strategies (NMi, 2020; İnci Dursun et al., 2019; Kleinschafer et al., 2021; Liu et al., 2021).

- **Effective Interventions to Promote Energy-Efficient Behaviors**
  Promoting energy-efficient behaviour among occupants can be achieved through a variety of interventions, such as educational programmes, feedback systems that show real-time energy use and incentives to reduce consumption. Smart home technologies, which automate energy-saving actions such as adjusting thermostats or turning off lights when rooms are empty, can also play a crucial role. In addition, behavioural change campaigns that highlight the environmental and economic benefits of energy savings can motivate occupants to adopt more sustainable practices (Hernández, 2014; Liu et al., 2021; Hafez et al., 2023).

1.8.5 Effective Interventions to Promote Energy-Efficient Behaviors

- **Promoting energy-efficient**
  Promoting energy-efficient behaviours among occupants can be achieved through various interventions, such as educational programs, feedback systems that show real-time energy use, and incentives for reducing consumption. Smart home technologies, which automate energy-saving actions like adjusting thermostats or turning off lights when rooms are empty, can also play a crucial role. Additionally, behaviour change campaigns that highlight the environmental and financial benefits of energy conservation can motivate occupants to adopt more sustainable practices (Hernández, 2014).

- **Improving energy efficiency in buildings: Review and compiling. Material Today Proceedings**
  The research of this project (Hic, 2020) aims to reduce energy consumption in the building sector while maintaining a satisfactory level of thermal comfort. It investigates the effect of integrating passive or semi-passive techniques (i.e., thermal insulation, thermal inertia for external walls, effects of a double slab, and integration of solar systems for heating, among others). For example, thermal insulation (one of the most reliable passive systems that improve thermal comfort in winter and summer) and ventilation techniques must be applied to reduce the risk of overheating. The installation of shading devices outside the windows is necessary. Well-located vegetation can create a natural fresh air reservoir for cooling. This project considers low-energy buildings (LEB), which have a primary energy consumption for heating, cooling, ventilation, hot water, and lighting of less than 50 kWh/year. The energy production in these buildings is generally achieved through renewable energy systems. Thermal solar panels provide heating and cooling and hot water, and the electricity consumed by lighting and ventilating is generated from photovoltaic solar collectors or small wind turbines.

  - **Renewable energies in heating and cooling in the residential and tertiary sectors**. This report analyses (Álvarez Pelegry et al., 2017), after making a short description of the leading European regulation related to renewable energies in buildings, the degree of penetration of renewable energy sources (RES) in the final uses of energy (i.e. in heating, cooling and domestic hot water systems and others such as cooking), comparing the overall situation with the situation in electricity, transport and final energy. It includes an analysis of the situation mainly in the residential sector in Spain and the Basque Country, focusing on biomass, solar thermal, geothermal energy and heat pumps. In the conclusions and suggestions section, some existing challenges in the heating and cooling sector were pointed out to address its more significant involvement in meeting renewable targets in the medium and long term.

- **Key factors prioritizing energy resource conservation measures in a portfolio of buildings**. This article's main objective (Lysandra and Amy, 2017) was to identify the main decision factors for green retrofits, particularly the selection and implementation of energy-efficient retrofits, considering a literature review. The results concluded that the underlying dimensions relate to occupant impact, environmental impact, stakeholder support, the economic feasibility of the proposals, and practicality and ease of implementation of the proposals.
- **Designing sustainable and healthy homes**. This paper (Hernández, 2014), aims to present research on designing a sustainable home with passive and active systems to improve the health of the inhabitants of a poor Mexican town called Azumiatla. The proposals made have taken into consideration the lifestyle and characteristics of the families (also considering the poverty of its citizens) and included the views and needs of the population (local materials, walls and roof materials with good thermal and acoustic properties, "dry" toilets, green roof, vegetable garden, daylight access, natural ventilation, and energy-efficient oven and lamps, as well as solar energy systems). The architectural design approach includes natural ventilation, daylight, thermal mass, solar protection, evaporation, insulation, climate characteristics, and all forms of passive houses or, in general, bioclimatic architecture.

In conclusion, developing countries with low-quality housing stock should seek environmentally friendly and user-friendly solutions. These solutions include a flexible design of adaptable, comfortable and affordable houses according to people's needs, beliefs and traditions, families' changes and characteristics, and climate conditions.

1.9 Everyday Appliances and Energy Efficiency

Trends in appliance energy use

The energy consumption of household appliances varies considerably depending on the type of appliance and user behaviours. For example, behaviours such as doing laundry in professional laundries rather than at home can reduce energy consumption, as commercial machines are generally more efficient in terms of water and electricity use. In addition, the decision to replace appliances such as ceramic hobs often involves extensive research by consumers, who often consult multiple online resources and customer reviews before making a purchase. The criteria influencing these decisions vary by region, with some prioritising price and performance, while others place equal importance on energy efficiency (De and D'équipement, 2020; Vincent, 2016).

Impact of energy-efficient appliances on overall consumption

Energy-efficient appliances can significantly reduce total household energy consumption. This is especially true when people are well informed about the environmental impact of their energy consumption and have been educated from an early age on sustainable practices. Public displays of energy consumption, such as competitive energy-saving campaigns, can also encourage people to adopt more energy-efficient behaviours, further increasing the impact of these appliances on reducing energy consumption (Kelleher, 2016; Graffeo et al., 2015).

1.9.1 Behavioral Interventions

Programs and policies to encourage the use of energy-efficient appliances

Programmes and policies to encourage the use of energy-efficient appliances: Behavioural interventions that foster energy-efficient behaviours often focus on increasing consumer awareness and education. For example, information systems that display energy consumption in real-time or public comparisons of energy consumption can motivate people to reduce their consumption. Programmes that highlight the energy-saving potential of shared appliances in multi-apartment buildings also contribute to more sustainable energy consumption habits (Graffeo et al., 2015; Lemoine, 2021).

Consumer behaviour regarding appliance use and energy conservation

Consumer behaviour is a key factor in the adoption of energy-efficient appliances and conservation practices. The decision-making process often involves consulting online reviews, seeking advice from friends and family, and assessing products in-store before making a purchase. In addition, factors such as the convenience of using the appliance, perceived energy savings and the visual appearance of the appliances can influence consumers' decisions. For example, in laundromats, the quality of service, the efficiency of the machines and even the cleanliness and ambience of the space can influence whether people choose to use these services instead of washing at home (Russo, 2019; De and D'équipement, 2020).

1.9.2 Market and Policy Considerations

Role of market incentives and regulatory policies in promoting energy-efficient appliances

The role of market incentives and regulatory policies in promoting energy-efficient appliances: Market incentives and regulatory policies are key to promoting the uptake of energy-efficient appliances. These may include subsidies, tax incentives or regulations requiring certain energy standards for appliances. In addition, public awareness campaigns and educational programmes can complement these policies by making consumers more aware of the long-term economic and environmental benefits of energy-efficient products. In regions where energy criteria are as important as price, such as parts of Europe, these incentives can be particularly effective in driving market changes(Coin-Meter, 2017; MLA, 2020).

1.9.3 Insights into future scenarios for household appliances and energy efficiency

Minimum

When it comes to changing daily behaviour in a sustainable way, one of the major determinants is the degree of information that an individual already has or receives. Ecological awareness is found particularly in individuals who were educated in the family environment from an early age, about consumerist actions and their consequences on the environment. For these people, the propensity to act on a daily basis by limiting energy consumption is important (Kelleher, 2016). Another factor that fosters ecological action in one's home is the public display of its energy consumption. The experiment was carried out in a group of students: for each of them, a poster in their residency showed the most economical (the students' names were highlighted in green) and the most consumerist (those were highlighted in red). Quickly, changes in behaviour were observed among the "red students" who began to reduce their electricity consumption by simple gestures: turning off the lights, lowering the thermostat, and wearing warm clothes... Putting people in competition is a way to trigger behavioural changes. Finally, another factor that leads to behaviour change is allowing the individual to see the habits of a similar group. The experiment was conducted in a hotel: each room had a poster in its bathroom informing that 75% of the guests were reusing the same towel, thus limiting laundry expenses. Rapid results were observed, as guests increasingly reused the same towel (Graffeo et al., 2015).

Probable

When we look at the behaviour of individuals in a purchasing process (in our scenario, the replacement of ceramic hobs), one of the major reflexes is to consult the existing offer on the internet: On average, consumers consult 4 websites before buying (De and D'équipement, 2020). On these sites, 70% of buyers consult customer feedback beforehand. Many also watch videos of the products in operation and take into account the advice of family or close friends if they know the product (by having tested it or by expertise in the field). After learning about the product from a distance, via the internet and word of mouth with friends and family, the next step is usually to go and see the product in store. This is the case for 68In the shop, before the final act of purchase, the criteria of choice differ from country to country. In France, the first factor is the selling price as well as the technical performance of the product. Then comes the consumption and the energy label. Finally, to a lesser extent, the design. In Italy and Germany, on the other hand, the energy criterion is as important as the price.

Plausible

There are many things that can encourage an individual to do their laundry in a laundromat. Even if you have to count the travel time, washing at a professional laundry is faster than at home: 60 minutes on average, that is to say, 30 minutes less. Since you have to get out of the house, one of the arguments in favour of using such a service is productivity: take advantage of the washing time to do activities such as shopping, sports, and walks. Another element to take into account is the level of performance of the equipment available from a professional. They are more economical in water and electricity than domestic equipment and can accommodate up to 20kg of laundry (compared to 5kg on average for a standard washing machine). The quality of the wash is also better, the toughest stains will be removed. Finally, as the in-line capacity is larger, you can take advantage of it to wash large fabrics: tablecloths, curtains, carpets (Vincent, 2016). If the above elements are present, one factor in the decision will obviously be the proximity of the laundromat to the living area. As with the purchase of a new household appliance, customers of this type of service look to user feedback to make their decision. If additional services are offered (like wash-dry-fold services, dry cleaning, or even seemingly small amenities like WiFi, to make the wait pleasant if you decide to stay during the wash), this will encourage people to go to a professional. Finally, an individual wishing to see the laundromat with his own eyes in order to make a decision will take into account the visual aspect of the place: he will associate the cleanliness, the aesthetic aspect with the quality of the service, in particular, because it is about (laundry) cleaning. The paintings and lighting of the facade but also the cleanliness of the interior, and the visual aspect of the washing machines and dryers will be taken into account. Details that will influence the decision: advisors in the laundromat and also the possibility to see the water level through the washing machines (Russo, 2019).

Ideal

When it comes to sharing a home appliance within a community (multi-apartment building), the first decision factor is the guarantee of the same benefits as private ownership. These are proximity, autonomy of use, availability at the moment of need, and permanent good functioning. Also, a person considering moving to the pooling of household goods will not want to be in charge of it and maintain it; he will only want to use it for his function (Lemoine, 2021). If these conditions are met and demonstrated (via a member of the dwelling who would succeed in convincing the community), the benefits obtained would be the following: access for all to a variety of better quality appliances, implying speed of washing, allowing residents to do more loads per week (MLA, 2020), energy (Coin-Meter, 2017) (and therefore financial) savings, reduction of constraints (of space and maintenance in particular). In the literature, the "space saving" factor is recurrent and a decision factor in particular for students or young workers living in small apartments, where a washing machine generally takes a non-negligible space. Sometimes, there is no space for such an appliance or the individuals cannot afford to buy it. In other cases it is the discouragement at the idea of mounting the appliance on several floors that is mentioned. In these contexts, people are inclined to share household goods. Finally, if an isolated space in the building is dedicated to laundry, it will save the residents from noise pollution.

1.10 Modelling to better understand and predict household energy demand - A causality approach

This study represents a significant advance in enhancing energy demand modelling to predict the domestic sector's energy consumption taking into account the future challenges facing the electrical system. The study aims to map the factors that influence people's behaviour, even under interventions, and to enhance green energy policy actions from local systems to international contexts. The focus is on modelling to better understand and predict household energy demand, thereby facilitating more informed policy-making and energy management strategies.

1.10.1 **Solution base on Causal models**

The system aims to enhance understanding of household energy consumption by analyzing human decision-making and responses to interventions like policy changes. It focuses on various household services, their usage, and energy consumption patterns, both synchronous and asynchronous. The model seeks to transition from association rules to a causation model, allowing for more accurate predictions of energy consumption outcomes under different scenarios, including future developments.

The solution will be implemented in the context of the WHY project to improve energy demand modelling to forecast the domestic sector's energy consumption (WHY-Consortium, 2020b,b,a).

To address climate change, rapid action across all economic sectors is essential to substantially reduce greenhouse gas emissions. While Energy System Models (ESM)s are effective in analyzing the supply side, they fall short in accurately assessing household energy usage. The novel Causal Modeling approach addresses this gap by quantitatively analyzing how people make decisions regarding energy use and their responses to policy changes, thereby enhancing the precision of demand-side energy modelling. The new Causal Modeling will be used to quantitatively analyse human decision-making in energy consumption and human reactions to interventions (WHY-Consortium, 2020a), As it is shown in fig 1.2.

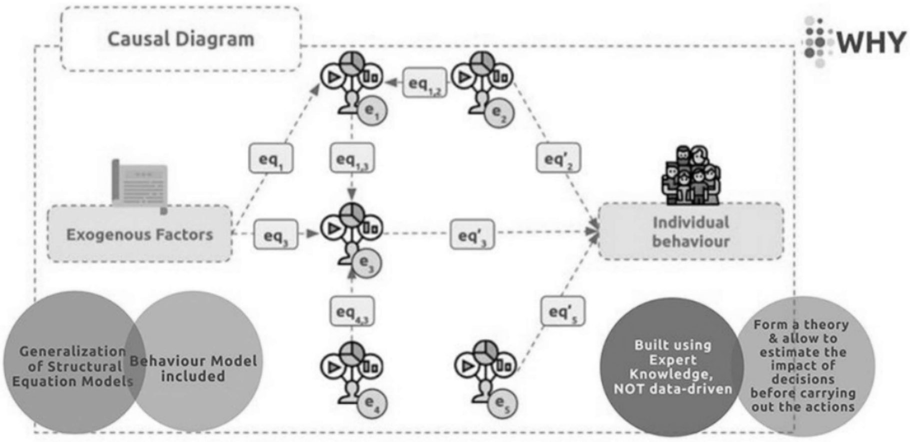

Figure 1.2: Causal model framework developed for the WHY project. The model analyze and predict individual behaviour in relation to exogenous factors (WHY-Consortium, 2020a).

Causal Modellling Techniques

Causal modelling techniques are used to discern and scrutinise the cause-and-effect relationships among variables. These techniques play an integral role in comprehending how alterations in one variable may precipitate changes in another, thereby enabling researchers to formulate predictions and guide policy and decision-making processes. Key causal modelling techniques considered to develop the WHY project solution include the following:

- Directed Acyclic Graphs (DAGs): DAGs serve as graphical depictions of causal relationships between variables. They are vital for pinpointing potential confounding variables that must be controlled to derive valid causal inferences (Pearl et al., 2016; Pearl and MacKenzie, 2019).
- Structural Equation Modelling (SEM): SEM represents a robust statistical approach that amalgamates regression analysis and factor analysis. It facilitates the examination of intricate relationships between observed and latent vari-

ables and enables the testing of theoretical models for causal connections (Jöreskog and Sörbom, 1993; Smith and Hoyle, 1996).

- Counterfactual Reasoning: This involves hypothesizing about scenarios in the absence of the treatment or intervention. It forms the conceptual foundation for many causal inference techniques and seeks to estimate causal effects by juxtaposing actual outcomes with hypothetical counterfactuals (Pearl, 2008).
- Propensity Score Matching (PSM): As a statistical matching technique, PSM aims to estimate the impact of an intervention while accounting for covariates predictive of treatment reception. It's instrumental in mitigating selection bias in observational studies (Austin, 2007; Pearl et al., 2016; Austin, 2011).
- Randomized Controlled Trials (RCTs): Regarded as the pinnacle for causal inference, RCTs involve random allocation of participants into treatment or control groups, with subsequent comparison of outcomes. Randomization ensures that the groups are comparable, barring the treatment, thereby enabling causal interpretations of outcome disparities (MacGill, 2018; Pearl and MacKenzie, 2019).
- Difference-in-Differences (DiD): DiD, a quasi-experimental technique, estimates the causal effect of an intervention by comparing outcome changes over time between a treatment group and a control group. This method is prevalently utilised in policy evaluation and economics (Torres-Reyna, 2015; Zeldow and Hatfield, 2019).

Each technique possesses unique strengths and limitations, and the selection hinges on the research question, data nature, and justifiable assumptions. Causal modelling is an influential tool in understanding complex phenomena, necessitating meticulous application and interpretation for valid causal relationship conclusions.

Directed Acyclic Graphs in Modeling Human Behaviour

Directed Acyclic Graphs (DAGs) are graphical representations of causal relationships between variables, widely used in fields like statistics, epidemiology, and social sciences to model human behaviour. Below are the advantages and disadvantages of employing DAGs for this purpose:

Advantages of DAGs:

- *Clarification of Causal Relationships*: DAGs elucidate complex causal relationships through a visual representation of the direction of causality between variables (Hernan and Robins, 2024; Pearl and MacKenzie, 2019).
- *Identification of Confounding Variables*: These graphs are instrumental in identifying potential confounders, crucial for making valid causal inferences in a study (Pearl et al., 2016; Hernan and Robins, 2024).
- *Facilitation of Communicatio*n: DAGs provide a clear and intuitive means to describe the assumed causal structure of data, enhancing communication among researchers (Pearl and MacKenzie, 2019; Hernan and Robins, 2024).
- *Guidance for Statistical Analysis*: They aid in selecting appropriate statistical models and methods for data analysis, based on the depicted causal relationships (Pearl, 2019).
- *Transparency of Assumptions*: The assumptions underlying causal inferences are made explicit in DAGs, which is essential for the scrutiny and validation of research findings (Pearl et al., 2016; Hernan and Robins, 2024).
- *Avoidance of Bias*: By carefully analyzing paths in a DAG, researchers can design studies and analyses to avoid common biases, such as collider and selection bias (Hernan and Robins, 2024).

Disadvantages of DAGs:

- *Complexity in Large Systems*: DAGs can become cumbersome and challenging to interpret in systems with numerous variables and intricate interactions.
- *Dependence on Correct Specification*: The accuracy of inferences from DAGs hinges on the correct graph specification. Misrepresentation can lead to misleading conclusions.
- *Challenges in Establishing Causality*: Although DAGs indicate causal relationships, empirical data and rigorous study designs are necessary to establish causality.

- *Static Representation*: DAGs usually depict static relationships and may not capture dynamic behaviours that evolve over time.
- *Risk of Oversimplification*: Simplifying complex human behaviours into a DAG might not capture all nuances and contextual factors influencing behaviour.
- *Assumption of Acyclicity*: DAGs presume acyclic relationships, which may not always reflect real-world systems where feedback loops are present.

Real-World Applications of Directed Acyclic Graphs in Modelling Human Behaviour

Directed Acyclic Graphs (DAGs) are utilized in multiple fields to model human behaviour and comprehend causal relationships among behavioural, social, and environmental factors. Though specific examples of DAGs in human behaviour modelling were not detailed in the search results, the broader context of consumer behaviour and decision-making provides a foundation for understanding their application. Here are several real-world uses of DAGs in modelling human behaviour:

1. *Health Behaviour and Epidemiology*: DAGs model the intricate interplay of factors influencing health behaviours, like smoking, diet, and exercise. They aid researchers in pinpointing key health outcome determinants and crafting interventions for healthier lifestyles (Pearce et al., 2019; McDowell, 2023).
2. *Marketing and Consumer Research*: In marketing, DAGs elucidate causal pathways leading to consumer purchasing decisions, helping marketers grasp how advertising, brand perception, and social influences drive consumer choice and loyalty (CoreXM, 2022).
3. *Social Policy and Economics*: Applied in social policy, DAGs model intervention effects on social outcomes such as education and employment, enlightening policymakers about policies' direct and indirect impacts on individual and societal behaviour.
4. *Psychology and behavioural Sciences*: DAGs in psychology study relationships among cognitive processes, emotions, and behaviours, assisting in identifying behavioural causes and change potentials (Sloman and Lagnado, 2015; Young, 2016).

5. *Environmental behaviour*: They model how environmental factors and personal beliefs impact sustainability-related behaviours, like recycling or energy use, useful in environmental campaign designs (Hopwood et al., 2021; Trivedi et al., 2018).
6. *Technology Adoption*: DAGs model new technology adoption, considering perceived usefulness, ease of use, and social influence, aligning with the Technology Acceptance Model (TAM) and Innovation Diffusion Theory (IDT) (Hooks et al., 2022; Alfaro-Serrano et al., 2021).
7. *Public Transport Use*: DAGs help understand factors influencing public transport use, such as convenience, cost, and climate, aiding transport authorities in system design for public preference (Rasca and Saeed, 2022; Cahigas et al., 2022).

In summary, DAGs are a versatile tool across domains, offering structured visualization and analysis of causal relationships between factors influencing behaviour, guiding research, interventions and policy formulation.

1.10.2 Advantages of Causal Diagrams Usege in this study

Causal diagrams, including Directed Acyclic Graphs (DAGs), offer a structured and visual way to represent and analyze the causal relationships between variables that stand for the human behaviour of household inhabitants related to Energy Transition, They provide clarity on complex causal relationships, support the design of effective interventions and contribute to the development of evidence-based policies.

1.11 A use case of the CausalDec methodology - The WHY Project

This study will assess the validity of its findings by using the objectives of the WHY project as a case study. The WHY Project aims to: (i) **Policymakers**. The WHY-Consortium recommends changing planning routines and urges develop efficient, equitable and sustainable policies to decarbonise the European building stock by 2050 alleviating potential regressive impacts, especially on low-income households (e.g. energy poverty). Read our Policy Briefs for Local Policy Makers (WHY-H2020-Project, 2024c) and EU Policy Makers (WHY-H2020-Project, 2024b). (ii) **Scientific Community**. The WHY Causal Model will allow to improve the understanding of the human decision factors leading to energy demand patterns in the residential sector. The Model will improve the forecasting accuracy of policy intervention impacts. Given the long-term projections needed to assess the emission targets set by the different policies, the Causal Model will allow for the long-term evolution of various scenarios (WHY-H2020-Project, 2024a). (iii) **Energy experts.** Traditional energy models are not able to correctly assess the impact that a certain policy might have on the energy demand at the residential level. WHY builds a Causal Model to improve the understanding of human decision processes behind these demand patterns, enabling to accurately forecast How different policies impact household energy consumption. Five use cases will be used to assess different policy scenarios with specialy focus on the EU Green Deal and the Renovation Wave policies (WHY-H2020-Project, 2024d).

1.11.1 Predicting Policy Decision Impacts

In the context of Europe and LATAM, both regions can serve as use cases, each characterized by a unique combination of geographical scope, time frame, and policy objectives to support policy decisions. Alternative scenarios can be designed to estimate the impact of changes in energy policy, thereby informing these policies before their implementation. Initially, the modeller will define the scenario by determining:

- The geographic and temporal scale,
- The interventions to be considered,
- The household segments that will be affected,
- And any other information necessary to run the model.

Subsequently, The results causal diagrams will be coded to be implemented in a software tool for modellers, They will be able to perform simulation.

1.12 Behavioural Science: Insights from Sister Projects

Many of projects place a strong emphasis on behavioural science principles. They recognize that influencing individual and collective behaviours is essential for achieving their goals. Understanding the psychological drivers behind human actions, decision-making processes, and the formation of habits is critical in designing effective interventions and strategies.

This is an updated analysis at the time of writing this thesis, which illustrates how other sister projects address the factors involved in the investment decision process of energy end-users. It first presents an overview of the objectives and, based on the taxonomy (section 7 developed in this study, which factors are prioritised in investment decision-making of energy end-users (section 8.3). Finally, Table 1.5 shows the factors addressed in the analysed projects and their association with psychological needs.

REFEREE project (EC, 2024b)—*Real ValuE oF EneRgy EfficiEncy*—is developing an online decision-support tool for energy efficiency measures and will quantify the multiple benefits of energy efficiency, e.g. in terms of CO2 and pollution reduction, health improvement and well-being, employment and monetary gains; this is what causal modelling can accomplish, it can provide policymakers with a tool that allows them to estimate the impact of the actions on the energy policy. an integrated set of analysis tools from the macro-economic level to the micro level at the consumer and firm scale (REFEREE-Consortium, 2020). In parallel, the **REScoopVPP** project (REScoopVPP-Consortium, 2023)—*Smart Building Ecosystem for Energy Communities*—aims to set up a community-driven virtual power plant that can actually provide flexible services to the grid and contributes to a 100% share of renewable energy sources into the grid (REScoopVPP-Consortium, 2023). environmental, economic and social community benefits are set as the primary purpose for developing flexibility tools. Additionally, the **frESCO** project (EC, 2021c)—*Fast and Reliable Symbolic Computation*—is the new generation of hybrid energy services for Energy Service Companies (ESCOs) and aggregators that combine both the provision of energy efficiency and demand flexibility in the residential sector. frESCO targets domestic consumers and prosumers; these correspond to some of the archetypes defined in this paper; in addition, this paper addresses four aspects of the energy transition, Buildings and Flexibility are two of them. An analysis of the framework conditions reveals important factors that can impact the technology deployment in the market in the future: Factors such as Political and legal factors, Economic, Social, Technological, and Environmental (Aranda and EASME, 2021).

These three projects are mainly focused on factors such as *profits*, *technical fit*, *environmental concerns*, *socialising*, and *wellbeing*.

sEEnergies project (EC, 2022c)—*Quantification of synergies between Energy Efficiency first principle and renewable energy systems*—aims to conduct a comprehensive assessment and quantification of the Energy Efficiency First principle policies impact and will develop a holistic framework that takes into account the synergies between different sectors to maximise energy savings (EC, 2022c); as changes in one energy sector can contribute to impacts in another sector, it is only possible to have a comprehensive assessment and quantification of the EEFP policies' impacts if we look at the energy systems from a holistic perspective and take them into consideration the synergies between sectors; sEEnergies, as discussed in sEEnergies, uncover the supply chain effects of the EEFP in 28 countries; that is why transport, buildings, and industry are the main focus sectors of sEEnergies, with up to 95% of the final energy demand being attributed to these sectors(EC, 2022f). In **MICAT** project (EC, 2023d)—*Multiple Impacts Calculation Tool*—aims to develop a comprehensive approach and user-friendly online tool to estimate the multiple impacts or multiple benefits of energy efficiency measures (MICAT-Consortium, 2023); MICAT will enable analyses at three different governance levels (local, national and EU) to address a broad target group and interested actors; this allows simplified analyses to be carried out on the basis of different data and policy scenarios in order to compare and assess the relevance of the multiple impacts (MICAT-Consortium, 2021); The MICATool seeks to enable policy-makers and practitioners to conduct simplified analyses for different data and policy scenarios, in order to compare and assess the relevance of the multiple impacts and strengthen reporting and monitoring at the three governance levels (MICAT-Consortium, 2023). And, **ENEFIRST** project (EE1st)—*Making*

Energy Efficiency First principle operational— prioritises demand-side resources over supply-side alternatives whenever these provide greater value to society in meeting decision objectives (EC, 2022b); Demand-side resources here refer to technologies and consumer actions that reduce the amount and/or time pattern of energy use for the same level of utility; Price - as a key trigger of consumer behaviour.

These projects address human behaviour from the financial side, focusing on profits and cost-efficiency, in addition to considering knowledge and climate protection factors.

SENTINEL project (EC, 2022d)—*Sustainable Energy Transition*—responds to the Modelling in support of the transition to a Low-Carbon Energy System in Europe; the transition to a low-carbon energy system, as understood by the scientific and policy communities, will involve a major redesign of the energy system, primarily around renewable sources, in accordance with 2030 and 2050 targets that the European Union has defined (SENTINEL-Consortium, 2023). Reductions in final energy consumption by 2030 are mostly driven by the buildings sector, particularly in the Climate neutrality scenario (EC, 2023e). **DECIDE** project (DECIDE-Consortium, 2023)—*Developing Energy Communities through Informative and Collective Actions*—aims to gain a better understanding of how energy communities and energy efficiency services are established and managed; it has published a Catalogue of potential legal and economic barriers and facilitators of energy citizenship, in which, it shows three major barriers to citizens' activity and engagement in community energy projects (Bertel et al., 2022): (1) the legal framework does not sufficiently support or even prevent the establishment and successful operation of energy communities; (b) a lack of reliable and easily accessible information, accompanied by a highly complex and not sufficiently transparent legal framework; A gap in the knowledge and skills (managerial, financial, technological) between incumbent actors and newly established communities. (3) Many households are not able to afford to start or be part of an energy community. **EC²** project (EC, 2021a)—*Energy Citizenship and Energy Communities*—introduces an inter-disciplinary understanding of energy citizenship EC², "Energy citizenship is people's rights to and responsibilities for a just and sustainable energy transition"; The transition to a low-carbon society needs empowered energy citizens at its heart; EC² aims to discover what it takes for energy citizenship and energy communities to thrive; model and assess current trends of a citizenship-based energy transition on the individual level (Bertel et al., 2022) and point out the Barriers and Facilitators from the Legal Perspective, i.e. "not all countries studied have implemented the IMED (Directive for common rules for the internal markets for electricity) and RED II. "No implementation at all can be a barrier because citizens cannot make use of the possibilities energy communities are offering. In **NEWTRENDS** project (NewTrends-Consortium, 2021)—*New trends in energy demand modelling*—aims to increase the qualitative and quantitative understanding of the impact of New Social Trends on energy consumption and to improve the modelling of energy demand, energy efficiency and policy instruments. **NUDGE** project citeEC-CORDIS2023-NUDGE—*NUDging consumers towards enerGy Efficiency through behavioural science*—is set up to analyse people's behaviour, and design and test nudging interventions in five EU Member States in households, energy communities and schools; ll interventions are rooted in fundamental principles of behavioural science and the largest share of household energy consumption across Europe is space heating, with an average of 63% in the European Union; after local climate, thesecond most important factor determining energy demand (even more important than building characteristics) is the behaviour of household occupants; thus, in order to fully exploit the potential for limiting building energy consumption, an understanding of occupant behaviours is essential (EC, 2022a); a better understanding of people's needs can assist in the design of policies that encourage changes in inhabitants' use of the heating system, lowering its carbon footprint. **GreenSoul** project (EC, 2019)—*Eco-aware Persuasive Networked Data Devices for User Engagement in Energy Efficiency*—pursues higher energy efficiency in public buildings by altering the way people use energy-consuming shared devices (lights, printers) and personal devices (personal pluggable appliances); there, the persuasion of users is particularly challenging since they hardly perceive the benefits of having eco-friendly behaviour, i.e. they do not pay the electricity bill. GreenSoul aims to build energy awareness in users and help them change their energy consumption behaviour, focusing on the reduction of energy consumption above 20% (Apostolou et al., 2016); a

Meta Model has been developed and one of its applications is to be used to inform the design of behaviour change interventions. This way, why and how these interventions improve awareness of sustainable behaviour could be studied and analysed (Apostolou et al., 2016). **ENCHANT** project (EC, 2023a)—*Energy Efficiency through behaviour Change Transition*—aims to support the energy transition by testing the impact of interventions affecting energy consumption behaviour on a large-scale across Europe; the interventions will be developed, fitted, and tested with the objective to unlock an energy efficiency potential in the public, through behavioural change. ENCHANT will combine the data gathered from implementing these interventions, with a re-analysis of already existing data, in an empirically informed decision tool for impactful campaign design targeting energy-efficiency, relevant for a number of public and private actors (e.g. policymakers) (Project-Consortium, 2023b). **EVIDENT** project (EC, 2023c)—*Behavioural insights and effective energy policy actions*—focuses on explaining behaviour and identifying drivers of household energy consumption, will evaluate and propose policies to promote energy efficiency, and examine behavioural biases and heuristics that affect consumers' energy savings; Lytos (Project-Consortium, 2022a) mentions Energy efficiency lies at the very core of policy interventions for energy security, energy poverty and climate change, while it also is promoted by technological innovations and investments; however, it seems that these technologies are not adopted by consumers at least to the extent that the assumption of rational behaviour would predict; the project also aims to study individuals' decision-making process on energy consumption decisions and understand their habits (Project-Consortium, 2022a). **EU 1.5° Lifestyles** project (EC, 2021b)—*Policies and tools for mainstreaming 1.5° Lifestyles*—says households are estimated to account for around 72% of global emissions; considering the drastic emissions reductions needed, and the small window of time for effective action, technological solutions alone won't be enough; Dana Vigran (Vigran and Coscieme, 2021) emphasizes that we must also think about how we can change our lifestyles to help achieve the 1.5° target: our lifestyles are not shaped only by individual choices, they are shaped by the physical, social and political environments in which we live. Lifestyles project shows that important personal norms inducing the adoption of low-carbon lifestyles at the individual level are self-awareness and responsibility (Vigran and Coscieme, 2021).

This set of projects primarily focuses on human behaviour through knowledge, technical fit, and environmental concerns, with less emphasis on cost-efficiency.

ENPOR project (EC, 2023b)—*Energy poverty*—remains at high levels in the EU Member States due to increasing energy costs and slow progress on energy efficiency improvements; despite various policies in place that directly or indirectly mitigate energy poverty in the household level, energy poverty is increasing in the private rented sector (Project-Consortium, 2023a). **SocialRES** (EC, 2022e)—*Fostering Socially Innovative and Inclusive Strategies For Empowering Citizens In The Renewable Energy Market Of The Future*—is focussing on the energy system of the future, this project aims to devise more effective ways of increasing social innovation, leading to greater social acceptability as well as more durable governance arrangements and socioeconomic benefits; it will set the basis for a better understanding of the socio-economic, socio-cultural, socio-political and gender factors that influence the behaviour of consumers in the energy system (Project-Consortium, 2022c); what's more, we will foster the development of new cooperation patterns among the key enabling actors for energy democracy: cooperatives, energy aggregators and crowdfunding platforms (Project-Consortium, 2022b). Too much demand for the existing infrastructure. The renewables communities' paradox in the energy crisis era.

The environmental concern factor is the behavioural core addressed in these two projects.

In summary, these 17 projects share several common behavioural factors that are central to their objectives. These factors underscore the significance of understanding and influencing human behaviour in various contexts related to energy efficiency, sustainability, and the transition to a low-carbon society. Below, we discuss the key behavioural factors that consistently emerge across these projects:

- **Environmental Concerns**: Environmental sustainability is a common thread in several projects. The urgency to address climate change and reduce greenhouse gas emissions is a driving force behind many of these initiatives. Projects

Table 1.5: Sister projects of WHY: Checkmarks indicate the behavioural factors addressed by each project, comparing projects on the basis of their alignment with these common behavioural factors.

Num	Project	Profits	Frugability	Cost-Efficiency	Knowledge	Technical Fit	Env. Concerns	Socialising	Climate Protection	Legal	Wellbeing
1	REFEREE	✓				✓	✓				✓
2	REScoopVPP	✓				✓	✓	✓			✓
3	frESCO	✓				✓	✓	✓			
4	sEEnergies	✓		✓		✓	✓		✓		
5	MICAT	✓		✓	✓				✓		
6	ENEFIRST	✓	✓	✓	✓	✓					
7	SENTINEL			✓		✓	✓		✓		
8	DECIDE				✓					✓	
9	EC^2				✓		✓			✓	
10	NEWTRENDS				✓	✓	✓		✓		
11	NUDGE			✓	✓	✓	✓				
12	GreenSoul			✓	✓	✓	✓				
13	ENCHANT			✓	✓	✓					
14	EVIDENT				✓	✓	✓				
15	EU 1.5° Lifestyles				✓		✓				
16	ENPOR					✓	✓				
17	SocialRES						✓	✓			

recognize that behavioural changes, such as adopting low-carbon lifestyles or embracing renewable energy solutions, are essential for mitigating environmental impacts.

- **Social Factors**: The projects acknowledge the role of social factors in shaping behaviour. Whether it's fostering cooperation among key actors, promoting energy citizenship, or encouraging social innovation, the importance of social interactions, norms, and communities is evident. Social factors play a significant role in influencing energy-related decisions and actions.

- **Policy Instruments**: Several projects explicitly address policy instruments and regulatory frameworks. They recognize that effective policy interventions are essential for guiding and incentivizing behavioural changes at both individual and organizational levels. Legal frameworks, directives, and regulations can either facilitate or hinder the adoption of sustainable practices.
- **Knowledge Acquisition**: Knowledge is a common theme in these projects. Whether it's gaining insights into energy consumption behaviour, understanding the impact of interventions, or informing decision-making processes, knowledge acquisition is crucial. Projects often rely on data analysis, modelling, and empirical research to inform their strategies.
- **Technical Considerations**: While not the primary focus, many projects involve technical aspects related to energy systems and technology adoption. These technical considerations are often intertwined with behavioural factors. For instance, projects may explore the adoption of energy-efficient technologies or the integration of renewable energy solutions, recognizing that user behaviour plays a pivotal role in their success.

In summary, these 17 projects collectively underscore the complexity of influencing behaviour in energy efficiency, sustainability, and the energy transition. They emphasise the significance of behavioural science, environmental awareness, social influences, policy tools, knowledge acquisition, and technical factors. A key focus of these initiatives is understanding and addressing these behavioural elements to fulfil their objectives and promote sustainable energy practices globally. Consequently, this research delves deeper into identifying and prioritising factors that influence investment decisions, particularly regarding archetypes or investment profiles.

Finally, Appendix B provides an extensive review of the theoretical framework used in this task. Including:

- An theoretical approach to causal models, including all the basic operations (section B.1).

- An introduction to several psychological theories that will be used to code the contributions made by the experts. In particular, a brief introduction to social cognitive theory and self-determination theory are presented (B.4).
- Finally, a description of the Transtheoretical model (TTM) is included. This model will be used in later sections to sort determinants on the different Archetypes (B.5).

CHAPTER

2

CausalDec: A Methodology for Causal Modelling of Human Behaviour

This chapter introduces the "CausalDec" methodology, a comprehensive approach developed for *Causal modelling of human behaviour in the decision-making process*. Specifically designed to identify *investment profiles* within a target audience, focusing on modelling their behaviour by extracting their key drivers and priorities. CausalDec has been developed to be applied in the context of domestic decision-making related to four key aspects of the current energy transition: mobility, flexibility, buildings, and everyday appliances.

The following sections provide an approach to collaborating with the expert panels and the activities through which both individual and consensus contributions can be drawn from them. This results in the development of the *CausalDec methodology* along with a detailed description of its steps.

2.1 Approach

Causal models can more effectively explain why people behave as they do, thus helping to identify the most effective interventions for change (Sgaier et al., 2020) . Furthermore, causal modelling offers an interventional and counterfactual mechanism for generating predictions and reasoning under various what-if scenarios (Chowdhury et al., 2023). Expert domain knowledge is essential in the development and validation of causal models (Mäkelä et al., 2022), countering the limitations inherent in a purely data-driven approach (Sgaier et al., 2020). Experts can enhance the performance of causal AI by incorporating constraints that reflect practical knowledge of how systems operate on the ground and by identifying potential confounding variables that may be absent from the data (Chowdhury et al., 2023).

To extract human expert knowledge from energy transition experts and integrate this expertise with causal modelling, as well as to enhance the reliability and practical utility of causal AI approaches, a methodology for collaborating with expert panels has been developed.

The methodology employed in this research is based on the traditional Delphi method principles, but it incorporates an online framework, an adaptation required due to COVID-19 restrictions. Known for its ability to build consensus in diverse fields, the Delphi technique is founded on the idea that collective decision-making typically results in more accurate outcomes than individual judgments, especially on comparison to other methods like prediction markets or statistical group analysis. The Delphi method, known for its effectiveness, employs an iterative process that steers a panel of experts towards consensus on specific topics (see Fig 2.1). Its fundamental simplicity and adaptability make it suitable for a variety of tasks requiring

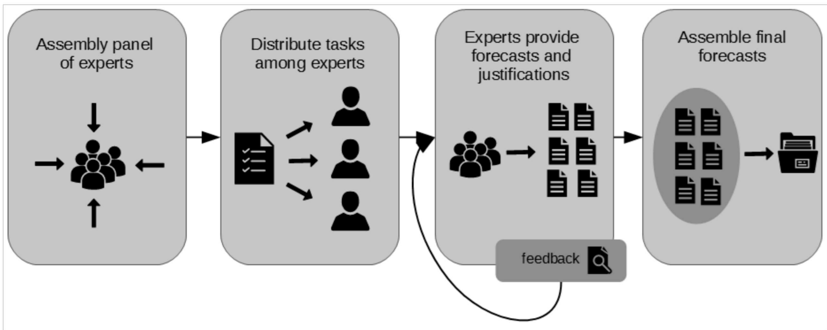

Figure 2.1: Visual representation of the Delphi method. Systematic and qualitative method of forecasting by collecting opinions from a group of experts through several rounds of questions.

consensus, such as judgmental forecasting, the selection of funding, and predicting technology usage.

Experts receive anonymous feedback and a synthesised summary of the panel's responses. This iterative mechanism is designed to encourage refined analytical thinking, potentially leading to more nuanced insights. In the final forecasting phase (stage 5), experts have the opportunity to cross-check their inputs. This verification will take place through structured workshops. Figure 2.1 provides a graphical representation of the stages described above.

2.1.1 Features of the panel of experts

Expert panels play a crucial role in the Delphi method, contributing their expertise and insights throughout the process, and the selection of panel members is an essential aspect of activity success (Nasa et al., 2021; Khodyakov et al., 2023); careful consideration is given to factors such as expertise, representativeness, and the size of the panel.

In this study, the key characteristics of the expert panel are as follows:

- **Energy aspec**t: The panel will cover key energy aspects such everyday appliances, mobility, flexibility and Building.

- **Interdisciplinary**: Members are drawn from a range of academic and professional backgrounds, providing a rich, multidisciplinary perspective on the research.
- **Number of members**: With a minimum size of 5 members to encourage effective discussion and decision-making, while maintaining a diversity of opinions and expertise.
- **Intersectorial**: The panel includes experts from sectors such as public, government, industry, academy and civil society to ensure a well-rounded approach to the subject matter.
- **International**: The group has an international composition from countries across all EU, bringing diverse global perspectives and experiences that are crucial for a comprehensive understanding of the research topic.
- **Gender equity**: A conscious effort is made to achieve gender balance within the panel, reflecting the commitment to diverse and inclusive perspectives in the research process.

2.2 The CausalDec Methodology

CausalDec is a methodology developed for *the causal modelling of human behaviour in the decision-making process* in the context of the current Energy Transition in EU (Widuto, 2023; Valkhof, 2020; Hainsch et al., 2022). This section describes the methodology used to collect human experiences related to the prediction of energy transition scenarios and the modelling of their causal behaviour. The objective is to discern the factors that influence the decision-making process in the different phases of change, identify clusters of behaviours, and generate their corresponding causal models. Specifically, it explores how residents in the residential sector allocate resources—whether money, time or effort—–to initiatives supporting the fight against climate change.

The table 2.1 presents the phases of the CausalDec methodology (Aguayo-Mendoza et al., 2024), and their visual representation is shown in figure 2.2. The following section provides a detailed description of each phase as well as its outcomes.

Table 2.1: CausalDec - Phases and activities.

PHASES AND ACTIVITIES
Literature review. This phase involves a comprehensive and systematic examination of existing research, theories, and findings related to the field of study. The primary objectives are to identify existing knowledge, recognize gaps, and establish a solid theoretical and empirical basis for subsequent research phases. LR.1 *Theoretical Framework Development*
Part I: Retrieving Expert Knowledge
Phase 0: Defining the topics of interest. In this study, four key aspects of the current energy transition: Buildings, Mobility, Flexibility, and Appliances. P0.1 *Defining the topics of interest* P0.2 *Recruitment of experts* P0.3 *Setting up panel of experts*
Phase 1: Design of fictional scenarios. Identify the key aspects in the residential sector that collectively contribute to the ongoing energy transition. P1.1 *Brainstorming and consensus among experts*
Phase 2: Identify the key factors for achieving fictional scenarios. Specific determinants that may cause an investment decision by family units, either monetary or behavioural. P2.1 *Individual contributions by experts.*
Phase 3: Coding. Analysis of the results through coding in pairs (inter-rater reliability). Separate panels of experts are established, each focusing on one of the energy aspects. Experts' contributions are gathered through a series of designated tasks. P3.1 *Agreements on expert contributions* (a) *Coding by researchers* (b) *Homogenise*

...CausalDec continues on the next page

PHASES AND ACTIVITIES

Phase 4: Development of the Taxonomy. Creation of a two-tier glossary of investment-based determinants using socio-psychological needs theory and its taxonomy.

P4.1 *Development of taxonomies.*

Part II: Causal Diagramas

This linking phase is the last one of Part I: Recovery of expert knowledge and the initial one of Part II: Causal diagrams.

Phase 5: Archetype crafting. Creation of decision-maker archetypes (investment profiles) at the household level.

P5.1 *Clustering.* Clustering archetypes into investment profiles.

P5.2 *Archetypes Mapping***

(a) *Assembling new panels of experts.*

(b) *Activity-1 for experts: Individual contributions on archetypes.* Contributions about the target population archetypes.

(c) *Coding individual contributions into archetypes.*

(d) *Clustering of archetypes*

(e) *Activity-2 for experts: Sorting of the determinants into the TTM stages.*

**From this activity, the expert knowledge generated so far: fictional scenarios—Glosary, Taxonomy and archetypes of the European Community context—can be used to map the archetypes of other similar contexts, as in this case, the Latin American context.

Phase 6: Cross-Sectorial Survey. Conducting a cross-sectional survey to validate (or identify new) the defined archetypes.

P6.1 Develop the survey instrument.

P6.2 *Data analysis.*

...CausalDec continues on the next page

PHASES AND ACTIVITIES
Phase 7: Causal Modelling. Selection of the most impactful determinants for each archetype and crafting of a causal diagram for them. P7.1 *Colective mapping by experts.* Classification of the determinants of archetypes in the TTM phase. P7.2 *Causal modelling by Directed Acyclic Graphs (DAG)s.*

Last section of CausalDec.

2.2.1 CausalDec Methodology - Part I: Retrieving Expert Knowledge (Phases 0 to 5)

The first part of the CausalDec methodology is crucial establish a structured methodology for acquiring and analyzing expert knowledge, which serves as the foundation for subsequent phases. This section outlines a versatile and adaptable framework, initially designed for the energy transition domain, but generalized here to be applicable across various fields of knowledge. The part-I of the CausalDec methodology encompasses phases 0 to 5 and involves structured steps to gather, analyze, and utilize expert insights. Here is a detailed description:

- *Phase 0: Defining the Topics of Interest.* The first phase involves identifying the critical issues and areas of expertise necessary for the study. By defining broad and specific topics relevant to the field, recruiting experts with diverse backgrounds, and organizing panels, researchers can ensure a robust foundation for subsequent phases.
- *Phase 1: Design of Fictional Scenarios.* Creating fictional scenarios allows researchers to explore future possibilities and their impacts. This phase engages experts in collaborative scenario development sessions, covering key aspects of potential outcomes and setting the stage for detailed analysis.
- *Phase 2: Identify the Key Factors for Achieving Fictional Scenarios.* In this phase, expert insights are extracted to identify the factors influencing outcomes within the fictional scenarios. By collecting detailed inputs on intrinsic and extrinsic

factors, decision-making processes, possible barriers, and rebound effects, researchers gain a deeper understanding of the determinants of success.

- *Phase 3: Coding.* Systematic coding of qualitative data from expert contributions is essential for consistent and reliable analysis. This phase involves pair-wise analysis, inter-rater reliability checks, and resolving discrepancies to ensure uniformity and accuracy in the data classification.
- *Phase 4: Development of the Taxonomy.* Creating a structured glossary and taxonomy of factors influencing decision-making provides an organized framework for understanding the determinants. This phase leverages theoretical frameworks and expert inputs to develop a comprehensive classification system.
- *Phase 5: Archetype Crafting.* Identifying and describing distinct behavioural archetypes based on expert contributions is crucial for targeted interventions. This phase involves clustering similar behaviours and decision-making patterns into archetypes, validating and refining these profiles through expert panels, and systematically classifying and aggregating inputs.

Applicability of CausalDec Part-I for Extracting Expert Knowledge from Any Knowledge Domain

The structured approach of the CausalDec methodology ensures that expert knowledge can be systematically gathered and analyzed, regardless of the field of study. This adaptability makes it highly suitable for various disciplines, ensuring that expert insights are effectively utilized to inform subsequent research and decision-making processes.

This generalized methodology offers a reproducible and adaptable framework for expert knowledge acquisition, applicable to a wide range of disciplines. By following these structured phases, researchers can achieve robust and reliable outcomes, thereby enhancing the quality and impact of their studies across various fields of knowledge.

While this study specifically addresses four key aspects of the energy transition—mobility, buildings, appliances, and flexibility—the methodology's adaptability allows it to be applied to any area of specialization. By involving relevant experts and adhering to these structured phases, the methodology ensures robust and reproducible outcomes that can significantly contribute to the field of study.

2.2.2 **CausalDec Methodology - Part II: Causal diagrams (Phases 5 to 7)**

The second part of the CausalDec methodology focuses on developing causal models to express assumptions about a particular matter in any field of knowledge. This part involves creating detailed causal diagrams based on the expert knowledge gathered in the earlier phases. Here is a detailed description of these phases, specifically tailored to understand their application across various fields:

Phase 5: Development of Archetypes. The final phase of this part involves creating archetypes of decision-makers, such as investment profiles. These archetypes represent different patterns of behaviour and decision-making processes within the studied context.

Phase 6: Cross-Sectorial Survey. A tool used to design surveys based on the taxonomy to validate the existence and proportions of the archetypes identified by the experts within the target population.

Phase 7: Causal Modeling. Develop causal diagrams that represent the relationships between different factors and behaviours, as identified in the previous phases. Researchers use the sorted determinants to build DAGs for each archetype, visually representing the causal relationships and transitions through the TTM stages.

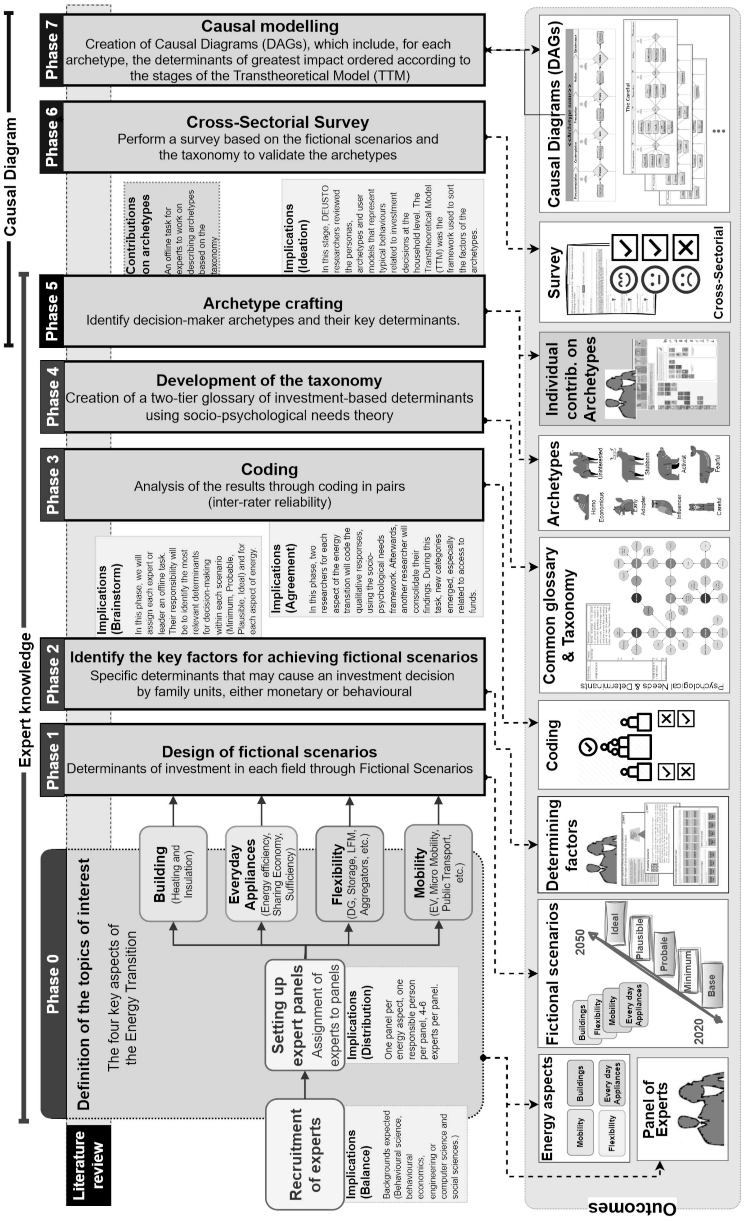

Figure 2.2: Visual representation of the CausalDec Methodology.

2.3 Description of the CausalDec phases

2.3.1 Literature review phase

This phase is a cross-cutting activity that, through an overview of the existing literature in the field of causal modelling of human behaviour in relation to the current energy transition, aims to gain a thorough understanding of aspects related to several psychological theories:

- The current energy transition regarding the four aspects at the residential level (section 1.3).
- Psychological theories that will be used to code the contributions made by the experts (section B.4). Internal factors such as beliefs, values, or environmental concerns serve as the primary drivers of change in people's everyday behaviour. Stages of change during the decision-making process.
- The theoretical approach to causal modelling and causal modelling of human behaviour from human expert knowledge (section B.1).

Outcome

i) Guidelines to identify and model the decision-making process of the human behaviour of household inhabitants in the European residential sector.

2.3.2 Phase 0: Defining the topics of interest

The key objective is to improve the assessment of electrical energy consumption trends in households by including causal models in leading Energy Management Systems (EMS).

Activities

P0.1 *Defining the topics of interest.* Identify and make a literature review to describe the topics of interest. In this study, four aspects of the energy transition have been selected, which are as follows:

- **Building**. Heating and Cooling.
- **Flexibility**. Distributed Generation, storage, Local Flexibility Markets (LFM).
- **Everyday appliances**. Energy efficiency, Sharing economy, and sufficiency.
- **Mobility**. Electric Vehicle (EV), Micro mobility, Public transport.

P0.2 *Recruitment of experts.* Assembling experts from four key aspects of energy. The experts represent a mix of fields, including technical, social, economic, psychological and end-user perspectives. In an induction session, they are introduced to the objectives of their participation and the individual (online) and collaborative (in-person) activities through which they will be able to contribute their expertise.

P0.3 *Setting up expert panels.* A panel must consist of at least eight experts and is characterized by its multidisciplinary nature, multisectoral composition, international representation and gender balance. Depending on their specialization, experts are assigned to one of four different panels.

Outcomes

i) Four selected aspects of the current energy transition.
ii) List of participating experts.
iii) Four expert panels, one for each energy aspect.

2.3.3 Phase 1: Desing of Fictional Scenarios

To identify the key aspects of the residential sector that collectively contribute to the ongoing energy transition, the divide et impera strategy was used. Specifically, this activity was segmented into four use cases, one for each energy aspect: appliances, building renovation, flexibility services and mobility. These scenarios are designed to represent distinct realities for each aspect analyzed (Dunne and Raby, 2013; Auger, 2013).

- **Baseline**: these scenarios try to reflect the current status of the aspects. They attempt to be a general description of a regular house in a city in Europe now.
- **Minimum**: in this case, these scenarios include the minimum effort required to improve the base scenario towards the decarbonisation of the particular use case or field of application (appliances, building renovation, flexibility services and mobility). Usually, these scenarios are based on behavioural aspects rather than monetary actions.
- **Probable**: these scenarios are a projection of the most probable decision-making that citizens in whatever European city would take in the following years from the base scenario to advance to decarbonisation objectives.
- **Plausible**: these sets of scenarios are less probable than the previous ones (probable), yet their happening would not be too strange to be observed in some EU cities and family units in the following years towards attaining decarbonisation objectives.
- **Ideal**: these are the ideal scenarios towards attaining decarbonisation objectives, yet these are highly unlikely to happen due to the massive social innovation that should carry on or the cultural change that they entail.

Figure 2.3 shows a visual representation of the scenarios. Please remember that the scenarios described here do not reflect on individual buildings but are rather the representation of an entire city. Next, we will provide a description of each scenario for each aspect.

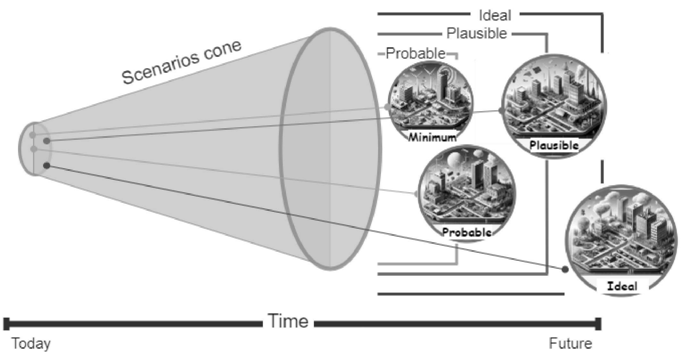

Figure 2.3: Scenarios cone: a visual representation of different fictional future scenarios over time. The cone widens as it moves from ‘Today’ to ‘Future’, indicating the increasing range of possibilities as time progresses. The cone highlights four scenarios: Minimum, Probable, Plausible and Ideal.

Activity

P1.1 *Brainstorming and consensus among experts.* Each panel builds five fictional scenarios (What-if) related to the energy aspect assigned to them. Initially, the panellist identified the factors that influenced or drove investment decisions in these scenarios. In the end, each panel reached consensus on the key factors that accurately described each of the five fictional scenarios.

Outcome

i) A total of 20 fictional scenarios, encompassing five scenarios for each energy aspect. These include baseline (current), minimum, probable, plausible, and ideal scenarios.

2.3.4 **Phase 2: Identify the key factors for achieving fictional scenarios**

Fictional scenarios have been created to obtain from experts a set of specific determinants or factors. These factors can influence household investment decisions,

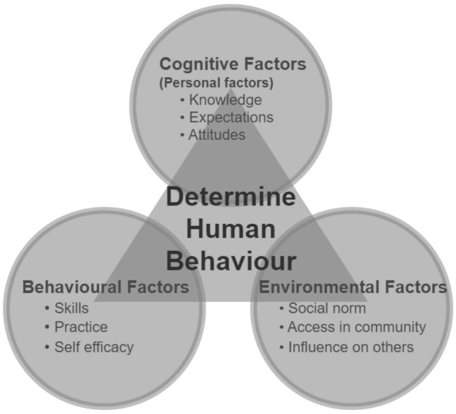

Figure 2.4: The Social Cognitive Learning Theory (Bandura, 2001).

whether monetary or behavioural, in one or more of the selected energy aspects. Experts are introduced to the Social Cognitive Theory (HC3, 2020) to enhance their understanding of the types of determinants expected of them. Fig 2.4 shows the three factors that determine human behaviour.

Activities

P2.1 *Individual contributions by experts.* This is an offline task for experts to work on defining the most relevant determinants for decision-making on each scenario: minimum, probable, plausible, and ideal of a given energy aspect.

Outcome

i) A template filled in with the determinants of the minimum, likely, plausible, plausible, and ideal scenarios of the energy aspect in which the expert participates.

2.3.5 Phase 3: Coding

Analysis of speculative scenarios results through coding in pairs (inter-rater reliability). Coding the qualitative answers using as a framework the socio-psychological needs. Upon receiving all the contributions from experts on each of the different aspects of the energy transition and by each of the future scenarios presented to them, an agreement over the codification of data has been reached.

Activities

3.1 Agreements on expert contributions.

(a) *Coding by two researchers.* The consensus of the expert panel generated a list of determinants, which were grouped, according to the cognitive learning theory, into personal cognitive factors that are affected by the environment influence behaviour (see Section 6.1). The classification of the determinants was done individually by a pair of researchers. Then, these two researchers met and tried to resolve any despair between them. This resulted in a first codification, in which there was consensus on most of the determinants but for these determinants without consensus, a third round was carried out.

(b) *Homogenise.* This round was carried out by a third expert. The aim was to homogenise the answers from all four panels and solve any potential disagreements left.

Outcome

i) Final code of the matrix of the most relevant determinants for decision-making in each scenario (minimum, probable, plausible, ideal) and per each energy aspect.

2.3.6 Phase 4: Development of the Taxonomy

Two-tier glossary of investment-based determinants and their taxonomy (systematic classification). The qualitative information collected was analysed using the universal psychological needs, such as competence, relatedness, popularity, stimulation, meaning, security, or autonomy (many of them very much connected to the self-determination theory) as a framework to create a common glossary of 32 terms. The glossary is made up of two levels. The top tier level is all about psychological needs plus one theme related to financial factors. The second tier is related to the determinants in each category.

Activities

P4.1 **Development of taxonomies**. The research team carried out an analysis of the results of the coding phase in order to develop a common glossary and a corresponding taxonomy.

Outomes

i) A common glossary of psychological needs and behavioural factors linked to them. Needs on the upper tier and determining factors on the lower tier.
ii) The two-tier taxonomy.

2.3.7 Phase 5: Archetype crafting

Identify decision-maker archetypes and their key determinants. Personas are essentially fictional characters crafted through research efforts to represent diverse user types involved in household investment decisions. Constructing personas serves to enhance comprehension of end-user needs, experiences, behaviours, goals, and challenges. It facilitates the acknowledgement that individuals possess varying needs and expectations, fostering a deeper connection with the user being designed for. Therefore, personas generated using this approach should be viewed as approximations of user cases that illustrate some of the real individuals encountered in any energy-related project related to residences.

Based on the variety of determinants that can be identified, obtaining statistical information on all of them from the European population is challenging. To address this issue, a finite, limited set of personas (archetypes) will be developed based on the taxonomy of determinants outlined in phase 4 (Fig 2.5). These persona archetypes, derived from both the body of knowledge and expert insights from the research team, represent a combination of inductive and deductive approaches.

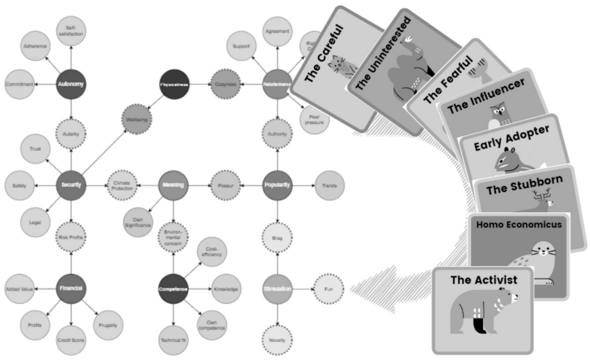

Figure 2.5: Archetype mapping (on the right) through taxonomy (on the left).

From activity P5.2 of this Phase, through the bellow activity P5.2, the expert knowledge generated so far: fictional scenarios—Glosary, Taxonomy and archetypes of the European Community context (figure 2.6-a)—can be used to map the archetypes of other similar contexts, as in this case, the Latin American context (fig2.6-b).

(a) EU (b) LATAM

Figure 2.6: (a) European and (b) Latin American contexts (AI-generated images).

Activities

P5.1 *Clustering.* This activity carries out archetypal profiling, which consists of creating typical investment profiles within the European population by using the taxonomy to describe them.

P5.2 *Archetypes mapping***

(a) *Assembling new panels of experts.* In order to set up an expert panel for each energy aspect on the context—EU, Latin America (LATAM)—and following the features for expert panels (section 3.1.2, a list of potential experts was generated and experts were contacted for inviting them to attend an Induction session. The induction session aims to introduce experts to the objectives, background and methodology of the WHY project, as well as the energy transition aspect.

(b) *Activity-1 for experts: Individual contributions on archetypes.* The objective of this activity is to extract expert knowledge on the behavioural factors of archetypes in the target population (LATAM).

(c) *Coding individual contributions into archetypes.* The individual contributions are compiled and coded—based on the 32-factor taxonomy—into archetypes.

(d) *Clustering of archetypes.* The archetypes resulting from *activity-1* are clustered—by their likeness degree—into groups that correspond to one of the European archetypes. Focused on identifying and analysing the determining factors of various archetypes.

(e) *Activity-2 for experts: Sorting of the determinants into the TTM stages.* Reach a consensus on the factors that encompass each final archetype, as well as the stage of change (TTM) in which they should appear (sorting determining factors).

Outomes

i) European archetypes, along with the factors that shape them.
ii) An expert panel per energy aspect.
iii) Coding individual contribution into individual archetypes.
iv) The compilation of individual archetypes (individual contributions).
v) Clustering, Individual archetypes clustered into European archetypes.
vi) Causal Flows: This represents the final archetypes and their associated factors, sorted according to the stages of the Transtheoretical Model (TTM) of Change.

2.3.8 Phase 6: Cross-Sectorial Survey

Perform a survey based on the fictional scenarios and the taxonomy to validate the archetypes. A cross-sectional survey collects data about a population of interest at one point in time. They could be considered as snapshots of the populations about which they gather data. The survey aims to characterise the European population (archetypes) with respect to the taxonomy to try to locate clusters of similar behaviours. Identifying these clusters allows us to build the different investment archetypes and compare them with the ones we initially identified. This process is represented by the fig 2.7.

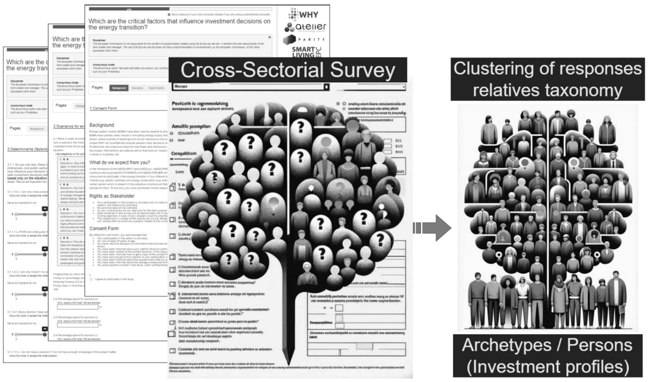

Figure 2.7: Cross-Sectional survey and clustering of responses according to taxonomy. The figure depicts the design of the cross-sectorial survey aiming to collect a wide range of responses regarding fictional scenarios (left side), and the clustering process, where responses are categorized into different archetypes or investment profiles based on the taxonomy (right side). Figure created by the author incorporating some AI-generated elements.

Activities

P6.1 Develop the Survey Instrument. Create the survey based on future scenarios, the taxonomy, and a set of socio-economic variables. This survey will be based on fictitious scenarios and the established taxonomy. Cross-sectional surveys are specifically designed to collect data on a particular population at a single point in time. They act as snapshots, providing information on the characteristics and behaviours of the population at that specific point in time.

P6.2 *Data analysis.* Data collection, cleaning, and preparation are essential for clustering taxonomy-related responses into archetypes. The analysis focuses on the self-assessment of respondents regarding their level of agreement with a set of statements derived from the factors outlined in the taxonomy. The final dataset will be published for open access.

Outomes

i) An online survey

ii) Data analysis

2.3.9 Phase 7: Causal Modelling

Selection of The most impactful determinants of each archetype sorted based on the Transtheoretical Model (TTM) stages. Once the archetypes have been identified, they will be mapped based on their most relevant determinants of investment decision-making for each archetype. To do that, we decided to use as a framework the Transtheoretical model of behaviour change (TTM). TTM characterises behaviour change as a process that unfolds over time, a non-linear transition through a sequence of qualitatively distinct stages. At each stage there are individual, stage-specific sources of resistance to change that can keep people stuck at an early stage for a long period of time, so specific skills and strategies are needed. Successful transition through the stages is reflected in increasing readiness to change. The TTM is explained thoroughly in the section Transtheoretical Model (Stages of Change) in Annex 6, but in a nutshell, it is based on six stages of change:

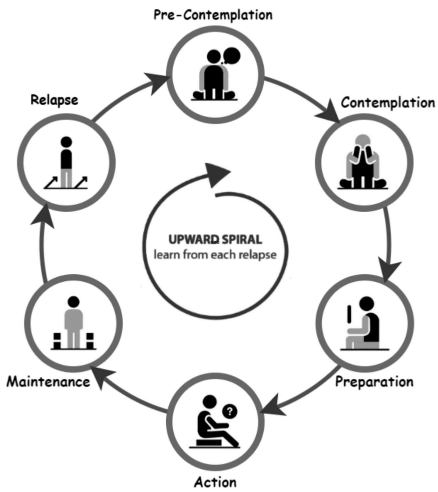

Figure 2.8: The Transtheoretical Model´s stages of change, which represent the process of intentional behaviour change.

1. **Precontemplation**: A stage where people do not intend to act for a short period of time, usually measured as the next six months. People may be in this stage because they are not well informed about the consequences of their behaviour or they may have tried to change several times and have become demoralised.
2. **Contemplation**: A stage where people are trying to change their behaviour over the next six months. They are more aware of the pros of change, but are also very conscious of the cons. This balancing of pros and cons can produce deep ambivalence and keeps people stuck in contemplation for long periods of time.
3. **Preparation**: A stage where people intend to act soon, usually within the next six months. Usually, they have already taken some significant steps towards the behaviour in the last year and have an action plan.
4. **Action**: Stage where people have made concrete and overt lifestyle changes in the last six months. Not all behavioural changes count as action in this model, certain criteria that scientists and practitioners consider sufficient must be met.
5. **Maintenance**: Stage where people have made specific and overt lifestyle modifications and work to avoid relapse, they do not apply the change processes as frequently as people in action. They are increasingly confident that they can continue with the changes.
6. **Completion**: Stage where people have zero temptation to relapse and 100% self-efficacy. It is as if the behaviour never existed in the first place or their new behaviour has become automatic. This criterion may be too strict, being an ideal goal for most people.

Once the determining factors of each archetype have been organized we have organized in the TTM stages, the causal model or DAG for each will be represented using the template shown in Fig 2.9. This template combines the elements of the TTM and the DAGs.

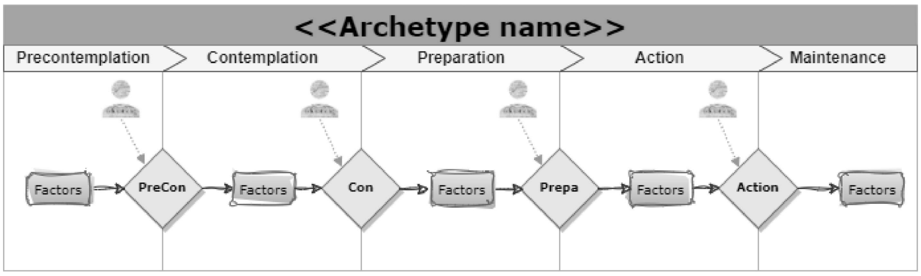

Figure 2.9: Base causal diagram of an archetype or investment profile. This depicts the transition through the stages of change, from Precontemplation to Maintenance. The diagram highlights the causal relationships between the factors in each stage that influence the transition from one stage to the next (from left to right).

Activities

P7.1 *Colective mapping by experts.* Sorted according to the Transtheoretical Model (TTM), the factors that comprise an archetype.

P7.2 *Causal modelling by DAGs.* Build the causal models for each archetype through DAGs.

Outcome

i) A template for each archetype, including its factors arranged according to the stages of the Transtheoretical Model (TTM) in which they emerge.

ii) A causal diagram (DAG) for each archetype

2.4 Validation Method: Triangulation

Triangulation as a method of validation in qualitative research refers to the use of multiple methods, theories or data sources to ensure the validity and credibility of the findings (Carter et al., 2014). Triangulation enabled the integration of diverse data sources, methods, and disciplinary perspectives (Briller et al., 2008). The advantages of triangulation include reducing research bias, increasing validity, establishing credibility, and confirming research findings (Lambert and Loiselle, 2008). However, it can be time-consuming, labor-intensive, and require larger samples. In general, it is a valuable strategy for gaining a comprehensive understanding of phenomena and ensuring the reliability of research results.

To improve the validity of both the data collection process and the results, strategies aimed at increasing reliability and eliminating bias were incorporated. Triangulation, a comparative strategy used to examine data, reinforces the integrity of qualitative, multi-method research. Three forms of triangulation were used in this study:

- **Interdisciplinary triangulation** occurs between experts from technical, societal, economic, psychological and end users. The triangulation process in this case considers the comparison between different observers with energy experience) of the different personality archetypes included in the model (García et al., 2016).
- **Methodological triangulation** by gathering qualitative data through both one-on-one interviews and focus groups. In this case, data have been collected from these two different methods to assess the same phenomenon; identifying the group of archetypes for each community (Bhandari, 2022b; Bekhet and Zauszniewski, 2012).
- **Collaborative triangulation** involved the articulation, negotiation and accommodation of divergent views and was key to achieving our shared goal of classifying the determinants of each archetype in a trans-theoretical model. Collaborative triangulation, therefore, facilitates a more thorough understanding of the phenomenon under study and can lead to more credible and nuanced findings (Swanson, 2021).

The validation or triangulation process will be carried out through activities in which experts and researchers participate. Activities such as:

- Participation in workshops to formulate contributions and reach agreements to design the functional scenarios and to define the relevant determinants for the decision-making process on functional scenarios (phases 1 and 2).

- Participation of experts and researchers in codifying activities: Coding (phase 2) Glossary and Taxonomy (3) and Archetype crafting (phase 4).
- Workshops - Consensus-building activities by experts to reach a common understanding for classifying factors into TTM stages (phase 5).
- The participation of the respondents, through the survey, to validate the archetypes and the prioritisation of the factors through responses (phase 5).

triangulation will enhance the validation of findings regarding behavioural patterns of residential sector inhabitants and improve the overall robustness of this study. This is essential for better understanding complex social phenomena, such as modelling human behaviour, and increasing people's engagement in behaviour change in favour of the energy transition.

2.5 Response cross validation

Cross-validation of responses is a methodological approach used to assess the reliability and consistency of expert judgements within a panel. This technique is crucial when eliciting expert knowledge on specific topics, as it ensures that the information provided is reliable and representative of the consensus among experts. The process involves comparing the responses of different experts to the same questions, allowing researchers to identify possible biases, inconsistencies or areas of uncertainty. This method is particularly valuable in fields that rely heavily on subjective judgement and experience, such as risk assessment, forecasting and decision-making. By employing cross-validation of responses, researchers can increase the credibility and robustness of conclusions derived from expert panels (**?**Fernández-Gómez et al., 2020; Colson and Cooke, 2017).

2.5.1 Discussion of Sampling Limitations and Bias Neutralization Techniques

Intentional Sampling and Its Limitations

The purposive sampling method is another type of validation that could introduce bias. Purposive sampling, also known as purposive sampling, involves selecting participants based on specific characteristics or criteria relevant to the research. Although this method ensures that the sample includes people with the necessary knowledge or experience, it may not fully represent the general population. This may result in the following limitations:

1. Selection Bias: The deliberate selection of participants may over-represent certain characteristics or viewpoints, leading to a non-representative sample.
2. Limited Generalizability: Findings based on a purposively sampled group may not be easily generalizable to the entire population.
3. Subjectivity: The researcher's judgment in selecting participants can introduce subjective biases.

Bias Neutralization Techniques: Response Cross-Validation

To mitigate these limitations, bias-neutralization techniques, such as response cross-validation, can be employed. Response cross-validation is a method used to validate survey responses and ensure the reliability and accuracy of the data collected. Here's how this technique works:

1. Splitting the Sample: The sample is divided into two or more subsets. Each subset is used to validate the responses of the other subsets.
2. Internal Consistency Check: By comparing the responses across different subsets, researchers can identify inconsistencies or anomalies in the data. This helps to ensure that the responses are consistent and reliable.
3. Repeat Surveys: In some cases, the same survey can be administered to the same participants at different times. Comparing the results can help identify and correct for any inconsistencies or biases.

4. Statistical Analysis: Statistical techniques, such as correlation analysis, can be used to measure the degree of agreement between responses from different subsets. High correlation indicates consistency and reliability of the data.

Application in this study

In this study, response cross-validation can be implemented as follows:

- Initial Survey: Conduct the survey based on the fictional scenarios and taxonomy to collect initial data.
- Sample Splitting: Divide the participants into two or more groups randomly.
- Validation Phase: Use the responses from one group to validate the responses of the other group(s).
- Analysis: Perform statistical analysis to check for consistency and reliability of the responses.
- Adjustment: Identify and adjust for any biases or inconsistencies found during the validation phase.

By incorporating response cross-validation, the reliability and validity of the survey data can be significantly enhanced, reducing the impact of biases introduced by intentional sampling. This approach helps to ensure that the findings are robust and can be generalized more confidently to a broader population.

Part I

First part: Retrieving Expert Knowledge

CHAPTER

3

Phase 0: Defining the Topics of Interest

In this initial phase of the *CausalDec methodology*, the starting point is to identify the critical energy issues to be addressed. These selected topics then determine the specific areas of expertise needed for the experts to be recruited. For each topic of interest, at least one panel of experts is assembled. The careful selection of these experts is crucial to developing a comprehensive understanding and expertise base on each topic (expert knowledge).

3.1 Literature Review

3.1.1 Key aspect of the energy transition

At the household level, energy is used to operate appliances and machines that deliver services to residents, such as heating, lighting, and cooling. While this often involves conscious and voluntary decisions, some appliances, like refrigerators, automatically consume energy to maintain their functionality. The WHY project's primary aim is to analyze household energy consumption patterns – identifying what energy is used, when and how much is used, and the reasons behind its use.

To mitigate the effects of climate change, it is essential to take prompt action to sharply reduce greenhouse gas emissions, in this research, on four key aspects associated with the participation of the inhabitants of the residential sector at the residential level.

The key objective is to improve the assessment of electrical energy consumption trends on households by including causal models in leading Energy System Models (ESM) focusing on:

- *Mobility.* Electric Vehicle (EV), Micro mobility, Public transport. Human habits and psychological factors are deeply interconnected with commuting mode choice. By understanding and addressing these influences, policy makers and urban planners can develop more effective strategies to encourage the use of public transport and other sustainable mobility options, contributing to the broader goals of reducing emissions and improving urban livability (Yazdanpanah and Hosseinlou, 2017; Phithakkitnukoon et al., 2017).
- *Flexibility.* Distributed Generation, storage, Local Flexibility Markets (LFM). The adoption of domestic energy storage systems and participation in LFMs can be influenced by individual and collective behaviours towards energy consumption and conservation (Devika et al., 2020). Social practices, such as the timing and flexibility of energy use in households, can affect the demand for and supply of flexibility services (Blue et al., 2020).
- *Building.* Heating and Cooling. The way people use heating, cooling, ventilation and lighting can greatly influence a building's energy consumption (Smale et al., 2017). Strategies that influence the behaviour of building occupants include eco-feedback, social interaction and gamification (Paone and Bacher, 2018). Occupants have a direct effect on the heating, cooling and ventilation of buildings and are one of the most important reasons for the energy performance gap (Hopwood et al., 2021).

- *Everyday appliances*. Energy efficiency, Sharing economy, and Sufficiency. Human behaviour plays a crucial role in the energy consumption of appliances. For instance, the way individuals use heating, cooling, ventilation, and lighting can greatly influence a building's energy consumption (Harputlugil and de Wilde, 2021). Understanding and influencing occupant behaviour is essential for driving energy efficiency. For example, DNV's guide on the impact of human behaviour on energy efficiency emphasizes that employee behaviour and attitude towards energy conservation are critical for realizing energy savings in industrial settings (Goemans, 2024; DNV-GL, 2024).

3.1.2 **Features of the Panel of Experts**

Panel of experts

In this phase, experts from the four energy aspects are assembled and assigned to one of them (Panel). The expert panel tries to mix experts from different fields: technical, social, economic, psychological and end-users. Furthermore, the expert panels are multidisciplinary, multi-sectoral, international and gender-balanced.

3.2 **Activities**

P0.1 **Defining the topics of interest**. In a brainstorming activity of the researchers, four key aspects have been selected to address the energy transition at the residential level.
Outcome: (i) Four selected aspects of the current energy transition (Table 3.1).

P0.2 **Recruitment of experts**. The expert panel aims to include experts from diverse fields: technical, social, economic, psychological, and end-users. Additionally, these panels are multidisciplinary, multi-sectoral, international, and maintain gender balance (refer to section 2.1.1 for more details).
A list of potential experts was compiled, and they were contacted (via email,

phone call, or interview) and invited to an induction session. In this session, the objectives of the WHY project and the specific energy aspects to be studied were presented. The session also outlined the activities through which the experts will contribute.
Outcome: List of participating experts (Table G.1).

P0.2 **Setting up panel of experts**. After induction sessions, a total of 31 experts agreed to participate. The experts signed the consent agreement, were registered as members of the advisory board, and were assigned to one of four expert panels: mobility, flexibility, building and appliances. The panels are a combination of experts from different fields, ranging from technical, social, economic, psychological and end-user, as well as meeting the characteristics mentioned in the section 2.1.1.
Outcome: A panel of experts for each energy aspect, Table G.1 groups experts in panels, and the final composition of the panels is shown in Table G.1.

3.3 Outcomes

i) Four selected aspects of the current energy transition (Table 3.1).
ii) List of participating experts (Table G.1).
iii) A panel of experts for each energy aspect, Table G.1 groups experts in panels, and the final composition of the panels is shown in Table **??**.

Table 3.1: The four key energy aspects of the energy transition.

Num	Energy aspects	Description
1	**Mobility**	Electric Vehicle (EV), Micro mobility, Public transport.
2	**Flexibility**	Distributed generation, Storage, and Local Flexibility Markets (LFM).
3	**Building**	Heating and cooling.
4	**Appliances**	Energy efficiency, sharing economy, and sufficiency.

Table 3.2: Composition of the panel of experts that participated in the activities for the elicitation of the determinants leading to a scenario.

Nun	Partner	Sector	Expertise	Job position	Organization	Country
			Panel for Mobility			
1	Grzegorz Sierpin-ski	Academy	Expert in Transport engineering, Green economy, Transport economics, Civil engineering, Civil engineering	Head of Department	Silesian Technology University	Poland
2	Chris Merveille	Industry	Coordinated the EU-funded research and innovation effort to promote a citizen-centred sustainable energy transition	European Projects Coordinator	GoiEnerr	Spain
3	Javier Goikoetxea	Industry	Professional with more than 18 years of experience in business development and expertise in start-ups, technology and industry services	CEO of NEXT Group	NEXT Group	Spain
4	Merit Tatar	Public policy	Doctor in Public Administration, she is also a consultant in the development of EU-funded projects for local authorities, companies and NGOs in Estonia and abroad	Director of Development	Institute of Baltic Studies	Estonia
			Panel for Buildings			
5	Thomas Nacht	Industry	Doctor of Engineering, Senior Researcher at 4ward Energy Research GmbH	Senior Researcher	4ward Energy	Austria
6	Sebastian Seebauer	Academy	Doctor, Research in Science, Technology and Environmental Politics, Applied Psychology, Environmental Psychology and Social Psychology	PostDoc Position	Joanneum Research Forschungs-gesellschaft mbH	Austria
7	Urko Buendia	Academy	Public / Private Administration or Civil society	Member of the Tertiary Area	Energy Agency of the Basque Government	Spain
8	José Manuel Borque	Governmei	Industrial engineer, Energy techniques, Public / Private, Efficiency and Renewable Energy, Administration or Civil society, Energy	Head of the Tertiary Area	Energy Agency of the Basque Government	Spain

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Nun	Partner	Sector	Expertise	Job position	Organization	Country
9	Mirela Panait	Academy	Doctor, scientific researcher at the Institute ofNational Economy and PhD advisor at the doctoral school of the Romanian Academy	PhD Professor at Faculty of Economic Sciences	Petroleum-Gas University of Ploiesti	Romania
10	Daniel Rodik	Consultancy	MSc, Expert for energy and climate challenges Advisor for climate change mitigation and adaptation strategies and planning, energy efficiency in households and renewable energy systems	Business Consultant	Društvo za oblikovanje održivog razvoja (DOOR)	Croatia
11	Jakub Sokołowski	Academy	Experience of eight years in the energy sector, dealing mainly with energy poverty Member of the Management Committee of COST Action dedicated to Energy Poverty in Europe	PhD Candidate	Faculty of Economic Sciences of the University of Warsaw	Poland
			Panel for Flexibility			
12	Leire Astigarraga Urzelai	Industry	Engineer of Renewable Energy, Industry & Energy Department, Electrical Insulation System Engineer, Wind Energy, Demand Response to Energy Communities: the energy transition with a user-centric approach	Market technician	GoiEner	Spain
13	Guntram Preßmair	Consultancy	MSc in Environmental and Bioresource Management , member of the e7 team as project support and junior consultant	Consultant	e7 energy innovation & engineering	Austria
14	Frauke Wiese	Academy	Doctor, Energy and Environmental Management (EUM), fluctuating wind energy and inflexible base-load coal-fired power plants, energy transition, electricity supply without fossil energies	Professor	Europa-Universität Flensburg	Germany
15	Pedro Manuel Sasia Santos	Academy	Doctor in Chemical Sciences, 20 years in the environmental and occupational health areas	Senior Lecturer	University of Deusto	Spain

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Nun	Partner	Sector	Expertise	Job position	Organization	Country
16	Desislava Asenova	Consultancy	Seven years of experience in Science, Technology and Innovation Policy Programme	Project Manager	Applied Research and Communications Fund	Bulgaria
17	Oier Etxebarria	Industry	Industrial Engineer, Organisation, Energy community promoter	Community creation processes	GoiEner	Spain
18	Diana Süsser	Sustainability	Doctor, researcher in group Energy Transitions and Public Policy, focuses on socio-technical transitions, energy policy-model interactions and innovations for a sustainable energy transition	Research Associate	Institute for Advanced Sustainability Studies	Germany
			Panel for Appliances			
19	Markus Puchegger	Academy	PhD candidate, Senior Researcher in Energy Transition Area	Senior Researcher	Forschung Burgenland Research	Austria
20	Daniel Bell	Academy	Research on Urban Climate Adaptation Measures, research into social and environmental science aspects of urban climate adaptation measures	Senior Lecturer & Researcher	Fachhochschule Technikum Wien	Austria
21	Alvaro Gutiérrez Martín	Academy	Doctor in computer science, experience on Artificial intelligence, Automatic and Control Systems, swarm robotics, mobile robotics, control systems, sensor networks, and demand-side management applications	Associate Professor	Polytechnic University of Madrid	Spain
22	Christian A. Klöckner	Academy	Doctor, leader of the research group for “Citizen, Environment, and Safety” which is focused on researching individual, social and contextual drivers of environmental decisions. Coordinator of several national and international research projects, among them the H2020 projects ECHOES, SMARTEES, and ENCHANT	Professor	Norwegian University of Science and Technology	Norway

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Num	Partner	Sector	Expertise	Job position	Organization	Country
23	Apostolos Tsolakis	Industry	Electrical Engineer, Ph.D. Experience in the research sector includes a highly diverse scientific and working background on a daily routine. Characterised by strong ideation skills and self-motivation	Senior Project Manager	Q-PLAN INTERNATIONAL	Greece
24	Edina Vadovics	Sustainability	PhS Manager of GreenDependent's professional work in the European/International research projects. Experience in corporate environmental and sustainability management. External expert for the European Environment Agency and UNEP	Scientific director	GreenDepender Institute (GDI)	Hungary
25	Karagiorgou Pennyà g	Comercial	Marketing	Communication Trainee	BSH Home Appliances Group	Greece
26	Paraskevaid Vickyà	Comercial	Marketing	Communicatio Trainee	BSH Home Appliances Group	Greece
27	Piliou Afroditià	Comercial	Marketing	Communication Trainee	BSH Home Appliances Group	Greece
28	Vlachos Anastasiosà	Comercial	Marketing	Communicatio Trainee	BSH Home Appliances Group	Greece
29	Vassilisà	Comercial	Marketing	Communication Trainee	BSH Home Appliances Group	Greece
30	Moraitis Anastasiosà	Comercial	Marketing	Communicatio Trainee	BSH Home Appliances Group	Greece
31	Dedes Vassilisà	Service	Expertise	Job	Organization	Country
30	Giannaklis Spyrosà	Comercial	Marketing	Communicatio Trainee	BSH Home Appliances Group	Greece
31	Pattas Ioannis à Head	Academy	Expertise	Job	Organization	Country

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Table 3.3: Description of the expert panels.

Aspect	Num	Interdisciplinar	Intersectorial	International	Females
Mobility	7	Except psychology	Academia & Industry	Poland, Spain, Greece, Estonia & Netherlands	2
Flexibility	7	All four fields	Academia, Industry & Civil Society	Spain, Austria, Germany, Sweden & Bulgaria	4
Building	7	All four fields	Academia, Industry & Public Authorities	Austria, Spain, Romania, Croatia & Poland	1
Appliances	13	All four fields	Academia & Industry	Austria, Norway & Greece	3

CHAPTER

4

Phase 1: Design of fictional scenarios

Once the four expert panels—one for each energy aspect—have been set up (Table 3.3), this chapter uses their experience to develop a set of five fictional scenarios for each of the four energy aspects (mobility, flexibility, building, appliandes). These scenarios are classified as baseline, minimum, probable, plausible, and ideal. They gather expert perspectives on technological advances, emerging habits, and services. The baseline scenario represents the current situation, while the minimum, probable, plausible, and ideal scenarios project future possibilities. Collaboration and triangulation are crucial to harnessing the expert knowledge needed to build these prospective scenarios.

4.1 Literature review

4.1.1 Speculative design

To identify key factors influencing behavioural change or investment decisions, this study introduces an innovative approach: the utilization of fictional scenarios. This method, though unconventional in research, has the potential to yield insightful and impactful outcomes, particularly with expert participation. Complex social phenomena, which are often challenging to quantify or manipulate experimentally, necessitate a deeper understanding beyond mere task-focused research. Recognizing the crucial role of users' social influences, such as their motivations, expectations, trust, identity, and societal norms, is essential for producing outcomes that transcend mere aesthetic appeal. This research adopts a user-centred methodology to discern the primary factors affecting these fictional scenarios, drawing inspiration from Dunne and Raby's concepts of speculative design and imaginary futures (Dunne and Raby, 2013). Opting for scenario-based inquiries provides a straightforward and alternative approach for soliciting expert opinions, circumventing the need for full-scale system implementation or simulations. Auger (Auger, 2013), a pioneer in speculative design, emphasises the necessity of connecting the audience's real-world perception with the fictional aspect of the design. This rationale underpins the study's focus on technological and ICT advancements as core elements of the proposed scenarios.

Xiao highlights the significance of considering various futures in speculative design (Xiao, 2020), viewing the future as a spectrum of possibilities ranging from the probable to the impossible. A ten-year projection is deemed most suitable for this type of design. Balagtas, of the Design Futures Initiative (Balagtas, 2021), advises a balanced approach to future speculation, avoiding too distant a projection to prevent mere speculation and too immediate a focus to ensure comprehensive research. Speculative design effectively occupies this middle ground, enabling the exploration of unlikely but impactful scenarios that could significantly influence society. This approach reinforces the concept that our present-day decisions actively shape our future.

In order to obtain specific determinants to create the causal diagram, we have followed a divide and impera strategy. In this sense, we have divided the task into four use cases/fields of application as follows:

- Mobility with decisions related to car use.
- The penetration of flexibility markets.
- Energy efficiency through appliances.
- Insulation in buildings.

Moreover, for each field, we have created five speculative scenarios in which each panellist has to define the factors that induce or elicit them to make an investment decision. Each scenario is meant to describe a different reality for each of the aspects analysed, borrowing from the ideas of Dunne, Raby and Auger that have been introduced in the literature review:

- **Baseline**: these scenarios try to reflect the current status of the aspects. They attempt to be a general description of a regular house in a city in Europe now.
- **Minimum**: in this case, these scenarios include the minimum effort required to improve the base scenario towards the decarbonization of the particular use case or field of application (appliances, building renovation, flexibility services, and mobility). Usually, these scenarios are based on behavioural aspects rather than monetary actions.
- **Probable**: these scenarios are a projection of the most probable decision-making that citizens in whatever European city would take in the following years from the base scenario to advance to decarbonisation objectives.
- **Plausible**: these sets of scenarios are less probable than the previous ones (probable), yet their happening would not be too strange to be observed in some EU cities and family units in the following years towards attaining decarbonisation objectives.
- **Ideal**: these are the ideal scenarios towards attaining decarbonisation objectives, yet these are highly unlikely to happen due to the massive social innovation that should carry on or the cultural change that they entail.

Figure 4.1 visually represents the scenarios. Please remember that the scenarios described here do not reflect on individual buildings but are rather the representation of an entire city. Next, we will provide a description of each scenario for each aspect.

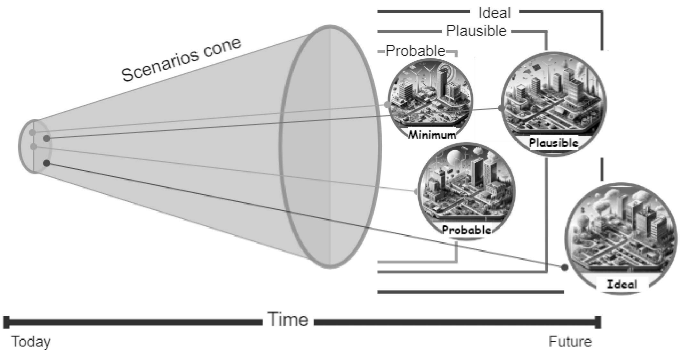


Figure 4.1: Scenarios cone: a visual representation of different fictional future scenarios over time. The cone highlights four scenarios: Minimum, probable, Plausible and Ideal (Figure created by the author incorporating some AI-generated elements).

4.1.2 **Theoretical Framework (LR.1)**

Finally, the *literature review* results in a *Theoretical Framework* included in Appendix B details the theoretical background for each scenario. In summary, it appears that internal factors such as personal beliefs, values, and environmental concerns are key drivers in motivating individuals to change their daily behaviour. This change is aimed at investing time and effort into reducing their carbon and energy footprint within their personal dwellings. Additionally, as discussed in Appendix B.4, the predominant external factors influencing such pro-environmental behaviour appear to be peer pressure, social comparison, and social norms. These include:

- An theoretical approach to causal models including all the basic operations (section B.1).

- An introduction to several psychological theories that will be used to code the contributions made by the experts. In particular, a brief introduction to social cognitive theory and self-determination theory are presented (section B.4).
- Finally, a description of the Transtheoretical model is included. This model will be used in later sections to sort determinants on the different archetypes (section B.5).

4.2 Activities

P1.1 **Brainstorming and consensus among experts**. This activity is specifically designed for experts to identify key determinants that have a direct connection to various future energy transition scenarios. In this context, the "divide and rule" strategy proved to be effective. It consisted of segmenting the task into four distinct energy domains: mobility, flexibility services, building, and appliances. For each of these fields, five fictional scenarios were developed: baseline/actual, minimum, probable, plausible, and ideal. The panellists were then tasked with identifying the factors that influence or drive their investment decisions in each scenario. Afterwards, each panel reached consensous on the descriptions of each fictitious scenario within their respective energy field.
Outcome: A total of 20 Future Scenarios of the Energy Transition, five scenarios per energy aspect (sections 4.3.1, 4.3.2, 4.3.3, 4.3.4).

4.3 Outcome

i) A total of 20 Future Scenarios of the Energy Transition, five scenarios per energy aspect.

Future Scenarios of the Energy Transition. In light of theoretical frameworks, the study developed five speculative scenarios addressing four key areas of energy transition: appliance-based energy efficiency, building insulation, vehicle-related mobility decisions, and the development of flexibility markets. Each scenario is detailed in the following sections sections 4.3.1, 4.3.2, 4.3.3, 4.3.4.

Outlining the theoretical basis for its construction. A synthesis of these scenarios indicates that internal factors such as personal beliefs, values, and environmental concerns are primary motivators for individuals to alter their daily habits, investing time and resources to minimise their carbon and energy footprint at home. Furthermore, external elements like peer pressure, social comparison, and prevailing norms appear to be significant influencers in promoting environmentally friendly behaviours.

4.3.1 Mobility

Fossil fuel (Base): You live in a metropolitan area where almost everyone has at least one combustion car. The car is used extensively, even for destinations easily reachable on foot or with personal mobility devices (i.e. bicycles). Public transport in short distance travel is seldom used, either by people that do not own a vehicle or for travel to zones where it is difficult to find parking. The public transport is partly electrified, though still dependent on fossil fuels. Travelling by foot or using personal mobility is common in some regions but is far from being the typical means of transport. Large distances are travelled usually by public transport or by private car more or less evenly. In low population density zones, the only viable option is to have a car, as public transport is non-existent and the distances to travel are too large to be covered by other means of transport.

Electric Vehicle (Minimum): All transport modes are free of emissions (mainly electric except for very long-range transport modes). Gas stations are converted into fast charging points and slow charging points are deployed everywhere. Apart from that, the behaviour of the citizens does not change.

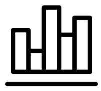
Public transport (Probable): All public transport and private cars are electric and a significantly lower number of vehicles are needed (mainly in low-density zones). The migration to cities and the blooming of teleworking changed the modal split towards public transport and new modes of mobility, such as e-hailing (e.g. Uber, Cabify, MyTaxi…), ride-sharing (e.g. BlaBlaCar) and micro-mobility services (bikes, scooters, etc.). Car-sharing (e.g. Car2go) and ride-sharing businesses increase their market share even far from the big cities. Long-distance transport is mostly made using high-speed trains and travel by plane is significantly reduced, mostly for long distances.

Robotaxis (Plausible): Electric robotaxis and new modes of mobility (e-hailing, ride-sharing, micromobility, etc.), made private vehicles obsolete in cities and low-density zones, but it is not possible to live without using them. Cities continue to have high traffic density but now have far better air quality and there is more space for pedestrians. Public transport continues to be used for medium distances (intercity) but the traditional public transport means inside the city almost disappears (cannibalised by new modes of mobility). Long-distance transport is mostly made using high-speed trains and the amount of travel by plane is reduced.

15' cities (Ideal): The cities are re-designed (e.g., with 15-minute cities or superblocks) in a way that all services are at foot distance, so the number of vehicles is drastically reduced and a combination of public or private personal mobility, robotaxis, and electric public transport supply the rest of travel needs (inter and intra city). For these reasons, traffic jams are something from the past. Long-distance transport is only possible using high-speed trains and the amount of travel by plane is drastically reduced to intercontinental travel.

4.3.2 Flexibility

Consumer (Base): You live in a home that has poor insulation and fossil fuel-based heating (such as lignite, heating oil, or natural gas). It does not have mechanisms for generating or storing energy (except for a small thermal storage tank). The household appliances are not very efficient and there is no energy management system. Your electricity rate does not include time-of-use tariffs, so you do not worry about when you use the appliances. Simply, when you need them, you plug in and use them.



Time of Use (Minimum): A new electric tariff scheme has been approved, so several time-of-use tariffs are defined, with the possibility of each hour of the day having a different price. Since the difference between the low and high-tariff hours could be substantial, you decide to use an APP that informs you of the prices each day and you change your behaviour as much as you can. This includes the installation of several smart plugs to control some loads and adjusting the thermostat and other controls in accordance to the hours when the price signal is low.

Prosumer (Probable): Some problems have been detected in the house's roof and you or your neighbours have decided to carry out comprehensive renovations. As the building is already well insulated and a large portion of the roof needs to be refurbished, it has been taken the opportunity to install an electricity generation system based on Building Integrated PV. It will be integrated into the façade and an energy community will be created to distribute the energy generation.

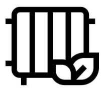
Energy Management (Plausible): The neighbours decide to carry out a comprehensive refurbishment of the building including an improvement of the insulation, the deployment of an electricity generation system integrated into the façade and the creation of an energy community. Moreover, given the actual price of the storage and its durability, they also include the installation of a community battery and an energy management system to increase the long-term return on investment.

Local Market (Ideal): You live in a recently built passive house. The low heating demand is generated by an intelligent heat pump that uses low-temperature district heating as a source of energy. The heat pump also feeds the Domestic Hot Water (DHW). You have solar panels integrated into the building and a battery system that allows you to store excess daily energy to consume at night. The generation system is slightly oversized, and in summer, you have a surplus of energy generated that is used at the community electrolyzer that generates and stores H2 that is later used in a community fuel cell CHP system. This CHP system only works in winter and is responsible for powering the district heating and helping the electricity generation during the low irradiation days. The system is controlled by energy management systems (EMS) that control not only the heat pump but also some other devices (including the battery, electrolyzer and the chargers of EVs). The EMS allows you to sell your energy surpluses and buy your energy needs from your neighbourhood. Moreover, all EMS coordinate with each other and can also participate in flexibility markets for the DSO, increasing or decreasing the energy consumption when requested.

4.3.3 **Building**

Not insulated (Baseline): You live in an old house (please consider the different possibilities mentioned in the introduction) built between the 1970s and 1980s that has either poor or no insulation (depending on country-level standards) and a heating system based on fossil fuels. It has no renewable energy generation and limited storage mechanisms (for instance a thermal storage tank for domestic hot water (DHW). The appliances in the house have a low to medium energy efficiency, and the house does not have an energy management system. Your electricity tariff for the dwelling is a standard tariff with a fixed energy price. In addition, there is no time-of-use (ToU) scheme, therefore you do not usually worry about what time you switch your appliances on. Thus, you plug them in and use them when needed.

Thermostat (Minimum): After reading about decarbonisation targets in the newspaper, you decide to find out what measures you need to take to ensure your comfort while reaching those targets. Consequently, you set the thermostat following your utility recommendation that the ideal temperature for a home ranges between 20 and 21ºC during the day, and between 15 and 17ºC at night; your clothing is suitable to the weather (for instance, in winter you wear different layers), you have checked your windows and doors for air leaks, replaced the seals on doors and windows, fixed any cracks inside and weather-stripped the windows, among others.

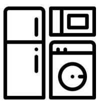


Minor Renovation (Probable): Several urgent renovation and repair measures are necessary. First, you need to repair and replace the roof and the facade, as water leaks are affecting different neighbours. Second, the oil heating system needs to be replaced with a more efficient gas model (although it does not decarbonise 100%, there will be a reduction in emissions and probably savings on the bill). Thirdly, the installation of a lift would provide additional accessibility. These renovations cannot be undertaken simultaneously.

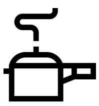
Deep Renovation (Plausible): At the last residents' meeting, the neighbourhood decided to renovate the building entirely to improve energy efficiency and comfort. The facade and roof will be insulated, air sealed, and waterproofed, and all the windows will be replaced with more efficient ones (for instance triple pane windows which can save you at least 3% on your heating bill, more in colder regions without compromising the light). In addition, a lift is going to be installed. The government or a public authority may be granting aid to carry out comprehensive building renovations, giving you the opportunity to invest in the replacement of the old oil heating system for a modern heat pump system or to connect to district heating.

Passive (Ideal): You live in a new passive home. In addition to having a first-class facade, roof, and window insulation, an intelligent high-performance heat pump supplies the dwelling with low heating needs and hot water. An energy management system controls the heat pump and some other devices, giving the system the potential to exchange thermal energy with the neighbours. You are very environmentally conscious, so you prioritise saving energy and are willing to sacrifice your comfort, especially in the context of the thermostat temperature. You try to optimise your energy consumption.

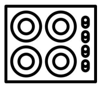
4.3.4 **Appliances**



Legacy Appliances (Baseline): You have been living in the same house since you moved for work 10 years ago. The appliances in your home are still working but are starting to break down more and more frequently. This situation worries you about the cost-benefit between keeping the equipment and extending its useful life for longer or upgrading to more efficient options (at least the most energy-consuming appliances such as refrigerators, TVs, lighting, the oven, or the ceramic hob). If your appliances were evaluated according to the new European labelling that goes from A (the most efficient) to G (the least efficient), your equipment would be labelled between F and G. It is important to note that your environmental values are in line with the European decarbonisation challenges to achieve climate neutrality by 2050. However, you are not very clear on how to contribute to it.



Sufficiency (Minimum): You start looking for information for this change to happen. You start asking friends who are more or less knowledgeable on energy efficiency and you conclude that you should rethink your daily practices before investing in new energy-efficient equipment. In other words, you ask yourself first if you are making efforts to minimise the impact of your energy use. Some of the actions you are considering are: reducing the temperature of the radiators while maintaining comfort, always cooking with the pots covered so that heat does not escape, only to always using the shortest program for everyday clothing and reserving longer programs and/or high-temperature programs for linen, always fill the dishwasher to the maximum before running it, completely turn off the devices when not in use avoiding the standby, etc.



A+ (Probable): Let's imagine that your ceramic hob breaks down again (please, bear in mind that this is just an example and that we would like to get general ideas from a broader spectrum of appliances and situations. However, for the sake of clarity, we make up this explicit example for the scenario). This time, you decide to buy a new one according to your energy efficiency objectives. Thus, you decide to change your broken appliance and buy an induction cooktop which is much more efficient than the ceramic hob. Furthermore, among all the options that you have in the market for the new cooktop, you decide to get the one which offers you the best cost-benefit compromise at the environmental and economic level.

Service economy (Plausible): The washing machine breaks down again (please again, bear in mind that this is just an example and that we would like to get general ideas from a broader spectrum of appliances and situations. However, for the sake of clarity, we make up this explicit example for the scenario). As your main goal is to contribute to climate neutrality, you decide to find the nearest laundry and drying service to use regularly instead of buying a new washing machine. Luckily, there are coin-operated laundry machines within two blocks of your house. In addition, the service has a loyalty system, and you can buy more economical cleaning and drying vouchers. Hence, in economic terms your decision pays-off. Furthermore, the laundry service ensures you as a customer a high quality operation of their machines so the washing will be as good or better as the washing you may do at home if you owned this appliance.

Communal use (Ideal): One of the appliances you use occasionally (e.g. the oven, the washing machine, a drill or the vacuum cleaner) breaks down again (please again, bear in mind that this is just an example and that we would like to get general ideas from a broader spectrum of appliances and situations. However, for the sake of clarity, we make up this explicit example for the scenario). In order to contribute to the climate neutrality objectives, you decide not to buy a new piece of equipment for individual use but to propose its purchase to your community for shared and common use. To do this, you first try to convince your closest neighbour and then you try to persuade the entire community of your building (ten families) to share these household appliances for common everyday use. Luckily, you have space in the basement to accommodate them and you propose to your community to adhere to this initiative when they have to replace their equipment and not before. Otherwise, you also think that some families would be interested in making their appliance available for others to join the initiative sooner, so you open the room to this idea as well. In addition, if new equipment has to be acquired, you have recently learned that from 2021 all appliances must be easily repairable in the EU and that the suppliers or repair services must have spare parts for 10 years after you make the appliance's purchase. Therefore, these appliances will last for longer and the return on investment is assured for your community even for the top high-end and high-efficiency appliances.

4.4 Validation of the Fictional Scenarios

In order to validate the fictional scenarios, the following steps were carried out:

1. Assembling the expert panel
2. Scenario classification activity
3. Technology selection and prioritisation activity

These steps are described below:

1. Assembling the expert panel. The panel of experts. Table 4.1 contains the list of experts and their affiliations. In the following, experts were presented with each of the scenarios without labels (namely, without the pre-classification made by the experts of the project). Then, experts had to read the scenario and carry on different tasks.

2. Scenario classification activity. In this first task, the experts were asked to classify those scenarios as base, minimum, probable, plausible, and ideal (as introduced in the previous step). Each evaluation was supposed to be done in the context of the three next decades (covering the 2020–2050 period). The results can be seen in Fig 4.2. In general, results show that for flexibility and appliance aspects, the experts map the scenarios as expected (near the diagonal and move the elements up in each decade). Nevertheless, for building and mobility aspects, the trend is not clear. One potential explanation was that these were the first two aspects to be made, and the description of the task could not have been clear to the experts (in fact, this was verbally said during the session by one of the experts).

3. Technology selection and prioritisation activity. This second task was to discuss which components or technologies should be included and prioritised in the WHY toolkit. To this end, experts should write for each scenario the technologies they consider as more important. Fig. 4.3 shows six groups of technologies, and in which scenarios they are mentioned as drivers of change in people's behaviour. The last column ranks the technologies by priority, this value is based on the number of times a technology has been mentioned throughout the scenarios.

Table 4.1: Panel of experts for the scenario validation group dynamic

Name	Affiliation	Country
Astigarraga, Leire	GoiEner/WHY	Spain
Bätjer, Stephanie	Renewables Grid Initiative/WHY	Germany
Borges, Cruz E.	University of Deusto/WHY	Spain
Ceglarz, Andrzej	Renewables Grid Initiative/WHY	Germany
Chatterjee, Souran	Central European University	Hungary
Dalla Longa, Francesco	TNO/WHY	The Netherlands
Daniel, Ewelina	European Commission	Belgium
Edelenbosch, Oreane	Netherlands Environmental Assessment Agency (PBL)	The Netherlands
Fragkos, Panagiotis	E3Modelling S.A./WHY	Greece
NA	Buildings Performance Institute Europe	Belgium
Lewarski, Michał	Centre for Climate and Energy Analyses	Poland
Loffredo, Jaume	The European Consumer Organisation (BEUC)	Belgium
Nacht, Thomas	4ward Energy Research/WHY	Austria
Schibline, Amanda	Renewables Grid Initiative/WHY	Germany
Tual, Roland	REScoop	Belgium
Elena Verdolini	European Institute on Economics and Environment	Italy
Zucker, Andreas	European Commission	Belgium

Decades	Scenarios	Flexibility					Appliances					Buildings					Mobility				
		Consumer	Time of Use	Prosumer	Enery Management	Local Market	Legacy Appliances	Sufficiency	A+	Communal use	Service economy	Not insulated	Thermostat	Minor Renovation	Deep Renovation	Passive	Fossil fuel	Electric Vehicle	Public transport	Robotaxis	15' cities
2030	Not Applicable	1				2									2	1	1		1	3	2
	Base	2					3					3	1	1	1		1	1			
	Minimum		3					3	1						2		1	1			
	Probable												2	2			1				
	Plausible			2							1		1			2		2			
	Ideal			1	3					2	1		1		1	2	1		1		1
2040	Not Applicable	2					3										2				
	Base	1						1	2					1					1		
	Minimum		3					1	1			2	1		2						
	Probable			1									1			2		1			
	Plausible			2	1					1	2	1	1	1	1		1	2	1		
	Ideal				1	1				1	3					1	1		2	2	2
2050	Not Applicable	3					3					3		1			2				
	Base							1	3				2								
	Minimum		2	1				1								1		1			
	Probable				2						1					1		1	1		
	Plausible			2									1	2	2	1	1		1	1	1
	Ideal				1	1				3	1					1	1	1		1	2

Figure 4.2: Mapping of scenarios to labels: Green shading highlights the intensity or relevance of the alignment between the scenario and the label, and darker shades indicate a stronger relationship.

GROUPS	TECHNOLOGY	Flexibility: Consumer	Flexibility: Time of Use	Flexibility: Prosumer	Flexibility: Enery Management	Flexibility: Local Market	Appliances: Legacy Appliances	Appliances: Sufficiency	Appliances: A+	Appliances: Communal use	Appliances: Service economy	Buildings: Not Insulated	Buildings: Thermostat	Buildings: Minor Renovation	Buildings: Deep Renovation	Buildings: Passive	Mobility: Fossil fuel	Mobility: Electric Vehicle	Mobility: Public transport	Mobility: Robotaxis	Mobility: 15' cities	Priority
Generation	Photovoltaic energy (PV)			●	●	●						●				●						
	Geothermal															●						1
	Renewable energy															●						1
	Biofuels (Advanced)																●					1
	Bioenergy					●																1
	Electrolyzer					●																1
Storage	Batteries (Energy storage)		●	●	●	●							●			●		●				7
	Thermal storage		●		●	●																3
	Buffer hot water storage systems							●														1
	Hot water tanks							●														1
Energy Efficiency	Smarts appliances								●				●									2
	Boiler (Gas, Oil)											●		●								2
	Smart thermostat		●		●								●									3
	Smart meters		●	●																		2
	Occupancy sensors		●																			1
	Reliable artificial intelligence					●	●															2
	Products for retrofitting (older buildings)														●							1
	Insulation		●	●		●										●						4
	Heating system							●								●					●	3
	Lighting								●													1
	Smart grids															●						1
	Smart infrastructure																				●	1
Electrification	heat pump backup system															●						1
	Charging spaces																	●		●	●	3
	Heating appliances								●													1
	Heat pump				●																	1
	Energy management system (EMS)				●																	1
	Virtual power plant (VPP)					●																1
	Appliances are used very seldom										●											1
Transport means	Cars									●												1
	Electric vehicles (EV)			●	●																	2
	Shared mobility									●												1
	good roads																●					1
	Public transport																					0
	Personal transporter																					0
Interventions	Dynamic tariff with price caps		●		●																	2
	Financial constraints													●							●	2
	Long term investment in infrastructure																		●	●		2
	New business model																		●			1
	Raw materials production and processing																	●				1
	Urban logistics/supply chain																		●		●	2
	Novel urban design concepts															●		●			●	3
	parking																●					1
	Behavioral change (in people)												●		●				●	●		4
	Broadband internet everywhere																		●	●		2

Figure 4.3: Distribution of the technologies per scenario: An overview of how different technologies fit into different future scenarios, helping to identify which technologies are most critical in different scenarios.

CHAPTER

5

Phase 2: Identify the Key Factors for Achieving Fictional Scenarios

At this phase, the expert groups have defined both the current scenario and four fictional scenarios, each addressing a specific energy aspect. These are described in detail in the table 3.1 and in the respective sections: 4.3.1, 4.3.2, 4.3.3, and 4.3.4. During this phase, the experts on each panel will provide their expert views on the factors that encourage or inhibit people from taking action.

5.1 Literature review

5.1.1 Social cognitive theory as a guide to understanding the determinants that we expect to

In sectionB.4.1 there is a detailed description of this theory, but, in a nutshell, the Social Cognitive Theory (SCT) is a framework for understanding, predicting, and changing human behaviour. Fig 5.1 show the SCT components.

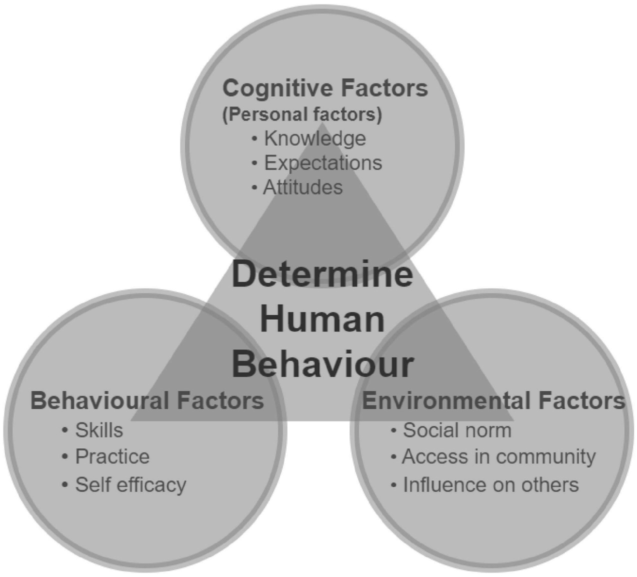


Figure 5.1: Main components of the Social Cognitive Theory (Bandura, 2001).

5.1.2 Self-determination theory: understanding determinants according to motivation

In sectionB.4.2 there is a detailed description of this theory, but, in a nutshell, the SCT is a framework for understanding, predicting, and changing human behaviour. Fig 5.2 shows the SCT components.

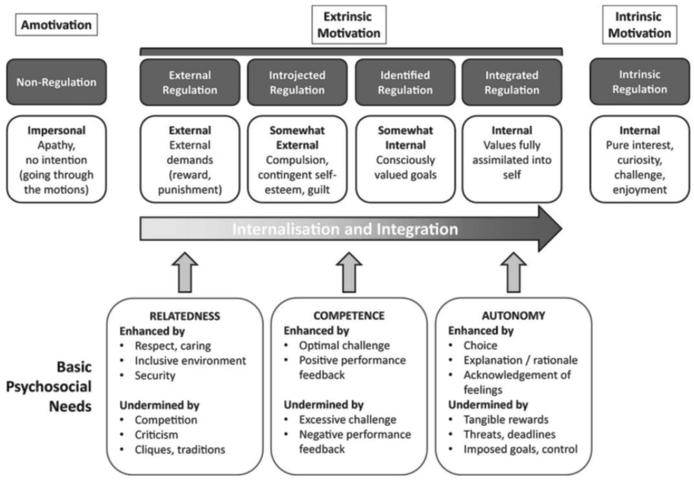


Figure 5.2: Self-determination theory. This is adapted from Ryan and Deci's theory. Self-determination theory hypothesises three main motivation types: amotivation (lack of motivation), extrinsic motivation and intrinsic motivation, and six 'regulatory styles' (dark-background boxes). Intrinsic motivation (intrinsic regulation) is entirely internal, emerging from pure personal interest, curiosity or enjoyment of the task. At the other extreme, amotivation (non-regulation) results in inaction or action without real intent. In the middle is extrinsic motivation, with four regulatory styles that vary from external regulation (actions motivated purely by anticipated favourable or unfavourable consequences) to integrated regulation (in which external values and goals have become fully integrated into one's self-image). The transition from external to integrated regulation requires that values and goals become internalised (personally important) and integrated (fully assimilated into one's sense of self). Internalisation and integration are promoted (or inhibited) by fulfillment (or non-fulfillment) of three basic psychosocial needs: relatedness, competence and autonomy (Ryan and Deci, 2017).

5.2 **Activities**

P2.1 **Individual contributions by experts**. In this activity, for a fictitious scenario, the experts individually fill in a template (fig 5.3) by addressing the following questions about archetypes in the European context:

- Which are the internal & external factors that would lead you/people to invest time and resources in a given fictional scenario?
- What are the main factors that would hinder you/people from making the aforementioned investment to achieve a given fictional scenario?
- What are the main rebound effects for you and the others that would have appeared if the scenario happened?

Given the restrictions in place due to the COVID pandemic, the activity was held entirely online. Experts were contacted by email, and after their agreement to participate in the activity, a second email was sent with some rules. Table 5.1 shows the email sent:
Appendix C includes an example of the templates used by the experts to record their contributions in each of the fictional scenarios of mobility, flexibility, building, and appliances.

Outcomes: (i) A total of 32 individual templates filled in by experts from each panel. (ii) Compilation of individual contributions grouped by energetic aspect.

Table 5.1: email sent to the experts with instructions on how to complete the study on human behaviour in the energy transition.

Title: [WHY] Instructions to complete the study on human behaviour towards the energy transition

Dear XXX/ representative of XXX,

Thanks for participating in this activity organised as part of the H2020 project WHY.
As I have informed you already, the objective of this task is to identify the factors that influence human energy behaviour. In order to retrieve this information, we will ask you to read 4 short texts describing different scenarios (minimum, probable, plausible, and ideal) in the attached Google Slides [LINK]. For each one of the scenarios, we will ask you to complete a list of the internal and external determinants that would lead you to invest your time and effort in order to participate in the scenario described.

The attached file includes an introduction, an example completed and several slides with tips to help you complete the task. If you feel confident, you can skip these but you can go back and consult them if you need inspiration.

We expect that each week you complete one of the scenarios. As there are 4 scenarios, the deadline to complete this task would be the 18th of July. You can complete all 4 scenarios in one row but we would encourage you to divide it over several days in order to allow you to review your own contributions. We estimate that you would need to dedicate between 1 - 2 hours in total to finalise the task. Every week we will contact you to remind you to complete the scenario of the week and to provide information about the status or some insights collected from other experts, as they will be completing this task simultaneously. On the 23rd July, we would contact you again to provide an assessment of the results and ask for additional feedback, if relevant. After summer we will contact you again to complete the second task of this activity. Further instructions will be provided in this communication.

All contributors to the study will be invited to collaborate as co-authors of the end results. Moreover, you can abandon the task at any point or ask to delete all the information collected. Finally, your participation does not produce any costs for you.

If you have any questions in the meantime, please do not hesitate to contact me.

Kind regards
The WHY project team

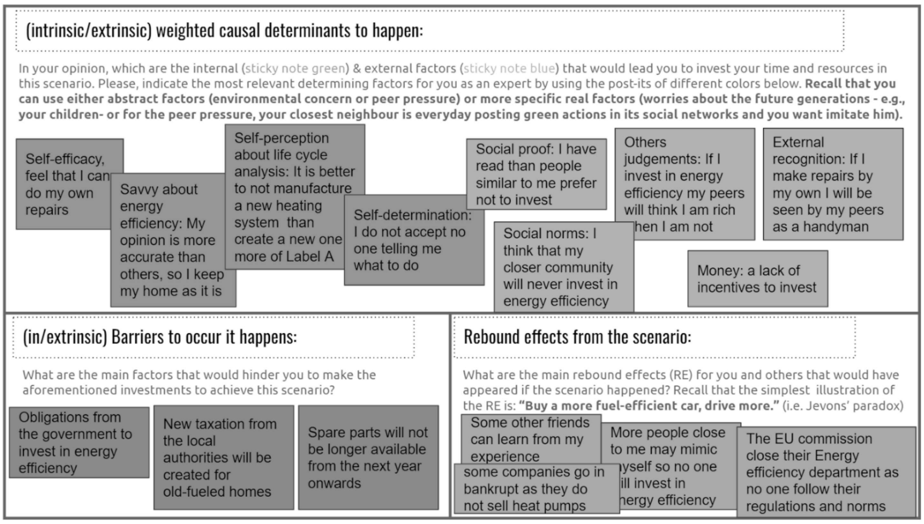


Figure 5.3: Template of individual contributions by experts on factors in reaching fictional scenarios: It is divided into three main sections, each capturing different aspects of expert input regarding intrinsic and extrinsic factors influencing the achievement of a fictional scenario (WHY-H2020-Project, 2024a)

5.3 **Outcome**

i) A total of **32** individual templates were filled in by experts from each panel, with more than **1200** contributions.
   The task at hand was to provide compelling reasons for individuals to invest their time or money in each of the given scenarios. It is necessary to present barrier, extrinsic, and intrinsic elements in addition to any possible spillover effects.
ii) Compilation of individual contributions grouped by energetic aspect. All of the experts contributed more than a thousand distinct factors. Table 5.2 shows the contributions broken down by energy aspects and scenarios. There, it is evident that the distribution is somewhat homogeneous.

Table 5.2: Individual contributions by panel on factors that motivate/block people in each fictitious scenario.

	Minimum	Probable	Plausible	Ideal	Totals
Flexibility	84	70	72	65	**291**
Appliances	107	101	88	92	**388**
Buildings	58	97	67	70	**292**
Mobility	79	74	63	46	**262**
	328	**342**	**290**	**273**	**1233**

CHAPTER

6

Phase 3: Coding

Based on the individual contributions of experts (section 2.3.4). In this phase is carried out an analysis of speculative scenarios results through coding in pairs (inter-rater reliability). Coding the qualitative answers using, as a framework the socio-psychological needs in order to retrieve the decision-making determining factors.

6.1 Activities

P3.1 **Agreements on expert contributions**. Upon receiving all the contributions from experts on each of the different aspects of the energy transition and each of the future scenarios presented to them, an agreement over the codification of data has been reached. To this end:

- **Coding by two researchers.** The consensus of the expert panel generated a list of determinants, which were grouped, according to the cognitive learning theory, into personal cognitive factors that are affected by the environment influencing behaviour (see Section 6.1). The classification of the determinants was done individually by a pair of researchers. Then, these two researchers met and tried to resolve any despair between them. This resulted in a first codification, in which there was consensus on most of the determinants but for these determinants without consensus, a third round was carried out.

– **Homogenise**. This round was carried out by a third expert. The aim was to homogenise the answers from all four panels and solve any potential disagreement left.

6.2 Outcomes

i) Coding of expert contributions by researchers, One per energy aspect, An example of this exercise focusing on the mobile aspect is shown in Fig 6.1 (The Minimum and Probable scenarios) and fig 6.2. Appendix D includes all expert contributions, coded by the researchers and grouped by energy aspects."

ii) Code of the Matrix of the most relevant determinants for decision-making on each scenario (Minimum, probable, plausible, ideal) and per each energy aspect, Figs 6.3 and 6.4 show the summary of individual contributions to future scenarios in each energy aspect, This summary is also published at `https://zenodo.org/records/11236053`

Intrinsic Determinants

Minimum Scenario				
Expert	RAW	Key Concept	Key Concept	Final Coding
1	The need to adapt to the environment No conventional gas stations	Trends	Environmental Concerns	**Environmental Concerns**
1	The belief in the right behavior - environmentally friendly traveling	Proseur	Poseur	**Poseur**
1	The belief in the right behavior - caring for future generations	Own Significance	Own Significance	Own Significance
2	The need to buy an electric vehicle (no gas stations, because they have been converted to charging stations)	Technical Fit	Technical Fit	Technical Fit
2	The need to change to an electric vehicle, because that's what everyone else does	Authority	Trends	**Trends**
2			Cozyness	Cozyness
3	Self-efficacy: dopting this scenario is easy for me: it requires minimal personal behaviour change. I am a competent driver and know my way around	Own Competence	Own Competence	Own Competence
3	Self-perception: I would feel some sense of collective pride to live in a city/region where such a scenario has been realised, knowing that my city/region has a decarbonised transport system.	Support	Support	Support
3	Self-sufficiency and Individualism: I would buy my own electric car. This continues to give me the (perceived) freedom of deciding when and where to travel, without range anxiety and without sharing my private vehicle with other people.	Self-Satisfaction	Autarky	**Autarky**
3	Self-perception and virtue signalling: If I drive a nice new EV, then I feel and show that I am making a positive contribution to the climate by driving without emissions and pollution.	Support	Brag	**Own Significance**
3				
3	Values: As some one with strong Environmental Concerns, I should lead by example, showing others that more environmentally-friendly behaviour is possible.	Authority	Authority	Authority
3	Self-efficacy: Even when all transport modes are emission-free, I would continue to rely mainly on public transport, (folding) bicycle and bike-sharing; sometimes combining both modes to cover larger distances or get to my final destination more quickly.	Support	Frugality	**Frugality**
3	Self-determination: I am an experienced and confident user of public transport and bikes. I want to and know how to get by without a private car. I plan accordingly and am willing to sacrifice the comfort and privacy of a private motor vehicle.	Authority	Adherence	**Environmental Concerns**
10	Personal care about the climate issues	Own Significance	Poseur	**Environmental Concerns**
10	Believe that this is the future anyway and available infrastructure supports the decision	Own Significance	Trends	**Trust**
10	Feeling better as sensing the personal contribution to better and cleaner living environment, being part of the "climate community"	Own Significance	Self-Satisfaction	**Own Significance**

Probable Scenario				
Expert	RAW	Key Concept	Key Concept	Final Coding
1	Remote work eliminates the need to travel to / from work	Trends	Frugality	**Cozyness**
1	Occasional use of your own vehicle: vehicle operating costs	Self-Satisfaction	Added value	**Added value**
1	Occasional use of your own vehicle: the unused vehicle wears out faster	Self-Satisfaction	Added value	**Added value**
2	Distance to work	Wellbeing	Technical Fit	**Technical Fit**
2	Less need to travel	Wellbeing	Frugality	**Frugality**
2	Traveling by bike is healthy	Self-Satisfaction	Wellbeing	**Wellbeing**
2	Easy access to sharing services (no need to have your own vehicle)	Trends	Safety	**Safety**
3	Self-perception: I am happy and proud that my city has much lower emissions than other cities.	Self-Satisfaction	Self-Satisfaction	Self-Satisfaction
3	Self-efficacy: I know how to manage mobility apps for PT and ride-sharing which help me plan my trips.	Own Competence	Own Competence	Own Competence
3	Self-determination: On occasion I am willing to sacrifice the comfort and privacy of a my own (or a shared/co-owned) motor vehicle, because I know it has a lower impact on the environment.	Environmental Concerns	Frugality	**Frugality**
3	Self-perception: I would feel a significant sense of collective pride to live in a city/region where such a scenario has been realised, knowing that my city/region has a decarbonised transport system and reduced private car use.	Environmental Concerns	Support	**Support**
3	Self-efficacy: I would combine PT with micro-mobility services for urban trips, use train for inter-city travel, and ride-/car-sharing for peri- or extra-urban trips.	Self-Satisfaction	Knowledge	**Knowledge**
3	Self-determination: I am an experienced and confident user of PT and (public) bikes. I want to and know how to get by without a private car. I plan accordingly and am willing to sacrifice the comfort and privacy of a private motor vehicle.	Self-Satisfaction	Adherence	**Environmental Concerns**
10	Do not want to differ from mainstream practices, climate friendly is the "mainstream"	Support	Trends	**Trends**
10	Pressure to feel that not owning any car (even electric) is better, therefore using public and shared transport modes shows care for climate concerns	Obligation - peer presure	Peer-Pressure	**Peer-Pressure**

Figure 6.1: Coding of expert contributions by researchers: The Minimum and Probable scenarios.

Intrinsic Determinants

Plausible Scenario				
Expert	RAW	Key Concept I	Key Concept II	Final Coding
1	Occasional use of your own vehicle - vehicle operating costs - the unused vehicle wears out faster	Profits	Added value	**Added value**
1	One vehicle for a family - occasional trips	Self-Satisfaction	Technical Fit	**Frugality**
2	Need to change life style: No possibility of using public transport (replaced by other forms of mobility)	Adherence	Adherence	Adherence
2	Health point of view: Traveling by bike is healthy	Wellbeing	Wellbeing	Wellbeing
2	No sharing services (need to have your own vehicle or use robotaxi)	Technical Fit	Technical Fit	Technical Fit
3	Self-perception: It's cool to be driven around in an autonomous vehicle.	Brag	Brag	Brag
3	Self-perception: I feel good about myself when I use an electric robotaxi, because I know I do not pollute, it's safer than a driver, and I do not take up car parking space.	Own Significance	Own Significance	Own Significance
3	Self-perception: It's nice to live in a city that is a lot more liveable with less noise and other pollution and more public space.	Wellbeing	Wellbeing	Wellbeing
3	Self-perception: When I sit in my car in a traffic jam, I feel ashamed because I realise I am part of the cause.	Environmental Concerns	Environmental Concerns	Environmental Concerns
10	Purchasing any car is not an option, as there is strong believe that it is more climate friendly if there is less need to produce any type of vehicle	Environmental Concerns	Environmental Concerns	Environmental Concerns

Ideal Scenario				
Expert	RAW	Key Concept I	Key Concept II	Final Coding
1	Limitation of travel with the use of vehicles (acceptable time for pedestrians to reach the destination)	Rights and Duties	Technical Fit	**Technical Fit**
1	Change of road infrastructure into pedestrian ways	Technical Fit	Technical Fit	Technical Fit
1	Development of the concept of green cities	Added value	Technical Fit	**Technical Fit**
1	Elimination of environmental pollution resulting from vehicle traffic	Wellbeing	Technical Fit	**Wellbeing**
1	Everything is close to home (15 minutes cities)	Cozyness	Technical Fit	**Cozyness**
2	Good place to live: A pedestrian-friendly city – good for health	Wellbeing	Wellbeing	Wellbeing
2	Environmental friendly – much more quiet streets	Wellbeing	Wellbeing	Wellbeing
2	Everything is close to home (15 minutes cities)	Cozyness	Cozyness	Cozyness
2	Only small road traffic	Technical Fit	Technical Fit	Technical Fit
3	It's a delight living in a city free of traffic, healthy and safe, with lots of public spaces	Cozyness	Cozyness	Cozyness
3	Self-determination: Walking everywhere is healthier for me. I easily get my 8000 steps a day.	Wellbeing	Wellbeing	Wellbeing
3	Self-sufficiency: My kids can now safely walk or cycle to school and sports activities. I do not need to chauffeur them around everywhere.	Trust	Safety	**Safety**
3	Convenience: Owning a car is inconvenient and costly: there is nowhere to park it or even drive it in or near the city centre. It would only be useful on holidays or for excursions	Profits	Profits	Profits

Figure 6.2: Coding of expert contributions by researchers: The Plausible and Ideal scenarios.

Code	Concept	Flexibility				Appliances				Buildings				Mobility				TOTALES	
		Minimum	Probable	Plausible	Ideal	Minimum	Probable	Plausible	Ideal	Minimum	Probable	Plausible	Ideal	Minimum	Probable	Plausible	Ideal		
Financial	Profits	7	5	6	4	6	0	4	5	6	9	3	4	2	1	1	1	64	7%
	Credit Score	1	4	3	4	0	10	0	1	0	10	7	6	5	0	0	1	52	6%
	Risk Profile	1	2	4	2	2	1	0	0	0	3	5	0	2	1	0	0	23	3%
	Added Value	0	0	0	2	0	1	2	0	0	5	6	3	2	2	1	0	24	3%
	Frugality	0	0	0	0	3	0	3	0	2	0	0	1	2	2	1	0	14	2%
Security	Legal	0	3	1	2	1	0	2	1	0	2	1	1	4	6	7	3	34	4%
	Trust	1	2	3	3	2	0	5	7	0	1	0	3	2	2	3	1	35	4%
	Safety	0	1	0	3	1	0	2	4	1	3	1	0	0	3	1	1	21	2%
Security + Meaning	Climate Protection	2	1	0	1	6	3	0	0	1	0	1	0	0	0	0	0	15	2%
Competence	Cost-Efficiency	7	3	4	3	3	5	12	5	2	0	2	2	2	0	1	0	51	6%
	Knowledge	10	6	6	7	9	8	1	3	3	1	1	3	0	1	1	1	61	7%
	Own Competence	5	2	1	0	1	4	1	3	1	3	3	4	1	1	0	1	31	3%
	Technical Fit	2	1	2	2	2	14	3	4	1	2	1	0	6	8	3	10	61	7%
Competence + Meaning	Environmental Concerns	1	1	2	2	3	3	2	1	3	1	3	2	3	2	2	0	31	3%
Autonomy	Self-Satisfaction	0	0	1	3	1	0	0	0	2	0	0	3	0	1	0	0	11	1%
	Commitment	0	1	3	1	0	0	1	2	1	0	0	0	0	0	1	2	12	1%
	Adherence	4	0	0	0	8	2	2	0	2	0	1	0	0	1	1	0	21	2%
Security + Autonomy	Autarky	0	2	2	3	0	0	0	0	0	0	0	0	2	0	1	0	10	1%
Physicalness + Security	Wellbeing	0	0	1	0	2	0	1	0	4	5	4	1	0	1	2	4	25	3%
Physicalness + Relatedness	Cozyness	0	0	0	0	0	0	0	0	2	3	0	1	1	3	0	3	13	1%
Relatedness	Rights and Duties	0	2	1	1	0	0	0	2	1	3	1	1	0	0	1	0	13	1%
	Peer-Pressure	5	6	6	2	5	2	4	0	2	1	0	1	2	4	1	0	41	5%
	Support	4	1	1	2	2	1	3	1	1	3	0	0	1	2	0	0	22	2%
	Socialising	1	1	3	0	0	0	7	6	1	0	0	1	0	0	1	0	21	2%
	Agreement	3	5	5	2	2	0	2	11	2	3	7	0	2	0	0	0	44	5%
Stimulation	Novelty	1	0	1	1	0	3	0	2	1	0	0	1	0	0	0	0	10	1%
	Fun	2	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	4	0%
Stimulation + Popularity	Brag	1	1	2	1	1	5	1	1	1	0	3	3	2	1	1	0	24	3%
Popularity	Trends	5	2	0	0	8	5	1	0	0	2	1	1	3	3	1	1	33	4%
Popularity + Relateness	Authority	5	4	1	4	7	6	4	6	5	2	2	6	1	0	0	1	54	6%
Meaning	Own Significance	3	2	3	0	3	2	1	1	3	0	1	2	3	0	1	0	25	3%
Meaning + Popularity	Poseur	0	0	0	0	0	0	0	0	0	2	0	2	1	0	0	0	5	1%

Figure 6.3: Summary of individual contributions to future scenarios in each energy aspect, part 1 of 2.

Concept	Flexibility Minimum	Flexibility Probable	Flexibility Plausible	Flexibility Ideal	Appliances Minimum	Appliances Probable	Appliances Plausible	Appliances Ideal	Buildings Minimum	Buildings Probable	Buildings Plausible	Buildings Ideal	Mobility Minimum	Mobility Probable	Mobility Plausible	Mobility Ideal	TOTALES	
Financial	9	11	13	12	11	12	9	6	8	27	21	14	13	6	3	2	**177**	20%
Security	2	7,5	5,5	10	8	1,5	9,5	12	3,5	8,5	4,5	4,5	7	11,5	12,5	7	**115**	13%
Competence	24,5	12,5	14	13	16,5	32,5	18	15,5	8,5	6,5	8,5	10	10,5	11	6	12	**219,5**	24%
Autonomy	4	2	5	5,5	9	2	3	2	5	0	1	3	1	2	2,5	2	**49**	5%
Physicalness	0	0	0,5	0	1	0	0,5	0	3	4	2	1	0,5	2	1	3,5	**19**	2%
Relatedness	15,5	17	16,5	9	12,5	6	18	23	10,5	12,5	9	6,5	6	7,5	3	2	**174,5**	19%
Stimulation	3,5	0,5	2	1,5	0,5	5,5	1,5	2,5	1,5	0	1,5	3,5	1	0,5	0,5	0	**26**	3%
Popularity	8	4,5	1,5	2,5	12	10,5	3,5	3,5	3	4	3,5	6,5	5	3,5	1,5	1,5	**74,5**	8%
Meaning	4,5	3	4	1,5	7,5	5	2	1,5	5	1,5	3	4	5	1	2	0	**50,5**	6%

Financial	13%	19%	21%	22%	14%	16%	14%	9%	17%	42%	39%	26%	27%	13%	9%	7%
Security	3%	13%	9%	18%	10%	2%	15%	18%	7%	13%	8%	8%	14%	26%	39%	23%
Competence	35%	22%	23%	24%	21%	43%	28%	23%	18%	10%	16%	19%	21%	24%	19%	40%
Autonomy	6%	3%	8%	10%	12%	3%	5%	3%	10%	0%	2%	6%	2%	4%	8%	7%
Physicalness	0%	0%	1%	0%	1%	0%	1%	0%	6%	6%	4%	2%	1%	4%	3%	12%
Relatedness	22%	29%	27%	16%	16%	8%	28%	35%	22%	20%	17%	12%	12%	17%	9%	7%
Stimulation	5%	1%	3%	3%	1%	7%	2%	4%	3%	0%	3%	7%	2%	1%	2%	0%
Popularity	11%	8%	2%	5%	15%	14%	5%	5%	6%	6%	6%	12%	10%	8%	5%	5%
Meaning	6%	5%	6%	3%	10%	7%	3%	2%	10%	2%	6%	8%	10%	2%	6%	0%

	Flexibility	Appliances	Building	Mobility
Financial	18%	13%	32%	15%
Security	10%	11%	10%	24%
Competence	26%	29%	15%	25%
Autonomy	7%	6%	4%	5%
Physicalness	0%	1%	5%	4%
Relatedness	24%	21%	18%	12%
Stimulation	3%	4%	3%	1%
Popularity	7%	10%	8%	7%
Meaning	5%	6%	6%	5%

Figure 6.4: Summary of individual contributions to future scenarios in each energy aspect, ,part 2 of 2.

CHAPTER

7

Phase 4: Development of the Taxonomy

On the basis of the analysis of the key factors for achieving the fictional scenarios in phase 4, the objective of this phase is to create a two-level glossary. This glossary will classify the determinants according to the investment and provide their systematic classification in a taxonomy. The taxonomy introduced in this chapter focuses on the decision-making process of people in the residential sector regarding the energy transition within the European context. It consists of a comprehensive two-level taxonomy, with nine needs at the top level and determining factors at the lower level. These factors influence the decision-making process of European residents in the residential sector in relation to the energy transition.

7.1 Literature review

The concept of *universal psychological needs* refers to the innate, essential, and common motivations that drive human behaviour across different cultures and societies. The most widely recognized theory that outlines these needs is the Self-determination theory (SDT) described in section B.4.2 (Ryan and Deci, 2017), Autonomy, Relatedness and competence are directly related to SDT as shown in fig 7.1. Needs such as stimulation, meaning, and security—are not part of the core SDT framework but are recognized in various psychological theories as important aspects of human motivation and well-being.

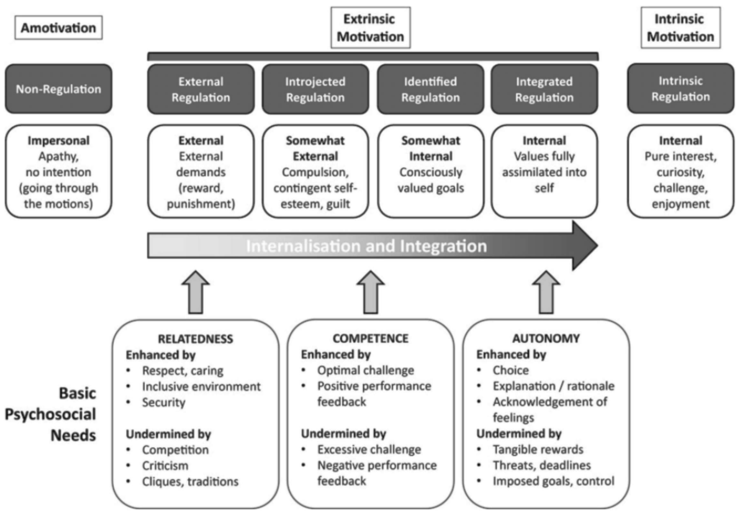


Figure 7.1: Self-determination theory. Self-determination theory (Ryan and Deci, 2017).

The psychological need for *financial security* was added to the taxonomy for being a fundamental aspect of human motivation and well-being. It is associated with the broader concept of safety needs, which are part of Abraham Maslow's hierarchy of needs (Wahba and Bridwell, 1973). Financial security refers to the need to have enough resources to cover one's living expenses and to feel secure about one's financial future.

7.2 Activity

P4.1 **Development of taxonomies**. In this activity, the research team analysed the results of the coding phase (tables 6.3, 6.4) in order to describe the psychological needs and behavioural factors linked to them. Each factor was described in detail in the common glossary. The research team then developed a taxonomy that—in two layers—graphically represents the psychological needs at the upper tier and the determinants linked to them at the lower tier. It should be noted that some determinants serve as a link between two different needs.
Outcomes: (i) Common glossary, (ii) Taxonomy

7.3 Outcomes

i) Common glossary of psychological needs and behavioural factors linked to them (Two-tiers taxonomy). Table 7.1 present the common glossary.
ii) The two-tier 32-factor taxonomy is illustrated in FigF.1. The two-tier taxonomy comprises nine psychological needs at the upper tier. At the lower tier, it includes 32 factors or determinants related to the decision-making process that influence people's behaviour.

Table 7.1: Common Glossary: A list of determinants grouped by psychological needs, along with their descriptions

Psychological need	Code	Description
FINANCIAL	Profits	All kinds of economic gains and losses including direct revenue streams (like selling energy or flexibilities to the grid) to the reduction of losses (like a reduction on heating bills) from carrying out the actions (not by invest on third parties)
	Credit Score	Access to funding (for example access to loans), direct investment on technology (by crowdfunding, for example or use of actual capital), grants or other fiscal instruments, etc.

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Psychological need	Code	Description
	Risk Profile	All kinds of economic risks related to the investment carried out (like for example long payback periods, uncertainties on the cash flows, unknown long-term behaviour of the infrastructures, etc.)
	Added value	Other indirect economic gains (or losses) related to the investments carried out (like increase of the real estate value)
	Frugality	Values to voluntarily reduce consumption and spending even at the cost of reducing the quality of life (including people that value money above all things)
SECURITY + MEANING	Climate Protection	All actions related to protecting or fighting to improve the climate condition. The important message is that climate is at risk and actions should be taken to keep it in its present or past status.
SECURITY	Legal	All legal aspects that allow (or not) to carry on a certain action (including the uncertainties given due to changes in the legislation)
	Trust	Degree of trust on the institutions (for example access to grants, availability of funds, creation of laws based on the best interest of enterprises and not citizens), people (for example related to the behaviour of neighbours) and technology (for example its actual performance, future support of the technology, etc.)
	Safety	Values related to the safety of the infrastructures and all types of actions that could change it (for example increasing the risk of structural damages) including also the safety and security of the people (for example risk of robbery or getting an infection disease).)
COMPETENCE	Cost Efficiency	Reflexible values related to the evaluation of the activities/investments to be carried out in terms of different criterias (for example after considering the pros and contras of the investment the person decides to not carry out due to the lack of added value, or large risks)
	Knowledge	Internal knowledge of the person or personal abilities/contacts to retrieve the knowledge required to solve a task. The knowledge considered here is mostly from a theoretical point of view (for practical knowledge see Own Competence). Fake news or hype (as anti-knowledge) are also considered here
	Own Competence	Practical knowledge of the task at hand (that increases self-esteem because is done in a rightful way). This includes the familiarity with the technologies and similar values
	Technical Fit	Technical issues of all kinds that foster or hinder the adoption of technologies like space for deployment of the technologies, access to qualified installers or waiting time, but also grid stability or unavailable access to the grid, etc.
COMPETENCE + MEANING	Environmental Concerns	Values related to the responsibility for our own actions towards the climate and the future perspective.
AUTONOMY	Self Satisfaction	The happiness from the feeling like you are the cause of your own actions. Emotions related to the freedom and the fulfilment of the inner essence of the individual.

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Psychological need	Code	Description
	Commitment	The willingness to give your time and energy to a job, activity, or something that you believe in. Besides, it is related to a firm decision to do something.
	Adherence	The capacity to maintain any given behaviour, task or action during the time.
SECURITY + AUTONOMY	Autarky	Autarky is related to the auto-sufficiency of the people. Having their own control of the things, and producing their own goods to feel independent from companies.
PHYSICALNESS + SECURITY	Wellbeing	Related to the wellbeing of the individual: any issue related to health, and to the impact on the physical wellbeing of the people(For example, having an adequate home for a child)
PHYSICALNESS + RELATEDNESS	Cosiness	Related to the comfortability of living. It involves the emotional side of being at home with your loved ones and feeling comfortable and happy at home
RELATEDNESS	Rights and Duties	Related to specific issues that may appear when living in a community: obligations and rules of neighbourhoods or tenants/landlords, and also the benefits and rights that are involved.
	Peer-Pressure	Susceptible to be influenced by peers that actually enforce the social norms.
	Support	Support is related to the idea of contributing to the community (or any other social cause) and doing your best for the improvement of the society (at any level)
	Socialising	The idea of having regular intimate contact with people who care about you rather than feeling lonely and uncared for. Feeling connected to other people and part of a community.
	Agreement	Understanding and cooperation between peers among any given issue
STIMULATION	Novelty	Values related to the positive feedback mechanism for doing new things. This includes the early adopters and the fear to new things
	Fun	Values related to the enjoyment (or the opposite) of carrying out an activity or investing in something
POPULARITY + STIMULATION	Brag	Values related to the persons that actively believe on the activities they are carrying out and perform proselytising or brag about it
POPULARITY	Trends	Susceptible to be influenced by external third parties (like advertisement or abstract social norms)
POPULARITY + RELATEDNESS	Authority	Susceptible to be influenced by the knowledge or examples carried out by peers (especially know and direct peers like family, friends or neighbours)
MEANING + POPULARITY	Poseur	Feelings, attitudes and actions are influenced by external factors (money, popularity) and not due to internal motivation. For example, accepting and following trends that are not inherent or truly representative of the individual

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Psychological need	Code	Description
MEANING	Own Significance	Feeling that you are developing your best potentials and making life meaningful rather than not getting anywhere and experiencing nothing of importance. Ideas related to their own significance and internal factors as emotions or feelings.

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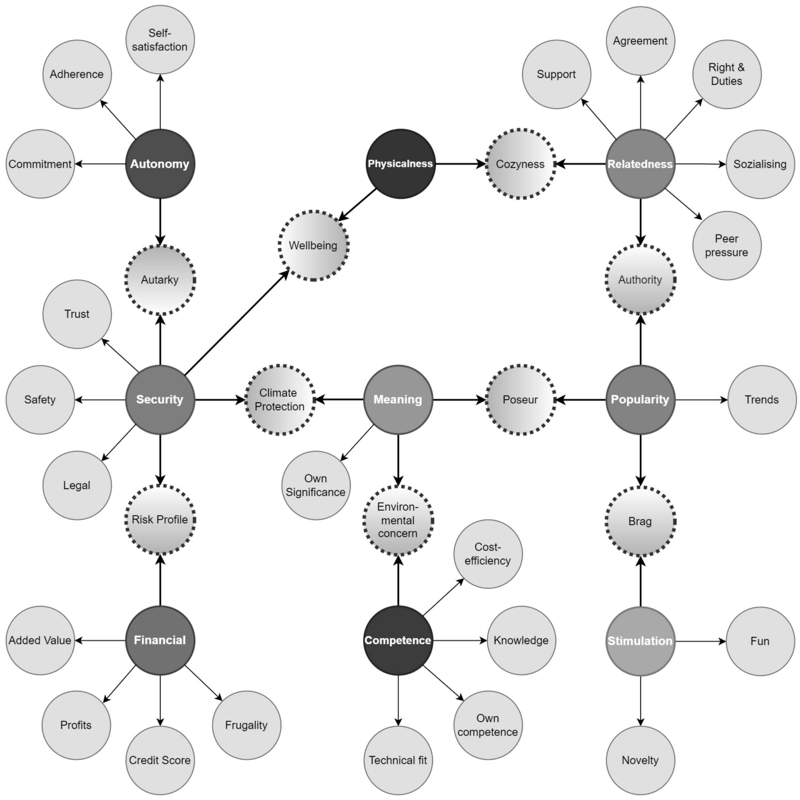

Figure 7.2: The 32-factor taxonomy: Nine psychological needs at the top tier (dark colours) and 32 behavioural factors at the bottom tier (light colours); factors associated with more than one need are shown in the dashed border.

Part II

Second part: Causal Modelling

CHAPTER

8

Phase 5: Archetype crafting

In the previous Phase 4, the expert panels virtually finalised the development of human expert knowledge in the context of the energy transition. The common glossary and its taxonomy will help other expert panels understand and explain how people behave within the scope of their respective panels.

This chapter introduces a perspective on typical end-users of energy consumption in Europe, identifying and describing from the experts' contribution in this phase a number of seven distinct archetypes, and one more emerging as a result of the survey analysis, for a total of eight European archetypes or investment profiles. These archetypes encapsulate various behavioural patterns and reactions of individuals in response to changes related to the energy transition.

This Phase integrates three key aspects of the CausalDec methodology, which are as follows:

- *Consolidation of Expert Knowledge for Causal Modelling*: This phase marks the culmination of the phases (from 0 to 5) dedicated to retrieving human knowledge from expert panels.
- *First phase of causal modelling*: This phase represents the beginning of the stages specifically dedicated to causal modelling using Directed Acyclic Graphs (DAGs).
- *Mapping archetypes in similar contexts*: This phase can also be used as an initial stage to describe archetypes in other similar contexts, as is the case developed here for the context of the *Latin American* energy transition in the energy aspects of mobility and flexibility. It focuses on solidifying the expert insights required for effective causal modelling.

8.1 Literature review

The concept of using persona descriptions or archetypes to better understand people's needs is a common practice in several fields. Personas, or archetypes, are used to represent typical user types or personas and contain basic information about their needs, behaviours, and motivations.

Archetypes are universal, inborn models of people, behaviours, and personalities that play a role in influencing human behavior(Cherry, 2023). In the context of energy transition, archetypes and people are used to explore both the needs and the determinants that drive the decision-making processes of various types of individuals that characterise specific sectors of the population. Archetypes are representations of audience clusters, capturing major areas of overlap in user behaviours, attitudes, motivations, weaknesses, and goals (Laubheimer, 2022). This approach is beneficial for designing interventions to encourage public participation in energy transition initiatives and adopting energy efficiency habits.

In this phase of causal modelling, the generated models are qualitative causal diagrams (DAGs) that stand for investment profiles and are not derived from data-driven processes. But, how many determinants are ideally required to describe an investment profile? Additionally, how many distinct investment profiles can typify the European population? To answer these questions, the first approach was empirical. Based on the researchers' expertise and the 32-factor taxonomy, a set of initial archetypes was proposed. Then, following the construction of archetype theory (Cherry, 2023), by deductive reasoning, the initial archetypes were refined, resulting in the proposal of seven patterns of behaviour as investment profiles. In order to validate those initial archetypes, a cross-sectorial survey was the method chosen (following Chapter 6). A cross-sectional survey collects data about a population of interest at one point in time. They could be considered snapshots of the populations about which they gather data. In this case, the survey aims to characterise the European population concerning the taxonomy to try to locate clusters of similar behaviours. Identifying these clusters allows us to build different investment archetypes and compare them with the ones we initially identified.

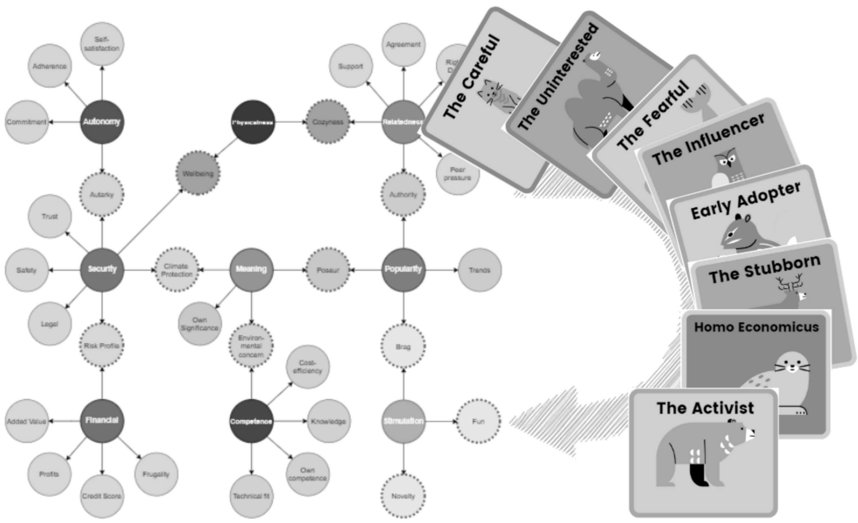

Figure 8.1: Archetype mapping (on the right) through taxonomy (on the left),

8.2 Activity

P5.1 **Clustering**. Clustering archetypes into investment profiles.
Empirical and deductive mapping of Archetypes. Taking into account the theory to define archetypes(Cherry, 2023), this activity carries out archetypal profiling, which consists of creating typical investment profiles within the European population by using the taxonomy to analyse the structure of investment decision patterns and the determinants that describe them.
Outcome: Description of the final European archetypes or investment profiles by the factors that shape them.

P5.2 **Archetypes mapping**: At first by mapping the European (EU) archetypes, and later by shaping the Latin American (LATAM) archetypes.

(a) **Assembling new panels of experts**. In order to set up an expert panel for each energy aspect on the context—EU, LATAM—and following the features for expert panels (section 3.1.2, a list of potential experts was generated and experts were contacted for inviting them to attend an Induction session. The induction session aims to introduce experts to the objectives, background and methodology of the WHY project, as well as the energy transition aspect.

(b) **Activity-1 for experts: Individual contributions on archetypes**. The objective of this activity is to extract expert knowledge on the behavioural factors of archetypes in the target population (LATAM).

(c) **Coding individual contributions into archetypes**. The individual contributions are compiled and coded—based on the 32-factor taxonomy—into archetypes.

(d) **Clustering of archetypes**. The archetypes resulting from *activity-1* are clustered—by their likeness degree—into groups that correspond to one of the European archetypes. Focused on identifying and analysing the determining factors of various archetypes.

(e) **Activity-2 for experts: Sorting of the determinants into the TTM stages**. Reach a consensus on the factors that encompass each final archetype, as well as the stage of change (TTM) in which they should appear (Sorting determining factors).

Outomes

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i) European archetypes, along with the factors that shape them.
ii) An expert panel per energy aspect.
iii) Coding individual contribution into individual archetypes.
iv) The compilation of individual archetypes (individual contributions).
v) Clustering, Individual archetypes clustered into European archetypes.
vi) Causal Flows: This represents the final archetypes and their associated factors, sorted according to the stages of the Transtheoretical Model (TTM) of Change.

8.3 Outcomes

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i) **Final European Archetypes** (investment profiles). A total of eight archetypes. Seven archetypes emerged from the previous activity—clustering (P5.1)—and an additional one (The Activist) found by the cross-sectorial survey (next phase); the latter is mentioned in this phase for the purpose of including all the investment profiles in the same section of this document.

The following are the descriptive sheets for each archetype. These sheets contain information such as name, description, icon, and the determining factors that characterise the archetype.

1. The Early Adopter

An archetype who is always affected and driven by novelty. Always want to be on trend and be the first to make changes at home or in their personal life (overall when cutting-edge technology is in the equation). Its motivations are mainly technical, but it does care about the environment nonetheless. Its enjoyment and excitement of what it does are predominant factors for their actions. It has a social status to maintain and its peers expect it to behave in this way. It may be the case that in certain situations it likes to show off or tries to be perceived as an authority.

Determining factors: *Safety, Cost-Efficiency, Knowledge, Environmental Concerns, Self-Satisfaction, Commitment, Adherence, Peer-Pressure, Socialising, Novelty, Fun, Brag, Trends, Authority, Own Significance.*

2. The Uninterested

An archetype that does not pay special attention to external information or incentives to make some kind of improvement in the home or in his personal life. The maintenance of comfort is what predominates its daily life when making decisions. It usually applies shortcuts for decision-making such as following peers' trends and applying defaults. Rarely it will accept changes without resistance.

Determining factors: *Legal, Cost-Efficiency, Knowledge, Technical Fit, Self-Satisfaction, Adherence, Wellbeing, Coziness, Peer-Pressure, Support, Socialising, Brag, Trends, Authority, Own Significance, Cost-Efficiency.*

3. The Homo Economicus

An archetype that has a medium-high degree of knowledge about economics and/or energy transition. Its motivations for undertaking any activity are merely economic, either to make profits or to reduce expenses. It will be more or less interested in making new investments depending on its risk perception, confidence in the current markets' situation, sales trends, and access to funds. Added value drives its choices.

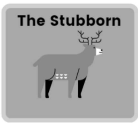
Determining factors: *Profits, Credit Score, Risk Profile, Trust, Safety, Cost-Efficiency, Knowledge, Technical Fit, Self-Satisfaction, Adherence, Socialising, Fun, Brag, Trends, Own Significance.*

4. The Fearful

An archetype with average environmental awareness who is able to understand the need to make legal, economic, or personal changes. However, it is usually so afraid or laziness that entails inaction because of the amount of risk and time involved. A driver for urgent and long-lasting decision-making will be a lack of confidence in the current situation that may affect their personal safety and well-being.

Determining factors: *Credit Score, Risk Profile, Trust, Safety, Climate Protection, Cost-Efficiency, Knowledge, Technical Fit, Self-Satisfaction, Commitment, Adherence, Wellbeing, Socialising, Brag, Own Significance.*

5. The Stubborn



An archetype who is highly committed to environmental issues. However, this situation makes it feel distressed, anxious, or angry. Therefore, it aims at making meaningful actions at any moment and whatever it takes to relieve its discomfort. The ambition and the degree of its actions will depend on its competence, personal satisfaction, the capabilities of the technology, the budget, or/and access to funds.

Determining factors: *Credit Score, Safety, Climate Protection, Cost-Efficiency, Knowledge, Own Competence, Technical Fit, Environmental Concerns, Self-Satisfaction, Commitment, Adherence, Wellbeing, Brag, Own Significance*

6. The Influencer

An archetype who enjoys influencing peers. It looks always for an added value to its actions, either monetary, authoritative, or increased social capital. Complying with what the group expects of it turns into an obligation.

Determining factors: *Credit Score, Added Value, Legal, Cost-Efficiency, Knowledge, Peer-Pressure, Support, Socialising, Agreement, Fun, Brag, Trends, Authority, Own Significance, Poseur*

7. The Careful

An archetype that aims at maximising personal, collective, and ecosystem well-being and security. Every decision it takes is strongly influenced by its perceived safety, self-competence, impact on the environment, and confidence in the outcomes of the action. Personal or group satisfaction is the main driver for action. In particular, when maintaining the physical and mental comfort of those who are close in relation to climate anxiety.

Determining factors: *Credit Score, Risk Profile, Trust, Safety, Climate Protection, Cost-Efficiency, Knowledge, Own Competence, Technical Fit, Environmental Concerns, Self-Satisfaction, Commitment, Adherence, Autarky, Wellbeing*

8. The Activist

An archetype that has the duty of supporting its community. Its pro-environmental values and beliefs are aligned with its way of living. Moral obligation drives it to take action. Nevertheless, it is well aware of regulations, norms, and restrictions so its actions are always aligned with the legal framework. It trusts in technology appropriation, open knowledge, and sharing economy.

Determining factors: *Legal, Trust, Safety, Cost-Efficiency, Knowledge, Technical Fit, Environmental Concerns, Self-Satisfaction, Commitment, Adherence, Peer-Pressure, Socialising, Brag, Trends, Own Significance*

8.4 Shaping Archetypes in LATAM

Feature-based Forecast Model Averaging (FFORMA) is utilized for enhancing the accuracy of predictive models. The process does not merely suggest that research takes time. It mainly implies that qualitative new knowledge results from a process that involves several phases, and above all iteration (Montero-Manso et al., 2020).

This section provides a detailed description of the validation process of the CausalDec methodology used to identify the relevant factors involved in household decision-making in relation to the energy transition, first in the context of the European Union (EU), the result of which are listed below; and second—as described following activities from *a* to *e*—in the context of Latin America.

The following products have been obtained so far:

- 5 speculative scenarios each for the energy aspects flexibility, mobility, buildings, and appliances make up the 20 speculative scenarios.
- A 32-factor taxonomy that influences the behaviour of energy end users.
- 8 behavioural archetypes that represent the decision-making processes of energy end users.

In contrast to the European context, where four energy aspects - mobility, flexibility, buildings and appliances - were addressed, the Latin American context focuses only on mobility and flexibility, as the final scenarios are considered to be similar.

- **Flexibility**. The penetration of flexibility markets
- **Mobility**. It is related to decisions about car use and public transport for commuting.

In Latin America, our collaborative research involved teams from Mexico, Colombia and Chile, representing the northern, central and southern regions of the continent, respectively. These countries offer a wide range of geographical, climatic and social contexts, especially in relation to energy transition. They serve as diverse study areas in which the methodology for identifying the determinants that drive or impede behavioural changes among residential energy end-users was applied and tested for validation. This methodology is crucial as it facilitates the extraction of expert knowledge. It forms the basis of causal modelling, a key aspect of the artificial intelligence technology used to estimate the impact of policy interventions on the energy transition. The list of Latino American partners and locations is shown in Table 8.1

Table 8.1: Latino American partners and locations

Country	Institute	Host researcher	Venue
México (MX)	National Institute of Astrophysics, Optics, and Electronics (INAOE), www.inaoep.mx	Luis Enrique Sucar, Senior Research Scientist, esucar@inaoep.mx, Computing Department	Luis Enrique Erro 1, Tonantzintla, Puebla, Mexico, Postcode: 72840, Tel.: (222) 266.31.00
Colombia (CO)	Fundacion Universitaria Cafam (UniCafam), www.unicafam.edu.co	Eduardo Rodriguez Aripe, Research Coordinato, eduardo.rodrigueza@unicafam.edu Jose Isaías Salas Hernández, Research Professor, jose.salas@unicafam.edu.co, Engineering Department	Av. Cra. 68 No. 90-88 – Bloque 1, – Piso 1 (Bogotá, Colombia), PBX:652 8600
Chile (CL)	Universidad Catolica de la Santísima Concepción (UCSC), www.ucsc.cl	Melany Rebeca Hebles Ortiz, Research Professor, mhebles@ucsc.cl, Faculty of Economics and Administrative Sciences	Alonso de Ribera 2850, Concepción, Chile, Postcode: 4090541, +56 41 234 50 00
El Salvador (SV)	Universidad Centroamericana José Simeón Cañas (UCA)	Luís Aarón Martínez Figueroa, Head of department, lamartinez@uca.edu.sv	Boulevard de los Próceres, San Salvador, Edificio de laboratorios de ingeniería, Tel: +503 2210 6600 Ext. 31

Table 8.2 provides a detailed list of both online and physical resources used for the experts' activities, which were designed to facilitate their participation. The complete set of resources can be found in Appendix F.

Table 8.2: Materials for the experts' activities

Num	Resource	Description	Activity
1	WHY-Latam induction session (slides)	A presentation for the induction of the experts to the WHY project, the advisory board and the activities for experts	Induction session
2	Determinants and archetypes template (Flowchart)	A template to contribute on archetypes. This form has been improved from *version-1*, used in Mexico, to *version-2*, used in Colombia and Chile. *Version-1* was designed to allow experts to contribute by typing archetypes in free text. Version-2 includes the cards of the European archetypes, their psychological needs and their behavioural determinants. The second version, in the words of the experts, allows them to contribute in an easy way by dragging & dropping cards.	Activity-1, Individual Contributions on Archetypes
3	Needs card (Printed cards)	Printed cards of the 32-factor taxonomy. Each card, on the obverse, describes a determinant by its name, icon, and description, as well as the psychological need (code colour) and the archetype (icon) to which it belongs.	Activity-2. Sorting determinants into TTM
4	TTM template (TTM stages, Archetypes name, Sample)	A TTM template on a paper canvas is used for sorting the determinants of an archetype onto the TTM stages	Activity-2. Sorting determinants into TTM

Activities

(a) **Assembling new panels of experts**. In order to set up an expert panel for each energy aspect on the context—EU, LATAM—and following the features for expert panels (section 3.1.2, a list of potential experts was generated and experts were contacted for inviting them to attend an Induction session. The induction session aims to introduce experts to the objectives, background and methodology of the WHY project, as well as the energy transition aspect.

The panel of experts has been assembled as part of the project's advisory board, bringing together specialists from various fields—including technical, societal, economic, psychology, and end-user perspectives—to address the energy aspects of mobility and flexibility. For example, we are looking for experts on the ethical implications of making 15-minute cities, psychologists who have studied why energy efficiency actions are taken in the home, forms of transport to work (public or private transport), modellers of the impact of implementing renewables on a large scale, engineers who are working on new batteries, people who study public policy around renewable deployment or entrepreneurs with technology products in the area.

A list of potential experts was generated and contacted to invite them, either by email or phone. to participate in our research as consultants in Latin America on the flexibility and mobility aspects of the energy transition. The Table 8.3 contains a summary of the main characteristics of the panel of experts and the final composition can be seen in Appendix G.

Table 8.3: Latin American Experts panel summary

Country	Energy aspects	Acceptance	Interdisciplinary	Intersectorial	Female
Mexico	Flexibility & mobility	9/16	All four fields	Academia, Industry & Civil Society	8/9
Colombia	Flexibility & mobility	10/91	Except psychology	Academia &Industry	2/10
Chile	Flexibility & mobility	9/13	All four fields	Academia, Industry, Private sector	3/9
El Salvador	Flexibility & mobility	13/15	Energy Engineering, Entrepreneur, Communications & Energy services	Civil Society, Commercial sector, Academy, & Government	4/11

Introductory session: An introductory session was held with all experts to introduce them to the objectives, background and methodology of the WHY project, with a special focus on the flexibility and mobility aspects of the energy transition. In addition, the session outlined the specific activities in which the experts would be involved and discussed the incentives associated with advisory board membership in Latin America.

Originally, the induction session was to be a group event. However, due to the varying availability of experts, individual sessions were necessary. In total, more than 40 sessions were held. An example of those sessions is shown in Fig 8.2.

Figure 8.2: Online induction sessions with experts in Latin America.

(b) **Activity-1 for experts: Individual contributions on archetypes**. The objective of this activity is to extract expert knowledge on the behavioural factors of archetypes in the target population (LATAM).

Individual mapping: The objective of this activity is to take advantage of the experts' knowledge of context archetypes in Latin America. To facilitate their participation, an online template was developed based on the 32-factor taxonomy. The experts used the factor charts to describe a minimum of two archetypes. These archetypes are the ones that, in their opinion, describe the types of employee profiles that currently exist in their professional context. In this Activity-1, online assistance for the experts was essential to resolve any doubts about the determinants and their meanings, as well as the description—in as much detail as possible—of the archetypes, as shown in the below fig 8.3.

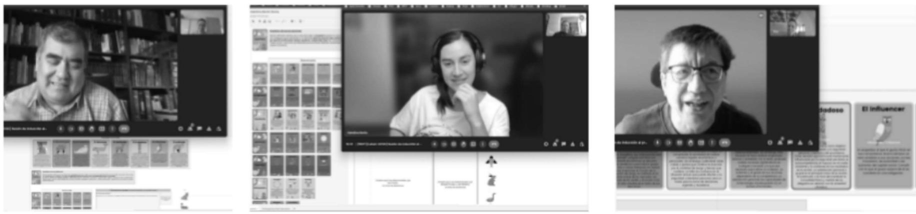


Figure 8.3: Experts working individually online to contribute to the development of archetype.

Appendix F contains the Individual template for experts - contributions on archetypes, Versions 1 and 2.

(c) **Coding individual contributions into archetypes**. The individual contributions are compiled and coded—based on the 32-factor taxonomy—into archetypes.

From Individual Mapping: Following the experts' inputs into the designated template, the archetypes they have described are compiled into a form. These archetypes are then decoded into specific determinants, utilizing the 32-factor taxonomy as a framework for analysis and categorization, The following figure 8.4 provides an example of a template used by an expert to contribute to the identification of archetypes, as well as the form used to consolidate all contributions.

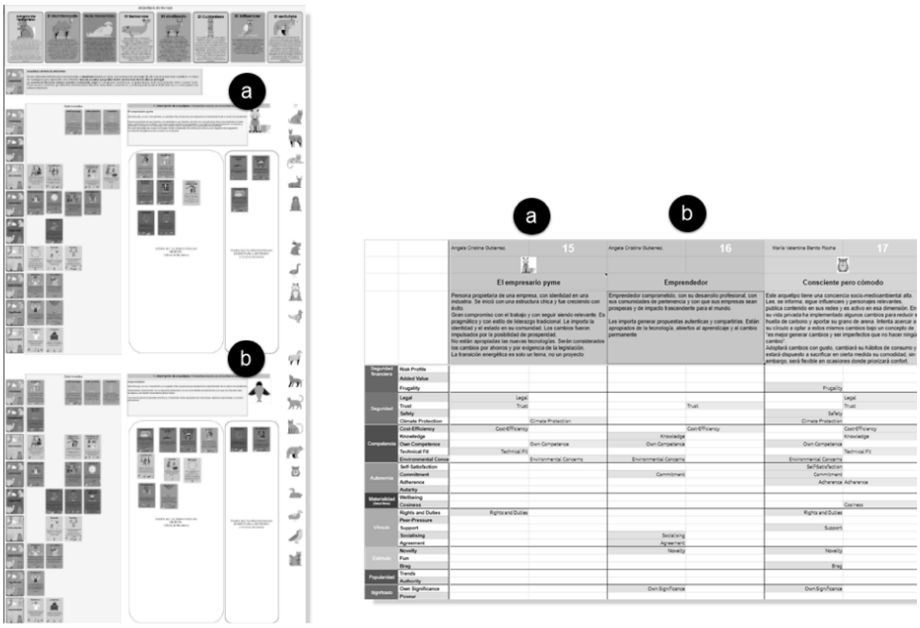


Figure 8.4: Template for experts to assist them in the individual construction of archetypes (on the left) and the form that concentrates the information of all archetypes provided by the experts (on the right),

(d) **Clustering of archetypes**. The archetypes resulting from Activity-1 are clustered—by their likeness degree—into groups that correspond to one of the European archetypes. Focused on identifying and analysing the determining factors of various archetypes.

From Individual Mapping: The contributions provided by the experts regarding Latin American archetypes are compiled in the form illustrated in the figure 8.4 above. This compiled data is then used to create a simplified representation of archetypes and their determinants in a separate form.

- The *formatted templates*, where archetypes are coded into determinants are shown in figure 8.5.
- The proportions of determinant occurrences within the Latin American context are detailed, as shown in Figures Figs. 8.6, 8.7.
- The categorization of determinants as facilitators, barriers, or ambiguous factors in the context of change is detailed, along with their proportions, as shown in Figure 8.8.

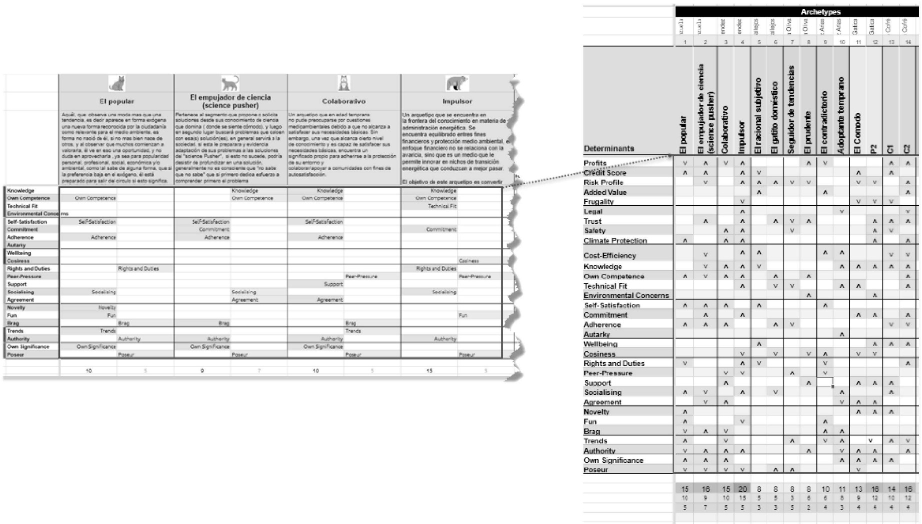


Figure 8.5: Compilation of Individual Contributions (on the left) into the Archetypes form (on the right),

Expert contributions on Latin American archetypes

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
		México																						Colombia																
	Expert ID	1		2					3			4				5				6		7		1		2	3				4	5		6		7		8		9
	Archetype ID per Country:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	Expert name:	Bello	Bello	man	man	man	man	man	doza	doza	doza	nde	nde	nde	nde	erez	erez	erez	erez	ucca	ucca	guez	guez	pana	pana	rzón	ppez	ppez	udo	udo	o Gil	llego	llego	ez A	ez A	doño	doño	rgas	rgas	enao
	Archetype ID:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
	Factors	dadoso	resado	Valiente	Ideal	stinado	novador	luencer	ndedor	genioso	ndeciso	nectado	orrador	lvidado	sciente	Astuto	ochador	orrador	ngenuo	ormado	r Moda	iligente	erezoso	exitoso	sentido	C1	olipsista	stigador	esurado	errotista	J1	ensante	El Ágil	E1	E2	ntajado	stinado	entenial	rginado	nciente
32-factor taxonomy: Financial	Profits	∧	∧	∧	∧	∧	∧	∧		∧	∧	∧	∧		∧			∧		∧	∧					∧		∧	∧	∧		∧	∧			∧		∧		∧
	Credit Score								∨	∨	∨	∨								∨						∨	∨	∨				∨	∨	∨			∨			
	Risk Profile																									∨	∨	∨	∨	∨		∧	∨		∨		∨			
	Added Value																∧			∧	∧					∧		∧				∧				∧				
	Frugality			∧	∧	∧				∧		∧	∧	∧				∧	∧	∧		∧			∧ ∨	∨		∧					∧						∧	
Security	Legal					∧	∨						∧		∧							∧		∨		∧	∨				∨			∨		∨			∧ ∨	∨
	Trust											∧		∨	∧								∧	∧		∧	∧						∧	∧			∧			
	Safety		∧		∧						∧				∧	∨						∧	∧			∨		∧		∧	∧	∧								
	Climate Protection				∧	∧			∧	∧		∧	∧				∧	∧		∧	∧	∧				∧		∧						∧				∧		
Competence	Cost-Efficiency									∧		∧															∧						∧		∧	∧			∧	∨
	Knowledge	∧							∧	∧	∨	∧			∧		∨	∨		∧	∧		∧		∧ ∨	∧	∧	∧			∨		∧				∨	∧		∧
	Own Competence			∧	∧				∧		∨	∧		∧	∧		∧	∨		∧	∧	∧		∧				∧	∨						∧					
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	Environmental Concerns	∧	∧		∧	∧	∧		∧	∧	∧									∧	∧	∧	∧	∧	∧	∧	∧						∨	∧	∧			∧		
Autonomy	Self-Satisfaction							∧												∧	∧			∧		∧		∧	∧			∧								∧
	Commitment	∧			∧	∧			∧							∧				∧	∧	∧			∧	∧			∧	∨	∧	∨	∨	∧	∧					∧
	Adherence	∧	∨		∧	∧	∨			∧			∧					∧		∧	∧				∧	∨	∧	∧						∨					∧	
	Autarky			∧		∧			∧	∧		∧								∧										∧			∧							∧
Physic	Wellbeing	∧	∧	∧	∧	∧	∧	∧		∧	∧	∧			∧		∧			∧		∧				∧		∧		∧		∧	∧							∧
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	Peer-Pressure		∧		∧	∧	∧	∧				∧		∧					∧	∧	∧					∧	∧		∧	∨		∨						∧ ∨		
	Support	∧	∧		∧	∧			∧		∧	∧		∧						∧	∧	∧				∧														∧
	Socialising					∧														∧			∧												∧					∧
	Agreement	∧							∧					∧		∧				∧									∨						∧					∧
Stimulation	Novelty	∧		∧	∧			∧		∧		∧								∧	∧	∧			∨	∨	∧	∧	∧			∧						∧		
	Fun									∧										∧	∧			∧		∧								∨					∧ ∨	
	Brag					∧		∧							∧					∧	∧			∧ ∨		∧		∧	∨			∧						∧		
Popula	Trends	∧						∧							∧						∧							∧					∧			∧		∧ ∨		
	Authority	∧			∧	∧		∧	∧							∧	∧		∧	∧	∧	∧			∨		∨		∧	∧			∨					∨	∧ ∨	
Meanin	Own Significance	∧				∧				∧				∧						∧	∧				∧	∧			∧		∧		∧	∧						
	Poseur							∧																		∨	∨	∧				∧					∨	∧		∨
	Num. of determinants:	13	8	7	14	18	9	12	11	14	9	14	7	8	11	5	7	6	5	24	19	12	6	9	8	24	14	18	11	10	5	12	15	9	9	5	6	10	7	14
	Fostering change:	13	7	7	14	18	7	12	10	13	6	13	7	7	11	4	6	4	4	23	19	12	6	7	4	15	8	16	7	6	3	9	10	5	7	4	2	7	4	10
	Barriers to change:		1				2		1	1	3	1		1		1	1	2	1	1				1	2	9	6	2	4	4	2	3	5	4	2	1	4	1		4
	Ambiguous determinants:																							1	2													2	3	

Figure 8.6: Formatted template - Compilation of individual contributions: México (MX) and Colombia (CO).

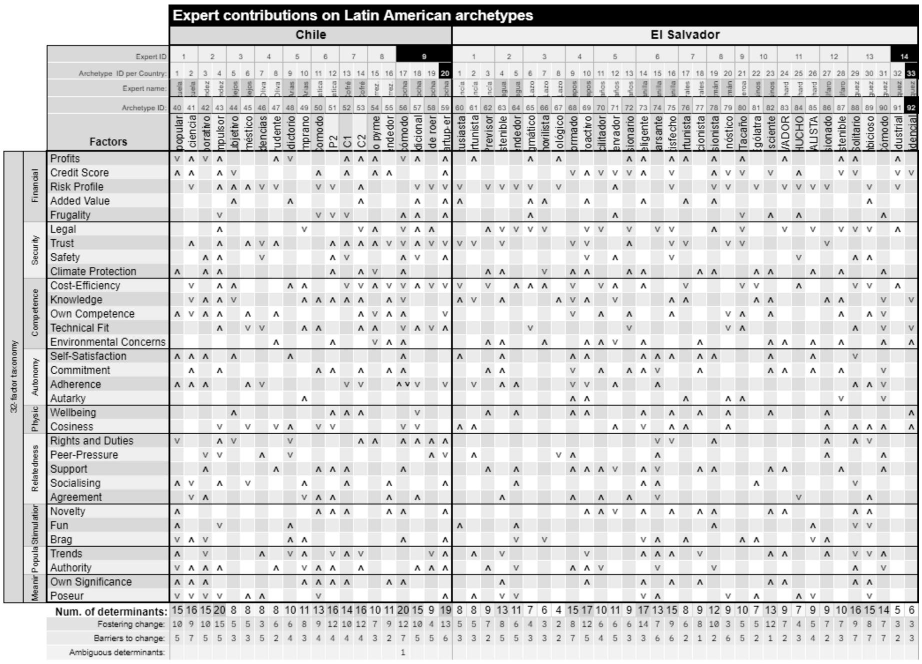


Figure 8.7: Formatted template - Compilation of individual contributions: Chile (CL) and El Salvador (SV).

The ratio of determinants in the Latin American context

Ratio of occurrences of a determinant in the Latin American context, and its ratio as either an enabler or barrier or ambiguous determinant of change.

Needs	Determinant	Occurencies of 59	%	Foster	Barries	Ambiguous
Financial	Profits	36	61.0%	89%	11%	
Financial	Credit Score	21	35.6%	38%	62%	
Financial	Risk Profile	21	35.6%	24%	76%	
Financial	Added Value	12	20.3%	100%		
Financial	Frugality	23	39.0%	74%	22%	4%
Security	Legal	20	33.9%	45%	50%	5%
Security	Trust	24	40.7%	75%	25%	
Security	Safety	20	33.9%	75%	25%	
Security	Climate Protection	22	37.3%	95%	5%	
Competence	Cost-Efficiency	21	35.6%	62%	38%	
Competence	Knowledge	31	52.5%	71%	26%	3%
Competence	Own Competence	27	45.8%	78%	22%	
Competence	Technical Fit	29	49.2%	79%	21%	
Competence	Environmental Concerns	25	42.4%	92%	8%	
Autonomy	Self-Satisfaction	15	25.4%	100%		
Autonomy	Commitment	25	42.4%	88%	12%	
Autonomy	Adherence	26	44.1%	62%	35%	4%
Autonomy	Autarky	10	16.9%	100%		
Physicalness	Wellbeing	25	42.4%	96%	4%	
Physicalness	Cosiness	25	42.4%	56%	44%	
Relatedness	Rights and Duties	24	40.7%	83%	17%	
Relatedness	Peer-Pressure	22	37.3%	68%	27%	5%
Relatedness	Support	19	32.2%	100%		
Relatedness	Socialising	13	22.0%	85%	15%	
Relatedness	Agreement	15	25.4%	80%	20%	
Stimulation	Novelty	23	39.0%	91%	9%	
Stimulation	Fun	10	16.9%	70%	20%	10%
Stimulation	Brag	18	30.5%	78%	17%	6%
Popularity	Trends	18	30.5%	67%	28%	6%
Popularity	Authority	30	50.8%	77%	20%	3%
Meaning	Own Significance	21	35.6%	100%		
Meaning	Poseur	16	27.1%	44%	56%	

Figure 8.8: The ratio of determinants in the Latin American context.

For each country, the archetypes submitted by the experts were collated and compared with the European archetypes, specifically in terms of their determinants. The Figs 8.9, 8.10, 8.11, and 8.12, provides insights into how specific Latin American behaviours and characteristics align with European archetypes, indicating the extent of similarity or deviation with a quantitative likeness factor. This comparison led to the formulation of the final archetypes. These final archetypes were then grouped into clusters based on their degree of similarity to the provided European archetypes, with each cluster corresponding to one European archetype. The final archetypes, as derived from this clustering process are displayed in Fig. 8.13.

Latin American vs European archetypes & Likeness ratio

(a) Clustering

México-INAOE, Colombia-UniCafam, Chile-UCSC

ID	Country	Final Latin American Archetypes	Num of Determinants	Num	European Archetypes	Likeness factor %
1	MX	Ecologista.informado	24	1	Stubborn	**100.0%**
2	MX	Ambientalista.por.Moda	19	2	Stubborn	88.9%
5	MX	Emprendedor	12	3	Stubborn	66.7%
6	MX	Ideal	15	4	Stubborn	66.7%
7	MX	Obstinado	19	5	Stubborn	66.7%
8	MX	Ingenioso	14	6	Stubborn	55.6%
9	MX	El.Cuidadoso	13	7	Stubborn	55.6%
10	MX	Diligente	12	8	Stubborn	44.4%
11	MX	Derrochador	7	9	Stubborn	33.3%
12	MX	Ahorrador	6	10	Stubborn	33.3%
3	CL	Consciente.pero.cómodo	20	11	Stubborn	80.0%
4	CO	El.investigador	18	12	Stubborn	73.3%
90	SV	El Eco-consciente	13	1	Stubborn	60.0%
91	SV	El Ambientalista	9	2	Stubborn	40.0%
92	SV	El visionario electromovilista	6	3	Stubborn	26.7%
13	CO	C1	24	1	Fearful	**86.7%**
17	CO	El.pensante	12	2	Fearful	46.7%
20	CO	E1	9	3	Fearful	40.0%
22	CO	El.Obstinado	6	4	Fearful	33.3%
14	CL	El.empujador.de.ciencia..science.pusher.	16	5	Fearful	73.3%
15	CL	Impulsor	20	6	Fearful	66.7%
18	CL	Interesado.condicional	15	7	Fearful	46.7%
21	CL	El.racional.subjetivo	8	8	Fearful	40.0%
23	CL	El.gatito.doméstico	8	9	Fearful	33.3%
16	MX	El.inconsciente	12	10	Fearful	57.1%
19	MX	Indeciso	9	11	Fearful	42.9%
24	MX	Valiente	7	12	Fearful	28.6%
74	SV	El Ególatra	7	1	Fearful	40.0%
75	SV	Inversionista Socialmente Presionado	9	2	Fearful	33.3%
76	SV	El Chuco	7	3	Fearful	26.7%

Figure 8.9: Latin American vs European archetypes & Likeness ratio, Archetypes: Stubborn and Fearful. The table shows a high likeness ratio for 'Stubborn' archetypes, particularly 'Ecologista informado' from Mexico, which has a likeness ratio of 100%. The archetype 'Ambientalista for Moda' also from Mexico shows a high likeness ratio of 88.9% to the 'Stubborn' European archetype. The 'Fearful' archetype has varying degrees of likeness ratios with different Latin American archetypes, reflecting the comparative analysis between these different cultural and behavioural models. The likeness factor provides an insightful quantitative measure of how Latin American archetypes align with established European archetypes.

Latin American vs European archetypes & Likeness ratio

(a) Clustering

México-INAOE, Colombia-UniCafam, Chile-UCSC

ID	Country	Final Latin American Archetypes	Num of Determinants	Num	European Archetypes	Likeness factor %
25	CL	Eco.startup.er	19	1	Homo.Economicus	**73.3%**
26	CL	C1	14	2	Homo.Economicus	66.7%
28	CL	Seguidor.de.tendencias	8	3	Homo.Economicus	40.0%
77	SV	El Solitario	16	1	Homo.Economicus	73.3%
78	SV	El insatisfecho	15	2	Homo.Economicus	60.0%
79	SV	El Entusiasta	8	3	Homo.Economicus	40.0%
80	SV	El Oportunista	8	4	Homo.Economicus	33.3%
81	SV	Oportunista	8	5	Homo.Economicus	33.3%
82	SV	Pragmático	7	6	Homo.Economicus	26.7%
83	SV	Arquetipo de usuario industrial	5	7	Homo.Economicus	26.7%
84	SV	El innovador tecnológico	4	8	Homo.Economicus	20.0%
27	MX	El.recién.conectado	14	4	Homo.Economicus	63.6%
29	MX	Perezoso	6	5	Homo.Economicus	27.3%
30	MX	Influencer	12	1	Early.Adopter	**66.7%**
31	CL	Colaborativo	15	2	Early.Adopter	60.0%
32	CL	El.popular	15	3	Early.Adopter	60.0%
33	CL	P2	16	4	Early.Adopter	53.3%
38	CL	Emprendedor	11	5	Early.Adopter	46.7%
39	CL	El.contradictorio	10	6	Early.Adopter	40.0%
71	SV	El Inteligente	17	1	Early.Adopter	60.0%
72	SV	Accionista	9	2	Early.Adopter	40.0%
73	SV	EL INNOVADOR	9	3	Early.Adopter	33.3%
34	CO	Profesional.en.busca.de.sentido	8	7	Early.Adopter	46.7%
35	CO	El.solipsista	14	8	Early.Adopter	46.7%
36	CO	Apresurado	11	9	Early.Adopter	46.7%
37	CO	Centenial	10	10	Early.Adopter	46.7%
40	CO	El.Marginado	7	11	Early.Adopter	26.7%

Figure 8.10: Latin American vs European archetypes & Likeness ratio, Archetypes: Homo Economicus and Early Adopter. The "Homo Economicus" archetype, is strongly represented across Chile and El Salvador (73%), suggesting that economic factors play a critical role in shaping behaviours in these regions, much like in Europe. Meanwhile, the "Influencer" archetype in Mexico (66.7%) and the "Colaborativo" in Chile (60%) align well with the "Early Adopter" archetype in EU, highlighting the importance of social influence and early adoption of innovations in this context.

Latin American vs European archetypes & Likeness ratio

(a) Clustering

México-INAOE, Colombia-UniCafam, Chile-UCSC

ID	Country	Final Latin American Archetypes	Num of Determinants	Num	European Archetypes	Likeness factor %
61	SV	Desinformado	15	1	Careful	**73.0%**
62	SV	Proactivo	17	2	Careful	67.0%
63	SV	El Cómodo	14	3	Careful	53.0%
64	SV	El conservador	11	4	Careful	47.0%
65	SV	El agnóstico	9	5	Careful	47.0%
66	SV	El Sostenible	10	6	Careful	47.0%
67	SV	El Previsor	9	7	Careful	40.0%
68	SV	El Visionario	9	8	Careful	40.0%
69	SV	Curioso Tacaño	10	9	Careful	40.0%
70	SV	Arquetipo de usuario residencial	6	10	Careful	33.0%
41	CL	C2	16	11	Careful	**66.7%**
43	CL	El.empresario.pyme	10	12	Careful	46.7%
46	CL	El.prudente	8	13	Careful	26.7%
42	CO	El.Ágil	15	14	Careful	60.0%
44	CO	Derrotista	10	15	Careful	33.3%
45	CO	E2	9	16	Careful	33.3%
47	MX	Innovador	9	1	Uninterested	**62.5%**
50	MX	Desinteresado	8	2	Uninterested	37.5%
51	MX	El.ahorrador	7	3	Uninterested	37.5%
48	CO	El.conciente	14	4	Uninterested	53.3%
49	CL	Duro.de.roer	9	5	Uninterested	40.0%
60	SV	El Guardían Sostenible	13	3	Activist	**60.0%**
58	CO	Profesional.en.áreas.técnicas.exitoso	9	1	Activist	40.0%
59	CO	J1	5	2	Activist	33.3%

Figure 8.11: Latin American vs European archetypes & Likeness ratio, Archetypes: Careful, Uninterested, and Activist. The European archetypes 'Early Adopter' and 'Careful' are most frequently matched with Latin American archetypes, with likeness ratios varying from as high as 73% to as low as 26.7%. The likeness ratio highlights the degree of similarity between the Latin American archetype and its European counterpart, offering a quantitative measure of cultural and behavioural alignment. The table reflects a diverse array of Latin American archetypes from Mexico (MX), Chile (CL), and El Salvador (SV), each exhibiting varying degrees of correlation to the European archetypes. The "Activist" archetype is represented in Latin America by the "El Guardián Sostenible" (60%) from Chile and the "Profesional en áreas técnicas exitoso" (40%).

Latin American vs European archetypes & Likeness ratio

(a) Clustering

México-INAOE, Colombia-UniCafam, Chile-UCSC

ID	Country	Final Latin American Archetypes	Num of Determinants	Num	European Archetypes	Likeness factor %
52	CL	Adoptante.temprano	11	1	Influencer	**60.0%**
53	CL	El.Comodo	13	2	Influencer	46.7%
85	SV	El Farsante	13	1	Influencer	60.0%
86	SV	Proveedor Emprendedor	11	2	Influencer	53.3%
87	SV	El Ambicioso	15	3	Influencer	53.3%
88	SV	El facilitador	10	4	Influencer	40.0%
89	SV	El inversionista	12	5	Influencer	40.0%
54	MX	El.olvidado	8	3	Influencer	40.0%
55	MX	Astuto	6	4	Influencer	30.0%
56	MX	Ingenuo	5	5	Influencer	30.0%
57	CO	El.visionario...Aventajado	5	6	Influencer	26.7%

Figure 8.12: Latin American vs European archetypes & Likeness ratio, Archetypes: Influencer. The "El Farsante" (60%) and "Adoptante.temprano" (60%) archetypes, both from different regions, show strong similarities to the "Influencer" archetype.

Cluster	European archetypes	MX	CO	CL	SV	Total Clusters	Highest likeness ratio
1	Stubborn	**10**	**1**	**1**	3	15	100.0%
2	Fearful	3	**4**	**5**	3	15	86.7%
3	Homo.Economicus	**2**	**0**	3	**8**	13	73.3%
4	Early.Adopter	**1**	**5**	**5**	3	14	66.7%
5	Careful	**0**	3	3	**10**	16	73.0%
6	Uninterested	**3**	**1**	1	0	5	62.5%
7	Influencer	3	**1**	**2**	**5**	11	60.0%
8	Activist	**0**	**2**	**0**	**1**	3	60.0%
	Total & Average(%) :	**22**	**17**	**20**	**33**	**92**	**72.8%**

Figure 8.13: Latin American archetype clusters vs European archetypes: Influencer. The archetypes 'The Faker' and 'Early Adopter', both from different regions, show strong similarities with the 'Influencer' archetype, suggesting a shared emphasis on persuasion, leadership and trend-setting.

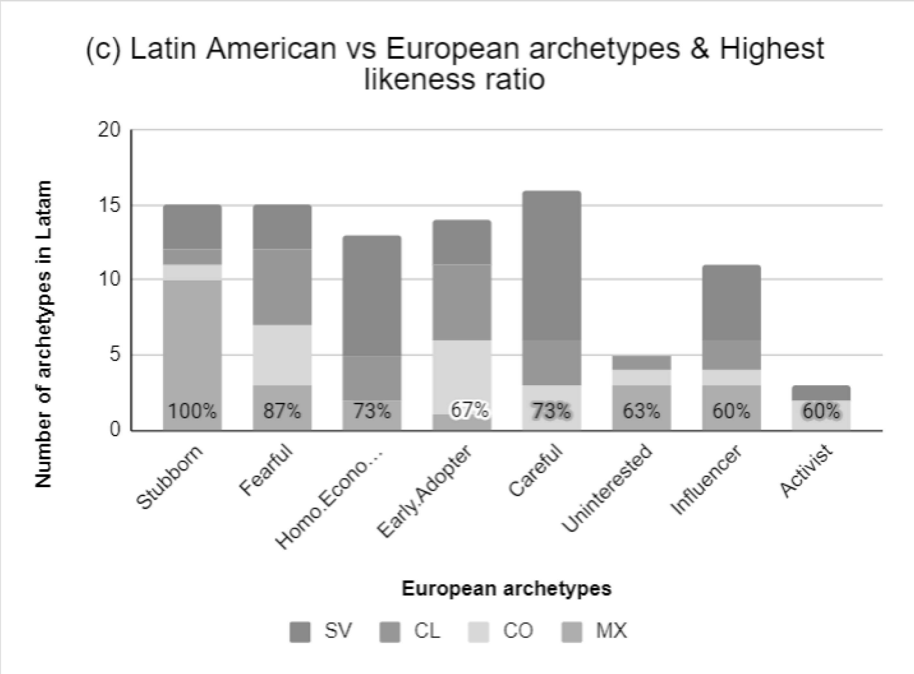


Figure 8.14: Latin American vs European archetypes & Highest likeness ratio: 'Stubborn' shows a 100% likeness ratio, the highest among all categories. 'Fearful' follows with an 87% likeness ratio, 'Homo Economicus' at 73%, 'Early Adopter' at 67%, and 'Careful' also at 73%. 'Uninterested' has a 63% likeness ratio, while 'Influencer' and 'Activist' both have the lowest likeness ratio at 60%. Each archetype's bar is segmented by country, illustrating the distribution and contribution of each Latin American country to the European archetype likeness.

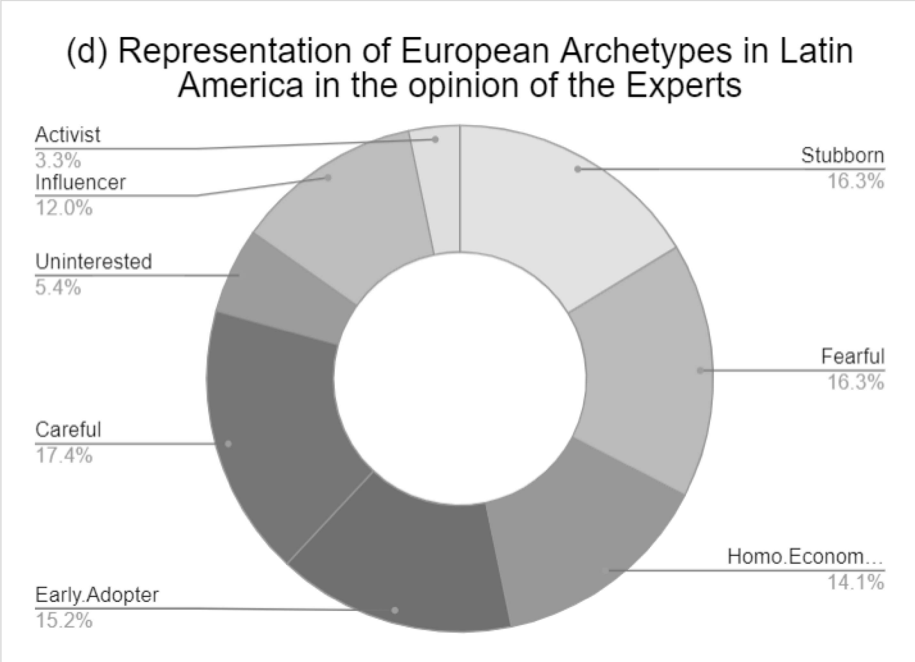


Figure 8.15: Representation of European Archetypes in Latin America in the opinion of the Experts. The donut-chart illustrates the proportions of European Archetypes as perceived in the Latin American context according to expert opinion. 'Careful' is the most represented archetype at 17.4%, followed closely by 'Stubborn' and 'Fearful', each at 16.3%. 'Early Adopter' constitutes 15.2% of the chart, and 'Homo Economicus' follows at 14.1%. 'Influencer' takes up a 12% share. Lesser represented archetypes include 'Uninterested' at 5.4% and 'Activist' at the lowest proportion of 3.3%. Each archetype is assigned a distinct colour, creating a visual hierarchy of their representation.

(e) **Activity-2 for experts: Sorting of the determinants into the TTM stages**. Reach a consensus on the factors that encompass each final archetype, as well as the stage of change (TTM) in which they should appear (sorting determining factors).

For this activity, experts were invited to participate in an in-person session. During this meeting, they were presented with all the archetypes they had contributed, along with the finalized archetypes that were generated. The objectives of this session included the following:

- Review and Refine the Final Archetypes: The experts were tasked with reviewing the final archetypes. By reaching a consensus, they were to add or remove determinants that most accurately described each evaluated archetype within their context. All agreements or disagreements encountered during this consensus process were documented (as shown in the figure 8.16 below).

Figure 8.16: Experts working during the in-person session

- Organize Determinants within the Stages of the TTM: The experts were provided with determinant cards and a paper template of the Transtheoretical Model (TTM). Working collaboratively, they were to order the determinants for each archetype according to the stages of the TTM model. This exercise aimed to illustrate the causal relationships within each archetype, as understood through the lens of the TTM (as shown in the figure 8.17 below).

Figure 8.17: Experts working on sorting determining factors into TTM Stages during the in-person session

The final archetypes and their determinants sorted by the TTM stage are shown in Fig 8.18 (México), Fig 8.19, Fig 8.20, and Fig 8.21

Concept	Early Adopter						Uninterested						Homo œconomicus					
	PR	CO	PR	AC	MA	RE	PR	CO	PR	AC	MA	RE	PR	CO	PR	AC	MA	RE
Profits							X						X					
Credit Score			X	X					X				X					
Risk Profile															X			
Added Value															X			
Frugality								X						X		X		
Legal														X				
Trust	X	X											X					
Safety			X													X		
Climate Protection			X											X				
Cost-Efficiency															X			
Knowledge			X				X						X					
Own Competence	X															X		
Technical Fit	X															X	X	
Environmental Concerns							X						X					
Self-Satisfaction	X					X				X								
Commitment				X						X								
Adherence				X						X								
Autarky							X											
Wellbeing						X						X						X
Cozyness						X	X											
Rights and Duties									X									
Peer-Pressure		X								X								
Support			X															
Socialising						X					X							
Agreement						X				X								
Novelty						X												
Fun					X													
Brag					X			X				X	X					
Trends	X									X								
Authority															X			
Own Significance	X																	
Poseur						X												
	6	2	5	3	2	7	5	2	2	6	1	2	6	3	4	4	1	1
						25						18						19

Concept	Fearful						Stubborn						Influencer						Careful						Activist					
	PRE	CON	REI	ACT	MAI	LAP	PR	CO	PR	AC	MA	RE	PRE	CON	REI	ACT	MAI	LAP	PR	CO	PR	AC	MA	RE	PRE	CON	REI	ACT	MAI	LAP
Profits																														
Credit Score							X														X									
Risk Profile																														
Added Value																														
Frugality										X										X			X							
Legal									X													X	X							
Trust																					X									
Safety								X		X											X			X						
Climate Protection										X		X							X											
Cost-Efficiency									X		X																			
Knowledge							X													X										
Own Competence										X												X								
Technical Fit									X														X							
Environmental Concerns																				X										
Self-Satisfaction												X										X		X						
Commitment																					X									
Adherence											X												X							
Autarky												X										X	X							
Wellbeing												X							X					X						
Cozyness																				X				X						
Rights and Duties								X													X									
Peer-Pressure																														
Support									X										X											
Socialising								X																						
Agreement										X												X		X						
Novelty																				X										
Fun							X																							
Brag																														
Trends																														
Authority									X												X	X								
Own Significance																														
Poseur																														
							3	3	5	5	2	4							3	5	6	6	5	5						
												22												30						

Figure 8.18: INAOE-Mexico. Determinants of final archetypes classified in the TTM stages

Concept	Early Adopter						Uninterested						Homo œconomicus						Fearful					
	PR	CO	PR	AC	MA	RE	PR	CO	PR	AC	MA	RE	PR	CO	PR	AC	MA	RE	PR	CO	PR	AC	MA	RE
Profits				X				X						X									X	
Credit Score		X							X				X							X				
Risk Profile		X							X							X				X				
Added Value													X										X	
Frugality		X								X				X							X			
Legal									X						X					X				
Trust					X			X						X					X					
Safety					X											X							X	
Climate Protection	X			X												X								
Cost-Efficiency				X				X					X							X				
Knowledge		X									X										X			
Own Competence	X														X						X			
Technical Fit		X								X				X							X			
vironmental Concer	X												X							X		X		
Self-Satisfaction	X						X			X			X										X	
Commitment	X									X						X						X		
Adherence					X					X				X								X		
Autarky			X												X							X		
Wellbeing			X				X												X					
Cozyness				X			X							X						X				
Rights and Duties		X	X						X							X				X				
Peer-Pressure			X	X						X						X					X			
Support		X								X					X				X					
Socialising		X									X			X								X		
Agreement				X				X													X			
Novelty	X												X						X					
Fun					X																		X	
Brag	X						X										X					X		
Trends	X										X								X					
Authority			X							X						X						X		
Own Significance							X						X		X				X					
Poseur	X						X						X						X					
	9	8	5	6	4	0	6	4	4	8	3	0	8	7	5	7	1	0	7	7	6	7	5	0
						32						25						28						32

Concept	Stubborn						Influencer						Careful						Activist					
	PR	CO	PR	AC	MA	RE	PR	CO	PR	AC	MA	PR	PR	CO	PR	AC	MA	RE	PR	CO	PR	AC	MA	RE
Profits					X			X															X	
Credit Score			X											X						X				
Risk Profile	X													X										
Added Value		X								X														
Frugality	X													X										
Legal		X											X								X			
Trust		X					X												X					
Safety					X																X			
Climate Protection				X									X						X					
Cost-Efficiency					X																		X	
Knowledge		X								X					X							X		
Own Competence	X																							
Technical Fit			X												X							X		
vironmental Concer	X												X						X					
Self-Satisfaction	X						X									X								
Commitment			X														X							
Adherence			X																					
Autarky											X													
Wellbeing				X										X										
Cozyness								X														X		
Rights and Duties		X														X								
Peer-Pressure			X					X							X									
Support			X					X																
Socialising								X						X										
Agreement		X							X															
Novelty							X						X							X				
Fun			X				X									X								
Brag							X																	
Trends							X										X			X				
Authority	X										X										X			
Own Significance	X						X						X											
Poseur				X						X														
	7	6	7	3	3	0	7	5	1	3	2	0	5	5	3	3	2	0	3	3	3	3	2	0
						26						18					18						14	

Figure 8.19: Cafam-Colombia. Determinants of final archetypes classified in the TTM stages

Concept	Early Adopter						Uninterested						Homo œconomicus						Fearful						Stubborn						Influencer						Careful						Activist					
	PRE	CON	REA	ACT	MAI	LAP	PRE	CON	REA	ACT	MAI	LAP	PRE	CON	REA	ACT	MAI	LAP	PRE	CON	REA	ACT	MAI	LAP	PRE	CON	REA	ACT	MAI	LAP	PRE	CON	REA	ACT	MAI	LAP	PRE	CON	REA	ACT	MAI	LAP	PRE	CON	REA	ACT	MAI	LAP
Profits														X						X												X							X									
Credit Score															X					X								X																				
Risk Profile								X							X					X																												
Added Value														X						X													X					X										
Frugality																									X																							
Legal			X					X													X							X				X						X										
Trust			X				X								X							X							X																			
Safety																							X			X												X										
Climate Protection			X																									X												X								
Cost-Efficiency														X						X												X																
Knowledge	X															X			X									X						X			X											
Own Competence				X																		X					X										X											
Technical Fit			X					X												X													X							X								
Environmental Concerns		X																							X												X											
Self-Satisfaction																										X					X										X							
Commitment			X																										X					X														
Adherence																	X												X																			
Autarky																													X																			
Wellbeing	X										X		X							X							X											X										
Cozyness										X									X																		X											
Rights and Duties										X											X																				X							
Peer-Pressure				X					X																							X																
Support																										X								X				X										
Socialising					X																		X				X								X													
Agreement											X										X													X					X									
Novelty		X																	X													X																
Fun	X																																															
Brag					X																				X																							
Trends		X								X				X																	X																	
Authority	X												X						X																X					X								
Own Significance					X																				X										X													
Poseur					X									X																																		
	4	3	5	2	4	0	1	3	1	3	2	0	2	5	3	1	1	0	4	7	3	2	2	0	4	3	3	4	4	0	2	5	2	4	3	0	4	5	2	3	2	0						
						18						10						12						18						18						16						16						

Figure 8.20: UCSC-Chile. Determinants of final archetypes classified in the TTM stages

Concept	Early Adopter						Uninterested						Homo œconomicus						Fearful						Stubborn						Influencer						Careful						Activist					
	PRE	CON	REL	ACT	MAI	LAP	PRE	CON	REL	ACT	MAI	LAP	PRE	CON	REL	ACT	MAI	LAP	PRE	CON	REL	ACT	MAI	LAP	PRE	CON	REL	ACT	MAI	LAP	PRE	CON	REL	ACT	MAI	LAP	PRE	CON	REL	ACT	MAI	LAP	PRE	CON	REL	ACT	MAI	LAP
Profits																X											X		X										X							
Credit Score																																X										
Risk Profile													X						X											X							X					X				
Added Value				X												X																X																
Frugality															X																															
Legal													X						X						X						X						X						X				
Trust		X											X						X													X					X							X				
Safety															X						X																		X					X			
Climate Protection		X																	X	X					X	X											X	X				X					
Cost-Efficiency		X											X						X														X				X											
Knowledge			X											X						X						X						X						X						X				
Own Competence			X												X												X																					
Technical Fit		X													X						X																		X									
Environmental Concerns	X																			X						X														X			X					
Self-Satisfaction				X													X												X					X							X					X		
Commitment	X																											X	X											X			X					
Adherence					X																														X						X		X					
Autarky																																									X			X				
Wellbeing				X													X						X						X					X	X						X					X		
Cozyness				X													X						X												X						X							
Rights and Duties																				X																								X				
Peer-Pressure	X																			X												X																
Support																										X	X							X					X				X					
Socialising	X																																X										X					
Agreement																																							X						X			
Novelty	X													X											X						X																	
Fun				X																																												
Brag					X												X						X												X							X							
Trends	X												X						X												X													X				
Authority			X											X																		X								X								
Own Significance			X												X												X												X				X					
Poseur	X												X																					X													
	7	4	4	5	2	0							4	5	3	2	6	0	3	7	2	1	3	0	1	5	4	1	4	0	3	6	3	5	3	0	2	4	6	4	7	0	7	7	2	2	0	0
						22												20						16						15						20						23						18

Figure 8.21: UCA-El Salvador. Determinants of final archetypes classified in the TTM stages

CHAPTER

9

Phase 6: Cross-Sectorial Survey

The main objective of this survey is to characterize the European population in relation to taxonomy in order to identify clusters of similar behaviour and validate the archetypes. By tracking down these clusters, it is possible to construct a number of investment archetypes. These newly identified archetypes can then be compared with the initial archetypes we identified, allowing for a thorough validation and refinement of the archetype models. This approach ensures that the archetypes accurately reflect the actual dynamics and behaviours of the target population.

9.1 Literature review

cross-sectorial surveys are a valuable tool for validating the existence of specific archetypes within a target population due to their broad representation, cost-effectiveness, speed, ability to identify current trends, multidimensional analysis capabilities, and their role in informing further research and practical applications. They also contribute to the conceptual, external, and empirical validity of archetype analysis and can involve stakeholders to enhance credibility (Goodwin et al., 2022; Mahmutovic, 2021; Schechter, 2023; Wang and Cheng, 2020; Wahba and Bridwell, 1973).

Cross-sectorial surveys offer several advantages when it comes to validating the existence of specific archetypes within a target population:

- Snapshot of a population: Cross-sectional surveys provide a snapshot of a population at a given point in time. This feature is invaluable for researchers seeking to determine the prevalence of certain archetypes in a population. It facilitates the understanding of the characteristics of these archetypes without the need for long-term follow-up, thus providing immediate and relevant information (Wang and Cheng, 2020; Wahba and Bridwell, 1973).
- Quick and cost-effective": One of the main advantages of cross-sectional studies is their relative speed and cost-effectiveness compared to other types of research methodologies. This attribute makes them particularly attractive to researchers who are working under budget or time constraints, but need an efficient means of validating archetypes (Team, 2022).
- Multiple Characteristics: Researchers can look at various characteristics at once or socio-economic features, such as age, gender, race, etc., which can be useful in identifying and validating archetypes that may be defined by a combination of such traits (Goodwin et al., 2022).
- No Loss of Follow-Up: Since cross-sectional studies are conducted at a single point in time, there is no loss of follow-up, which is a common issue in longitudinal studies (Carlson and Morrison, 2009).
- Broad Representation: Cross-sectorial surveys can encompass a wide range of industries and sectors, providing a diverse and comprehensive sample that can help ensure that the archetypes identified are not limited to a specific sector and are representative of the target population as a whole (Mahmutovic, 2021).
- Data-Driven Approach: When validating archetype, it offers comprehensive data analysis capabilities, cross-sectorial insights, and the ability to apply

validated archetypes in practical optimization strategies and business models (Sarnovsky et al., 2019).

9.2 Activity

P6.1 **Develop the Survey Instrument**. Create the survey based on future scenarios, the taxonomy, and a set of socio-economic variables. This survey will be based on fictitious scenarios and the established taxonomy. Cross-sectional surveys are specifically designed to collect data on a particular population at a single point in time. They act as snapshots, providing information on the characteristics and behaviours of the population at that specific point in time.

The survey is relatively straightforward; it aims to collect socio-economic information and, for some of the future scenarios/technologies used so far, asks each participant to score each of the 32 determinants presented in Chapter 7. This scoring is done when considering "investing" in a particular scenario and assessing the determinants (factors) that lead consumers to participate in the energy transition across four different aspects or scenarios:

1. Flexibility markets (e.g. PV panels),
2. Energy efficiency (e.g. building insulation),
3. Mobility (e.g. electric vehicles),
4. Energy conservation (e.g. sharing economy).

Our objective was to find a set of objective archetypes (the initial list of seven was completely inductively defined) that characterise as much as possible the European population (and then, also the Latin-American one) in order to create better policies for them. To this end, the core contribution of the participants of the survey to this research consisted of self-assessing how much respondents agree or disagree with a set of 32 statements (i.e., the 32 determinants). People were recruited using the Prolific platform and word of mouth.

The survey is made up of the following four sections:

- **Background**. This section includes the background of the survey, explains what we expect from the respondent, and sets out the rights of stakeholders and the consent form.
- **Scenarios**. In this section, the questions are oriented to know how the interviewee would act toward speculative scenarios related to the energy transition.
- **Determinants**. An ideal yet futuristic scenario presented in the previous section would only be possible if citizens, enterprises, and public authorities collaborate. In this section, the responder is provided with a list of statements describing factors that may influence their decision-making when it comes to contributing to making the selected scenario possible (e.g., change your daily behaviour, take investment decisions with money or time, or decide who to vote for to make the scenarios a reality). The responder will rate each of them, based only on the situation they selected as the highest priority in the previous question, on a scale from "Not at all important for you" to "Drastically important to you".
- **Further information**. This section elicits some details of the respondent's socioeconomic background.

This is a long survey (almost 100 questions) that needs to be carried out in multiple countries with a relatively unbiased sample (fig 9.1). Some rough calculations indicate that at least 1000 answers must be retrieved. A draft of the survey could be consulted in appendix H. The survey is scheduled to be carried out after summer using the PROLIFIC platform (Press-Prolific).

P6.2 ***Data analysis***. Data collection, cleaning, and preparation are essential for clustering taxonomy-related responses into archetypes. The analysis focuses on the self-assessment of respondents regarding their level of agreement with a set of statements derived from the factors outlined in the taxonomy. The final dataset will be published for open access.

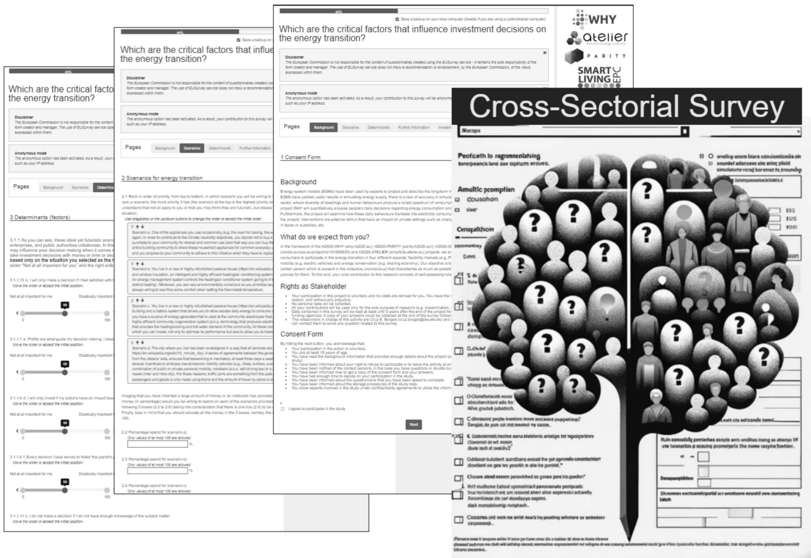


Figure 9.1: Cross-Sectorial survey for a target population. Screenshots of the cross-sectoral survey (left) together with a conceptual illustration of the diverse target population (right). The aim is to gather essential information on the factors influencing investment decisions in the energy transition (Figure created by the author integrating some AI-generated elements).

To assess the information, will be used clustering techniques such as K-means (H2O.ai, 2023) and SOM (Kohonen, 1982; Moriwaki, 2022) that will provide groups of individuals that share similar values of the determinants. If the determinants with the largest values in these groups are similar to the ones provided, we can validate the archetypes.

9.3 Outcomes

(i) *The survey*: **Which are the critical factors that influence investment decisions on the energy transition?** (WHY-Project, 2022) was posted online and is also transcribed in Appendix H.

The survey also includes as its first page the consent form, which provides the following to the participant: Background, What do we expect from you?, Rights as Stakeholder, and Consent form.

(ii) **Data analysis**: In addition to European responses (N=1000), Latin American people participated in this survey with more than 700 responses. These new inputs will be used to evaluate the determinants that lead Latin American end consumers to participate in the energy transition and make comparisons with their European peers.

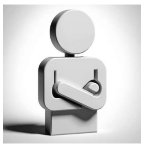
With the responses from Europe (N=1000), we utilized various data analysis and clustering methods to objectively aggregate the respondents' views based on the importance they attributed to the determinants. The different models tested, such as k-means dendrograms and SVMs, indicated that eight archetypes provided a better fit than the initial seven. Additionally, we applied statistical methods to better understand the composition of the resulting clusters. After several iterations of the models, it was determined that using 15 determinants per cluster was the optimal approach to retain most of the variance within each cluster. The results closely mirror those from the inductive process. Subsequently, the new archetype that emerged, referred to as 'the activist', is presented along with the determinants that most accurately describe this group. The 15 determinants associated with each archetype, including the newly identified one, are detailed in the previous section (8.3).

The survey dataset has been fully described and published as an open repository named *Characterization of investments profiles on the energy transition for European citizens* (Borges et al., 2022c).

9.4 Finding Hidden Archetypes

Finally, a session with a panel of experts with an ethics background have been conducted. The objective of this session was to find other potential archetypes missing in the data due to different biases. In particular, two archetypes were discussed:

The energy poor: this person has difficulties to properly heat his/her house. Usually has to make compromises with respect to their energy consumption (if I heat my meal I will not be able to heat the water to clean myself) and, as a consequence, have very limited energy consumption. They usually live in cheap rented houses with poor insulation and inefficient (but with low investment costs) energy services, which increases the problem. Access to energy is usually not their main problem but just another one that in some cases (heat or cold waves), could increase the importance of rented houses with poor insulation and inefficient (but with low investment costs) energy services which increase the problem. Access to energy is usually not their main problem but just another one that, in some cases (heat or cold waves), could increase importance.



The climate denier: persons in this archetype do not believe in climate change at all or that they are caused by the actions of humans. They usually waste energy and other resources and have zero consideration for the use of renewable energy or the impact on the climate that their actions have.

9.4.1 **Conclusions on the findings**

During the first part of the session, the objective was to construct a similar list of determinants as the previous ones, but quickly it was found that neither of the archetypes should be present in our discussion.

On the one hand, the climate denier is not an archetype but more a mixed determinant related to trust, commitment, authenticity, and environmental concern. It has not appeared as it is kind of a combination of these and in the population, it will appear in some cases as positive, in others as negative, and in others as neutral with respect to these variables.

On the other hand, even as the experts consider the energy poor as a relevant archetype, for this particular exercise, the energy poor does not play any role. Please note that an energy poor, by definition, is someone in a delicate financial position who cannot make any investment decisions. This includes behavioural changes, as they usually are quite energy austere. Moreover, the main characteristic of their situation is that it is not voluntary but structural. The consensus was that an energy poor could become any of the other archetypes if the persons in this archetype do not believe in climate change at all or if they are caused by the actions of humans. They usually waste energy and other resources and have zero consideration for the use of renewable energy or the impact on the climate that their actions have.

CHAPTER

10

Phase 7: Causal modelling

This chapter will introduce the causal models of the final investment profiles. The approach will give details about the behavioural model and the causal modelling tool used to represent the assumptions we have drawn from the expert panels to explain, through the 32-factor taxonomy—how each kind of person (archetype) behaves when the time to make a decision comes.

10.1 Causal Diagrams features

Judea Pearl's research on causal diagrams has significantly contributed to our understanding of causality and its application in various fields, including the study of human behaviour in decision-making processes. Based on Pearl's work, this study explains the robustness, advantages, and applications of causal diagrams in this context.

10.1.1 Advantages of Causal Diagrams

Causal diagrams offer several advantages in analyzing decision-making processes:

1. **Identification of confounders**: They help identify confounding variables that might obscure true causal relationships in decision-making scenarios.
2. **Clarification of direct and indirect effects**: Causal diagrams can distinguish between direct causal effects and indirect effects mediated through other variables.
3. **Counterfactual reasoning**: They support counterfactual analysis, allowing researchers to explore "what if" scenarios in decision-making processes.
4. **Integration of domain knowledge**: Causal diagrams can incorporate prior knowledge and expert insights about causal relationships in human behavior.
5. **Bias reduction**: By explicitly modeling causal structures, these diagrams help reduce bias in the analysis of observational data on decision-making.

10.1.2 Robustness of Causal Diagrams

Causal diagrams, also known as directed acyclic graphs (DAGs), offer a robust framework for representing and analysing causal relationships:

1. **Visual representation**: Causal diagrams provide a clear, intuitive visual representation of complex causal relationships, making them easier to understand and communicate.
2. **Formal mathematical foundation**: Underpinned by graph theory and probability theory, causal diagrams have a solid mathematical basis, ensuring their reliability in various applications.
3. **Flexibility**: They can represent a wide range of causal structures, from simple linear relationships to complex, multi-faceted causal networks.
4. **Testability**: Causal diagrams allow for the formulation of testable hypotheses about causal relationships, enhancing their scientific rigour.

10.1.3 Applications in Explaining Human Behavior in Decision-Making

Causal diagrams offer several advantages in analysing decision-making processes:

1. **Clarification of direct and indirect effects**: Causal diagrams can distinguish between direct causal effects and indirect effects mediated through other variables.
2. **Integration of domain knowledge**: Causal diagrams can incorporate prior knowledge and expert insights about causal relationships in human behaviour. Identification of confounders: They help identify confounding variables that might obscure true causal relationships in decision-making scenarios.
3. **Bias reduction**: By explicitly modelling causal structures, these diagrams help reduce bias in the analysis of observational data on decision-making.
4. **Counterfactual reasoning**: They support counterfactual analysis, allowing researchers to explore "what if" scenarios in decision-making processes.

By applying causal diagrams to these areas, one can gain deeper insights into the complex factors influencing human decision-making. This approach allows for more accurate predictions of behaviour and the development of more effective interventions or policies to guide decision-making processes. In conclusion, causal diagrams provide a robust, advantageous, and widely applicable tool for understanding human behaviour in decision-making. By explicitly modelling causal relationships, these diagrams offer a powerful framework for analysing complex behavioural phenomena and informing evidence-based interventions across various domains of human activity.

10.2 Approach

Once the archetypes were validated in an inductive and deductive way, the researchers decided to do an exercise to map the most relevant determinants of investment decision-making (N = 32) to each archetype. Again, in an inductive way first and then with more expert knowledge. For doing that, it was decided to use as a framework the Transtheoretical model of behaviour change (TTM) (Dunne and Raby, 2013). TTM characterises behaviour change as a process that unfolds over time, a non-linear transition through a sequence of qualitatively distinct stages (see figure 5). At each stage there are individual, stage-specific sources of resistance to change that can keep people stuck at an early stage for a long period of time, so specific skills and strategies are needed. A successful transition through the stages is reflected in an increasing readiness to change. The TTM (Fig 10.1) in a nutshell is based on six stages of change:

- **Precontemplation**: A stage where people do not intend to act for a short period of time, usually measured as the next six months. People may be in this stage because they are not well informed about the consequences of their behaviour or they may have tried to change several times and have become demoralised.
- **Contemplation**: A stage where people are trying to change their behaviour over the next six months. They are more aware of the pros of the change but are also very conscious of the cons. This balancing of pros and cons can produce deep ambivalence and keep people stuck in contemplation for long periods of time.
- **Preparation**: A stage where people intend to act soon, usually within the next six months. Usually, they have already taken some significant steps towards the behaviour in the last year and have a plan of action.
- **Action**: Stage where people have made concrete and overt lifestyle changes in the last six months. Not all behavioural changes count as actions in this model; certain criteria that scientists and practitioners consider sufficient must be met.
- **Maintenance**: Stage where people have made specific and overt lifestyle modifications and work to avoid relapse; they do not apply the change processes as frequently as people in action. They are increasingly confident that they can continue with the changes.
- **Completion**: Stage where people have zero temptation to relapse and 100% self-efficacy. It is as if the behaviour never existed in the first place or that their new behaviour has become automatic. This criterion may be too strict, which is not an ideal goal for most people.

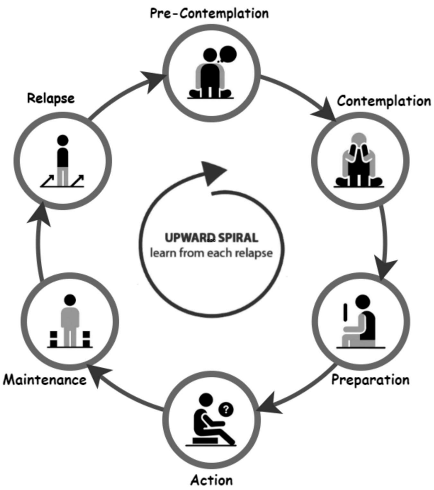


Figure 10.1: The Transtheoretical Model´s stages of change, which represent the process of intentional behaviour change.

In section 8.3, an overview of the most relevant determinants identified by each of the different phases of the TTM on each initial archetype identified in an inductive way. The identification of those determinants allowed us to understand what are the needs that have to be fulfilled by each individual behind an archetype to eventually make an investment decision through transitioning for the different stages. These initial diagrams can be understood as the causal diagrams or DAG. A Directed Acyclic Graph (DAG) is a graphical tool used in causal inference to represent and better understand the relationships between variables (Determinants) and the concept of causation. DAGs are used to encode researchers' a priori assumptions about the relationships between and among variables in causal structures (Sauer and VanderWeele, 2013). They are also useful for informing variable selection strategies for causal questions and for deducing which variables require control to minimize bias in estimating intervention effects (Peral, 2099).

The following diagram, through a DAG, shows the causal model of an archetype and its determinants, sorted into the stages of the TTM model. The causal diagram

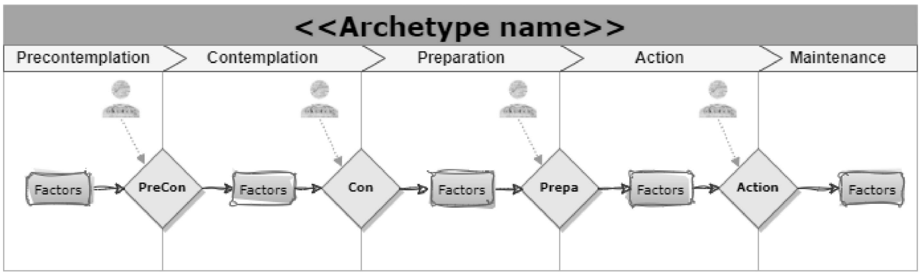


Figure 10.2: Base causal diagram of an archetype or investment profile. This depicts the transition through the stages of change, from Precontemplation to Maintenance. The diagram highlights the causal relationships between the factors in each stage that influence the transition from one stage to the next (from left to right).

Figure 10.2 represents a causal graph or directed acyclic graph (DAG) structured according to the stages of the Transtheoretical Model (TTM) of behaviour change. The TTM includes five stages through which individuals can progress in making a behaviour change: pre-contemplation, contemplation, preparation, action, and maintenance. Each stage of the DAG is causally linked to the next through factors that influence progression to the next stage. This visualization helps to understand the dynamics of behavioural change according to the TTM and what determinants influence the decision-making process of archetypes through these stages.

The first results obtained through the archetypes (section 8.3) will be validated at this stage of causal modelling. The validation will be done with the help of the expert panel to better understand which are the most predominant factors that affect the decision-making in stereotypical households regarding investment decisions towards the energy transition. A workshop was organised to this end.

10.3 **Activity: Workshop**

In the framework of the H2020-WHY (WHY-Consortium, 2021b), H2020-PARITY (Parity-Consortium, 2021), SmartLivingEPC (SmartLiving-Consortium, 2021) and H2020-ATELIER (ATELIER-Consortium, 2021; ATELIER-Consurtium, 2021) projects, an hybrid-multidisciplinary workshop session is organised to better understand which are the most predominant factors that affect the decision-making in stereotypical households regarding investment decisions toward the energy transition in the EU.

The workshop tackled four different aspects of the energy transition, namely:

- Energy efficiency and conservation actions (e.g., purchase a class A appliance or share appliances among neighbours),
- Distributed generation and flexibility markets (e.g., install PV panels, batteries or energy assets that can be remotely controlled),
- Building energy renovation (e.g., re-glazing or thermal Insulation in façade), and
- Mobility (e.g., uptake of public transport or investment in electric transport options)

The methodology that we used in each workshop was as follows:

1. After a recap of the methodology and the group formation all participants read the four scenarios related to the energy transition in which households will have to invest time and money to make the scenarios a reality. The scenarios per group are in Section 4.3.
2. After reading the scenarios, the groups broke down. People physically will go to separate rooms with one facilitator and people in remote areas will be assigned a Zoom breakdown room.
3. **Warm up**. The instructor guided the group through the materials we will use and the methodology to sort the determinants at each of the different stages of the behaviour model. For that, experts will have time to get familiar with the TTM, the investment archetypes, and the 32 determinants used to describe them. A set of cards including the archetypes and the determinants, was designed to ease the process. Annex 8 includes a digital copy of the material provided.
4. **Individual phase**. Experts had time to provide the first approach, sorting determinants into stages per archetype according to their knowledge and expertise.

   (a) Recall, not all the determinants affect all the archetypes equally. So each archetype will only have a subset of 15 out of the 32 determinants.
   (b) Rule: In this stage, once a determinant is used in one stage of a behaviour model based on stages, it cannot be used in another stage.
   (c) Please note that each group should proceed with the determinants in a certain order.

5. **Collective phase**. The experts moved to a different room to discuss in a panel of 4-6 their individual assessments, each group is expected to discuss a minimum of 3-4 archetypes.
6. **Wrap up**. The moderator of each session presented their main results.

This chapter will present the developed activity results from LATAM, but the European case is explained in the appendix E.

10.4 Activity: Causal modelling based on expert panel agreements

The following steps show how the final causal model of each archetype was built from the collective mapping results.

1. **Summarising consensus**. Figs 10.3, 10.4, 10.5, and 10.6 show the consensus reached in each group (MX, CO, CL, SV) on the factors that make up an archetype and the TTM phase in which they should arise. Figure 10.7 summarizes the consensus of the four groups, where the factors and all the MTT stages associated with each factor are marked with the number of groups agreeing on them. The TTM stage with the highest agreement value, and the candidate to be the final one, is highlighted in green.
   Figs 10.8 and 10.9 shows how many archetypes a given factor appears in (on the left) as well as the stages of the TTM model in which a factor may arise.
2. **Filtering factors by consensus**. Factors with less than 50% consensus (by groups) will not be considered further for their archetype. For instance, a factor cited by only one of the three groups will be ignored.

3. **Weighting of agreements-degree**. Based on the filtered factor (table 9), the agreement degree per factor was weighted (weight = total groups/agreement degree). The following cases help to assign the final TTM stages where a factor is placed.

   (a) **Case 1**: The cell of a factor with the highest weight stands for its final TTM stage.

   (b) **Case 2**: Equal agreement degrees. The highest weight is found by spatial autocorrelation: This technique analyses the spatial relationships between neighbouring cells. Cells with similar values tend to be assigned higher weights, capturing the spatial pattern of the data.

Fig 10.10 shows the final archetypes and the describing factors, including the TTM stage in which they appear, marked with a cross (X). Table 11 also shows (1) some squares with a lighter border, those indicating the ignored factors by filtering, (2) the final factor counts by TTM stage, and (3) the factors that were removed.

10.5 Activity: Crafting the causal graphs of investment profiles

This activity is carried out by researchers based on the results of Section E.2 (Causal modelling). In this activity, the factors of a given archetype are placed in a DAG following the structure described in Section 10.2 as is shown in Fig 10.2

Eight Causal Graphs or Directed Acyclic Graphs (DAG) of LATAM are introduced, representing the causal relationships between the factors of the archetypes (Figure 10.10). The absence of determinants at some stage of change (TTM) implies that archetypes are advancing directly to the next stage of the decision-making process. For example, the Early Adopter advances (Fig 10.11) directly from *contemplation* to *reparation* stage. Figs 10.11, 10.12, 10.13, 10.14, 10.15, 10.16, 10.17, and 10.18 sow the causal graphs of the LATAM archetypes.

		Context:	Latin American - Determinants sorted in the TTM stages by groups and archetypes																																															
		Group:	(e) Group MX																																														
		Archetype:	Early Adopter						Uninterested						Homo Economicus						Fearful						Stubborn						Influencer						Careful						Activist					
		TTM stages:	PREC	CON	PREP	ACT	MAI	REL	PREC	CON	PREP	ACT	MAI	REL	PREC	CON	PREP	ACT	MAI	REL	PREC	CON	PREP	ACT	MAI	RELAPSE	PREC	CON	PREP	ACT	MAI	REL	PREC	CON	PREP	ACT	MAI	RELAPSE	PREC	CON	PREP	ACT	MAI	REL	PREC	CON	PREP	ACT	MAI	RELAPSE
32-Factor teaxonomy	Financial	Profits							X						X																																			
		Credit Score			X	X					X				X												X														X									
		Risk Profile															X																																	
		Added Value															X																																	
		Frugality								X						X		X												X										X			X							
	Security	Legal														X													X													X	X							
		Trust	X	X											X																										X									
		Safety			X													X										X		X												X			X						
		Climate Protection			X											X														X		X							X											
	Competence	Cost-Efficiency															X												X		X																			
		Knowledge			X				X						X												X													X										
		Own Competence	X															X												X												X								
		Technical Fit	X															X	X										X														X							
		Environmental Concerns							X						X																									X										
	Autonomy	Self-Satisfaction	X					X				X																				X										X		X						
		Commitment				X						X																													X									
		Adherence				X						X																			X												X							
		Autarky							X																							X										X	X							
	Physical	Wellbeing						X						X						X												X							X					X						
		Cozyness						X	X																															X				X						
	Relatedness	Rights and Duties									X																	X													X									
		Peer-Pressure		X								X																																						
		Support			X																								X										X											
		Socialising						X					X															X																						
		Agreement						X				X																		X												X		X						
	Stimulation	Novelty						X																																X										
		Fun					X																				X																						
		Brag					X			X				X	X																																		
	Popularity	Trends	X									X																																					
		Authority															X												X												X	X								
	Meaning	Own Significance	X																																															
		Poseur						X																																									
		Total per TTM-Stages:	6	2	5	3	2	7	5	2	2	6	1	2	6	3	4	4	1	1							3	3	5	5	2	4	0	0	0	0	0	0	3	5	6	6	5	5						
		Total of determinants:						25						18						19												22						0						30						

Figure 10.3: MX group consensus on the factors that make up an archetype and the phase of the TTM in which they should emerge.

		Context:																								
		Group:	(f) Group CO																							
		Archetype:	Early Adopter						Uninterested						Homo Economicus						Fearful					
		TTM stages:	PREC	CON	PREP	ACT	MAI	REL	PREC	CON	PREP	ACT	MAI	REL	PREC	CON	PREP	ACT	MAI	REL	PREC	CON	PREP	ACT	MAI	REL
32-Factor taxonomy	Financial	Profits				X				X						X									X	
		Credit Score		X							X				X							X				
		Risk Profile		X							X							X				X				
		Added Value													X										X	
		Frugality		X								X				X							X			
	Security	Legal									X						X					X				
		Trust					X			X						X					X					
		Safety					X											X							X	
		Climate Protection	X			X												X								
	Competence	Cost-Efficiency				X				X					X							X				
		Knowledge		X									X										X			
		Own Competence	X														X						X			
		Technical Fit		X								X				X							X			
		Environmental Concerns	X												X							X		X		
	Autonomy	Self-Satisfaction	X						X			X			X										X	
		Commitment	X									X						X						X		
		Adherence					X					X				X								X		
		Autarky			X												X							X		
	Physical	Wellbeing			X				X												X					
		Cozyness				X			X							X						X				
	Relatedness	Rights and Duties		X	X						X							X				X				
		Peer-Pressure			X	X						X						X					X			
		Support		X								X					X				X					
		Socialising		X									X			X								X		
		Agreement				X				X													X			
	Stimulation	Novelty	X												X						X					
		Fun					X																		X	
		Brag	X						X										X					X		
	Popularit	Trends	X										X								X					
		Authority			X							X						X						X		
	Meaning	Own Significance							X						X		X				X					
		Poseur	X						X						X						X					
		Total per TTM-Stages:	9	8	5	6	4	0	6	4	4	8	3	0	8	7	5	7	1	0	7	7	6	7	5	0
		Total of determinants:						32						25						28						32

		Archetype:	Stubborn						Influencer						Careful						Activist					
		TTM stages:	PREC	CON	PREP	ACT	MAI	REL	PREC	CON	PREP	ACT	MAI	REL	PREC	CON	PREP	ACT	MAI	REL	PREC	CON	PREP	ACT	MAI	REL
32-Factor taxonomy	Financial	Profits					X			X															X	
		Credit Score			X											X						X				
		Risk Profile	X													X										
		Added Value		X								X														
		Frugality	X													X										
	Security	Legal		X											X								X			
		Trust		X					X												X					
		Safety					X																X			
		Climate Protection				X									X						X					
	Competence	Cost-Efficiency					X																		X	
		Knowledge		X								X					X							X		
		Own Competence	X																							
		Technical Fit			X												X							X		
		Environmental Concerns	X												X						X					
	Autonomy	Self-Satisfaction	X						X									X								
		Commitment			X														X							
		Adherence			X																					
		Autarky											X													
	Physical	Wellbeing				X										X										
		Cozyness								X														X		
	Relatedness	Rights and Duties		X														X								
		Peer-Pressure			X					X							X									
		Support			X					X																
		Socialising								X						X										
		Agreement		X							X															
	Stimulation	Novelty							X						X							X				
		Fun			X				X									X								
		Brag							X																	
	Popularit	Trends							X										X			X				
		Authority	X										X										X			
	Meaning	Own Significance	X						X						X											
		Poseur				X						X														
		Total per TTM-Stages:	7	6	7	3	3	0	7	5	1	3	2	0	5	5	3	3	2	0	3	3	3	3	2	0
		Total of determinants:						26						18						18						14

Figure 10.4: CO group consensus on the factors that make up an archetype and the phase of the TTM in which they should emerge.

	Context:																								
	Group:	(g) Group CL																							
	Archetype:	Early Adopter						Uninterested						Homo Economicus						Fearful					
32-Factor teaxonomy	TTM stages:	PREC	CON	PREP	ACT	MAI	REL	PREC	CON	PREP	ACT	MAI	REL	PREC	CON	PREP	ACT	MAI	REL	PREC	CON	PREP	ACT	MAI	REL
Financial	Profits														X						X				
	Credit Score															X					X				
	Risk Profile								X							X					X				
	Added Value														X						X				
	Frugality																								
Security	Legal			X					X													X			
	Trust			X				X								X							X		
	Safety																							X	
	Climate Protection			X																					
Competence	Cost-Efficiency														X						X				
	Knowledge	X															X			X					
	Own Competence				X																		X		
	Technical Fit			X					X												X				
	Environmental Concerns		X																						
Autonomy	Self-Satisfaction																								
	Commitment			X																					
	Adherence																	X							
	Autarky																								
Physical	Wellbeing	X										X		X							X				
	Cozyness										X									X					
Relatedness	Rights and Duties										X											X			
	Peer-Pressure				X					X															
	Support																								
	Socialising					X																		X	
	Agreement											X										X			
Stimulation	Novelty		X																	X					
	Fun	X																							
	Brag					X																			
Popularity	Trends		X								X				X										
	Authority	X												X						X					
Meaning	Own Significance					X																			
	Poseur					X									X										
	Total per TTM-Stages:	4	3	5	2	4	0	1	3	1	3	2	0	2	5	3	1	1	0	4	7	3	2	2	0
	Total of determinants:						18						10						12						18

	Archetype:	Stubborn						Influencer						Careful						Activist					
32-Factor teaxonomy	TTM stages:	PREC	CON	PREP	ACT	MAI	REL	PREC	CON	PREP	ACT	MAI	REL	PREC	CON	PREP	ACT	MAI	REL	PREC	CON	PREP	ACT	MAI	REL
Financial	Profits								X							X									
	Credit Score				X																				
	Risk Profile																								
	Added Value									X					X										
	Frugality	X																							
Security	Legal				X				X						X										
	Trust					X																			
	Safety		X												X										
	Climate Protection				X												X								
Competence	Cost-Efficiency								X																
	Knowledge				X						X			X											
	Own Competence			X										X											
	Technical Fit									X							X								
	Environmental Concerns	X												X											
Autonomy	Self-Satisfaction		X					X										X							
	Commitment					X					X														
	Adherence					X																			
	Autarky					X																			
Physical	Wellbeing			X											X										
	Cozyness													X											
Relatedness	Rights and Duties																	X							
	Peer-Pressure								X																
	Support		X								X				X										
	Socialising			X								X													
	Agreement										X					X									
Stimulation	Novelty								X																
	Fun																								
	Brag	X																							
Popularity	Trends							X																	
	Authority											X					X								
Meaning	Own Significance	X										X													
	Poseur																								
	Total per TTM-Stages:	4	3	3	4	4	0	2	5	2	4	3	0	4	5	2	3	2	0						
	Total of determinants:						18						16						16						

Figure 10.5: CL group consensus on the factors that make up an archetype and the phase of the TTM in which they should emerge.

Context:

Group: (sv) Group SV

32-Factor taxonomy		Archetype:	Early Adopter						Uninterested					
		TTM stages:	PREC	CON	PREP	ACT	MAI	REL	PREC	CON	PREP	ACT	MAI	REL
	Financial	Profits												
		Credit Score												
		Risk Profile												
		Added Value				X								
		Frugality												
	Security	Legal												
		Trust		X										
		Safety												
		Climate Protection		X										
	Competence	Cost-Efficiency		X										
		Knowledge			X									
		Own Competence			X									
		Technical Fit		X										
		Environmental Concerns	X											
	Autonomy	Self-Satisfaction				X								
		Commitment	X											
		Adherence					X							
		Autarky												
	Physical	Wellbeing				X								
		Cozyness				X								
	Relatedness	Rights and Duties												
		Peer-Pressure	X											
		Support												
		Socialising	X											
		Agreement												
	Stimulation	Novelty	X											
		Fun				X								
		Brag					X							
	Popularity	Trends	X											
		Authority			X									
	Meaning	Own Significance			X									
		Poseur	X											
		Total per TTM-Stages:	7	4	4	5	2	0	0	0	0	0	0	0
		Total of determinants:						22						0

Archetype:	Homo Economicus						Fearful					
TTM stages:	PREC	CON	PREP	ACT	MAI	REL	PREC	CON	PREP	ACT	MAI	REL
Profits					X							
Credit Score												
Risk Profile		X						X				
Added Value					X							
Frugality				X								
Legal		X						X				
Trust	X						X					
Safety				X						X		
Climate Protection								X	X			
Cost-Efficiency	X						X					
Knowledge		X						X				
Own Competence			X									
Technical Fit			X						X			
Environmental Concerns								X				
Self-Satisfaction					X							
Commitment												
Adherence												
Autarky												
Wellbeing					X						X	
Cozyness					X						X	
Rights and Duties								X				
Peer-Pressure								X				
Support												
Socialising												
Agreement												
Novelty		X										
Fun												
Brag					X						X	
Trends	X						X					
Authority		X										
Own Significance			X									
Poseur	X											
Total per TTM-Stages:	4	5	3	2	6	0	3	7	2	1	3	0
Total of determinants:						20						16

Archetype:	Stubborn						Influencer					
TTM stages:	PREC	CON	PREP	ACT	MAI	REL	PREC	CON	PREP	ACT	MAI	REL
Profits					X		X					
Credit Score												
Risk Profile								X				
Added Value									X			
Frugality												
Legal		X						X				
Trust								X				
Safety												
Climate Protection		X	X									
Cost-Efficiency									X			
Knowledge		X						X				
Own Competence			X									
Technical Fit												
Environmental Concerns		X										
Self-Satisfaction					X					X		
Commitment				X	X							
Adherence											X	
Autarky												
Wellbeing					X					X	X	
Cozyness											X	
Rights and Duties												
Peer-Pressure								X				
Support		X	X							X		
Socialising									X			
Agreement												
Novelty	X						X					
Fun												
Brag										X		
Trends							X					
Authority								X				
Own Significance			X									
Poseur										X		
Total per TTM-Stages:	1	5	4	1	4	0	3	6	3	5	3	0
Total of determinants:						15						20

Archetype:	Careful						Activist					
TTM stages:	PREC	CON	PREP	ACT	MAI	REL	PREC	CON	PREP	ACT	MAI	REL
Profits					X							
Credit Score		X										
Risk Profile			X					X				
Added Value												
Frugality												
Legal		X						X				
Trust	X							X				
Safety				X					X			
Climate Protection		X	X				X					
Cost-Efficiency	X											
Knowledge		X						X				
Own Competence												
Technical Fit			X									
Environmental Concerns				X			X					
Self-Satisfaction					X					X		
Commitment				X			X					
Adherence					X		X					
Autarky				X	X			X				
Wellbeing					X					X		
Cozyness					X							
Rights and Duties								X				
Peer-Pressure												
Support			X				X					
Socialising							X					
Agreement			X						X			
Novelty												
Fun												
Brag					X							
Trends								X				
Authority												
Own Significance			X				X					
Poseur												
Total per TTM-Stages:	2	4	6	4	7	0	7	7	2	2	0	0
Total of determinants:						23						18

Figure 10.6: SV group consensus on the factors that make up an archetype and the phase of the TTM in which they should emerge.

(i) Latin America- Archetypes & TTM stages
Summary of the groups: MX, CO, CL and SV

Number of groups: **4**

	Archetype	Early Adopter						Uninterested						Homo Economicus						Fearful					
	Number of panels:	4						3						4						3					
32-Factor teaxonomy	TTM Stages	PREC	CON	PREP	ACT	MAI	RELAPSE	PREC	CON	PREP	ACT	MAI	RELAPSE	PREC	CON	PREP	ACT	MAI	RELAPSE	PREC	CON	PREP	ACT	MAI	RELAPSE
Financial	Profits				1			1	1					1	2			1			1			1	
Financial	Credit Score		1	1	1					2				2		1					2				
Financial	Risk Profile		1						1	1					1	2	1				3				
Financial	Added Value				1									1	1	1		1			1			1	
Financial	Frugality		1						1		1				2		2					1			
Security	Legal			1					1	1					2	1					2	1			
Security	Trust	1	2	1		1		1	1					2	1	1				2			1		
Security	Safety			1		1											3						1	2	
Security	Climate Protection	1	1	2	1										1		1				1	1			
Competence	Cost-Efficiency		1		1				1					2	1	1				1	2				
Competence	Knowledge	1	1	2				1				1		1	1		1			1	1	1			
Competence	Own Competence	2		1	1											2	1					1	1		
Competence	Technical Fit	1	2	1					1		1				1	1	1	1			1	2			
Competence	Environmental Concerns	2	1					1						2							2		1		
Autonomy	Self-Satisfaction	2			1			1			2			1				1						1	
Autonomy	Commitment	2		1	1						2						1						1		
Autonomy	Adherence				1	2					2				1			1					1		
Autonomy	Autarky			1				1								1							1		
ysicalne	Wellbeing	1		1	1			1				1	1	1				1	1	1	1			1	
ysicalne	Cozyness				2			2			1				1			1		1	1			1	
Relatedness	Rights and Duties		1	1						2	1						1				2	1			
Relatedness	Peer-Pressure	1	1	1	2					1	2						1				1	1			
Relatedness	Support		1	1							1					1				1					
Relatedness	Socialising	1	1			1						2			1								1	1	
Relatedness	Agreement				1				1		1	1										2			
Stimulation	Novelty	2	1											1	1					2					
Stimulation	Fun	1			1	2																		1	
Stimulation	Brag	1				3		1	1				1	1				2					1	1	
Popularity	Trends	3	1								2	1		1	1					2					
Popularity	Authority	1		2							1			1	1	1	1			1			1		
Meaning	Own Significance	1		1		1		1						1		2				1					
Meaning	Poseur	2				1		1						2	1					1					
	Tot. num. of factors:	18	15	16	14	8		11	9	5	12	5		15	17	12	11	8		11	14	9	10	9	
						71						42						63						53	

	Archetype	Stubborn						Influencer						Careful						Activist					
	Number of panels:	4						4						4						2					
32-Factor teaxonomy	TTM Stages	PREC	CON	PREP	ACT	MAI	RELAPSE	PREC	CON	PREP	ACT	MAI	RELAPSE	PREC	CON	PREP	ACT	MAI	RELAPSE	PREC	CON	PREP	ACT	MAI	RELAPSE
Financial	Profits					2		1	2							1		1						1	
Financial	Credit Score	1		1	1										2	1					1				
Financial	Risk Profile	1							1						1	1					1				
Financial	Added Value		1							2	1				1										
Financial	Frugality	2			1										2			1							
Security	Legal		2	1	1				2					1	2		1	1			1	1			
Security	Trust		1			1		1	1					1		1				1	1				
Security	Safety		2		1	1									1	1	1		1			2			
Security	Climate Protection		1	1	3		1							2	1	1	1			2					
Competence	Cost-Efficiency			1		2			1	1				1										1	
Competence	Knowledge	1	2		1				1		2			1	2	1					1		1		
Competence	Own Competence	1		2	1									1			1								
Competence	Technical Fit			2						1						2	1	1					1		
Competence	Environmental Concerns	2	1											2	1		1			2					
Autonomy	Self-Satisfaction	1	1			1	1	2			1						2	2	1				1		
Autonomy	Commitment			1	1	2					1					1	1	1		1					
Autonomy	Adherence			1		2						1						2		1					
Autonomy	Autarky					1	1					1					2	2			1				
ysicalne	Wellbeing			1	1	1	1				1	1		1	2			1	1				1		
ysicalne	Cozyness								1			1		1	1			1	1				1		
Relatedness	Rights and Duties		2													1	1	1			1				
Relatedness	Peer-Pressure			1					3							1									
Relatedness	Support		2	3					1		2			1	1	1				1					
Relatedness	Socialising		1	1					1	1		1			1					1					
Relatedness	Agreement		1		1					1	1					2	1		1			1			
Stimulation	Novelty	1						2	1					1	1						1				
Stimulation	Fun	1		1				1									1								
Stimulation	Brag	1						1			1							1							
Popularity	Trends							3										1			2				
Popularity	Authority	1		1					1			2				1	2					1			
Meaning	Own Significance	2		1				1				1		1		1				1					
Meaning	Poseur				1						2														
	Tot. num. of factors:	12	12	15	11	9		8	12	5	9	7		12	14	15	13	13		8	9	4	5	2	
						59						41						67						28	

None agreement
Initial agreement
Final agreement - New factor and TTM stage position due data from El Salvador (SV)

Figure 10.7: Summarized the consensus of the four LATAMs: MX, CO, CL, and SV; agreements on the factors and the TTM stages where the factors may arise.

(o) Latin American Archetypes & TTM stages
Consensus on TTM stages

32-Factor teaxonomy	Archetypes	Early Adopter						Uninterested					
	Number of panels:	4						3					
	TTM Stages	PREC	CON	PREP	ACT	MAI	REL	PREC	CON	PREP	ACT	MAI	REL
Financial	Profits								X				
	Credit Score			X						X			
	Risk Profile								X				
	Added Value												
	Frugality								X				
Security	Legal									X			
	Trust		X						X				
	Safety												
	Climate Protection			X									
Competence	Cost-Efficiency												
	Knowledge			X				X					
	Own Competence	X											
	Technical Fit		X						X				
	Environmental Concerns	X											
Autonomy	Self-Satisfaction	X									X		
	Commitment	X									X		
	Adherence					X					X		
	Autarky												
Physical	Wellbeing	X						X					
	Cozyness				X			X					
Relatedness	Rights and Duties									X			
	Peer-Pressure				X						X		
	Support												
	Socialising		X									X	
	Agreement										X		
Stimulation	Novelty	X											
	Fun					X							
	Brag					X			X				
Popularit	Trends	X									X		
	Authority			X									
Meaning	Own Significance	X											
	Poseur	X											
	Tot. of determinants:	9	3	4	2	3	0	3	6	3	6	1	0
	Retained Factors:						21						19
	Discarded Factors:						6						0

32-Factor teaxonomy	Archetypes	Homo Economicus						Fearful					
	Number of panels:	4						3					
	TTM Stages	PREC	CON	PREP	ACT	MAI	REL	PREC	CON	PREP	ACT	MAI	REL
Financial	Profits		X									X	
	Credit Score	X							X				
	Risk Profile			X					X				
	Added Value		X									X	
	Frugality		X										
Security	Legal		X						X				
	Trust	X						X					
	Safety				X							X	
	Climate Protection								X				
Competence	Cost-Efficiency	X							X				
	Knowledge	X								X			
	Own Competence			X						X			
	Technical Fit		X						X				
	Environmental Concerns								X				
Autonomy	Self-Satisfaction												
	Commitment												
	Adherence												
	Autarky												
Physical	Wellbeing	X							X				
	Cozyness								X				
Relatedness	Rights and Duties								X				
	Peer-Pressure									X			
	Support												
	Socialising										X		
	Agreement									X			
Stimulation	Novelty							X					
	Fun												
	Brag					X					X		
Popularit	Trends							X					
	Authority		X					X					
Meaning	Own Significance			X									
	Poseur	X											
	Tot. of determinants:	6	6	3	1	1	0	4	10	4	2	3	0
	Retained Factors:						17						23
	Discarded Factors:						6						0

32-Factor teaxonomy	Archetypes	Stubborn						Influencer					
	Number of panels:	4						4					
	TTM Stages	PREC	CON	PREP	ACT	MAI	REL	PREC	CON	PREP	ACT	MAI	REL
Financial	Profits								X				
	Credit Score			X									
	Risk Profile												
	Added Value									X			
	Frugality	X											
Security	Legal		X										
	Trust												
	Safety		X										
	Climate Protection				X								
Competence	Cost-Efficiency					X							
	Knowledge		X								X		
	Own Competence			X									
	Technical Fit												
	Environmental Concerns	X											
Autonomy	Self-Satisfaction		X					X					
	Commitment					X							
	Adherence					X							
	Autarky												
Physical	Wellbeing			X									
	Cozyness												
Relatedness	Rights and Duties												
	Peer-Pressure								X				
	Support			X							X		
	Socialising								X				
	Agreement												
Stimulation	Novelty							X					
	Fun												
	Brag												
Popularit	Trends							X					
	Authority											X	
Meaning	Own Significance	X											
	Poseur												
	Tot. of determinants:	3	4	4	1	3	0	3	3	1	2	1	0
	Retained Factors:						15						10
	Discarded Factors:						9						9

32-Factor teaxonomy	Archetypes	Careful						Activist					
	Number of panels:	4						2					
	TTM Stages	PREC	CON	PREP	ACT	MAI	REL	PREC	CON	PREP	ACT	MAI	REL
Financial	Profits											X	
	Credit Score		X						X				
	Risk Profile								X				
	Added Value												
	Frugality		X										
Security	Legal		X							X			
	Trust							X					
	Safety			X						X			
	Climate Protection	X						X					
Competence	Cost-Efficiency											X	
	Knowledge		X						X				
	Own Competence												
	Technical Fit			X							X		
	Environmental Concerns	X						X					
Autonomy	Self-Satisfaction				X						X		
	Commitment			X				X					
	Adherence							X					
	Autarky				X				X				
Physical	Wellbeing		X								X		
	Cozyness		X								X		
Relatedness	Rights and Duties			X					X				
	Peer-Pressure												
	Support		X					X					
	Socialising							X					
	Agreement			X						X			
Stimulation	Novelty								X				
	Fun												
	Brag												
Popularit	Trends								X				
	Authority				X					X			
Meaning	Own Significance							X					
	Poseur												
	Tot. of determinants:	2	7	5	3	0	0	8	7	4	4	2	0
	Retained Factors:						17						25
	Discarded Factors:						7						0

Retained Factors (Tot):	147
Discarded Factors (Tot):	37

Figure 10.8: Factors versus archetypes and TTM stages in which they may arise.

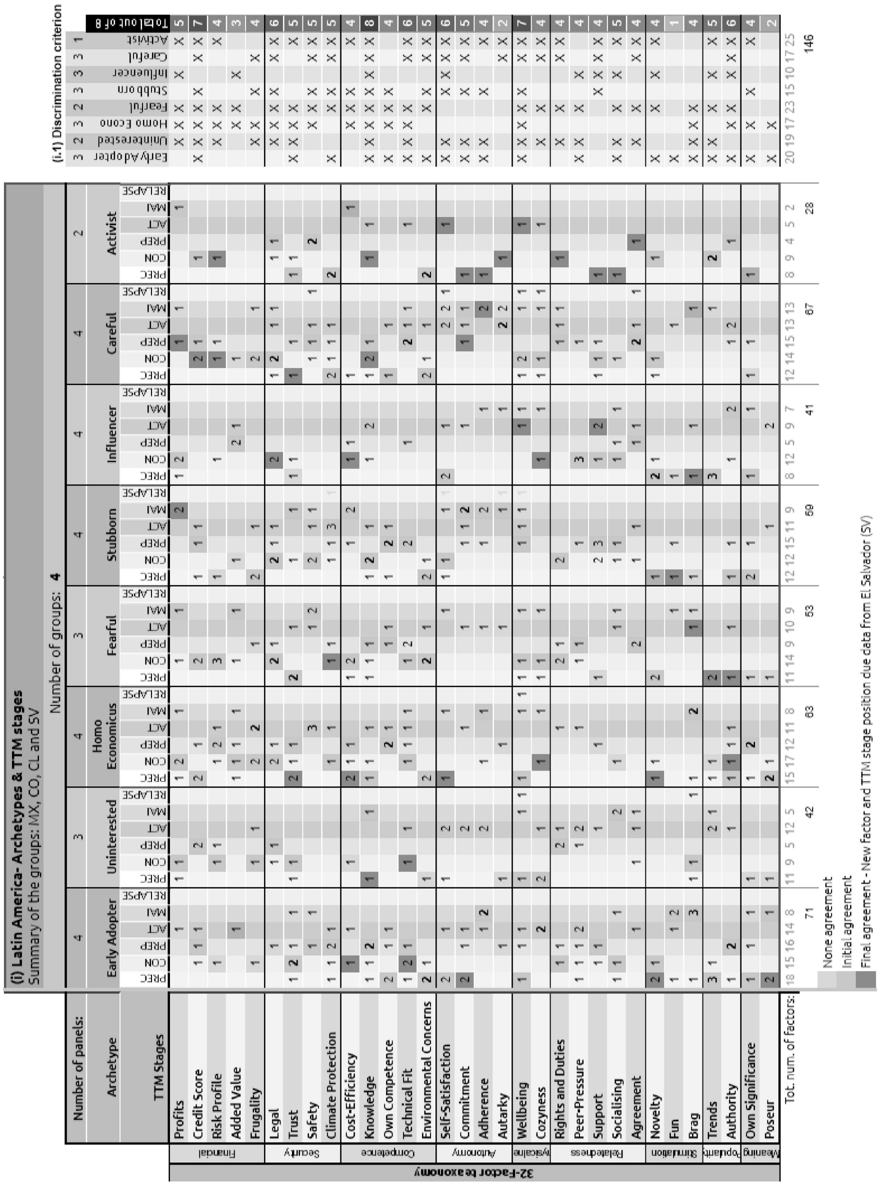


Figure 10.9: Filtering factors by discrimination criterion: Select factors with proportions greater than 50% (100 / Number of panels).

(o) Latin American Archetypes & TTM stages
Consensus on TTM stages

32-Factor teaxonomy	Number of panels:	4						3						4						3					
	Archetypes	Early Adopter						Uninterested						Homo Economicus						Fearful					
	TTM Stages	PREC	CON	PREP	ACT	MAI	REL	PREC	CON	PREP	ACT	MAI	REL	PREC	CON	PREP	ACT	MAI	REL	PREC	CON	PREP	ACT	MAI	REL
Financial	Profits								X						X									X	
	Credit Score			X						X				X							X				
	Risk Profile								X							X					X				
	Added Value														X									X	
	Frugality								X						X										
Security	Legal									X					X						X				
	Trust		X						X					X						X					
	Safety																X							X	
	Climate Protection			X																	X				
Competence	Cost-Efficiency													X							X				
	Knowledge			X				X						X								X			
	Own Competence	X														X						X			
	Technical Fit		X						X						X						X				
	Environmental Concerns	X																			X				
Autonomy	Self-Satisfaction	X									X														
	Commitment	X									X														
	Adherence					X					X														
	Autarky																								
Physical	Wellbeing	X						X						X							X				
	Cozyness				X			X													X				
Relatedness	Rights and Duties									X											X				
	Peer-Pressure				X						X											X			
	Support																								
	Socialising		X									X											X		
	Agreement										X											X			
Stimulation	Novelty	X																		X					
	Fun					X																			
	Brag					X			X									X					X		
Popularit	Trends	X									X									X					
	Authority			X											X					X					
Meaning	Own Significance	X														X									
	Poseur	X												X											
	Tot. of determinants:	9	3	4	2	3	0	3	6	3	6	1	0	6	6	3	1	1	0	4	10	4	2	3	0
	Retained Factors:						21						19						17						23
	Discarded Factors:						6						0						6						0

32-Factor teaxonomy	Number of panels:	4						4						4						2					
	Archetypes	Stubborn						Influencer						Careful						Activist					
	TTM Stages	PREC	CON	PREP	ACT	MAI	REL	PREC	CON	PREP	ACT	MAI	REL	PREC	CON	PREP	ACT	MAI	REL	PREC	CON	PREP	ACT	MAI	REL
Financial	Profits								X															X	
	Credit Score			X											X						X				
	Risk Profile																				X				
	Added Value									X															
	Frugality	X													X										
Security	Legal		X												X							X			
	Trust																			X					
	Safety		X													X						X			
	Climate Protection				X									X						X					
Competence	Cost-Efficiency					X																		X	
	Knowledge		X								X				X						X				
	Own Competence			X																					
	Technical Fit															X							X		
	Environmental Concerns	X												X						X					
Autonomy	Self-Satisfaction		X					X									X						X		
	Commitment					X										X				X					
	Adherence					X														X					
	Autarky																X				X				
Physical	Wellbeing			X											X								X		
	Cozyness														X								X		
Relatedness	Rights and Duties															X					X				
	Peer-Pressure								X																
	Support			X							X				X					X					
	Socialising								X											X					
	Agreement															X						X			
Stimulation	Novelty							X													X				
	Fun																								
	Brag																								
Popularit	Trends							X													X				
	Authority											X					X					X			
Meaning	Own Significance	X																		X					
	Poseur																								
	Tot. of determinants:	3	4	4	1	3	0	3	3	1	2	1	0	2	7	5	3	0	0	8	7	4	4	2	0
	Retained Factors:						15						10						17						25
	Discarded Factors:						9						9						7						0

Retained Factors (Tot): 147
Discarded Factors (Tot): 37

Figure 10.10: Archetypes and the final factors that compose them sorted in TTM stages.

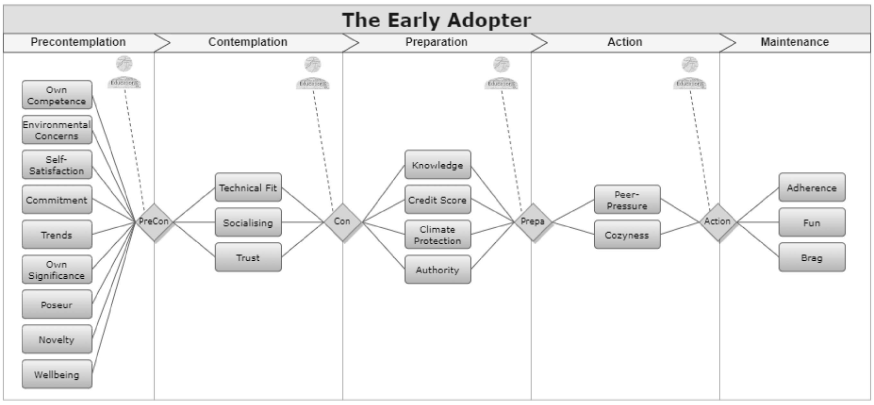


Figure 10.11: Causal graph of The Early Adopter Archetype.

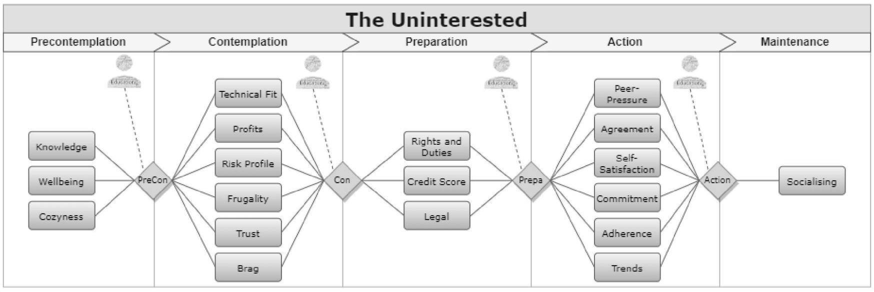


Figure 10.12: Causal graph of The Uninterested Archetype.

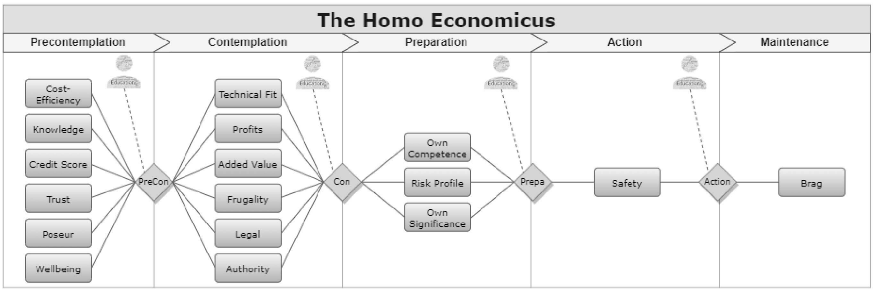


Figure 10.13: Causal graph of The Homo Economicus Archetype.

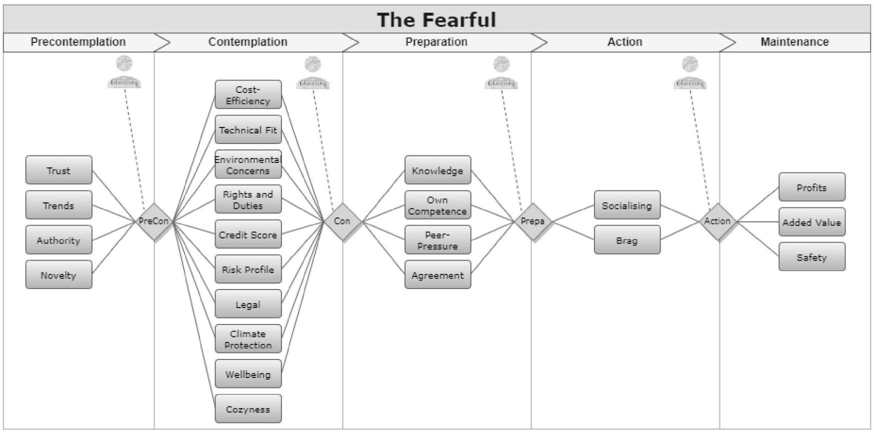


Figure 10.14: Causal graph of The Fearful Archetype.

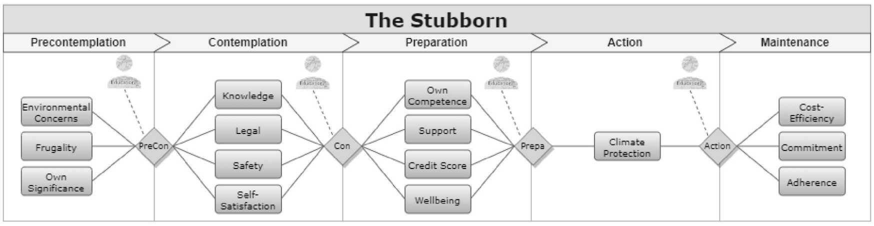


Figure 10.15: Causal graph of The Stubborn Archetype.

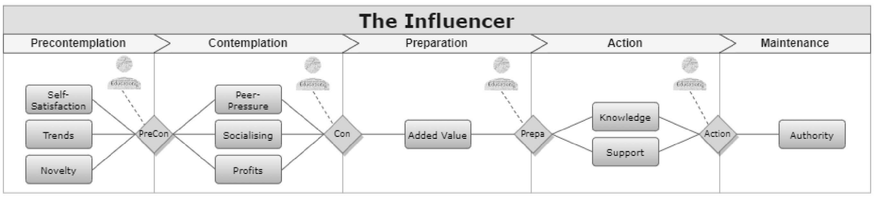


Figure 10.16: Causal graph of The Influencer Archetype.

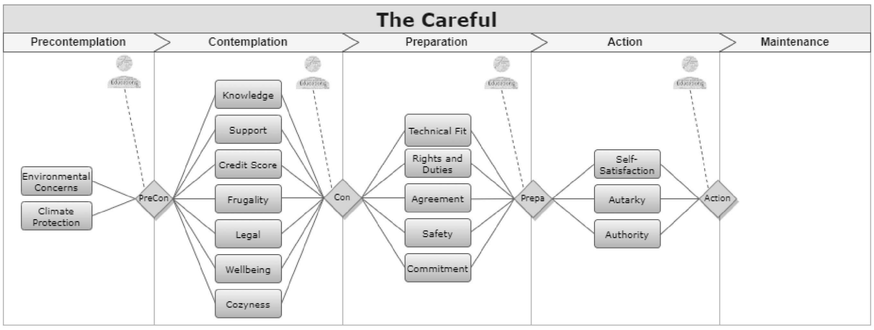


Figure 10.17: Causal graph of The Careful Archetype.

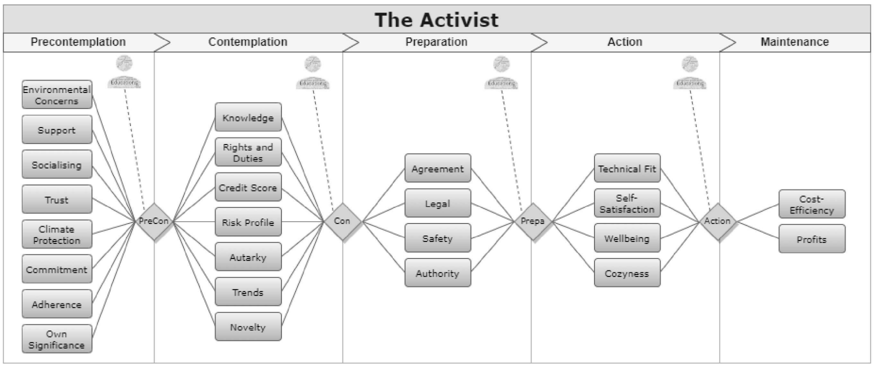


Figure 10.18: Causal graph of The Activist Archetype.

CHAPTER

11

Validation: Triangulation

11.1 Validation Method - Triangulation

To improve the validity of both the data collection process and the results, strategies to improve reliability were included (Vallejo and de Franco, 2009). Triangulation is a comparative strategy for examining data that strengthens qualitative and multi-method research. In this study, we employed three techniques of triangulation:

- **Interdisciplinary triangulation** occurs between experts from technical, societal, economic, psychology, and end users. The triangulation process in this case considers the comparison between different observers with energy experience) of the different personality archetypes included in the model (García et al., 2016).
- **Methodological triangulation** by gathering qualitative data through both one-on-one interviews and focus groups. In this case, data have been collected from these two different methods to assess the same phenomenon; identifying the group of archetypes for each community.

- **Collaborative triangulation** involved the articulation, negotiation and accommodation of divergent views and was key to achieving our shared goal of classifying the determinants of each archetype in a trans-theoretical model.

The validation or triangulation process will be carried out through activities in which experts and researchers participate. Activities such as:

- Participation in workshops to formulate contributions and reach agreements to design the functional scenarios and to define the relevant determinants for the decision-making process on functional scenarios (phases 1 and 2).
- Participation of experts and researchers in codifying activities: Coding (phase 2) Glossary and Taxonomy (3) and Archetype crafting (phase 4).
- Workshops - Consensus-building activities by experts to reach a common understanding for classifying factors into TTM stages (phase 5).
- The participation of the respondents, through the survey, to validate the archetypes and the prioritisation of the factors through responses (phase 5).

Triangulation will enhance the behavioural patterns of residential sector inhabitants.

11.1.1 Validation of the scenarios with stakeholders

The first session of the workshop was dedicated to the technical aspects of demand-side modelling. The main objective was to discuss with invited energy experts which components relevant to household energy consumption should be included and prioritised in the WHY toolkit, considering the European use case. We grouped these components into four different discussion themes: in round 1, we focused on elements related to building performance and mobility, whereas in round 2, we discussed aspects concerning flexibility and smart appliances. The proceedings underpinning the exchange on those themes were the same in each round. First, we introduced the concept of scenarios, divided into a base, a minimum, a probable, a plausible, and an ideal scenario. Figure 11.1 illustrates the main features of the

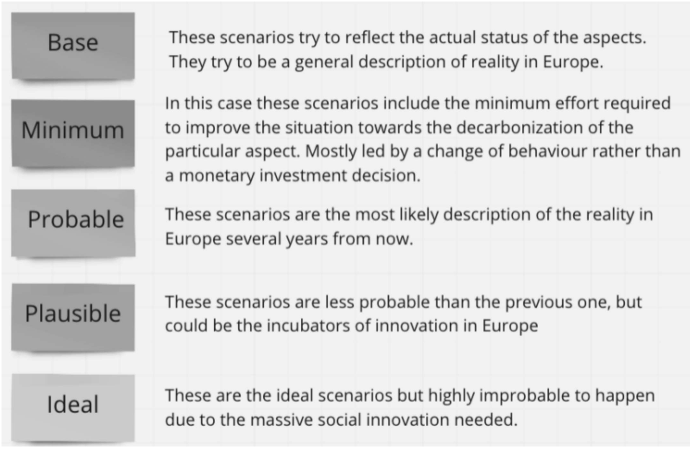


Figure 11.1: The scenarios applied in Session 1 of the workshop, "Energy Transition: Things to Consider when Modeling the Demand Side".

scenarios mentioned above, which were presented to the stakeholders, and provides their general description.

As the next step, the stakeholders read five different scenarios related to the Building Performance aspects (a similar task concerned also other main themes), to get acquainted with the visions of the potential developments in the European demand sector (section 4.3.3). Afterwards, the participants of this session were asked to classify those scenarios as a base, minimum, probable, plausible, and ideal (as introduced in the previous step). Each evaluation was supposed to be done in the context of the three next decades (covering the 2020-2050 period). This is depicted in Fig. 11.2

At first, the realisation of this task brought ambiguous results. Stakeholders were not unanimous in estimating the character of possible scenarios taking place in the upcoming decades, resulting in different colours of the dots placed in the matrix. The strongest unanimity considered the fact that the weakest decarbonisation scenarios would not be sufficient at the household level in 2040 and 2050. In general, the overall trend showed that the longer oriented the time perspective, the more

Decades	Scenarios	Flexibility					Appliances					Buildings					Mobility				
		Consumer	Time of Use	Prosumer	Enery Management	Local Market	Legacy Appliances	Sufficiency	A+	Communal use	Service economy	Not insulated	Thermostat	Minor Renovation	Deep Renovation	Passive	Fossil fuel	Electric Vehicle	Public transport	Robotaxis	15' cities
2030	Not Applicable	1				2									2	1	1		1	3	2
	Base	2					3					3	1	1	1		1	1			
	Minimum		3					3	1						2		1	1			
	Probable												2	2			1				
	Plausible			2							1		1			2		2			
	Ideal			1	3					2	1		1		1	2	1		1		1
2040	Not Applicable	2					3										2				
	Base	1						1	2					1					1		
	Minimum		3					1	1			2	1		2						
	Probable			1									1			2		1			
	Plausible			2	1					1	2	1	1	1	1		1	2	1		
	Ideal				1	1				1	3					1	1		2	2	2
2050	Not Applicable	3					3					3		1			2				
	Base							1	3				2								
	Minimum		2	1				1								1		1			
	Probable				2						1					1		1	1		
	Plausible			2									1	2	2	1	1		1	1	1
	Ideal				1	1				3	1					1	1	1		1	2

Figure 11.2: Evaluation of technologies during the three next decades

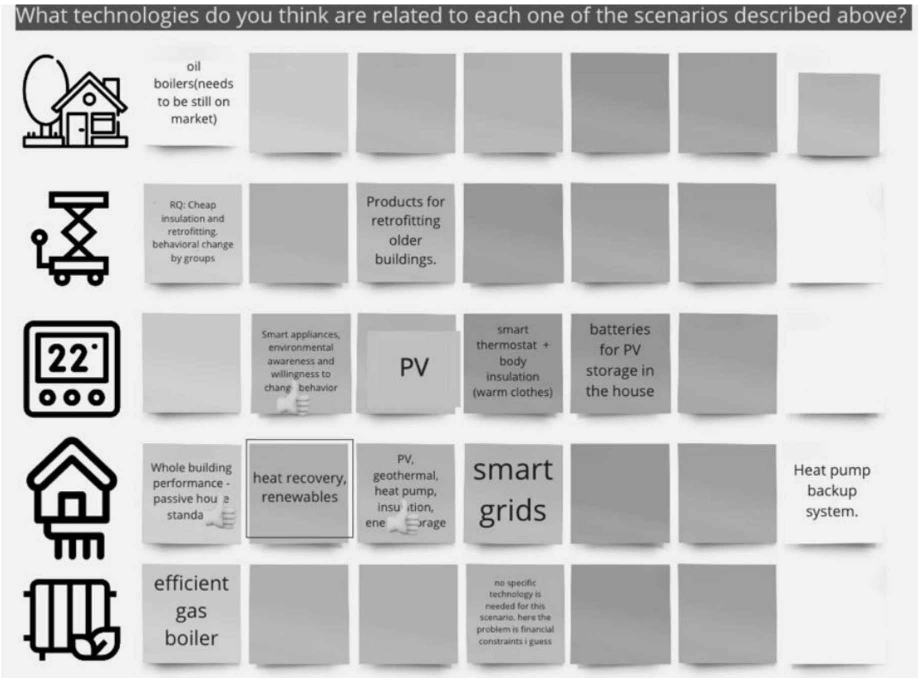


Figure 11.3: A set of technologies anticipated by stakeholders as relevant for the first set of scenarios.

agreeable the stakeholders were. In the next task, we asked the participants to write down specific technologies on sticky notes, which, in their opinion, will be essential in implementing the aforementioned scenarios. the above-mentioned scenarios. Importantly, under "technologies" we have not only understood technical solutions but also those related to social innovation. This task is visualised in Fig. 11.3.

The last task was linked to the previous one – we asked the stakeholders to indicate, which of the previously mentioned technologies they would prioritise in the modelling of the Building Performance aspects. The range of answers varied considering two dimensions: the degree of detail (low vs. high) and the answer time (fast vs. slow). We assumed that both dimensions are interrelated – the fast answer time also means a low level of detail, and vice-versa. In that context, the participants indicated

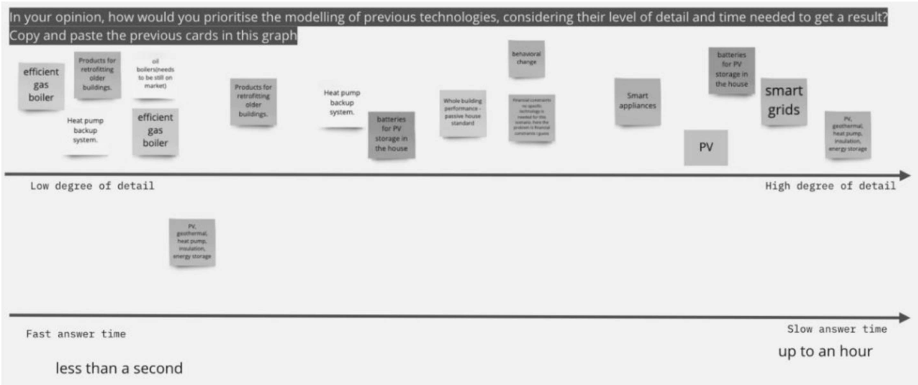


Figure 11.4: Technologies related to Building Performance, classified according to the level of detail and the answer time.

that, e.g., the gas boilers should not be given a lot of attention in the modelling runs, in contrast to renewable and renewable-related technologies, such as PV or smart grids. The results of this exercise are presented in Fig. 11.4.

After completing the last task related to the building performance aspects, the stakeholders undertook similar exercises in relation to the mobility aspects. First, the participants read potential future scenarios dealing with mobility (section 1.6), and afterwards, they indicated which of them were referring to a required minimum, which of them were most probable, plausible, ideal, not applicable, or presented the actual situation. The scenario classification is shown in Figure 11.2.

In the case of the mobility aspects, the participants indicated mixed assessments of the presented scenarios, being, however, in some cases unanimous. For example, stakeholders were sure that a scenario assuming a broad use of electric taxis would not be applicable until the end of this decade. Similarly, they assessed that it would be an ideal solution if, by 2040, the cities were planned in a way that private vehicles were not needed.

In the following task, the workshop's participants listed numerous technologies relevant to presented mobility scenarios. Noticeably, as Figure 11.5. shows, that they mentioned not only technological developments needed for the transformation of

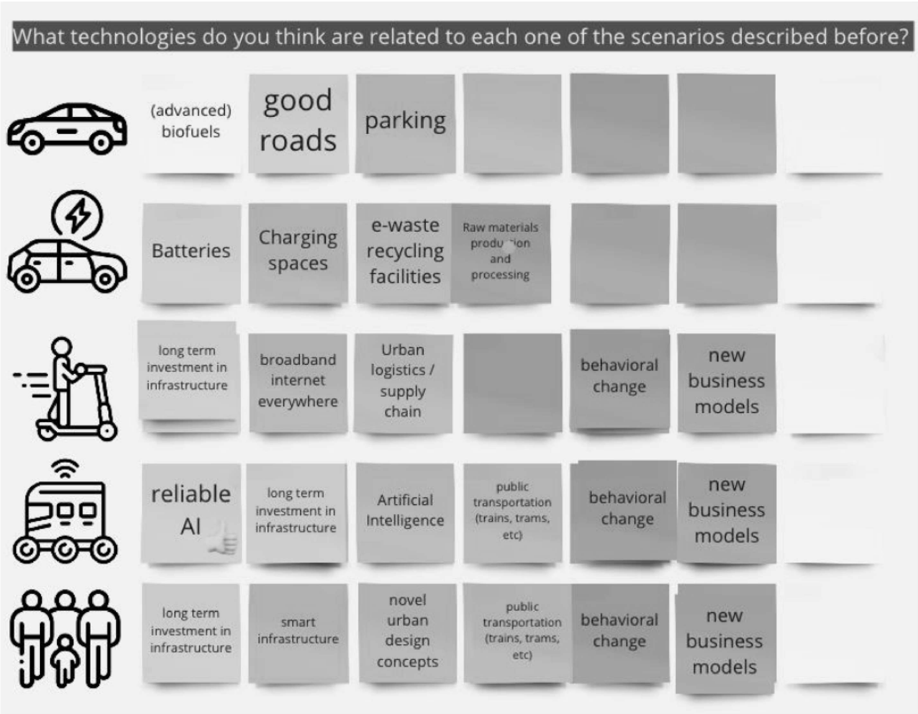


Figure 11.5: A set of technologies anticipated by stakeholders as relevant for the first set of scenarios.

the mobility system, such as reliable artificial intelligence or batteries, but they have also emphasised the importance of behavioural change and the emergence of new business models.

Against this backdrop, stakeholders claimed that most of those aspects should be characterised by moderate levels of detail and answering time. A visible deviation from this outcome concerned e-waste recycling facilities (low level of detail/ fast answer time) and reliable artificial intelligence (rather/ high level of details/ slow answer time). There was no clear agreement regarding the behavioural change. Fig. 11.6 presents these results.

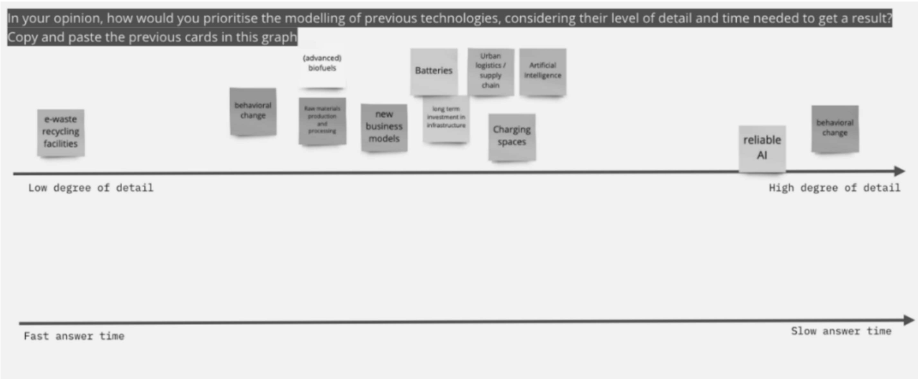


Figure 11.6: A set of technologies anticipated by stakeholders as relevant for the first set of scenarios.

This task finished round 1 of the parallel thematic sessions, and after the coffee break and re-shuffling of the stakeholders' groups, further energy demand aspects were discussed. At the beginning, stakeholders read five scenarios related to flexibility aspects (section 4.3.2).

Subsequently, they classified these scenarios as a minimum required, most probable, plausible, ideal, not applicable or presenting the actual situation. The experts participating in the workshop were rather consistent in their answers; they categorised the flexibility scenarios considering the time perspective by using mostly the same colour coding. More detailed results of this exercise are presented in Fig. 11.2.

Within the following task, stakeholders did not have problems indicating numerous technologies related to flexibility. Interestingly, they did not mention any technologies related to the first scenario. It resulted from the fact that this scenario did not present any progressive decarbonisation measures, and, therefore, the stakeholders recognised this scenario mostly as not applicable in the future and, hence, as a reality that will not require any technologies. Other results are depicted by Fig. 11.7.

Finally, the stakeholders classified the previous technologies according to their preferences regarding the level of modelling detail and time for receiving the modelling result. According to their input, the most desirable results in terms of high

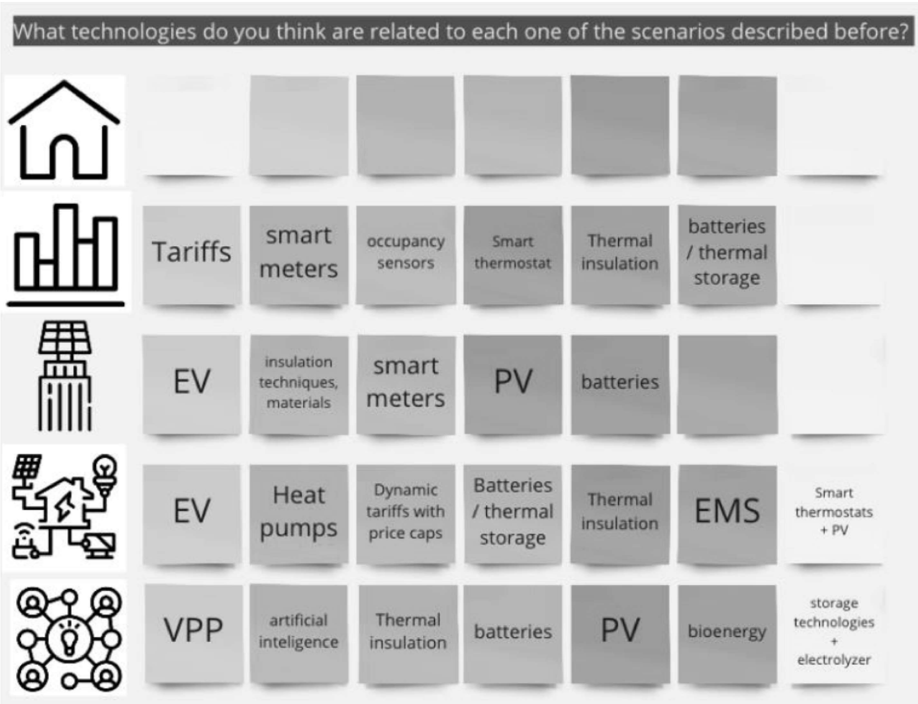


Figure 11.7: A set of technologies anticipated by stakeholders as relevant for the first set of scenarios.

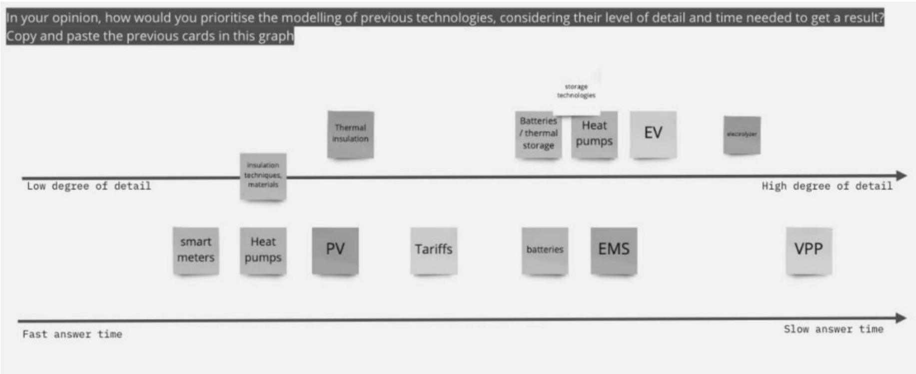


Figure 11.8: A set of technologies anticipated by stakeholders as relevant for the first set of scenarios.

detail are the results of the Virtual Power Plant's (VPP) modelling. On the opposite side of this axis, the workshop's participants placed smart meters. The full results of this exercise are visualised in Fig. 11.8.

The last group of aspects discussed with the stakeholders concerned smart appliances. Similarly, like in previous themes, the participants first read the descriptions of the possible future scenarios, and afterwards, they categorised them as a minimum required, most probable, plausible, ideal, not applicable (section 4.3.4) or presenting the actual situation. This is illustrated in Fig. 11.2. Again, stakeholders were quite consistent in their assessments; in most of the scenarios, they agreed on their character in the context of the decades to come. The most visible discrepancy in the answers occurred in the case of a scenario foreseeing the communal use of some of the appliances. In the next exercise, the invited experts indicated a few technologies related to the smart appliance scenarios, but clearly less than in the previous scenarios. Additionally, all of those technologies were assessed as requiring a low level of detail (but delivered quickly) while modelling. This is depicted in Fig. 11.9.

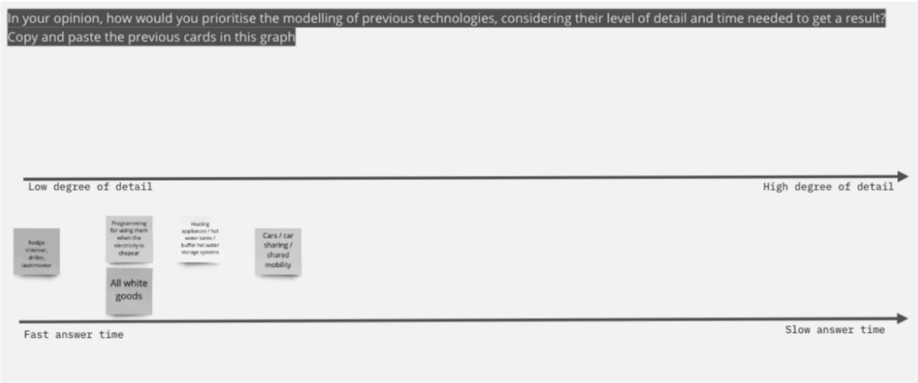


Figure 11.9: A set of technologies anticipated by stakeholders as relevant for the first set of scenarios.

11.1.2 **Validation of the full methodology**

Recognising that climate change transcends the European Union's borders, we proposed a validation strategy by replicating the EKCM in a different context, LATAM. Specifically, we focused on two of the four primary energy aspects: mobility and flexibility, as these were considered the most similar between Europe and Latin America.

Replicating this methodology in a non-European context serves two purposes: first, it validates the methodology used for causal modelling of human behaviour, and second, it extends the understanding of energy transition in the Latin American context, encompassing México (MX), Colombia (CO), Chile (CL), and El Salvador (SV). This approach sheds light on how Latin Americans are experiencing and responding to the energy transition. The following section presents the approach and findings related to these archetypes.

The term "process" doesn't just indicate that research requires time; it primarily signifies that generating qualitative new knowledge involves a multi-phase and iterative journey. This section provides a comprehensive account of how we have validated the CausalDec Methodology used to identify the crucial factors influencing household decision-making concerning the energy transition. This validation process has contributed to the results obtained so far in the EU context and to describe the context of the energy transition in other regions outside Europe.

CHAPTER

12

Designing an Intervention Strategy

This chapter seeks to answer the following question: "How to define an intervention strategy to promote energy transition in EU households?" The strategy focuses on modelling household behaviours related to energy transition investment decisions. It discusses various aspects of the WHY project, including the application of causal modelling as an alternative to traditional AI methods for behavioural prediction, and also emphasises the importance of understanding different household archetypes and their responses to various energy transition scenarios. It outlines the strategy, including surveys and socio-economic data to identify the dominant archetypes, and suggests policy-based interventions tailored to these archetypes to achieve effective energy transition strategies.

12.1 Approach based on WHY project objectives

The WHY Project, an ambitious initiative aimed at accelerating the energy transition, stands at the forefront of contemporary efforts to reshape our energy future. This project embodies a comprehensive and strategic approach, seeking not just to understand the intricate dynamics of the energy transition but also to actively facilitate it.

The energy transition depends fundamentally on actions and decisions in households. Homeowners or renters often deviate from rational decision-making models, suggesting that the classic archetype of the "resource man"-an individual who is assumed to make decisions purely based on rational economic calculations-is not an accurate representation (Strengers, 2014). Consequently, traditional models of decision-making, which presuppose an always rational actor, are not apt to capture the nuances of domestic behaviour (Browning et al., 2000). Since energy transition investment decisions are similarly influenced by these complex behavioural patterns, it is clear that a novel approach is needed. Such an approach must employ different optics to understand and encourage household engagement in the energy transition, taking into account the diversity of motivations and behaviours that drive household decisions.

The effectiveness of AI in behaviour modelling is debated, especially under intervention scenarios. Traditional AI struggles due to training on historical data that doesn't reflect dynamic changes, indicating a need for advanced AI that can adapt to evolving human behaviour. The WHY Project proposes Causal Modelling as a superior alternative to traditional methods for scenarios requiring intervention. Unlike data-driven models, Causal Models incorporate expert knowledge, are falsifiable, and generate robust predictions, even during interventions. They also provide counterfactuals and are more explainable, making them user-friendly.

12.2 What do I need to know to encourage change?

In the preliminary stages of designing an intervention, it is crucial for designers to engage in a process of reflective inquiry to ensure the effectiveness and relevance of their strategies. The following questions serve as a guide in this context:

- **Understanding the Desired Change**: *"Do I have a clear understanding of the specific changes to promote?*" This involves identifying the goals and objectives of the intervention, as well as the desired outcomes.
- **Variety of approaches**: "*Am I well-informed about my target audience?*" A deep understanding of the demographic, psychographic, and behavioural attributes of the target audience is crucial for tailoring the intervention effectively.
- **Variety in Approaches:** "*Am I aware of a range of strategies, incentives, policy changes, and interventions that could be effective in different scenarios*?" Knowledge of a diverse set of tools and techniques is essential for addressing varied circumstances and ensuring adaptability.
- **Integration of Elements**: "*Do I possess the capability to synthesize all these aspects effectively?*" The ability to connect the dots between the desired change, the target audience, and the appropriate strategies is key to creating a cohesive and impactful intervention plan.

12.3 Key Outcomes of the WHY Project: A Summary of Achievements to Date

The outcomes of the WHY Project, taken together, provide a roadmap for effective engagement and intervention. These findings are crucial for steering the energy transition toward a more sustainable and equitable future.

(i) WHY scenarios and prospective changes

The initial phase of this research focused on recovering expert knowledge. Four key aspects of the energy transition were addressed:

- Mobility. EV, Mmicrobobility, Public transport. etc.
- Flexibility.Distributed generation, storage, LRM, aggregators, etc.
- Building. Heating and insulation.
- Appliances. Energy efficiency, Shared economics, and sufficiency.

To dive deeper into each of these aspects, we assembled panels of experts, ensuring a comprehensive and interdisciplinary approach that encompassed technical, economic, social, and psychological perspectives. These expert panels were cross-sectoral, drawn from academia, business, public authorities, civil society, and international, with experts from various countries and cultural backgrounds. A special effort was made to achieve gender equality on the panels.

Then, a series of fictional scenarios for each aspect were developed. These included the following scenarios:

- Baseline: Representing the current status quo.
- Minimum: Outlining the least effort needed for improvement, often focused on behavioural changes.
- Probable: Predicting the most likely decisions of citizens in European cities in the near future.
- Plausible: encompassing less likely but still feasible developments.
- Ideal: Representing an optimal but highly ambitious vision requiring significant social innovation.

These scenarios serve as a framework for exploring and evaluating possible transition pathways and challenges.

(ii) Target Audience. The WHY archetypes

The identification of the *European archetypes* or *investment profiles* is a crucial outcome. These archetypes represent different types of decision-makers within the realm of energy investment, each with unique motivations, preferences, and behaviours. Understanding these archetypes is key to tailoring strategies that effectively engage different stakeholders in the energy transition, ensuring that interventions are relevant and impactful across diverse groups.

The 8 behavioural clusters: The Early Adopter, The Uninterested, The Homo Economicus, The Fearful, The Stubborn, The Influencer, The Careful, The Activist.

Cluster	Frequency
NA	6.8
Early Adopter	14.1
Uninterested	6.1
Homo Oeconomicus	9.6
Fearful	25.6
Stubborn	4.0
Influencer	16.6
Careful	15.1
Activist	2.2

Figure 12.1: Investment decision-maker's archetypes.

This section describes another perspective of the archetypes found in Section 8.3. For each of the eight archetypes, the name and subsequent description are given below:

- **Motivations/Values:** Primary drives of the archetype.
- **Decision-making**: how they approach choices.
- **Social Interactions**: How they navigate peer influence and authority.
- **Outcome/Behavior**: How they act upon decisions and in general.
- **Summary**: A summary of the archetype's essence.

1. The Early Adopter. Represents those who are forward-thinking and eager to embrace new technologies or practices, often driven by a sense of responsibility towards the environment. This group may be among the first to invest in renewable energy technologies, for instance.

- **Motivations/Values**: Responsibility, environmental consciousness, personal significance, and knowledge.
- **Decision-making**: Evaluates choices based on impact on satisfaction, trends, and authority. Avoids excessive bragging.
- **Social Interactions**: Navigates peer pressure and desire for novelty.
- **Outcome/Behavior**: Stays true to decisions and shares achievements in a balanced manner.
- **Overall**: Characterized by responsibility, knowledge, and commitment to significance.

2. The Uninterested. These individuals will make decisions based on existing norms and regulations. They might not be the first to adopt new energy-saving technologies, but they will if it aligns with their values or becomes a standard or required practice.

- **Motivations/Values**: Legal conformity, technical compatibility, well-being, and community obligations.
- **Decision-making**: Navigates peer pressure, stays updated with trends, respects authority.
- **Social Interactions**: Sometimes flaunts intentions, and seeks agreement with peers.
- **Outcome/Behavior**: Emphasizes agreement after decisions are made.
- **Overall**: Thoughtful and considerate; aligns choices with values and responsibilities.

3. The Homo Economicus. These individuals will make decisions based on existing norms and regulations. They might not be the first to adopt new energy-saving technologies, but they will if it aligns with their values or becomes a standard or required practice.

- **Motivations/Values**: Legal conformity, technical compatibility, well-being, and community obligations.
- **Decision-making**: Navigates peer pressure, stays updated with trends, respects authority.
- S**ocial Interactions**: Sometimes flaunts intentions, and seeks agreement with peers.
- **Outcome/Behavior**: Emphasizes agreement after decisions are made.
- **Overall**: Thoughtful and considerate; aligns choices with values and responsibilities

4. The Fearful. Driven by the desire for security, they might invest in energy-saving technologies if they believe it'll provide financial stability or safeguard their future.

- **Motivations/Values**: Well-being, financial security, trust, legality.
- **Decision-making**: Risk-averse, prioritizes cost-efficiency.
- **Social Interactions**: Relies on acquired knowledge and qualified technicians.
- **Outcome/Behavior**: Aims for a secure future for family.
- **Overall**: Driven by security and trust.

5. The Stubborn. Passionate about environmental causes, they'll likely be advocates for renewable energy, energy-saving technologies, and sustainable practices

- **Motivations/Values**: Motivations/Values: Environmental causes, combating societal discomfort.
- **Decision-making**: Actions influenced by competence, technology, and mental well-being.
- **Social Interactions**: Dedicated to significant actions.
- **Outcome/Behavior**: Alleviates societal discomfort and eco-anxiety.
- **Overall**: Deep dedication to the environment and society.

6. The Influencer. Their decisions are socially driven. If energy-saving becomes trendy or popular, they'll likely adopt it and even influence others to do the same.

- **Motivations/Values**: Social capital, novelty, popularity, shaping norms.
- **Decision-making**: Aims for societal influence and awareness.
- **Social Interactions**: Values successful socializing and community agreement.
- **Outcome/Behavior**: Seeks societal influence and connectedness.
- **Overall**: Driven by social capital and influence

7. The Careful, They need all the facts and assurances before making a decision. They'll invest in energy-saving technologies if they're convinced of the benefits and if it's deemed a safe and informed choice.

- **Motivations/Values**: Environmental concern, safety, autonomy.
- **Decision-making**: Requires legal compliance, financial access, and theoretical knowledge.
- **Social Interactions**: Values cooperation but seeks autonomy.
- **Outcome/Behavior**: Committed and seeks specific activities.
- **Overall**: Motivated by knowledge and control.

8. The Activist. Strongly driven by their beliefs, they'll proactively seek out ways to save energy and reduce environmental impact. They might also rally others to do the same.

- **Motivations/Values**: Environmental consciousness, moral obligation, responsible technology use.
- **Decision-making**: Follows regulations and norms.
- **Social Interactions**: Advocates for open knowledge and the sharing economy.
- **Outcome/Behavior**: Becomes a role model.
- **Overall**: Environmentally conscious and value-driven.

12.4 Decision-Making Heuristics: Selecting the Right Engagement Strategy for User Adoption

A heuristic tool is introduced. The tool helps decision-makers tailor their approach in a way that influences end users, thus increasing the likelihood that the desired change will be successfully adopted. This tool involves understanding the specific characteristics and preferences of the target audience and then selecting engagement strategies that align with these characteristics. The tool helps decision-makers to tailor their approach in a way that resonates with the end-users, thereby increasing the likelihood of successful adoption of the desired change.

(a) How can I know which are my salient archetypes?

In a nutshell, The following steps are aimed at identifying those prevalent investment profiles that can serve as the basis for specific engagement and intervention strategies.

1. **Run a survey over your target population**:
   The WHY method → We used a tool based on 32 items related to drivers when it comes to decision-making. Then, we clustered the answers and we found the 8 archetypes (each of them with salient characteristics)
2. Assume that **the majority of your sample will be similar to an archetype**:
   For example, in our population, we found that Fearful was the most repeated archetype.
3. Find out **measurable objective factors that can give you hints** about the archetypes that might be present in your population.
   For example, socio-economic data.

(b) When people (archetypes) make changes in their decision-making?

Energy transition investment decisions are rarely a binary yes or no choice, but tend to unfold in stages, reflecting a more complex behavioural process that evolves over time. This recognition of incremental progress is summarized in the Stages of Change model (TTM), which is integrated as an overarching dimension in the decision-making framework. Each stage of change is expressed as a distinct element or category within this dimension, recognizing the distinct and layered process that an individual undertakes during the investment process. Similarly, this staged approach reflects typical consumer behaviour in various buying experiences, underscoring the notion that rational choice, contrary to classical economic theory, is not always the operative principle in decision-making. Remembering this is critical: energy transition investment paths, like many other choices, are often characterized by a sequence of considerations and adjustments rather than by a single, definitive decision point.

(iii) Being up to date with potential strategies and policy-based interventions

In the intricate landscape of policy instruments aimed at guiding and influencing behaviour, a diverse array of mechanisms can be employed. These range from legislative and regulatory instruments, as is illustrated in the list below:

1. **Legislative and regulatory instruments**:
    - *Advantages*: (1) Actors are forced to comply whether they want to or not, (2) all actors are affected equally, and (3) they improve the predictability of the public authority's actions.
    - *Disadvantages*: (1) Costs to comply are paid by the involved actors, (2) limited coping abilities in complex dynamic situations and (3) change is not coming from the actors themselves but they are forced to comply.

2. Economic and fiscal/tax instruments:

- *Advantages*: (1) market failures can be corrected and (2) a functioning market could theoretically be created.
- *Disadvantages*: in some cases, they can generate additional costs due to the subsidies, (2) they cause additional efforts regarding the administrative aspects of loans and taxes.

3. Agreement-based or cooperative instruments:

- *Advantages*: (1) it relies solely on the voluntary contribution of individual actors, which indicates their motivation to comply.
- *Disadvantages*: (1) actors outside the network might not have an incentive to cooperate or might even oppose them, (2) not complying will very likely not have any consequences if no sanctions are agreed upon.

4. Information and Communication Instruments:

- *Advantages*: (1) the potential to provide the information to a large group of users.
- *Disadvantages*: (1) that information does not necessarily lead to compliance and (2) that it will be quite challenging to reach actors, who are not interested in the objectives.

5. Knowledge and innovation instruments:

- *Advantages*: (1) it allows the involved actors to contribute, which lowers the resistance, furthermore it is flexible enough to cope with complex situations, (2) involved actors will very likely be highly motivated to participate.
- *Disadvantages*: (1) the group of involved actors might be limited to a small group of frontrunners, (2) requires a high degree of cooperation and identification with the cause of all involved actors.

(iv) Matching archetypes and policy-based interventions

The table provided clarifies the synergy between various archetypes of decision-makers and the corresponding policy-based interventions that are most likely to resonate with them. It classifies archetypes according to their propensity to adopt particular types of policy instruments, from legislative and regulatory frameworks to knowledge and innovation strategies. Each archetype, defined by its unique values and behavioural tendencies, aligns with certain interventions that best tap into its intrinsic motivations. For example, the Early Adopter, prone to legal compliance and environmental awareness, is more inclined to legislative and regulatory instruments. In contrast, the Influencer, who values social capital, might be better engaged through cooperative agreements. This structured approach aims to optimize the effectiveness of policies by adapting intervention strategies to the characteristic motivations of the various social segments. A Matching archetypes and policy-based interventions is shown in table 12.3

Table 12.3: Matching archetypes and policy-based interventions

Policy-Based Intervention	Most Likely to Adopt
Legislative and Regulatory Instruments	-Early Adopter (Values legal compliance, environmental consciousness) -The Homo Economicus (Prioritizes legal compliance) -The Careful (Prioritizes legal aspects) -The Activist (Aware of regulations and norms) -The Uninterested (Conforms to legal requirements and standards)
Economic and Fiscal/Tax Instruments	-The Homo Economicus (Detail-oriented, assesses costs and benefits) -The Fearful (Concerned about financial matters)
Agreement-Based or Cooperative Instruments	-The Influencer (Values social capital and agreement amongst peers) -The Stubborn (Passionate about environmental causes) -The Activist (Aligns with values and beliefs, believes in the responsible use of technology)

Policy-Based Intervention	Most Likely to Adopt
nformation and Communication Instruments	-Early Adopter (Keeps up with trends) -The Influencer (Values social capital and popularity) -The Activist (Follows eco-trends, values open knowledge) - The Uninterested (May be reached if information becomes mainstream)
Knowledge and Innovation Instruments	-Early Adopter (Draws from knowledge to make decisions) -The Stubborn (Ambition depends on their competence) -The Activist (Values open knowledge, sharing economy)

12.5 **Intervention Strategy Steps**

This section initially outlines the strategy, thus delivering one of the key outcomes of this research: The intervention strategy. Details are given in the table below. This heuristic tool is designed to develop intervention-based engagement strategies that help policymakers design more effective policies. By targeting the investment profiles of the target population, or specific segments of the target population, these policies aim to increase public engagement in adopting the changes precipitated by energy policy reforms. In the following sections, we will outline the prerequisites that policymakers must have in place to effectively encourage change and promote public engagement.

The intervention strategy comprises the following steps:

1. **Identify the target population**:
   • Use surveys and socio-economic data to identify the dominant archetypes in your target population.

2 **Analyze the current stage of change**:
• Understand what stage of decision-making they are in. This will help in crafting a more personalized intervention approach.

3 **Choose the right policy-based intervention**:
• Based on the identified archetypes, select the policy interventions that would be the most effective.

4 **Implement & Communicate**:
• Roll out the interventions and ensure consistent and clear communication. For instance, if applying economic incentives, make sure all stakeholders are aware of the potential benefits.

5 **Monitor & Iterate**:
• Post-implementation, monitor the effectiveness of the interventions. If the desired behavioral change is not observed, iterate the strategy by possibly combining multiple interventions or tweaking the existing ones.

6 **Engage with the community**:
• Especially with influencers and activists, as they can amplify the message and bring about a more significant societal shift.

CHAPTER

13

Conclusions

13.1 Achievements

This research has achieved important milestones in understanding and predicting household energy demand and policy responses. It has developed a novel causal model, enhanced with advanced profiling techniques, to meticulously analyse household energy use and public reaction to changes in energy policy. This project stands out for its innovative methods of forecasting energy demand in the short and long term, examining various scenarios to assess the impact of potential policy interventions. Committed to wide adoption and meaningful impact, the WHY project has been a use case that ensures that all findings are shared openly, with extensive dissemination efforts aimed at a diverse range of stakeholders. The aim of this approach is to provide a comprehensive framework for energy specialists and policymakers to more effectively characterise energy systems and energy scenario outcomes, particularly at the national level. The main achievements are listed below:

- Recovering expert knowledge:

  - Bringing together a panel of experts specialised in the mobility, flexibility, building and appliance sectors relevant to today's energy transition.
  - Development of functional scenarios for the energy transition.
  - Development of a common glossary and a two-level taxonomy of 32 drivers.
  - Drawing up eight European investment profiles and adapting them to the Latin American context.

- Causal models:

  - Building specific causal models for Latin America.
  - Conducting a cross-sectional survey to validate the existence of archetypes in the target population.

13.2 Discussion

- **A methodology for the human causal model in the decision-making process.** The "CausalDec" methodology is an innovative approach crafted to investigate household decision-making in the context of energy transition The methodology leverages the strengths of the Delphi method for its group decision-making effectiveness, which is typically more accurate than individual decisions. This approach is favoured over prediction markets or statistical groups due to its collaborative nature. The key phases of the CausalDec methodology are:

  - Literature review.
  - Phase 0: Defining the topics of interest.
  - Phase 1: Design of fictional scenarios.
  - Phase 2: Identify the key factors for achieving fictional scenarios.
  - Phase 3: Coding.
  - Phase 4: Development of the Taxonomy.
  - Phase 5: Archetype crafting.
  - Phase 6: Cross-Sectorial Survey.
  - Phase 7: CausalModelling.

This comprehensive methodology integrates various techniques and perspectives to provide an in-depth understanding of the dynamics involved in household energy decision-making, particularly in the face of changing energy scenarios.

- **Behavioural determining factors of decision-making process**. The creation of the **Common Glossary** and **Taxonomy of 32 Factors** is a remarkable achievement of this research, which addresses the complex dynamics of household energy consumption and the transition to sustainable energy practices. The development of a standardised glossary unifies the language around psychological needs and behavioural factors, crucial for dissecting the drivers of human behaviour within the European household energy transition. By incorporating fundamental psychological concepts such as autonomy, relatedness and competence from self-determination theory, along with other important needs such as stimulation, meaning, security and economic security from Maslow's hierarchy, the taxonomy provides a comprehensive framework. It visually and graphically depicts the interaction of these needs and their behavioural determinants, facilitating an in-depth understanding of decision-making processes in the residential energy sector. This two-tiered taxonomy is particularly powerful as it unravels the motivations behind household energy decisions, providing a pathway for the development of effective energy transition strategies. With its comprehensive structure, encompassing nine psychological needs and 32 behavioural determinants, it equips policymakers and energy experts with the knowledge they need to design interventions that take into account the behavioural basis of energy use.
- **European and Latin American Investment profiles**. These archetypes are the introduction of European investment profiles as a means to comprehensively understand the behavioural patterns of decision-makers in investment scenarios. The concept of "archetypes" is central to this, as it represents different categories of decision-makers who exhibit specific characteristics, motivations, and behaviours when making investment choices. These archetypes are not merely broad categories, but carefully detailed profiles based on ob-

served behaviours and motivations that shape investment decision-making. Analysis of these archetypes provides a better understanding of the different approaches and thought processes that underpin investment strategies. This is essential for developing effective strategies and interventions tailored to the unique mindsets and priorities of different types of investors, leading to more informed and strategic investment decisions. In addition, the research has empirically mapped these archetypes using a cross-sectoral survey, providing a clear picture of the behaviour of the population. This allows validating investment profiles, aligning them with the identified archetypes and providing a predictive framework on how different individuals might respond to energy transition-related initiatives. By extending this profile to include Latin American archetypes and comparing them with European archetypes, the research brings a global dimension to the understanding of energy-related behaviour. This transcontinental perspective is essential for designing policy interventions that are sensitive to regional variations in investment behaviour, a significant advance in the field of behavioural economics within the energy sector. The following are the archetypes or investment profiles found.

1. The Early Adopter
2. The Uninterested
3. The Homo Economicus
4. The Fearful
5. The Stubborn
6. The Influencer
7. The Careful
8. The Activist

- **Intervention-based Strategy**. The development of an intervention-based strategy is a tool designed to help policymakers develop tailored policies for the energy transition in EU households. Going beyond traditional artificial intelligence (AI) methods, this research uses causal modelling to predict and understand household behaviours and investment decisions in response to energy transition scenarios. This novel approach takes into account the complex and varied motivations and behaviours that influence these decisions, presenting a more adaptive and realistic alternative to conventional modelling methods. The process involves:

1. Identifying the Target Population:.
2. Analyzing the Current Stage of Change.
3. Choosing the Right Policy-Based Intervention.
4. Implementing & Communicating.
5. Monitoring & Iterating.
6. Engaging with the Community.

- **Common behavioural factors are addressed**. indicating their significance in the context of decision-making processes and getting an understanding of which factors have been their primary focus, which leads to the following conclusion:

  1. **Financial factors**. This study shows that financial factors are not the only drivers of behavioural change in all energy transition contexts. On the contrary, household decision-makers prioritise other more crucial factors, especially flexibility, appliances and building context.
  2. **Competence factors.** The results of this study affirm the importance of competition factors, which are considered more crucial than financial factors in decision-making. Prioritising these factors in the formulation of energy policies becomes more important, especially when considering changes in energy policies related to environmental concerns and responsibilities.
  3. **Relatedness factors.** n this study, besides the "socializing" factor (feeling connected to others and part of a community), brings focus on the obligations and benefits in a community (rights and duties), the influence of peers enforcing social norms (peer pressure), contribution to community improvement and social causes (support), and the understanding and

cooperation among peers (agreement) to enhance the social acceptability of renewable energy strategies and energy democracy.

4. **Policy instruments.**

13.2.1 Limitations

Methodological Choices and Their Limitations

- **Intentional (Purposive) Sampling**. Intentional or purposive sampling was chosen to ensure that participants possess specific characteristics or expertise relevant to the research. While this method has its advantages, it also introduces several significant limitations:

    1. Selection Bias: By deliberately selecting participants based on certain criteria, the study may over-represent specific characteristics or viewpoints. This can result in a non-representative sample that does not adequately reflect the diversity of the broader population.
    2. Limited Generalizability: Findings from a purposively sampled group may not be generalizable to the entire population. The results may reflect the unique traits and experiences of the selected participants rather than providing insights applicable to a wider demographic.
    3. Subjectivity in Selection: The researcher's judgment in choosing participants can introduce subjective biases. The criteria for selection may inherently favor certain perspectives, potentially skewing the data.

- **Cross-Sectional Survey Design**. The study employs a cross-sectional survey to gather data at a single point in time. This design choice presents several limitations:

    1. Temporal Limitations: Cross-sectional surveys capture a snapshot of the population at one moment, which restricts the ability to observe changes and trends over time. Longitudinal studies, which follow the same participants over an extended period, would be more effective in capturing the dynamics of behavioral changes and decision-making processes.

- **Expert Knowledge and Subjectivity**. Phases involving the acquisition of expert knowledge (Phases 0-5) come with their own set of limitations:
    1. Consensus Building Challenges: Achieving consensus among experts can be challenging and time-consuming. Even with consensus, it may not fully eliminate biases or disagreements inherent to individual expert judgments.

Introduction of Bias in Purposive Samples

- **Purposive Sampling Bias**. Purposive sampling, by design, introduces several types of bias. Prolific primarily recruits participants who are internet users and willing to participate in online surveys, which may not accurately represent the broader population. This can lead to the overrepresentation or underrepresentation of certain demographic groups. For instance, participants might be more tech-savvy or have higher levels of education compared to the general population, leading to skewed results. Additionally, purposive sampling can result in a more homogeneous sample, reducing the variability needed to capture the full range of behaviors and perspectives within the population (Gronau and Wagenmakers, 2019). A new separate-sampling cross-validation error estimator can help to address these biases (Braga-Neto et al., 2014).

13.2.2 Data-sets

The dataset titled "Characterization of investments profiles on the energy transition for European citizens" is a comprehensive collection of data assembled to quantitatively examine the investment decisions of individuals concerning their energy consumption and responses to various policy interventions. This collection includes:

- Survey participants' consent forms
- Different scenarios related to the energy transition
- Factors influencing decisions within those scenarios
- Socioeconomic profiles of the participants

- Recorded investment decisions
- Descriptions of the households of the survey participants

The objective of gathering this data was to facilitate an analysis of how everyday people make decisions regarding energy consumption and how they react to specific political interventions aimed at shaping energy use. It offers a valuable resource for understanding the underlying patterns in energy investment decisions among European citizens.

13.3 Conclusions

This research outlines a methodological approach to develop a taxonomy of factors influencing households' decision-making on energy transition investments. A group of experts has identified 32 of these factors, which are closely related to the theory of planned behaviour and have been distributed across European households. Future efforts will be to categorise the population according to these factors in order to create distinct archetypes. From this taxonomy, we have constructed a set of seven behavioural archetypes, each comprising a set of determinants organised according to the stages of the Transtheoretical Model (TM) and illustrated by causal diagrams. However, these archetypes and their corresponding causal diagrams have not yet been confirmed as accurate and will require proper validation through three main activities: a cross-sectional survey to affirm or develop new archetypes, a longitudinal study to categorise the determinants of the archetypes according to the stages of the TTM, and expert workshops to further categorise these determinants.

This study not only provides a comprehensive behavioural taxonomy of 32 factors but also aims to clarify the causal links between these factors. By characterising different energy consumers as archetypes, representing specific patterns of decision-making behaviour, we apply causal models to these factors. Our aim is to provide policymakers with a resource to examine the effects of various interventions on these causal dynamics and to forecast individual responses to changes in energy policy. The survey results highlight the importance of socio-economic variables in group differentiation, especially with respect to gender, where there is clear variation in the prioritisation of 9 out of 32 factors. Moreover, the importance assigned to these factors in Europe differs considerably from that in Latin America.

Moreover, while many WHY sister projects highlight the influence of human behaviour on energy efficiency, focusing on a single need or a few needs with limited factors, this study covers nine needs and 32 factors identified by experts as critical energy policy objectives to drive societal commitment to energy efficiency. The next phase will be devoted to causally modelling behaviours within the European archetypes, meticulously mapping decision-making pathways and pinpointing behavioural factors amenable to policy intervention to encourage energy conservation practices. We also aim to extend our methodological framework to create archetypes in the Latin American context, which will serve as a stepping stone for their validation. This cross-cultural application will improve our understanding of Latin American energy transition behaviours and identify the differences between these behaviours and European ones, providing a rich perspective for ongoing research.

13.4 Future work and open issues

A longitudinal survey, in the context of monitoring the stages of change of the Transtheoretical Model (TM), is a research method that consists of repeatedly observing the same subjects over a period of time. This method is particularly suited to follow the progress of individuals through the different stages of change described by the TTM (pre-contemplation, contemplation, preparation, action, maintenance and termination). The main objective is to observe how individuals' attitudes, behaviours and conditions change over time in response to interventions or naturally occurring events.

However, there are several constraints and challenges associated with longitudinal surveys:

- Time and cost: Longitudinal studies are time-consuming and can be expensive. They require a long-term commitment of resources and staff to follow participants and collect data over long periods.

- Participant attrition: Over time, some participants may drop out of the study for a variety of reasons, such as loss of interest, moving, or other life changes. This dropout can lead to incomplete data and possible bias if the dropout is not random.
- Changing conditions: External factors such as social, economic or technological changes may influence survey results. These changes may affect the relevance of the data collected in the
- Respondent burden: Repeated participation can lead to respondent fatigue and respondent fatigue or disinterest in the survey, which can affect the quality of the data they provide.

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APPENDIX

A

State of the Art - Diagrams

The appendix contains diagrams that serve as supporting material for the section *Mobility* in the *State of the Art* (chapter 1). Fig A.1 represents a causal model depicting the factors influencing the *uptake of public transport.* Fig A.2 illustrates the influence of weather conditions on public transport uptake. Fig A.3 shows the factors that are considered by purchasers when selecting an electric vehicle. Fig A.4 illustrates the obstacles to the adoption of local flexibility markets. Fig A.5 shows the main risks categorisation of barries for LFM.

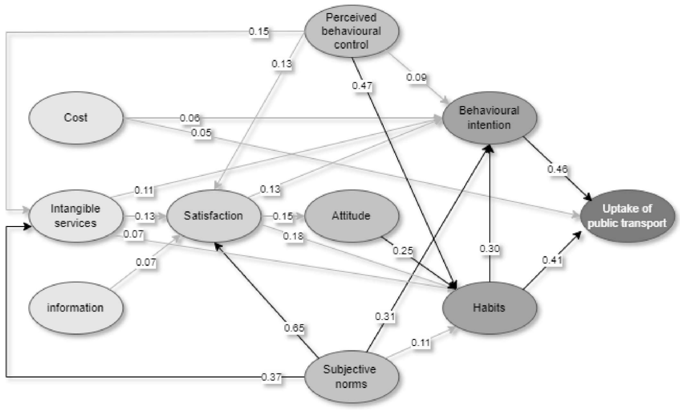


Figure A.1: This figure represents a causal model depicting the factors that influence the *uptake of public transport*. The darker arrows indicate that *perceived behavioural control* strongly influences *habits*, which in turn directly impact the *uptake of public transport*. In addition, *subjective norms* and *behavioural intention* directly influence the *uptake of public transport*.

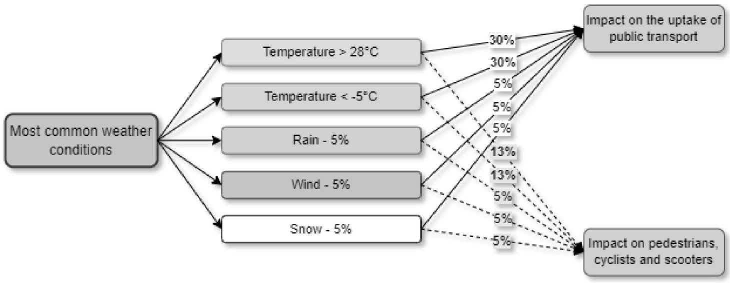


Figure A.2: Influence of weather conditions on public transport uptake. This figure illustrates the impact of different weather conditions on the uptake of public transport and the mobility of pedestrians, cyclists and scooter users. Extreme temperatures, both high (above 26°C) and low (below -5°C), have a high impact, influencing the use of public transport by as much as 30%. Other conditions, such as rain, wind and snow, have a lower effect (5%) and influence to a greater or lesser extent both the use of public transport and the mobility of pedestrians, scooter users, and cyclists.

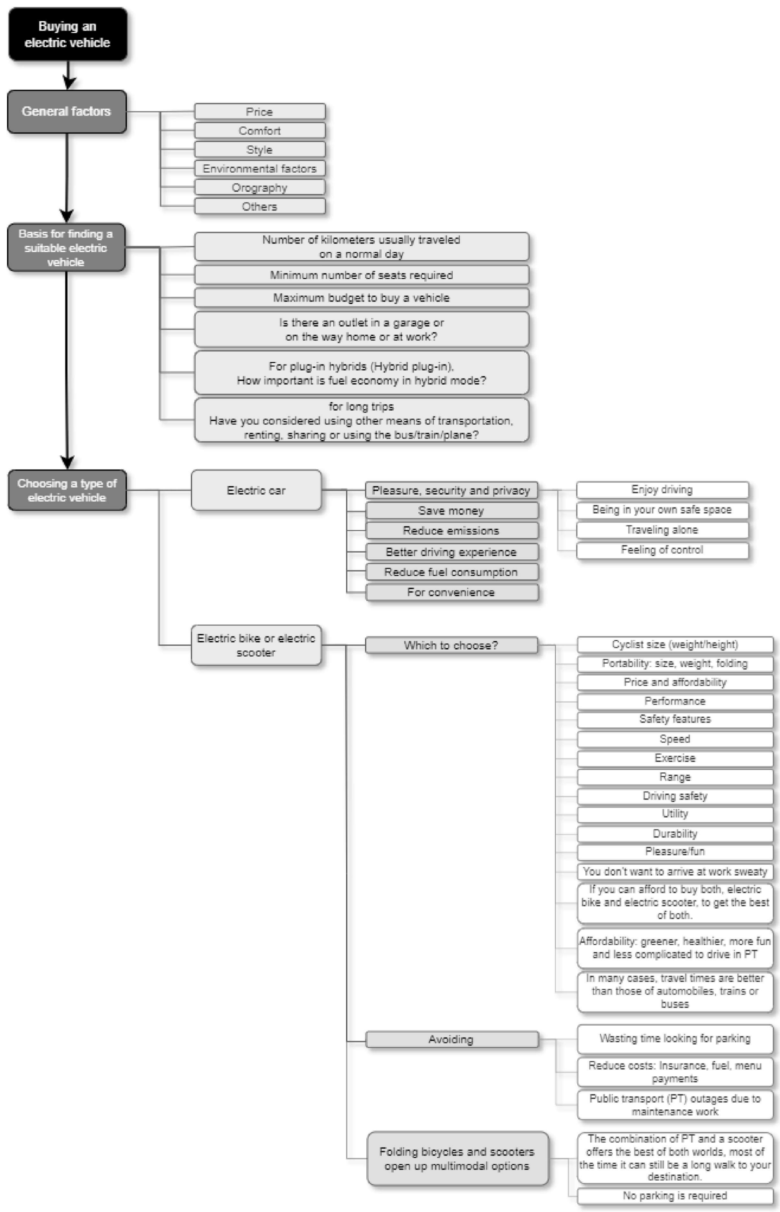


Figure A.3: Factors that are considered by purchasers when selecting an electric vehicle.

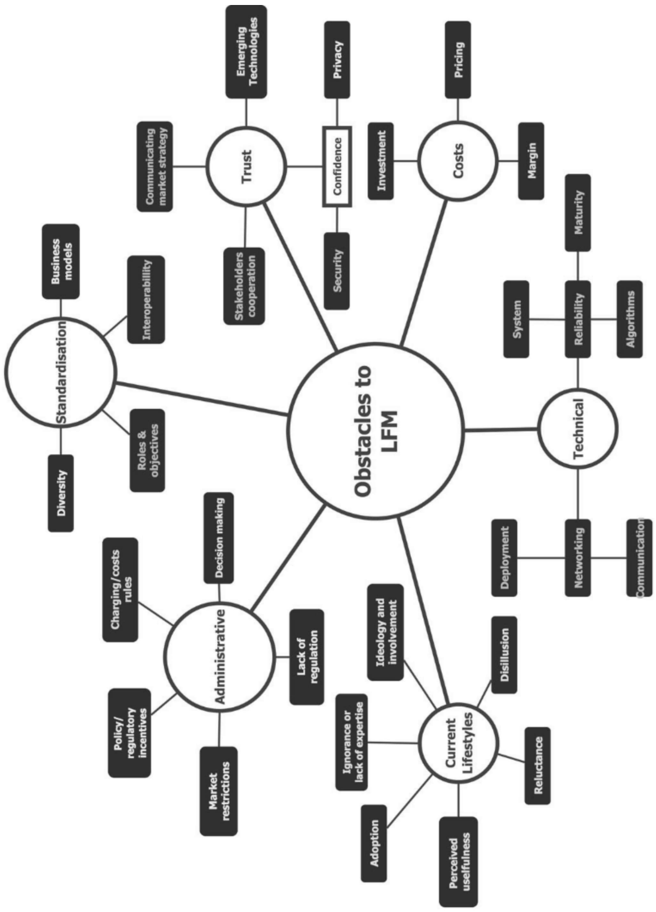


Figure A.4: Obstacles to the adoption of local flexibility markets (Zabaleta et al., 2020).

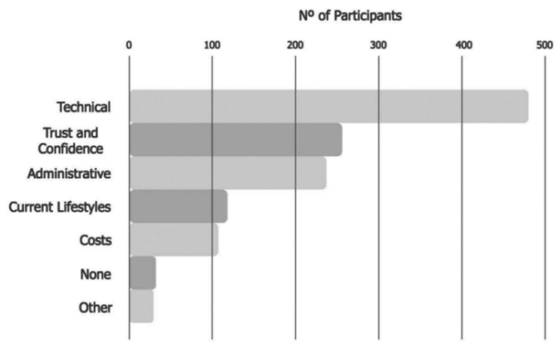


Figure A.5: Main risks categorisation. Barriers found for Local Flexibility Markets (Borges et al., 2022b).

APPENDIX

B

Theoretical Framework

As shown in fig 2.2, the *literature review* is a cross-cutting task that marks the beginning of the activities of the *CausalDec methodology*. It is carried out at the outset to provide information on methodologies that have been used successfully in previous research on similar topics. This illustrates researchers choosing appropriate methods for this study.

This appendix offers a comprehensive review of the theoretical framework and includes the following key topics:

- Causal modelling
  - Causal Diagrams - Graphical representation of the Causal Effect
  - Interventions
  - Backdoor Criterion
  - Front-Door Criterion
  - Do-Calculus
  - The Seven Tools of Causal Inference

- DoWhy – A library for causal inference

- Psychological theories
  - Social Cognitive Theory and Agency
  - Self-determination Theory, Social practice and Basic Psychological needs
  - Transtheoretical model

B.1 Causal modelling

A Causal Model is a mathematical abstraction that quantitatively describes the causal relationships between variables. First, Causal assumptions or prior causal knowledge can be represented by an incomplete Causal Model. Then, what is missing can be learned from the data (Pearl, 2019).

The two best known causal models are the Potential Outcome Framework (POF) and Structural Causal Models (SCM). Both allow for a consistent representation of prior causal knowledge, assumptions and estimates, and are therefore considered the foundations of causal analysis. In particular, the POF takes potential outcomes as a starting point and relates them through observational rules to observed outcomes. In contrast, the SCM perspective defines a model based on observed outcomes from which potential outcomes can be derived.

Both theoretical frameworks are logically equivalent, which means that an assumption in one can always be translated into its counterpart in the other. However, there are some differences between them. In POF, the causal effects of non-treatment variables, such as instrumental variables, are not defined, whereas in SCM it is possible to study the causal effect of any variable. Therefore, if all the causal relationships between a set of variables are known with certainty, it is preferable to use SCM, whereas if the objective is only to estimate a particular treatment effect, POF may be much simpler. In the WHY project (WHY-Consortium, 2021b), the objective is causal analysis of a wide range of variables, so SCMs will be used.

Potential Outcomes Framewok

The concept of "Potential Outcomes" is central to the field of causal inference, providing a framework for understanding the causal effect of interventions, policies, or treatments on individuals or units within a study. This framework, also known as the Rubin Causal Model or the Neyman-Rubin Causal Model, was developed to address the "fundamental problem of causal inference," which arises because we can only observe one of the potential outcomes for an individual under a specific condition (treatment or control), but not both simultaneously (Basse and Bojinov, 2021; Hernan and Robins, 2024).

The potential outcomes framework conceptualizes causality by considering the outcomes that would occur for each individual under different scenarios (e.g., receiving a treatment vs. not receiving it). For any given individual, the causal effect is defined as the difference between these potential outcomes. However, since we can never observe both outcomes for the same individual, causal inference seeks to estimate the average causal effect (ACE) across a population (Hernan and Robins, 2024)

Causal effect

The concept of causal effect in causality refers to the influence by which one variable (a cause) contributes to the production of another variable (an effect), where the cause is partly responsible for the effect, and the effect is partly dependent on the cause. In essence, causal effect means that something (the effect) happens or is happening because of something else (the cause) that has occurred or is occurring (Shonkoff and Phillips, 2000; Hernan and Robins, 2024).

Based on the above definition of causal effect, its difference with correlation is fundamental in understanding relationships between variables. Correlation refers to a statistical association between two variables, where changes in one variable are associated with changes in the other. However, correlation does not imply that one variable causes the changes in the other; it simply indicates that there is a relationship between them (Madhavan, 2019; Bhandari, 2022a; Sall, 2023).

- **Individual causal effects**. An individual causal effect refers to the effect of a treatment or intervention on the outcome of a particular individual. It is defined by comparing the potential outcomes of an individual if they received the treatment versus if they did not receive the treatment. If these potential outcomes differ, the treatment is said to have a causal effect on that individual's outcome (SP-Global, 2020).
  The formula for the individual causal effect, based on the potential outcomes framework, can be represented as follows:

  $$\text{Causal effect for individual } \textit{(i)}\text{: } Y_i^{a=1} \neq Y_i^{a=0}$$

- **Average causale ffects**. The average causal effect in a population is defined by the difference in the expected (or average) outcome Y when all individuals in the population are subject to intervention or treatment A, compared to when they are not. It is formally expressed as:

  $$\text{Average causal effect in population: } E[Y_{a=1}] \neq E[Y_{a=0}]$$

  This equation states that there is an average causal effect if the expected outcome under the treatment $a = 1$ is different from the expected outcome under the treatment $a = 0$. The average causal effect is essentially the average of the individual causal effects across the entire population.

Measures of causal effect

We have seen that the treatment *heart transplant A* does not have a causal effect on the outcome *death Y* in our population of 20 family members of Zeus. The causal null hypothesis holds because the two counterfactual risks $\Pr[Y^{a=1} = 1]$ and $\Pr[Y^{a=0} = 1]$ are equal to 0.5. There are equivalent ways of representing the causal null. For example, we could say that the risk $\Pr[Y^{a=1} = 1]$ minus the risk $\Pr[Y^{a=0} = 1]$ is zero (0.5 - 0.5 = 0) or that the risk $\Pr[Y^{a=1} = 1]$ divided by the risk $\Pr[Y^{a=0} = 1]$ is one $(0.5/0.5 = 1)$. That is, we can represent the causal null by:

- **The causala risk difference**:

$$\Pr[Y^{a=1}=1]-\Pr[Y^{a=0}=1]=0$$

- **The causal risk ratio**.

$$\frac{\Pr[Y^{a=1}=1]}{\Pr[Y^{a=0}=1]}=1$$

- **The causal odd ratio**.

$$\frac{\Pr[Y^{a=1}=1]}{\Pr[Y^{a=1}=0]}/\frac{\Pr[Y^{a=0}=1]}{\Pr[Y^{a=0}=0]}=1$$

Each effect measure may be used for different purposes. For example, imagine a large population in which 3 in a million individuals would develop the outcome if treated, and 1 in a million individuals would develop the outcome if untreated. The causal risk ratio is 3, and the causal risk difference is 0.000002. The causal risk ratio (multiplicative scale) is used to compute how many times treatment, relative to no treatment, increases the disease risk. The causal risk difference (additive scale) is used to compute the absolute number of cases of the disease attributable to the treatment. The use of either the multiplicative or additive scale will depend on the goal of the inference.

B.1.1 **Structural Causal Models**

Usually, a SCM consists of two sets of variables, U and V, and a series of functions f, called structural equations, which assign each variable in V a value, based on the values of the other variables in the model (Pearl et al., 2016). Another way to understand structural causal models is to think of them as the mechanism by which data are generated. As discussed in the previous section, it is usually known which variables are caused by other variables, but the strength or nature of these relationships is unknown. Even with such limited information, much can be discerned about the data set generated by the model. From the causal diagram it is possible to determine which variables in the data set are independent of each other and which are independent of each other conditional on other variables. These independencies will be true for each data set generated by any SCM with the same graphical structure. any SCM with the same graphical structure, regardless of the specific structural equations that generate each data set. specific structural equations that generate each data set. The following are the simplest and most relevant DAGs with which any causal diagram can be constructed. causal diagram and details the independence relationships underlying its structure. underlying its structure.

A key aspect of SCM is the differentiation between exogenous (U) and endogenous (V) variables. Exogenous variables are external to the model, meaning their causes are not explained within the model. Endogenous variables, on the other hand, are influenced within the model and are descendants of at least one exogenous variable. Exogenous variables have no ancestors and are represented as root nodes in graphs.

SCMs are associated with graphical causal models or graphs. These graphs consist of nodes representing the variables in U and V, and edges representing the functions in f. The graphical model for an SCM contains one node for each variable, and directed edges are drawn from variables upon which others depend. For example, if X depends on Y for its value, there will be a directed edge from Y to X in the graphical model. These graphical models are primarily DAGs (Barrett, 2024). In these graphs, if a variable X is a child of another variable Y, then Y is considered a direct cause of X. Additionally, if X is a descendant of Y, then Y is a potential cause of X, with some exceptions in rare intransitive cases

Causal diagrams, including DAGs, are graphical models widely used in causal inference to visually represent and understand relationships between variables (Suzuki et al., 2020). These diagrams are essential for identifying the variables that need to be controlled for in order to accurately estimate causal effects. Each node in a DAG corresponds to a random variable, and arrows indicate the presence of a causal effect from one variable to another. The absence of an arrow implies the absence of a direct causal effect between variables. DAGs are acyclic, meaning that they do not contain feedback loops, and represent causality in one direction, usually forward in time.

B.1.2 Causal Diagrams - Graphical representation of the Causal Effect

Causal diagrams are not only used to visualise hypothesised relationships between observed variables, but also to summarise and communicate researchers' understanding of possible interactions between variables (Pearl et al., 2016). They serve as communication devices and inference tools to estimate effect sizes from non-experimental data, derive testable implications from coded assumptions, manage missing data, and address selection bias (Barrett, 2024; Pearl and MacKenzie, 2019).

As Judea mentions, another way of understanding structural causal models is to think of them as the mechanism by which data are generated. As discussed in the previous section, it is usually known which variables are caused by other variables, but the strength or nature of these relationships is unknown. Even with such limited information, much can be discerned about the data set generated by the model.

From the causal diagram it is possible to determine which variables in the data set are independent of each other and which are independent of each other conditional on other variables. These independencies will be true for each dataset generated by any SCM with the same graphical structure. any SCM with the same graphical structure, irrespective of the specific structural equations generating each dataset. equations that generate each dataset.

The following are the simplest and most relevant DAGs with which any causal diagram can be constructed. causal diagram and details the independence relationships underlying their structure. underlying their structure.

Connecting Models to Data

Probabilities, graphs and structural equations, which are often treated as isolated mathematical objects, are in fact closely related. Concepts of independence between variables can be represented visually using DAGs. This graphical representation captures the probabilistic information embedded in a structural equations model, emphasising that a DAG structure can be used to predict patterns of independencies in the data without relying on quantitative information from the equations or error distributions. This helps to verify the correctness of a hypothetical model and to predict the outcomes of interventions (Pearl et al., 2016).

Chains, Forks and Colliders

Causal models serve as blueprints for the mechanisms underlying data generation. He explains that causal models can be used to simulate data, illustrating the concept with an example of generating mathematics test scores for high school seniors based on a full causal model. Causal diagrams have the practical limitation of specifying all the factors that influence an outcome, which highlights the common use of probability distributions to characterise exogenous variables (Pearl et al., 2016).

- **Chain**. This term refers to a linear sequence of variables where one variable directly affects the next. In a causal chain, a variable is influenced by its predecessor and, in turn, influences its successor. For example, in a simple causal chain, $X \rightarrow Y \rightarrow Z$, X affects Y, and Y affects Z, but X does not directly affect Z.
- **Fork**. A "fork" structure occurs when a single variable directly influences two or more other variables. This structure represents a common cause scenario. For instance, in a fork structure $X \rightarrow Y$ and $X \rightarrow Z$, variable Z is a common cause that directly influences both Y and Z.
- **Collider**. The concept of colliders in graphical models stand for a specific types of structures in a graph where two or more variables come together at a common effect (Pearl et al., 2016). A "collider" is a specific type of structure within a causal model. It occurs when two variables directly influence a third variable, which is known as the collider. The structure is characterized by having two arrows pointing into the collider. For example, if X and Y both directly influence Z, then Z is a collider in the structure $X \rightarrow Z \leftarrow Y$. The unique aspect of colliders in causal models is their effect on the independence or dependence of variables. Specifically, variables X and Y are unconditionally independent, but become dependent when conditioned on collider Z or any of Z's descendants. This phenomenon is known as collider stratification bias or collider bias. This phenomenon is known as collider-stratification bias

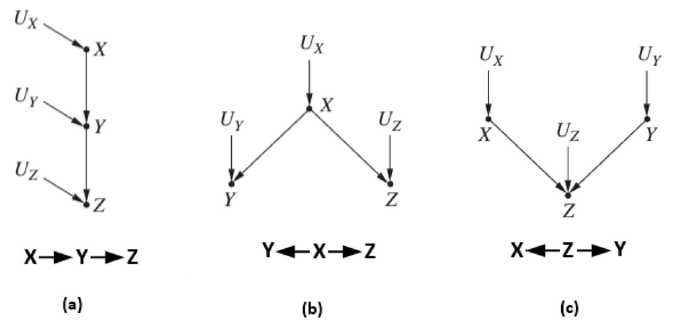


Figure B.1: Types of structures in Caudal diagrams: (a) Chain, (b) Fork and (c) Collider

or collider bias. It can lead to spurious associations when conditioning on a collider, which can mislead causal analysis. Understanding and handling colliders correctly is crucial in the study of causality and in solving problems such as Simpson's paradox.

The following figure B.1 illustrates the concepts of chain, fork and collider.

d-Separación

The d-separation criterion makes it possible to determine, for any pair of nodes, whether they are d-connected, which means that there is a connecting path between them, i.e. the variables are probably dependent, or, on the contrary, whether they are d-separated, which means that there is no such path and therefore the variables they represent are definitely independent. It is sufficient that there is only one non-blocked path for both nodes to be d-connected.

Taking into account the relationships obtained in the previous section, a classification of the types of nodes that can block a path can be established, depending on whether an unconditional or conditional d-separation is performed. The basic rules of d-separation are as follows:

1. **d-Connected and d-Separated Nodes**: Two nodes X and Y are considered d-separated if every path between them is blocked. If even one path is unblocked,

they are d-connected. d-Connected nodes imply possible or likely dependence, while d-separated nodes indicate definite independence.

2. **Blocking Paths**:
   - If not conditioning on any variable, only colliders can block a path. Colliders block unconditional dependence.
   - When conditioning on a set of nodes Z, a path can be blocked by:
     - A collider that is not in Z and has no descendants in Z.
     - A chain or fork where the middle node is in Z.
3. **d-Separation Definition**: X path pp is blocked by a set of nodes Z if and only if:
4. p contains a chain $\mathrm{X} \to \mathrm{Y} \to \mathrm{Z}$ or a fork $\mathrm{X} \leftarrow \mathrm{Y} \to \mathrm{Z}$ such that the middle node Y is in Z (i.e., Y is conditioned on).
5. p contains a collider $\mathrm{X} \to \mathrm{Y} \leftarrow \mathrm{Z}$ such that the collision node Y is not in Z and no descendant of Y is in Z.

B.1.3 **Interventions**

The concept of interventions in causal inference is central to understanding and predicting the effects of changes in one variable on another. Interventions are deliberate actions taken to modify the value of one or more variables in a study, with the aim of observing the resulting changes in other variables. This approach is fundamental in a wide range of fields, from public health (e.g., assessing the impact of a new drug on patient health) to social sciences (e.g., studying the effects of reducing access to violent television on children's aggressiveness) (Pearl et al., 2016).

The gold standard for testing the effects of interventions is the randomized controlled experiment, where all factors influencing the outcome are either constant or randomized, except for the intervention variable. This design ensures that any observed change in the outcome is due to the intervention itself, thereby establishing a causal relationship (Pearl and MacKenzie, 2019; Pearl et al., 2016).

In notation, fix $X = x$ is denoted by $do(X = x)$, So $P(Y{=}y|X{=}x)$ is the probability that $Y{=}y$ conditional on finding $X{=}x$, while $P(Y{=}y \mid do(X{=}x))$ is the probability that $Y{=}y$ when intervening to make $X{=}x$. $P(Y{=}y \mid X{=}x)$ reflects the population distribution of Y

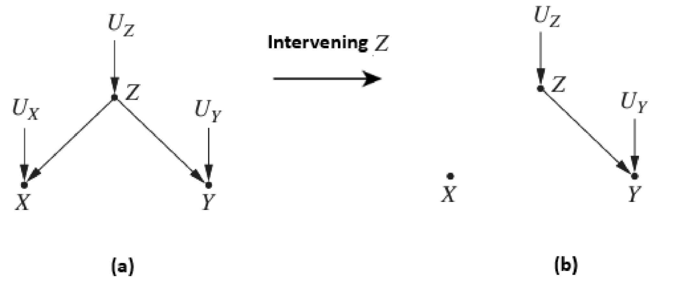


Figure B.2: (a) A graphical model representing the relationship between temperature(Z), ice cream sales (X),and crimerates(Y). (b) Graphical Mdel representing an intervention on the model (a) that lower sice cream sales

among individual whose *X* values *x*. On the other hand, *P(Y=y | do(X=x))* represents the population distribution of *Y* if everyone in the population had their X value fixed at x.

However, in many situations, conducting randomized controlled experiments may not be feasible or ethical. In such cases, researchers rely on observational studies, where data is recorded without any intervention. The challenge with observational studies is distinguishing between causal effects and mere correlations. For instance, it can be challenging to establish whether a correlation between two variables is indicative of a causal relationship or just a spurious association due to other factors (Pearl et al., 2016; Pearl, 2008).

When you intervene to fix the value of a variable, you restrict the natural tendency of that variable to vary in response to other variables. This is tantamount to performing a kind of surgery on the causal diagram, removing all edges directed at that variable (fig B.2-b).

Figure B.2-b shows how a causal diagram could change after an intervention in treatment *Z*. It can be seen how intervening on a variable results in a completely different pattern of dependencies than the pattern of dependencies caused by conditioning on the variable.

To understand the efficacy of a treatment in the population, a hypothetical intervention is imagined in which the treatment is administered uniformly to the entire population and the outcome is compared with the outcome that would be obtained with the complementary intervention. This would be denoted in the following fig B.3:

2.1

$$P(Y = 1 \mid \mathrm{do}(X = 1)) - P(Y = 1 \mid \mathrm{do}(X = 0))$$

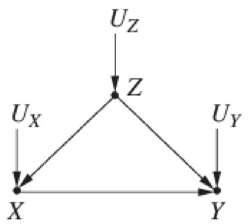


Figure B.3: Causal diagram representing the effects of a new drug, with Z representing gender, X standing for drug usage, and Y standing for recovery

Denoting the first intervention by do(X=1) and the second by *do(X=0)*, then the is to estimate the difference. This difference is known as the difference in causal effect or Average Causal Effect (ACE), which, if *X* and *Y* cane ach take on more than one value, we would wish to predict the general causaleffect *P(Y=y|do(X=x))*, where *x* and *y* are any two values that *X* and *Y* can take on. For example maybe the dosage of the drug and *y* the patient's blood pressure.

As is well known so far, causal effects cannot be estimated directly from the data without a causal story. However, from the causal diagrams B.2-b, an expression for calculating such an effect can be obtained from Equation 2.1.

Adjustment of the Formula

What variables, or set of variables (Z) must be included to the adjusted formula. The intervention on procedure, which led to the adjustment formula, dictates that Z should coincide with the parents of X, becauseit is the influence of these parents that were neutralize when we fix X by external manipulation. Denoting the parents of X by PA(X), we can therefore write a general adjustment formula and summarize it in a rule:

Rule 1 (The Causal Effect Rule) Given a graph G in which a set of variables PA are designated as the parents of X, the causal effect of X on Y is given by

$$P(Y = y|\mathrm{do}(X = x)) = \sum_z P(Y = y|X = x, PA = z)P(PA = z)$$

where z ranges over all the combinations of values that the variables in PA can take.

If we multiply and divide the summand in (3.6) by the probability $P(X = x|PA = z)$, we get a more convenient form:

$$P(Y|do(X)) = \sum_z \frac{P(X = x, Y = y, PA = z)}{P(X = x|PA = z)}$$

B.1.4 Backdoor criteria

The Backdoor Criterion is a fundamental concept in causal inference, particularly when working with Directed Acyclic Graphs (DAGs). It provides a method to identify sets of variables that, when conditioned upon, allow for the estimation of causal effects from observational data by blocking backdoor paths that could introduce bias into the causal estimate (Harrison, 2023; Pearl, 2008; Hernan and Robins, 2024).

Definition of the Backdoor Criterion

Given an ordered pair of variables (X, Y) in a DAG G, a set of variables Z satisfies the Backdoor Criterion relative to (X, Y) if:

1. No node in Z is a descendant of X, and
2. Z blocks every path between X and Y that contains an arrow into X.

Intuitively, the Backdoor Criterion ensures that the set Z blocks all backdoor paths from X to Y, which are paths that start with an arrow pointing to X, thereby isolating the direct effect of X on Y.

Formula for Estimating Causal Effects

If the Backdoor Criterion is satisfied, the causal effect of X on Y can be estimated using the adjustment formula:

$$P(Y|do(X)) = \sum_z P(Y|X,z)P(z)$$

This formula implies that to estimate the causal effect of X on Y, one needs to adjust for the variables in Z by summing over all possible values of Z, weighting by the probability of Z.

B.1.5 Front-Door Criterion

The back-door criterion provides a simple method for identifying the sets of covariates, i.e. variables that possibly predict the outcome under study, that need to be adjusted for when seeking to estimate causal effects from observational data. However, it is not the only way to estimate such effects. The do() operator can be applied to causal diagrams that do not satisfy the backdoor criterion to identify effects that at first glance appear to be beyond our reach. One such criterion is the Front Door Criterion.

Definition 3.4.1 (Front-Door) A set of variables Z is said to satisfy the front-door criterion relative to an ordered pair of variables (X, Y) if

1. Z intercepts all directed paths from X to Y.
2. There is no backdoor path from X to Z.
3. All backdoor paths from Z to Y are blocked by X.

Theorem 3.4.1 (Front-Door Adjustment) If Z satisfies the front-door criterion relative to (X, Y) and if $P(x|z) > 0$, then the causal effect of X on Y is identifiable and is given by the formula

$$P(Y|do(x)) = \sum_z P(z|x) \sum_{x'} P(Y|x',z)P(x')$$

- **Application and Importance**. The Backdoor Criterion and its associated adjustment formula are crucial for causal inference from observational data. By identifying the correct set of variables to condition on, researchers can estimate the causal effect of an intervention or treatment XX on an outcome YY without the need for randomized experiments. This is particularly valuable in fields where controlled experiments are impractical or unethical (Hernan and Robins, 2024; Pearl et al., 2016).

- **Challenges and Considerations**. While the Backdoor Criterion provides a powerful tool for causal inference, its application requires careful consideration of the causal diagram and the relationships between variables. Misidentification of the set ZZ or overlooking confounding variables can lead to biased or incorrect causal estimates. Therefore, a deep understanding of the underlying causal structure and the assumptions of the model is essential for the correct application of the Backdoor Criterion1 (Gonçalves, 2020; LmnICE, 2023; Hernan and Robins, 2024).

The Backdoor Criterion offers a methodological foundation for estimating causal effects from observational data by identifying and adjusting for confounding variables. Its application, however, demands rigorous analysis and a thorough understanding of the causal relationships among the variables involved.

B.1.6 **Do-Calculus**

Do-calculus is a mathematical framework developed by Judea Pearl that extends the toolkit for working with conditional probability distributions to include interventions. It allows to estimate the causal effect of an intervention on a system by comparing probabilities before and after the intervention. The calculus consists of a set of rules that can be applied to probability formulas containing the "do" operator, which represents an intervention, to replace them with ordinary conditional probabilities (Pearl and MacKenzie, 2019; Pearl et al., 2016; Behbehani, 2023).

The Purpose of Do-Calculus

The primary purpose of do-calculus is to identify causal effects when traditional methods such as backdoor or front door adjustments are not applicable. It is particularly useful when neither the backdoor criterion nor the front door criterion is satisfied, and it helps in identifying any causal quantity that is identifiable, keeping in mind that not all causal quantities are identifiable (Pearl and MacKenzie, 2019; Bhandari, 2022a).

The Formula for Do-Calculus

The general non-counterfactual causal quantity that one might be interested in can be expressed as (Pearl et al., 2016; Heis, 2021):

$$P(Y|\text{do}(X))$$

Here, Y represents the outcome variable, and do(X) represents the intervention on the variable X. The goal of do-calculus is to derive an equivalent formula for $P(Y|\text{do}(X))$ that no longer contains any "do" operators, so it can be estimated from observational data alone. If this derivation is possible, the causal query is said to be identifiable.

The Rules of Do-Calculus

Do-calculus consists of three rules that permit the transformation of interventional distributions into observational distributions under certain conditions specified by the causal diagram:

Rules of the do-Calculus. Let G be a directed acyclic graph associated with a causal model, and let P() be the probability distribution induced by that model. For any disjoint subsets of variables X, Y , Z and W , we have the following rules:

$$P(y|do(x), z, w) = P(y|do(x), w) \;\; si \;\; (Y \perp\!\!\!\perp Z|X; W)_{G_{\bar{X}}}$$

Figure B.4: Rule 1) Insertion/suppression of observations.

where *Z(W)* is the set of *Z-nodes* that are not ancestors of any *W-node* in G_X .

Rule 1 restates d-separation as a valid test for conditional independence in the distribution resulting from the intervention *do(X = x)*, hence the graph G_X . This rule

$$P(y|do(x), do(z), w) = P(y|do(x), z, w) \ \ si \ (Y \perp\!\!\!\perp Z|X;W)_{G_{\bar{X}\underline{Z}}}$$

Figure B.5: Rule 2) Exchange of actions/observations.

$$P(y|do(x), do(z), w) = P(y|do(x), w) \ \ si \ (Y \perp\!\!\!\perp Z|X;W)_{G_{\bar{X}\bar{Z}(W)}}$$

Figure B.6: Rule 3) Insertion/deletion of actions

follows from the fact that the elimination of the equations of the system does not introduce any dependence between the remaining disturbance terms.

Rule 2 provides a condition for an external intervention do($Z = z$) to have the same effect on Y as the passive observation $Z = z$. The condition is equivalent to $\{X \cup W\}$ blocking all backdoor paths from Z to Y (in G_X), since G_{XZ} preserves all and exclusively those paths.

Rule 3 establishes the conditions for introducing, or eliminating, an external intervention do($Z = z$) without affecting the probability of $Y = y$. The validity of this rule derives, again, from simulating the intervention do($Z = z$) by suppressing all the equations corresponding to the variables of Z, hence the graph G_{XZ}.

Rules 1-3 are complete. That these rules are complete means that they are sufficient to derive all identifiable causal effects. The proof of Theorem 2.1.6 can be found in the literature (Ilya and Pearl, 2006).

The task of deciding whether a sequence of rules exists to reduce an arbitrary causal effect expression can be a very complex job. This is why different software is used for causal analysis. The following section presents the tasks that causal models must provide to be useful and classifies the libraries available to build these models according to these tasks.

B.2 The Seven Tools of Causal Inference

According to Pearl (Pearl and MacKenzie, 2019), causal models need to provide seven tasks to be useful. The following is an overview of these tasks in the SCM framework, the tools used in each, and the unique contribution each tool makes to the art of automated reasoning.

- **Coding Causal Assumptions** - Transparency and Verifiability. Transparency allows analysts to discern whether the coded assumptions are plausible or whether additional assumptions are warranted. Testability allows one to determine whether the coded assumptions are compatible with the available data and, if not, to identify those that need to be repaired. Testability is facilitated by the graphical criterion d-separation, which provides the fundamental connection between causes and probabilities (Pearl, 2008).
- **The do-Calculus and Confounding Control**. For models where the backdoor criterion is not met, the do-Calculus is available, which predicts the effect of interventions whenever possible (Shpitser and Pearl, 2008).
- **The Algorithmisation of Counterfactuals**. This task formalises the counterfactual reasoning within the graphical representation. Each structural equation model determines the truth value of each counterfactual statement.
- **Mediation Analysis and Evaluation of Direct and Indirect Effects**. This task refers to the mechanisms that transmit changes from a cause to its effects, which is essential for generating explanations, and counterfactual analysis must be used to facilitate the identification of these.
- **Adaptability, External Validity and Sample Selection Bias**. Robustness is recognised by AI researchers as a lack of adaptability that comes to the fore when environmental conditions change. The do-Calculus offers a comprehensive methodology to overcome biases due to changes in the environment.

It can be used to readjust learned policies, to circumvent changes in the environment and to control for disparities between non-representative samples and a target population (Bareinboim and Pearla, 2016).

- **Recovery of Missing Data**. The use of causal models can formalise the conditions under which causal and probabilistic relationships can be recovered from incomplete data and, provided the conditions are met, produce a consistent estimate of the desired relationship.

- **Causal Discovery.** The d-separation criterion detects and lists testable implications of a given causal model. This opens up the possibility of inferring, with mild assumptions, the set of models that are compatible with the data, and of representing this set in a compact form. Under certain circumstances, the set of compatible models can be significantly pruned to the extent that causal questions can be estimated directly from that set (Jaber et al., 2019).

In addition to these seven tasks, certain implementation aspects have been taken into account for the selection of the library:

Licensing. The licence that the library and the rest of the environment (IDE) have. Only open source models have been found.

- **Programming language**. The programming language used to build the models. All the libraries considered are implemented in R or Python, some of them accept both.
- **Documentation and Support Channels**. In all cases there is good written documentation (tutorials, API descriptions, examples and Q&A guides).
- **Tools for writing Causal Diagrams**. Availability of support tools for writing from scratch, uploading and modifying and converting from different file formats the causal diagram.

Table B.1 presents the different libraries considered, as well as their main features based on the seven tasks and implementation requirements detailed above. As can be seen, DoWhy (Sharma, Kiciman et al., 2019 and Sharma and Kiciman, 2020) is the only library that covers all the tasks. Moreover, it has a very permissive licence, has several bindings to different programming languages and has one of the most active communities. For all these reasons, DoWhy, implemented through the Python programming language, will be the library used to implement the Causal model that will be developed in the project.

KEY FEATURES	DAGitty	DoWhy	Causal Graph Models	Causality	Causal Inference
Codification of assumptions causality, Transparency and Verifiability	✓	✓	✓	✓	✓
do-Calculus and Confusion control	✓	✓	✓	✓	✓
Algorithmization of Counterfactuals	✓	✓		✓	✓
Mediation analysis and Evaluation of direct and indirect effects	✓	✓	✓	✓	✓
Adaptability, External validity and Sample selection bias	✓	✓			
Lost data recovery		✓			
Discovery of the cause	✓	✓	✓	✓	
Tools for generating causal diagrams	✓	✓	✓	✓	✓
Licence	GNU	MIT	MIT	Open	BSD
Programming language	R	R & Py	Py	Py	Py
Documentation and support					
	R - R language, **Py** - Python				

Table B.1: Main features of the libraries available to implement the Causal Model

B.3 **DoWhy – A library for causal inference**

The Microsoft Research blog introduces "Do-Why" a new software library designed to facilitate the widespread use of causal inference in computer science (Sharma and Kiciman, 2018), inspired by Judea Pearl's (Pearl and MacKenzie, 2019) do-calculus.

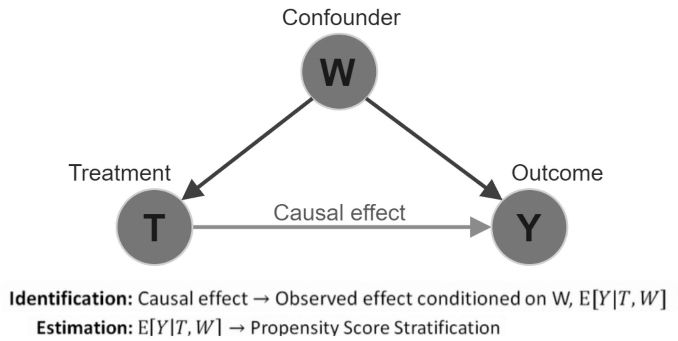


Figure B.7: DoWhy. Separating identification and estimation of causal effect.

This library is particularly relevant as computing systems increasingly intervene in various aspects of work and daily life, raising important cause-and-effect questions. DoWhy aims to address the critical yet often overlooked assumptions underlying causal inference analyses by making these assumptions explicit and incorporating sensitivity analysis and other robustness checks as integral parts of the causal inference process. The library distinguishes between identification and estimation, emphasizing the importance of explicitly representing identified estimands and testing the robustness of estimates against violations of underlying assumptions (fig B.7. This approach is intended to help users focus on identifying and validating key assumptions in their causal inference analyses (Sharma and Kiciman, 2018).

B.4 **Psychological theories**

B.4.1 **Social Cognitive Theory and Agency**

The concept of collective agency and self-determination (understood as empowerment) is closely linked to the theories of Human Development and the capabilities approach (Sen, 2000). This approach, also known as the capabilities approach, is based on Sen's revision of Rawls' theory of justice (Rawls, 1999) in terms of primary goods, which translates into a theoretical approach to assess various aspects of individual, group and societal well-being, such as inequality, poverty, lack of development and quality of life. This capabilities approach has a highly evaluative and normative dimension and this is where the concept of agency comes in. According to Sen, agency is the ability to define one's own goals autonomously and to act on them: "that which a person is free to do and achieve in pursuit of goals or values that he or she considers important" (Sen, 2000). In subsequent literature this definition has been complemented as a way of explaining aspects of autonomous human functioning (Alkire, 2008; Sydie and Archer, 2002; Bandura, 1989; Kagitcibasi, 2005) by referring to personal competence, placing the main focus on the individual as an actor operating in a social context. As a concept with a strong evaluative dimension, the Personal Agency and Empowerment Scale (Pick et al., 2007), which incorporated items grouped into the following variables: 1) Self-efficacy, 2) Self-determination, 3) Control over my behaviours, 4) Independent thinking, 5) Identification of need for change, 6) Fear of success, 7) Recognition of my learning, 8) Perception of my context and 9) Control over my environment, seems particularly relevant to us. Fig. B.8 graphically represents this.

Very tightly coupled with agency concepts, the Social Cognitive Theory is a theory about how humans learn behaviour by observing it in our environment (Bandura, 2002). This theory models the interaction that occurs between an individual and the environment. For this reason, it is supported by three main aspects: Environmental Factors, Behavioural Factors, and Cognitive Factors, also called Personal Factors. In the Social Cognitive Theory, a key concept developed by Bandura was reciprocal determinism, which states that a person's behaviour both influences and is influenced

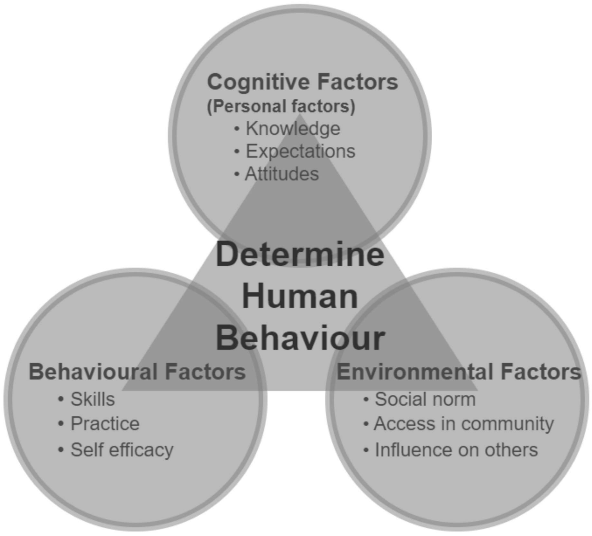


Figure B.8: Main components of the Social Cognitive Theory

by personal factors and the social environment. This concept was born in contrast to previous theories of learning that argued that people's behaviour was always controlled by the environment or the rewards that were given to them (Catania et al., 1988). Observational learning is then the main concept of the Social Cognitive Theory. Bandura argued that learning can occur even in the absence of reinforcement and punishment and people can learn by simply observing others or collaborating with others as in the CoP. Besides, Social Cognitive Theory advocates for fostering people's expectations. This refers to the anticipated consequences of a person's behaviour. People anticipate the consequences of their actions before engaging in the behaviour, and these anticipated consequences can influence successful completion of the behaviour or enrollment. Finally, Social Cognitive Theory fosters the Self-efficacy which refers to the level of a person's confidence in his or her ability to successfully perform a behaviour. Self-efficacy is influenced by a person's specific capabilities and other individual factors, as well as by environmental factors (barriers and facilitators). The collective dimension of the Social Cognitive Theory proposes three levels of agency (Bandura, 2002): 1) personal agency exercised individually; 2) proxy agency in which people secure desired outcomes by influencing others to act on their behalf; and 3) collective agency in which people act in concert to shape their future. This final level is also encompassed by the perceived collective efficiency representing shared beliefs in the power to produce desired effects by collective action. Perceived collective efficiency is not simply the sum of the efficiency beliefs of individual members. Rather, it is an emergent group-level property that embodies the coordinative and interactive dynamics of group functioning. In essence, according to this theory, interventions should:

- Promote role models who practise the desired behaviours and experience resulting benefits. This can be done through education activities, and through community events in which people performing the desired behaviours are celebrated so others can be influenced by them.
- Promote the intrinsic and extrinsic rewards and benefits that can be expected from engaging in the desired behaviours.
- Provide information, tools and skills to increase people's perceived ability to engage in the desired behaviours.

Finally, it is worth mentioning that the collective efficacy pathway proposed by Bandura is only one of the options for the people to take collective action. Other models (Bamberg et al., 2015) reviewed are: 1) The cost-benefit pathway; 2) The group-based emotions pathway; and 3) The social identity pathway. The emerging model will be fed by the collective efficacy pathway, though.

B.4.2 **Self-determination Theory, Social practice and Basic Psychological needs**

The Social Practice theory explores how practices are constructed (Shove et al., 2012). In this theory practices are contextualized as units of analysis, understanding them like an entity composed of three main elements. These elements are human competencies (i.e., skills and knowledge needed to perform a practice), meaning (i.e., emotions and feelings emerged from the practice) and materials (e.g., artefacts, tools, and infrastructures). This framework considers these elements as linked, and thus, any changes will have an impact on the entire practice. Following this rationale, any variation in materials will influence the meaning of the practice. Pre-defining the meaning of a practice will not get people to engage in it. The question of why people engage in some practices and not others is based on their motivation. Hence, an effective, sustainable practice is both motivating and pro-environmental. Considering the motivation to perform a practice, Klapperich et al. propose an approach that links the fulfilment of basic psychological needs (e.g., competence, relatedness, autonomy) with the meaning of practices. Based on Experience Design (Shove et al., 2012; Hassenzahl et al., 2013) the approach describes that the design of the technology forms the meaning of a practice. However, people are more likely to perform a practice if it fulfils a psychological need (i.e., is motivating). Thus, if an individual feels genuinely motivated when performing a specific practice, she will find it enjoyable and, therefore, will engage with it. Thus, the following work aims at finding the motivations and pleasures of being sustainable to improve the individuals' wellbeing while developing Pro-Environmental actions.

Furthermore, among the most influential models in contemporary behavioural science, self-determination theory offers a broad framework for understanding the factors that promote human motivation and psychological flourishing. In this authoritative work SDT co-founders Richard M. Ryan and Edward L. Deci systematically review the theory's conceptual underpinnings, empirical evidence base, and practical applications across the lifespan (Ryan and Deci, 2017). Ryan and Deci demonstrate that supporting people's basic needs for competence, relatedness, and autonomy is critically important for virtually all aspects of individual and societal functioning as can be seen in Fig. B.9. In their manuscript, beginning with theoretical foundations, they explored how self-determination theory was developed and how it diverges from other major approaches to human motivation and self-regulation.

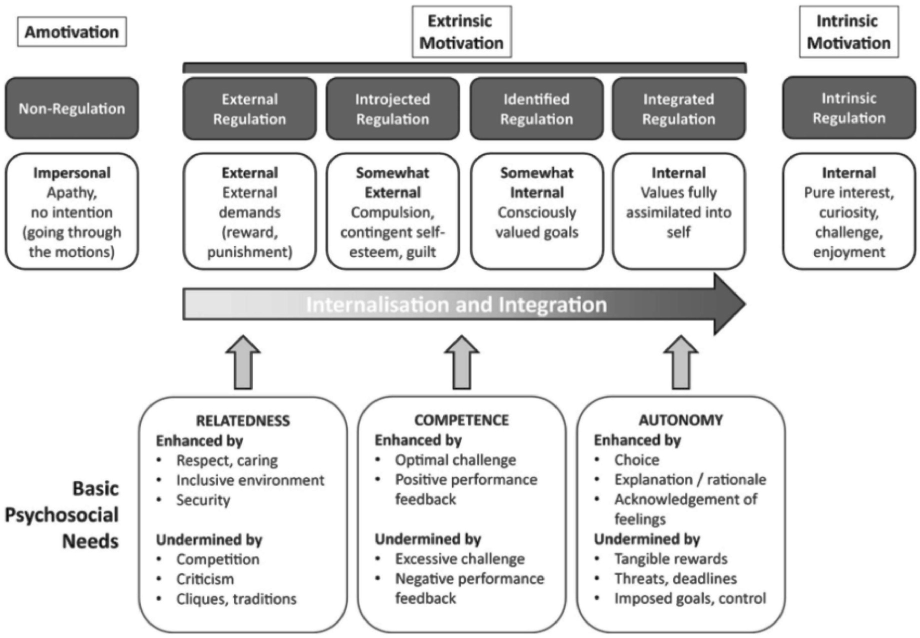


Figure B.9: Self-determination theory. Three main motivation types: amotivation (lack of motivation), extrinsic motivation and intrinsic motivation, and six 'regulatory styles' (dark-background boxes). Intrinsic motivation (intrinsic regulation) is entirely internal, emerging from pure personal interest, curiosity or enjoyment of the task. At the other extreme, amotivation (non-regulation) results in inaction or action without real intent. In the middle is extrinsic motivation, with four regulatory styles that vary from external regulation (actions motivated purely by anticipated favourable or unfavourable consequences) to integrated regulation (in which external values and goals have become fully integrated into one's self-image). The transition from external to integrated regulation requires that values and goals become internalised (personally important) and integrated (fully assimilated into one's sense of self). Internalisation and integration are promoted (or inhibited) by fulfillment (or non-fulfillment) of three basic psychosocial needs: relatedness, competence and autonomy.

B.5 Transtheoretical model

The Transtheoretical Model (TTM) uses a temporal dimension, the stages of change, to integrate the processes and principles of change from the major intervention theories. This model emerged from a comparative analysis of the major theories of psychotherapy and behaviour change in an effort to integrate a field that had become fragmented into over 300 theories (Prochaska and Clemente, 1982).

This impetus for the model emerged when Prochaska conducted a comparative analysis of people who quit smoking independently with those who undergo professional treatment. Ten processes of change were identified as preceding successful smoking cessation, including awareness from Freud's theory, contingency management from Skinner's theory, and helping relationships from Rogers' theory (Prochaska et al., 2008):

- **Awareness**. Finding and learning new facts, ideas and advice that support behaviour change.
- **Meaningful relief**. Experiencing the negative consequences of engaging in a certain behaviour.
- **Self-re-evaluation**. Realising that behaviour change is an important part of one's identity as a person.
- **Environmental reappraisal**. Realising the impact of behaviour change on the immediate environment.
- **Self-liberation** - making a firm commitment to change.
- **Helping relationships**. Seeking and using social support for behaviour change.
- **Counter-conditioning**. Substitution of the behaviour with a more appropriate alternative.
- **Reinforcement management**. Increasing rewards for positive behaviour change and decreasing rewards for negative behaviour change.
- **Stimulus control**. Adding cues or reminders to perform the more appropriate behaviour.
- **Reinforcement management**. Increasing rewards for positive behaviour change and decreasing rewards for negative behaviour change.
- **Stimulus control**. Adding cues or reminders to perform the most appropriate behaviour.
- **Social release**. Realising that social norms are changing in the direction of supporting appropriate behaviour change.

Participants used different processes at different times in their struggle with addiction. These individuals revealed to the researchers that behaviour change develops through a series of stages, a phenomenon that was not captured in any therapeutic theory and which led to the development of Temporomandibular Disorders (TMD).

Stages of change

In the past, behaviour change was understood as a discrete event, such as quitting smoking. TTM characterises behaviour change as a process that unfolds over time, a non-linear transition through a sequence of qualitatively distinct stages. At each stage there are individual, stage-specific sources of resistance to change that can keep people stuck at an early stage for a long period of time, so specific skills and strategies are needed. A successful transition through the stages is reflected in increasing readiness to change. The TTM is based on six stages of change:

- **Precontemplation**: a stage where people do not intend to act for a short period of time, usually measured as the next six months. People may be in this stage because they are not well informed about the consequences of their behaviour or they may have tried to change several times and have become demoralised.
- **Contemplation**: A stage where people are trying to change their behaviour over the next six months. They are more aware of the pros of change but are also very conscious of the cons. This balancing of pros and cons can produce deep ambivalence and keep people stuck in contemplation for long periods of time.
- **Preparation**: a stage where people intend to act soon, usually within the next six months. Usually they have already taken some significant steps towards the behaviour in the last year and have a plan of action.
- **Action**: the stage where people have made concrete and overt lifestyle changes in the last six months. Not all behavioural changes count as action in this model, certain criteria that scientists and practitioners consider sufficient must be met.

- **Maintenance**: the stage where people have made specific and overt lifestyle modifications and work to avoid relapse, they do not apply the change processes as frequently as people in action. They are increasingly confident that they can continue with the changes.
- **Completion**: stage where people have zero temptation to relapse and 100% self-efficacy. It is as if the behaviour never existed in the first place or their new behaviour has become automatic. This criterion may be too strict, being an ideal goal for most people.

Evolution of the Transtheoretical Model

Originally the TTM was developed to understand the adoption of personal health behaviours, however, this model has been transferred to other fields. Bamberg proposed the Stages Model of Self-Regulated Behaviour Change, a model that assumes that environmental behaviour change can be characterised as a transition through an orderly sequence over time through four qualitatively different stages, the name of which is borrowed from the Transtheoretical Model.

The TTM has been criticised for being a mainly descriptive model, which does not provide clear answers to important questions such as the separation of the stages and the processes that trigger the transition between them. For this reason, the Stages Model of Self-Regulated Behaviour Change integrates the stage concept with well-established constructs taken from the TPB (Bamberg, 2013) and the Norm Activation Model (NAM), giving a detailed description of the tasks that a person has to solve in the four stages considered, as well as the specific cognitive mindset that people adopt to solve them. The model assumes that the transition through the stages is marked by three critical transition points, goal intention, behavioural intention and performance intention, which reflect the successful solution of the specific tasks of each stage:

- **Precontemplation**: the process of change begins when people start to consciously reflect on their current behaviour, realising that it causes negative social and environmental effects. If the person accepts their individual responsibility, they will experience negative effects such as guilt and feel concerned about what others expect them to do (social norms), feeling obliged to change this behaviour (personal norm).

If the personal norms and the positive emotions for meeting them are strong and the perceived feasibility of changing the current behaviour is high, a goal intention is formed which indicates the transition to the second stage.

- **Contemplation**: the person values the personal consequences associated with alternative behavioural options (reflected in their attitude), as well as that of carrying it out (reflected in perceived behavioural control). Behavioural intention, which marks the transition between the contemplation stage and the preparation/action stage, is the result of the person's weighing of the pros and cons of different behavioural options to achieve the goal, as well as the perceived difficulty of carrying out these options.
- **Preparation/action**: The main task of this stage is to initiate the actions necessary to implement the new behavioural intentions. This is done by planning when and where to act in order to achieve the intended goal by performing the intended behaviour. Here, cognitive planning abilities and skills to cope with actual or anticipated performance problems are important variables. At the end of this phase, an implementation intention is established and the behaviour is carried out.
- **Maintenance**: involves the stabilisation of the modified behaviour and the implementation of new routines or behavioural habits based on the modified behaviour. The task at this stage is to cope with unpleasant experiences with the new behaviour and the consequent temptation to return to the previous behaviour.

This requires the skills to resist this temptation and, if a relapse occurs, the skills to recover and re-establish the new behaviour, This is shown in Fig B.10.

This model is used in the systematic development of interventions aimed at promoting environmentally relevant behaviour change. Christian Klöckner, using a variation of the Stages of Self-Regulated Behaviour Change Model, tested the specific effect of 24 barriers and drivers at different stages of decision-making on energy

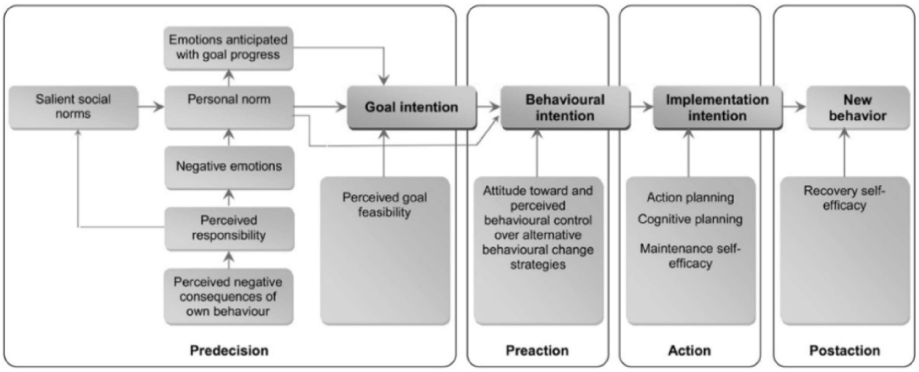


Figure B.10: Stages of self-regulated change model.

efficiency improvement in private households (Gatersleben et al., 2016). In his study, he proposes the use of four distinct stages. The first stage is "not being in decision mode", which corresponds to the mindset of the precontemplation stage in Bamberg's model. The second he called "deciding what to do", which has a clear link to the contemplation stage.

The third, "deciding how to do it" would be positioned between contemplation and action. And finally, the fourth stage, "deciding how to implement it" corresponds to Bamberg's action stage. The figure below shows the most relevant barriers and drivers for progression through the different stages.

The third, "deciding how to do it" would be positioned between contemplation and action. And finally, the fourth stage, "deciding how to implement it" corresponds to Bamberg's action stage. The figure below shows the most relevant barriers and drivers for progression through the different stages. The analysis of barriers and drivers for energy efficiency improvement decisions at each stage provides information that would be lost if the barriers and drivers were analysed without taking into account how far the decision-maker has gone in the decision making process. In this study, the non-linearity of the process is not sufficiently represented and the last stage of the decision process, i.e. whether the measures decided upon were actually implemented at some point in time, was not taken into account.

At the same time, the correlations between stages 2-4 are high, indicating that they are probably not sufficiently distinct or that the measurement instrument was not good enough.

Despite these drawbacks, these results could be used to find ways to promote the adoption of energy efficiency measures in residential buildings and other high-cost pro-environmental investments. They can also be used to adapt communication and support schemes, both public and private, to get stakeholders over the threshold to implement this technology.

Undoubtedly, this is one of the main objectives of the WHY project, to find the causes that lead to the adoption of measures for the decarbonisation of the residential sector in order to be able to intervene on them through different policies. This is why the different Causal Models that are built for the different aspects of the energy transition are based on the Transtheoretical Model described in this section, and in particular, the model described in Klöckner and Nayum (Gatersleben et al., 2016). This is intended to provide the Causal Models with a faithful representation of human behaviour, and with the main drivers that lead to positive change in it.

B.5.1 Pro-Environmental Behavior Theory

The Value-Belief-Norm (VBN) theory was used to understand the acceptability and expected effects of a car pricing policy (Hiratsuka et al., 2018). It explores how biospheric, altruistic, and egoistic values influence beliefs, norms, and behaviors related to environmental policies. The study found that biospheric values lead to stronger pro-environmental beliefs and norms, while hedonic values have the opposite effect. This research highlights the critical role of personal values in shaping sustainable transportation choices and supporting the energy transition through informed policy design.

These insights can guide the design of effective policies for the energy transition in four key areas: promoting sustainable mobility, encouraging participation in Local Flexibility Markets, fostering energy-efficient behaviours in buildings, and increasing the use of energy-efficient appliances. By understanding and leveraging the values

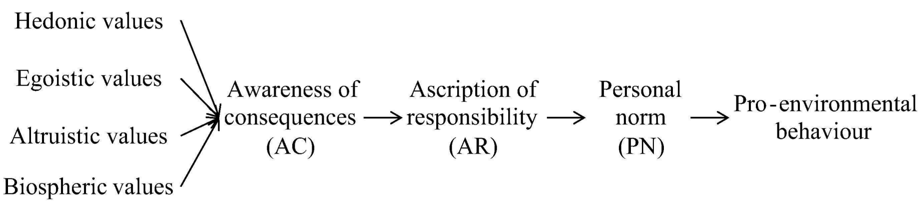


Figure B.11: Relationships between values, pro-environmental beliefs, norms, and behaviour in an adapted VBN theory tested in this study.

driving these behaviours, policymakers can create targeted interventions to support the transition and mitigate climate change.

B.5.2 Theory of Planned Behavior (TPB)

The Theory of Planned Behavior (TPB) (Ajzen, 1991b), posits that behavioural intentions are influenced by three key factors:

- **Attitudes**: Reflect an individual's overall evaluation of the behaviour. In the context of energy consumption, this involves beliefs about the benefits or drawbacks of energy-saving actions.
- **Subjective Norms**: Represent perceived social pressure to engage in energy-saving actions. This includes beliefs about whether important others approve or disapprove of these behaviours.
- **Perceived Behavioral Control**: Relates to an individual's belief in their ability to perform the behaviour. For energy consumption, this might involve beliefs about one's capacity to implement energy-saving measures.

These factors collectively shape intentions, which in turn predict actual energy-saving behaviours including green purchasing and energy-saving practices as is shown in Fig B.12.

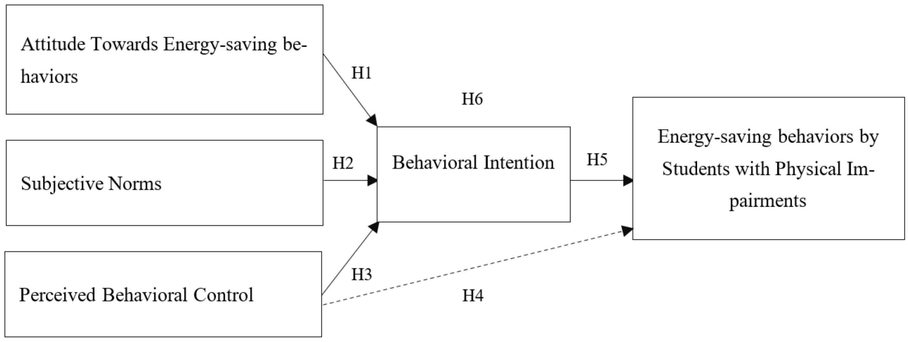


Figure B.12: Theoretical Framework of the Theory of Planned Behavior. H1 - Attitude towards energy-saving behaviours positively impacts the intentions of students with physical impairments to perform energy-saving behaviours. H2 - Subjective norms positively impact the intentions of students with physical impairments to perform energy-saving behaviours. H3 - Perceived behavioural control positively impacts the intention of students with physical impairments to perform energy-saving behaviours. H4 - Perceived behavioural control positively impacts the participation of students with physical impairments in energy-saving behaviours. H5 - Intention to perform energy-saving behaviours positively impacts the participation of students with physical impairments in energy-saving behaviours. H6 - Intention to perform energy-saving behaviours mediates the effect of perceived behavioural control on the energy-saving behaviours of students with physical impairments.

APPENDIX

C

Templates for Experts: Contributions on the key factors for achieving fictional scenarios

Mobility

Introduction

We have created four speculative scenarios in order to obtain from **you** as an expert a set of **specific determinants or factors that <u>may cause an investment decision</u> by family units, either monetary or behavioural, to make the family unit to become a prosumer**.

Each scenario describes a different reality for each of the aspects analysed. Please remember, the scenarios described here do not reflect a specific individual building, but are rather a representation of the majority of households in a city.

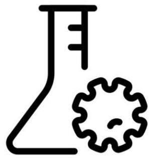
Remember that we are asking about **your opinion as an expert** taking into account not only your experience and beliefs but also the state of the art you know [but you should not include references therein].

We will start from the baseline scenario and we build on it throughout this document. Thanks a lot for your time!

Base Scenario

You live in a metropolitan area where almost everyone has at least one combustion car. The car is used extensively, even for destinations easily reachable on foot or with personal mobility devices (i.e. bicycles). Public transport in short distance travels is seldom used, either by people that do not own a vehicle or for travel to zones where it is difficult to find parking. The public transport is partly electrified, though still dependent on fossil fuels. Traveling by foot or using personal mobility is common in some regions but is far from being the typical means of transport. Large distances are travelled usually by public transport or by private car more or less evenly. In low population density zones the only viable option is to have a car as the public transport is non-existent and the distances to travel are too large to be covered by other means of transport

Dry run!



In the following slides, we will provide an example of what we are expecting from you in each of the four scenarios. <u>We will start with the dry run.</u>

Just relax and see :)

Dry run - This is a (test) example of a speculative scenario on top the baseline provided before

---

WHY

You start looking for information to help determine whether or not to invest in the technologies involved to become a prosumer. You ask advice from friends who are already prosumer and **you conclude that the easiest way to participate on these actions is buying a private electric vehicle (e.g. car, bicycle, scooter)**

Dry run - after reading the scenario…

WHY

… You will be provided with a canvas/framework in which you will have to fill determinants **(i.e., intrinsic and extrinsic factors that trigger a purchase decision)**. We will also ask you about barriers and rebound effects for each scenario.

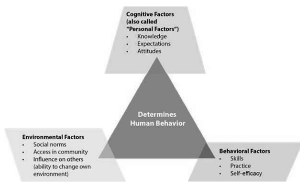
But before, we will be always offering you some tips to provide these determinants. See the next slide.

Social Cognitive Theory can help you understand better the type of determinants we expect

WHY

The Social Cognitive Learning Theory acknowledges the constant interaction that exists between the individual and his or her environment, both structural and social, to shape behavior. Three personal cognitive factors that are affected by the environment influence behavior:

- **Observational learning:** Individuals are more likely to perform a desired behavior if they observe others modeling that behavior and experiencing the subsequent positive rewards.
- **Outcome expectations:** Individuals are more likely to practice a desired behavior if they believe the benefits of performing that behavior and outweigh the costs.
- **Self-efficacy:** Individuals are more likely to practice a desired behavior if they perceive that they have the necessary skills and capacity to do so (Bandura, 2001; Glanz & Rimer, 2005).



Source: https://sbccimplementationkits.org/

(intrinsic/extrinsic) weighted causal determinants to happen:

In your opinion, which are the internal (sticky note green) & external factors (sticky note blue) that would lead you to invest your time and resources in this scenario. Please, indicate the most relevant determining factors for you as an expert by using the post-its of different colors below. **Recall that you can use either abstract factors (environmental concern or peer pressure) or more specific real factors (worries about the future generations - e.g., your children- or for the peer pressure, your closest neighbour is everyday posting green actions in its social networks and you want imitate him).**

- **Self-efficacy**: I am doing this purchase I feel more confident
- **Savvy**: I can estimate fuel a[…] maintenance savings
- **Self-perception**: I feel better after this purchase because I feel that I am contributing to fight climate change
- **Self-determination**: I am confident that this behaviour is positive for the society
- **Social proof**: I have read that people similar to me make the same purchase
- **Social norms**: I think that my closer community will never do more steps than this
- **Others judgements**: If I buy a electric car my peers will think I am rich [when I am not]
- **Money**: In the long term, fuel savings offset purchase price
- **External recognition**: Buying an electric vehicle grants you recognition

(in/extrinsic) Barriers to occur it happens:

What are the main factors that would hinder you to make the aforementioned investments to achieve this scenario?

- lack of knowledge on electric vehicles and their performance
- Lack of trust on the concept of free maintenance
- Lack of positive attitude towards new technologies and climate change

Rebound effects from the scenario:

What are the main rebound effects (RE) for you and others that would have appeared if the scenario happened? Recall that the simplest illustration of the RE is: **"Buy a more fuel-efficient car, drive more."** (i.e. Jevons' paradox)

- The initial price could mean reducing everyda[…] financial slack
- The public infrastructure for electric charging is sti[…] limited
- Difficulties in maintaining the attitude in favor of climate change

Hands on in the real scenarios (your turn)!

WHY

FOR YOU

Please read the four speculative scenarios and **provide a comprehensive list of relevant factors for the decision-making determinants. Your input will be structured as the example in the dry run**.

Therefore, we ask you to **provide as many determinants, which cause an purchase decision of an electric car, the public transport uptaking by family units in each scenario, as possible (we will provide some references after each scenario to inspire you)**.

Remember that we are asking about **your opinion as expert** taking into account not only your experience and believes but also the state of the art you know [but you should not include references therein].

Please, recall the baseline scenario on slide **3** and **let's start with the minimum scenario!**

Minimum Scenario

WHY

All transport modes are free of emissions (mainly electric except for very long range transport modes). Gas stations are converted into fast charging points and slow charging points are deployed everywhere. Apart from that, the behaviour of the citizens does not change.

(intrinsic/extrinsic) weighted causal determinants to happen: Minimum Scenario

In your opinion, which are the internal (sticky note green) & external factors (sticky note blue) that would lead you to invest your time and resources in this scenario. Please, indicate the most relevant determining factors for you as an expert by using the post-its of different colors below. **Recall that you can use either abstract factors (environmental concern or peer pressure) or more specific real factors (worries about the future generations - e.g., your children- or for the peer pressure, your closest neighbour is everyday posting green actions in its social networks and you want imitate**

Put here some internal determinants

Put here some internal determinants

Put here some internal determinants

Put here some external determinants

Put here some external determinants

Put here some external determinants

(in/extrinsic) Barriers to occur it happens:

What are the main factors that would hinder you to make the aforementioned investments to achieve this scenario?

Put here some barriers

Put here some barriers

Put here some barriers

Rebound effects from the scenario:

What are the main rebound effects (RE) for you and others that would have appeared if the scenario happened? Recall that the simplest illustration of the RE is: **"Buy a more fuel-efficient car, drive more."** (i.e. Jevons' paradox)

Put some spillover effects here

Put some spillover effects here

Put some spillover effects here

Minimum Scenario is completed!

WHY

Minimum

Probable

Plausible

Ideal

Probable Scenario

WHY

All public transport and private cars are electric and a significantly lower number of vehicles are needed (mainly in low density zones). The migration to cities and the blooming of teleworking change the modal split towards public transport and new modes of mobility, such as e-hailing (e.g. Uber, Cabify, MyTaxi…), ride-sharing (e.g. BlaBlaCar) and micro mobility services (bikes, scooters, etc.). Car sharing (e.g. Car2go) and ride sharing businesses increase their market share even far from the big cities. Long distance transport is mostly made using high-speed trains and travel by plane is significantly reduced, mostly for long distances

(intrinsic/extrinsic) weighted causal determinants to happen: Probable Scenario

In your opinion, which are the internal (sticky note green) & external factors (sticky note blue) that would lead you to invest your time and resources in this scenario. Please, indicate the most relevant determining factors for you as an expert by using the post-its of different colors below. **Recall that you can use either abstract factors (environmental concern or peer pressure) or more specific real factors (worries about the future generations - e.g., your children- or for the peer pressure, your closest neighbour is everyday posting green actions in its social networks and you want imitate**

Put here some internal determinants

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(in/extrinsic) Barriers to occur it happens:

What are the main factors that would hinder you to make the aforementioned investments to achieve this scenario?

Put here some barriers

Put here some barriers

Put here some barriers

Rebound effects from the scenario:

What are the main rebound effects (RE) for you and others that would have appeared if the scenario happened? Recall that the simplest illustration of the RE is: **"Buy a more fuel-efficient car, drive more."** (i.e. Jevons' paradox)

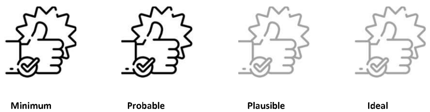
Put some spillover effects here

Put some spillover effects here

Put some spillover effects here

Probable Scenario is completed!

WHY



Plausible Scenario

WHY

Electric robotaxis and new modes of mobility (e-hailing, ride-sharing, micromobility, etc.), made private vehicles obsolete in cities and low density zones, but it is not possible to live without using them. Cities continue to have high traffic density but now have a far better air quality and there is more space for pedestrians. Public transport continues to be used for medium distances (intercity) but the tradicional public transport means inside the city almost disappears (cannibalized by new modes of mobility). Long-distance transport is mostly made using high speed trains and the amount of travel by plane is reduced.

(intrinsic/extrinsic) weighted causal determinants to happen: Plausible Scenario

In your opinion, which are the internal (sticky note green) & external factors (sticky note blue) that would lead you to invest your time and resources in this scenario. Please, indicate the most relevant determining factors for you as an expert by using the post-its of different colors below. **Recall that you can use either abstract factors (environmental concern or peer pressure) or more specific real factors (worries about the future generations - e.g., your children- or for the peer pressure, your closest neighbour is everyday posting green actions in its social networks and you want imitate**

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(in/extrinsic) Barriers to occur it happens:

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Put some spillover effects here

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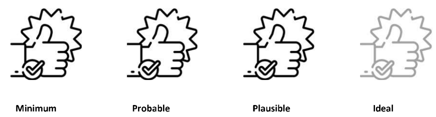
Plausible Scenario is completed!

WHY



Ideal Scenario

WHY

The cities are re-designed (for example with 15 mins cities or superblocks) in a way that all services are at foot distance so the number of vehicles is drastically reduced and a combination of public or private personal mobility, robotaxis and electric public transport supply the rest of travel needs (inter and intra city). For these reasons, traffic jams are something from the past. Long distance transport is only made using high speed trains and the amount of travel by plane is drastically reduced to intercontinental travel.

(intrinsic/extrinsic) weighted causal determinants to happen: Ideal Scenario

In your opinion, which are the internal (sticky note green) & external factors (sticky note blue) that would lead you to invest your time and resources in this scenario. Please, indicate the most relevant determining factors for you as an expert by using the post-its of different colors below. **Recall that you can use either abstract factors (environmental concern or peer pressure) or more specific real factors (worries about the future generations - e.g., your children- or for the peer pressure, your closest neighbour is everyday posting green actions in its social networks and you want imitate**

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(in/extrinsic) Barriers to occur it happens:

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Put some spillover effects here

Put some spillover effects here

Put some spillover effects here

Ideal Scenario is completed!

WHY

Minimum

Probable

Plausible

Ideal

Thank you!

WHY

If you have any questions or comments, please complete some sticky note(s) below.
We appreciate receiving additional relevant feedback, and will also take it into account.

WHY

Flexibility

WHY

Introduction

We have created four speculative scenarios in order to obtain from **you** as an expert a set of **specific determinants or factors that may cause an investment decision by family units, either monetary or behavioural, to make the family unit to become a prosumer.**

Each scenario describes a different reality for each of the aspects analysed. Please remember, the scenarios described here do not reflect a specific individual building, but are rather a representation of the majority of households in a city.

Remember that we are asking about **your opinion as an expert** taking into account not only your experience and beliefs but also the state of the art you know [but you should not include references therein].

We will start from the baseline scenario and we build on it throughout this document. Thanks a lot for your time!

WHY

Base Scenario

You live in a home that has poor insulation and fossil fuel-based heating (such as lignite, heating oil, or natural gas). It does not have mechanisms for generating or storing energy (except for a small thermal storage tank). The household appliances are not very efficient and there is no energy management system. Your electricity rate does not include time-of-use tariffs, so you do not worry about when you use the appliances. Simply, when you need them, you plug in and use them.

WHY

Dry run!

In the following slides, we will provide an example of what we are expecting from you in each of the four scenarios. We will start with the dry run.

Just relax and see :)

Dry run - This is a (test) example of a speculative scenario on top the baseline provided before

---

WHY

You start looking for information to help determine whether or not to invest in the technologies involved to become a prosumer. You ask advice from friends who are already prosumer and **you conclude that the easiest way to participate on these actions is to invest in a crowdfunding campaign to deploy a PV array in the roof of a public building of your city**.

Dry run - after reading the scenario…

WHY

… You will be provided with a canvas/framework in which you will have to fill determinants **(i.e., intrinsic and extrinsic factors that causes an investment decision)**. We will also ask you about barriers and rebound effects for each scenario.

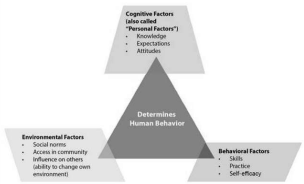
But before, we will be always offering you some tips to provide these determinants. See the next slide.

Social Cognitive Theory can help you understand better the type of determinants we expect

WHY

The Social Cognitive Learning Theory acknowledges the constant interaction that exists between the individual and his or her environment, both structural and social, to shape behavior. Three personal cognitive factors that are affected by the environment influence behavior:

- **Observational learning:** Individuals are more likely to perform a desired behavior if they observe others modeling that behavior and experiencing the subsequent positive rewards.
- **Outcome expectations:** Individuals are more likely to practice a desired behavior if they believe the benefits of performing that behavior and outweigh the costs.
- **Self-efficacy:** Individuals are more likely to practice a desired behavior if they perceive that they have the necessary skills and capacity to do so (Bandura, 2001; Glanz & Rimer, 2005).



Source: https://sbccimplementationkits.org/

(intrinsic/extrinsic) weighted causal determinants to happen:

In your opinion, which are the internal (sticky note green) & external factors (sticky note blue) that would lead you to invest your time and resources in this scenario. Please, indicate the most relevant determining factors for you as an expert by using the post-its of different colors below. **Recall that you can use either abstract factors (environmental concern or peer pressure) or more specific real factors (worries about the future generations - e.g., your children- or for the peer pressure, your closest neighbour is everyday posting green actions in its social networks and you want imitate him).**

- **Self-efficacy**: I am used to this type of investment so I feel more confident
- **Savvy**: I can estimate the returns on investment easily and with low risk
- **Self-perception**: I feel better after this investment as I feel I am contributing to fight climate change
- **Self-determination**: I am confident that this behaviour is positive for the society
- **Social proof**: I have read that people similar to me make the same investments
- **Social norms**: I think that my closer community will never do more steps than this
- **Others judgements:** If I invest PV panels my peers will think I am rich [when I am not]
- **Money**: the interest rate seems fair
- **External recognition**: Investment in green technologies grants you recognition

(in/extrinsic) Barriers to occur it happens:

What are the main factors that would hinder you to make the aforementioned investments to achieve this scenario?

- Lack of competitiveness of the interest rates
- Lack of trust on the crowdfunded platforms
- Lack of knowledge about the opportunities

Rebound effects from the scenario:

What are the main rebound effects (RE) for you and others that would have appeared if the scenario happened? Recall that the simplest illustration of the RE is: **"Buy a more fuel-efficient car, drive more."** (i.e. Jevons' paradox)

- It is a relative hig[h] risk investment t[hat] should be controlled
- If the market is saturated it is possible to have a lack of professional that affect the quality of the installations
- The abuse of the instrument could make more difficult other actions more relevant for the energy transition

Hands on in the real scenarios (your turn)!

WHY

Please read the four speculative scenarios and **provide a comprehensive list of relevant factors for the decision-making determinants. Your input will be structured as the example in the dry run**.

FOR YOU

Therefore, we ask you to **provide as many determinants, which cause an investment decision by family units in each scenario, as possible (we will provide some references after each scenario to inspire you)**.

Remember that we are asking about **your opinion as expert** taking into account not only your experience and believes but also the state of the art you know [but you should not include references therein].

Please, recall the baseline scenario on slide **3** and **let's start with the minimum scenario!**

Minimum Scenario

WHY

A new electric tariff scheme has been approved, so several time-of-use tariffs are defined, with the possibility of each hour of the day having a different price. Since the difference between the low and high-tariff hours could be substantial, you decide to use an APP that informs you of the prices each day and you change your behaviour as much as you can. This includes the installation of several smart plugs to control some loads and adjusting the thermostat and other controls in accordance to the hours when the price signal is low.

Remember!

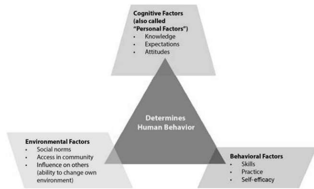
WHY

According to the existing literature, it seems that internal factors such **as personal beliefs, values or environmental concern (e.g. someone may feel we, as society, are not doing enough against climate change)** are the prominent drivers that foster a change in people's daily behaviour to invest time and effort in reducing the carbon and energy footprint in their personal dwelling.

Besides, the dominant external factors for such pro-environmental behaviour to occur seem to be **peer pressure (e.g. your partner is already doing energy efficiency actions), social comparison (e.g. your neighbours do green actions and exhibit them openly) and social norms (e.g. doing energy efficiency actions is well recognised in your community and may enhance your social capital)**.

Tip or helping guide: Clusters of factors that affects someone's behaviour

WHY



EXTRA TIP!

First consider that your property is a single-family house (SFH) in each scenario. Then, think about what would change in the scenarios if you were the owner of a multifamily residential unit (multi-dwelling unit, MDU) instead of a SFH. Finally, considering you are a tenant of the property instead of being an owner, what would change in the scenarios?

WHY

(intrinsic/extrinsic) weighted causal determinants to happen: Minimum Scenario

In your opinion, which are the internal (sticky note green) & external factors (sticky note blue) that would lead you to invest your time and resources in this scenario. Please, indicate the most relevant determining factors for you as an expert by using the post-its of different colors below. **Recall that you can use either abstract factors (environmental concern or peer pressure) or more specific real factors (worries about the future generations - e.g., your children- or for the peer pressure, your closest neighbour is everyday posting green actions in its social networks and you want imitate him).**

Add here internal factors | Add here intern factors | Add here internal factors | Add here exte factors | Add here external factors | Add here external factors

(in/extrinsic) Barriers to occur it happens:

What are the main factors that would hinder you to make the aforementioned investments to achieve this scenario?

Add here some barriers | Add here some barriers | Add here some barriers

Rebound effects from the scenario:

What are the main rebound effects (RE) for you and others that would have appeared if the scenario happened? Recall that the simplest illustration of the RE is: **"Buy a more fuel-efficient car, drive more."** (i.e. Jevons' paradox)

Add here rebound effects | Add here rebound effects | Add here rebound effects

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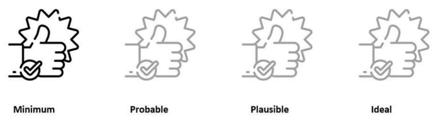
Minimum Scenario is completed!

WHY



Probable Scenario

WHY

Some problems have been detected in the house's roof and you or your neighbors have decided to carry out comprehensive renovations. As the building is already well insulated and a large portion of the roof needs to be refurbished, it has been taken the opportunity to install an electricity generation system based on Building Integrated PV. It will be integrated into the façade and an energy community will be created to distribute the energy generation.

(intrinsic/extrinsic) weighted causal determinants to happen: Probable Scenario

In your opinion, which are the internal (sticky note green) & external factors (sticky note blue) that would lead you to invest your time and resources in this scenario. Please, indicate the most relevant determining factors for you as an expert by using the post-its of different colors below. **Recall that you can use either abstract factors (environmental concern or peer pressure) or more specific real factors (worries about the future generations - e.g., your children- or for the peer pressure, your closest neighbour is everyday posting green actions in its social networks and you want imitate him).**

Add here internal factors

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Add here exte factors

Add here external factors

Add here external factors

(in/extrinsic) Barriers to occur if it happens:

What are the main factors that would hinder you to make investments to achieve this scenario?

Add here some barriers

Add here some barriers

Add here some barriers

Rebound effects from the scenario:

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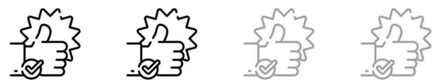
Add here rebound effects

Add here rebound effects

Add here rebound effects

Probable Scenario is completed!

WHY



Plausible Scenario

WHY

You or your neighbors decide to carry out a comprehensive refurbishment of the building including an improvement of the insulation, the deployment of an electricity generation system integrated into the façade and the creation of an energy community. Moreover, given the actual price of the storage and its durability, it also been decided to include the installation of a community battery and an energy management system to increase the long term return on investment.

(intrinsic/extrinsic) weighted causal determinants to happen: Plausible Scenario

In your opinion, which are the internal (sticky note green) & external factors (sticky note blue) that would lead you to invest your time and resources in this scenario. Please, indicate the most relevant determining factors for you as an expert by using the post-its of different colors below. **Recall that you can use either abstract factors (environmental concern or peer pressure) or more specific real factors (worries about the future generations - e.g., your children- or for the peer pressure, your closest neighbour is everyday posting green actions in its social networks and you want imitate him).**

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Add here rebound effects

Add here rebound effects

Add here rebound effects

Plausible Scenario is completed!

WHY

Minimum | Probable | Plausible | Ideal

Ideal Scenario

WHY

You live in a recently built passive house. The low heating demand is generated by an intelligent heat pump that uses low-temperature district heating as a source of energy. The heat pump also feeds the Domestic Hot Water (DHW). You have solar panels integrated into the building and a battery system that allows you to store excess daily energy to consume at night. The generation system is slightly oversized, and in summer, you have a surplus of energy generated that is used at the community electrolyzer that generates and stores H_2 that is later used in a community fuel cell CHP system. This CHP system only works in winter and is responsible for powering the district heating and helping the electricity generation during the low irradiation days. The system is controlled by energy management systems (EMS) that control not only the heat pump but also some other devices (including the battery, electrolyzer and the chargers of EVs). The EMS allows you to sell your energy surpluses and buy your energy needs from your neighbourhood. Moreover, all EMS coordinate with each other and can also participate in flexibility markets for the DSO, increasing or decreasing the energy consumption when requested. Of course, the appliances are all efficient and smart, and your electric rate is indexed (to the wholesale market or similar maket).

(intrinsic/extrinsic) weighted causal determinants to happen: Ideal Scenario

In your opinion, which are the internal (sticky note green) & external factors (sticky note blue) that would lead you to invest your time and resources in this scenario. Please, indicate the most relevant determining factors for you as an expert by using the post-its of different colors below. **Recall that you can use either abstract factors (environmental concern or peer pressure) or more specific real factors (worries about the future generations - e.g., your children- or for the peer pressure, your closest neighbour is everyday posting green actions in its social networks and you want imitate him).**

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Add here rebound effects

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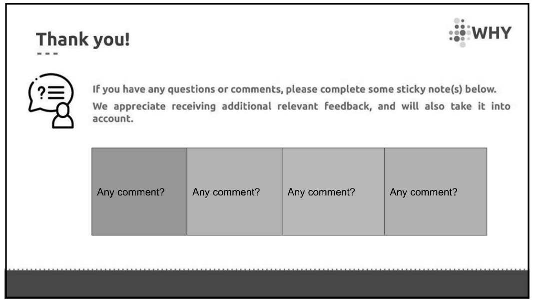
Ideal Scenario is completed!

WHY

Minimum | Probable | Plausible | Ideal


Thank you!
WHY
If you have any questions or comments, please complete some sticky note(s) below.
We appreciate receiving additional relevant feedback, and will also take it into account.
Any comment?
Any comment?
Any comment?
Any comment?

WHY

Appliances

WHY

Introduction

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Each scenario describes a different reality for each of the aspects analysed. Please remember, the scenarios described here do not reflect a specific individual building, but are rather a representation of the majority of households in a city.

Remember that we are asking about **your opinion as an expert** taking into account not only your experience and beliefs but also the state of the art you know [but you should not include references therein].

We will start from the baseline scenario and we build on it throughout this document. Thanks a lot for your time!

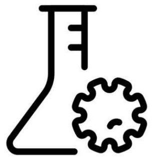
WHY

Base Scenario

You have been living in the same house since you moved for work 10 years ago. The appliances in your home are still working, but are starting to require repairs more and more frequently. This situation makes you question the cost-benefit of keeping the equipment and extending its useful life for longer, compared to upgrading them to more efficient options (esp. the most energy-consuming appliances like the refrigerator, TV, lighting, the oven or the ceramic hob). If your appliances were evaluated according to the new European labelling that goes from A (the most efficient) to G (the least efficient), your existing equipment would be labelled between F and G. It is important to note that your environmental values are in line with the European decarbonization challenges to achieve climate neutrality by 2050. However, you are not very clear on how to contribute to it.

WHY

Dry run!



In the following slides, we will provide an example of what we are expecting from you in each of the four scenarios. <u>We will start with the dry run.</u>

Just relax and see :)

Dry run - This is a (test) example of a speculative scenario on top the baseline provided before

WHY

You start looking for information to help determine whether or not to invest in energy efficiency at your home *[from the baseline scenario]*. You ask advice from friends who are relatively knowledgeable on energy efficiency. **You conclude that you should make some improvements and repairs in your home**.

Dry run - after reading the scenario…

WHY

…You will be provided with a canvas/framework in which you will have to fill determinants **(i.e., intrinsic and extrinsic factors that causes an investment decision)**. We will also ask you about barriers and rebound effects for each scenario.

But before, we will be always offering you some tips to provide these determinants. See the next slide.

Social Cognitive Theory can help you understand better the type of determinants we expect

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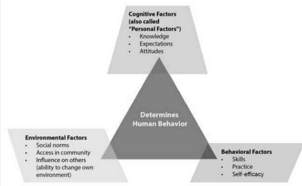
- **Outcome expectations:** Individuals are more likely to practice a desired behavior if they believe the benefits of performing that behavior and outweigh the costs.
- **Self-efficacy:** Individuals are more likely to practice a desired behavior if they perceive that they have the necessary skills and capacity to do so (Bandura, 2001; Glanz & Rimer, 2005).



Source: https://sbccimplementationkits.org/

(intrinsic/extrinsic) weighted causal determinants to happen:

In your opinion, which are the internal (sticky note green) & external factors (sticky note blue) that would lead you to invest your time and resources in this scenario. Please, indicate the most relevant determining factors for you as an expert by using the post-its of different colors below. **Recall that you can use either abstract factors (environmental concern or peer pressure) or more specific real factors (worries about the future generations - e.g., your children- or for the peer pressure, your closest neighbour is everyday posting green actions in its social networks and you want imitate him).**

- Self-efficacy, feel that I can do my own repairs
- Savy about energy efficiency: My opinion is more accurate than others, so I keep my home as it is
- Self-perception about life cycle analysis: It is better to not manufacture a new heating system than create a new one more of Label A
- Self-determination: I do not accept no one telling me what to do
- Social proof: I have read than people similar to me prefer not to invest
- Social norms: I think that my closer community will never invest in energy effiicency
- Others judgements: If I invest in energy efficiency my peers will think I am rich hen I am not
- External recognition: If I make repairs by my own I will be seen by my peers as a handyman
- Money: a lack of incentives to invest

(in/extrinsic) Barriers to occur it happens:

What are the main factors that would hinder you to make the aforementioned investments to achieve this scenario?

- Obligations from the government to invest in energy efficiency
- New taxation from the local authorities will be created for old-fueled homes
- Spare parts will not be longer available from the next year onwards

Rebound effects from the scenario:

What are the main rebound effects (RE) for you and others that would have appeared if the scenario happened? Recall that the simplest illustration of the RE is: **"Buy a more fuel-efficient car, drive more."** (i.e. Jevons' paradox)

- Some other friends can learn from my experience
- some companies go in bankrupt as they do not sell heat pumps
- More people close to me may mimic yself so no one ill invest in energy ficiency
- The EU commission close their Energy efficiency department as no one follow their regulations and norms

Hands on in the real scenarios (your turn)!

WHY

Please read the four speculative scenarios and **provide a comprehensive list of relevant factors for the decision-making determinants. Your input will be structured as the example in the dry run**.

Therefore, we ask you to **provide as many determinants, which cause an investment decision by family units in each scenario, as possible (we will provide some references after each scenario to inspire you)**.

Please, recall the baseline scenario on slide **4** and **Let's start with the minimum scenario!**

Minimum Scenario

WHY

You start looking for information for this change to happen. You start asking friends who are more or less knowledgeable on energy efficiency and you conclude that you should rethink your daily practices before investing in new energy efficient equipment. In other words, you ask yourself first if you are making efforts to minimize the impact of your energy use.

Some of the actions you are considering are: reduce the temperature of the radiators while maintaining comfort, always cook with the pots covered so that heat does not escape, only to always use the shortest program for everyday clothing and reserve longer programs and/or high-temperature programs for linen, always fill the dishwasher to the maximum before running it, completely turn off the devices when not in use avoiding the standby, etc.

(intrinsic/extrinsic) weighted causal determinants to happen: Minimum Scenario

In your opinion, which are the internal (sticky note green) & external factors (sticky note blue) that would lead you to invest your time and resources in this scenario. Please, indicate the most relevant determining factors for you as an expert by using the post-its of different colors below. **Recall that you can use either abstract factors (environmental concern or peer pressure) or more specific real factors (worries about the future generations - e.g., your children- or for the peer pressure, your closest neighbour is everyday posting green actions in its social networks and you want imitate him).**

Put here some determinants

Put here some determinants

Put here some determinants

Put here some determinants

Put here some determinants

Put here some determinants

(in/extrinsic) Barriers to occur it happens:

What are the main factors that would hinder you to make the aforementioned investments to achieve this scenario?

Put here some barriers

Put here some barriers

Put here some barriers

Rebound effects from the scenario:

What are the main rebound effects (RE) for you and others that would have appeared if the scenario happened? Recall that the simplest illustration of the RE is: **"Buy a more fuel-efficient car, drive more."** (i.e. Jevons' paradox)

Put some spillover effects here

Put some spillover effects here

Put some spillover effects here

Minimum Scenario is completed!

WHY

Minimum

Probable

Plausible

Ideal

Probable Scenario

WHY

Let's imagine that your ceramic hob breaks down again *(please, bear in mind that this is just an example and that we would like to get general ideas from a broader spectrum of appliances and situations. However, for the sake of clarity, we make up this explicit example for the scenario).*

This time, **you decide to buy a new one according to your energy efficiency objectives**. Thus, you decide to change your broken appliance and buy an induction cooktop which is much more efficient than the ceramic hob. Furthermore, among all the options that you have in the market for the new cooktop, you decide to get the one which offers you the best cost-benefit compromise at environmental and economic level.

(intrinsic/extrinsic) weighted causal determinants to happen: Minimum Scenario

In your opinion, which are the internal (sticky note green) & external factors (sticky note blue) that would lead you to invest your time and resources in this scenario. Please, indicate the most relevant determining factors for you as an expert by using the post-its of different colors below. **Recall that you can use either abstract factors (environmental concern or peer pressure) or more specific real factors (worries about the future generations - e.g., your children- or for the peer pressure, your closest neighbour is everyday posting green actions in its social networks and you want imitate him).**

Put here some determinants

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(in/extrinsic) Barriers to occur it happens:

What are the main factors that would hinder you to make the aforementioned investments to achieve this scenario?

Put here some barriers

Put here some barriers

Put here some barriers

Rebound effects from the scenario:

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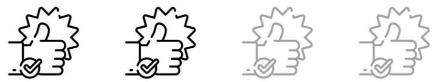
Put some spillover effects here

Put some spillover effects here

Put some spillover effects here

Probable Scenario is completed!

WHY



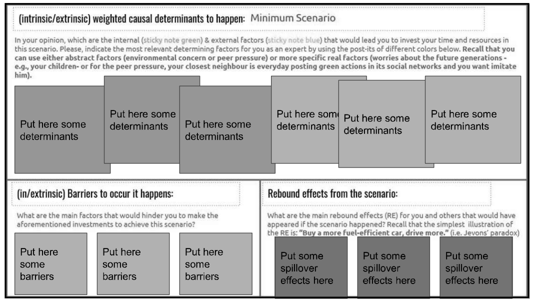
Minimum | Probable | Plausible | Ideal

Plausible Scenario

WHY

The washing machine breaks down again *(please again, bear in mind that this is just an example and that we would like to get general ideas from a broader spectrum of appliances and situations. However, for the sake of clarity, we make up this explicit example for the scenario).*

As your main goal is to contribute to climate neutrality, **you decide to find the nearest laundry and drying service to use regularly instead of buying a new washing machine.** Luckily, there are coin-operated laundry machines within two blocks of your house. In addition, the service has a loyalty system, and you can buy more economical cleaning and drying vouchers. Hence, in economic terms your decision pays-off. Furthermore, the laundry service ensures you as a customer a high quality operation of their machines so the washing will be as good or better as the washing you may do at home if you owned this appliance.


(intrinsic/extrinsic) weighted causal determinants to happen: Minimum Scenario
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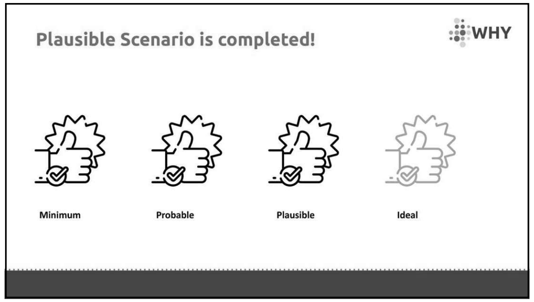
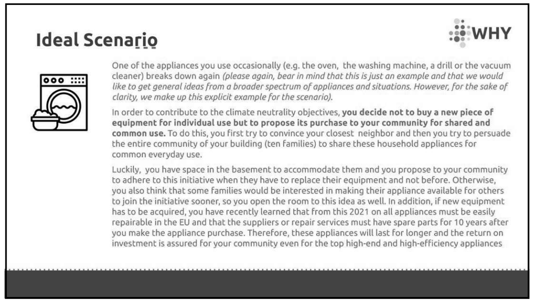
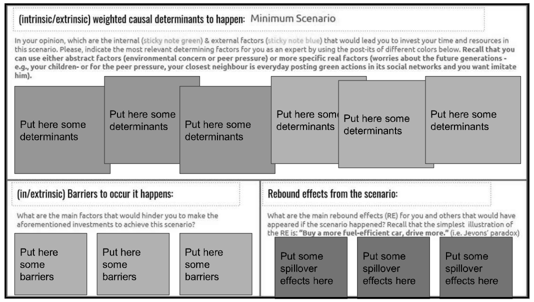
Put some spillover effects here
Put some spillover effects here
Put some spillover effects here


Plausible Scenario is completed!
WHY
Minimum
Probable
Plausible
Ideal


Ideal Scenario
WHY
One of the appliances you use occasionally (e.g. the oven, the washing machine, a drill or the vacuum cleaner) breaks down again (please again, bear in mind that this is just an example and that we would like to get general ideas from a broader spectrum of appliances and situations. However, for the sake of clarity, we make up this explicit example for the scenario).
In order to contribute to the climate neutrality objectives, you decide not to buy a new piece of equipment for individual use but to propose its purchase to your community for shared and common use. To do this, you first try to convince your closest neighbor and then you try to persuade the entire community of your building (ten families) to share these household appliances for common everyday use.
Luckily, you have space in the basement to accommodate them and you propose to your community to adhere to this initiative when they have to replace their equipment and not before. Otherwise, you also think that some families would be interested in making their appliance available for others to join the initiative sooner, so you open the room to this idea as well. In addition, if new equipment has to be acquired, you have recently learned that from this 2021 on all appliances must be easily repairable in the EU and that the suppliers or repair services must have spare parts for 10 years after you make the appliance purchase. Therefore, these appliances will last for longer and the return on investment is assured for your community even for the top high-end and high-efficiency appliances


(intrinsic/extrinsic) weighted causal determinants to happen: Minimum Scenario
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Put here some determinants
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(in/extrinsic) Barriers to occur it happens:
What are the main factors that would hinder you to make the aforementioned investments to achieve this scenario?
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Rebound effects from the scenario:
What are the main rebound effects (RE) for you and others that would have appeared if the scenario happened? Recall that the simplest illustration of the RE is: "Buy a more fuel-efficient car, drive more." (i.e. Jevons' paradox)
Put some spillover effects here
Put some spillover effects here
Put some spillover effects here

Ideal Scenario is completed!

WHY

Minimum

Probable

Plausible

Ideal

Thank you!

WHY

If you have any questions or comments, please drag and drop a sticky note(s).

We appreciate receiving additional relevant feedback, and will also take it into account.

Buildings

Introduction

We have created four speculative scenarios in order to obtain, from you as an expert, a set of **specific determinants or factors that <u>may cause an investment decision</u> by family units, either monetary or behavioural, to make their home more energy efficient**.

Each scenario describes a different reality for each of the aspects analysed. Please remember, the scenarios described here do not reflect a specific individual building but are rather a representation of the majority of households in a city.

Remember that we are asking about **your opinion as an expert** taking into account not only your experience and beliefs but also the state of the art you know [but you should not include references therein].

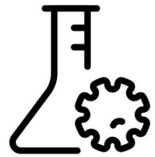
We will start from the baseline scenario and we build on it throughout this google slides.

Thanks a lot for your time!

Base Scenario

You live in an old house (please consider the different possibilities mentioned in the introduction) built between the 1970s and 1980s that has either poor or no insulation (depending on country-level standards) and a heating system based on fossil fuels. It has no renewable energy generation and limited storage mechanisms (for instance a thermal storage tank for domestic hot water, DHW). The appliances in the house have a low to medium energy efficiency, and the house does not have an energy management system. Your electricity tariff for the dwelling is a standard tariff with a fixed energy price. In addition, there is no time-of-use (ToU) scheme, therefore you do not usually worry about what time you switch your appliances on. Thus, you plug them in and use them when needed.

Dry run!



In the following slides, we will provide an example of what we are expecting from you in each of the four scenarios. <u>We will start with the dry run.</u>

Just relax and see :)

Dry run - after reading the scenario…

…You will be provided with a canvas/framework in which you will have to fill determinants **(i.e., intrinsic and extrinsic factors that causes an investment decision)**. We will also ask you about barriers and rebound effects for each scenario.

But before, we will be always offering you some tips to provide these determinants. See the next slide.

WHY

Social Cognitive Theory can help you understand better the type of determinants we expect

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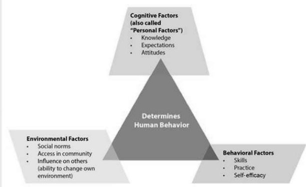
The Social Cognitive Learning Theory acknowledges the constant interaction that exists between the individual and his or her environment, both structural and social, to shape behavior. Three personal cognitive factors that are affected by the environment influence behavior:

- **Observational learning:** Individuals are more likely to perform a desired behavior if they observe others modeling that behavior and experiencing the subsequent positive rewards.
- **Outcome expectations:** Individuals are more likely to practice a desired behavior if they believe the benefits of performing that behavior and outweigh the costs.
- **Self-efficacy:** Individuals are more likely to practice a desired behavior if they perceive that they have the necessary skills and capacity to do so (Bandura, 2001; Glanz & Rimer, 2005).



Source: https://sbccimplementationkits.org/

WHY

(intrinsic/extrinsic) weighted causal determinants to happen:

In your opinion, which are the internal (sticky note green) & external factors (sticky note blue) that would lead you to invest your time and resources in this scenario. Please, indicate the most relevant determining factors for you as an expert by using the post-its of different colors below. **Recall that you can use either abstract factors (environmental concern or peer pressure) or more specific real factors (worries about the future generations - e.g., your children- or for the peer pressure, your closest neighbour is everyday posting green actions in its social networks and you want imitate him).**

Self-efficacy, feel that I can do my own repairs

Savy about energy efficiency: My opinion is more accurate than others, so I keep my home as it is

Self-perception about life cycle analysis: It is better to not manufacture a new heating system than create a new one more of Label A

Self-determination: I do not accept no one telling me what to do

Social proof: I have read than people similar to me prefer not to invest

Social norms: I think that my closer community will never invest in energy effiicency

Others judgements: If I invest in energy efficiency my peers will think I am rich [w]hen I am not

External recognition: If I make repairs by my own I will be seen by my peers as a handyman

Money: a lack of incentives to invest

(in/extrinsic) Barriers to occur it happens:

What are the main factors that would hinder you to make the aforementioned investments to achieve this scenario?

Obligations from the government to invest in energy efficiency

New taxation from the local authorities will be created for old-fueled homes

Spare parts will not be longer available from the next year onwards

Rebound effects from the scenario:

What are the main rebound effects (RE) for you and others that would have appeared if the scenario happened? Recall that the simplest illustration of the RE is: **"Buy a more fuel-efficient car, drive more."** (i.e. Jevons' paradox)

Some other friends can learn from my experience

some companies go in bankrupt as they do not sell heat pumps

More people close to me may mimic [m]yself so no one [w]ill invest in [en]ergy efficiency

The EU commission close their Energy efficiency department as no one follow their regulations and norms

Hands on in the real scenarios (your turn)!

WHY

FOR YOU

Please read the four speculative scenarios and **provide a comprehensive list of relevant factors for the decision-making determinants. Your input will be structured as the example in the dry run.**

Therefore, we ask you to **provide as many determinants, which cause an investment decision by family units in each scenario, as possible (we will provide some references after each scenario to inspire you)**.

Please, recall the baseline scenario on slide **4** and **Let's start with the minimum scenario!**

Minimum Scenario

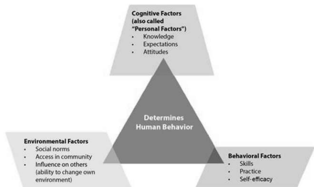
After reading about decarbonisation targets in the newspaper, you decide to find out what measures you need to take to ensure your comfort while reaching those targets. Consequently, you set the thermostat following your utility recommendation that the ideal temperature for a home ranges between 20 and 21ºC during the day, and between 15 and 17ºC at night; your clothing is suitable to the weather (for instance, in winter you wear different layers), you have checked your windows and doors for air leaks, replaced the seals on doors and windows, fixed any cracks inside and weather-stripped the windows, among others.

Remember!

According to the existing literature, it seems that internal factors such **as personal beliefs, values or environmental concern (e.g. someone may feel we, as society, are not doing enough against climate change)** are the prominent drivers that foster a change in people's daily behaviour to invest time and effort in reducing the carbon and energy footprint in their personal dwelling.

Besides, the dominant external factors for such pro-environmental behaviour to occur seem to be **peer pressure (e.g. your partner is already doing energy efficiency actions), social comparison (e.g. your neighbours do green actions and exhibit them openly) and social norms (e.g. doing energy efficiency actions is well recognised in your community and may enhance your social capital)**.

Tip or helping guide: Clusters of factors that affects someone's behaviour



EXTRA TIP!

Please, first consider that your property is a single-family house (SFH) in each scenario. Then, think about what would change in the scenarios if you were the owner of a multifamily residential unit (multi-dwelling unit, MDU) instead of a SFH. Finally, considering you are a tenant of the property instead of being an owner, what would change in the scenarios?

(intrinsic/extrinsic) weighted causal determinants to happen: Minimum Scenario

In your opinion, which are the internal (sticky note green) & external factors (sticky note blue) that would lead you to invest your time and resources in this scenario. Please, indicate the most relevant determining factors for you as an expert by using the post-its of different colors below. **Recall that you can use either abstract factors (environmental concern or peer pressure) or more specific real factors (worries about the future generations - e.g., your children- or for the peer pressure, your closest neighbour is everyday posting green actions in its social networks and you want imitate him).**

teest

(in/extrinsic) Barriers to occur it happens:

What are the main factors that would hinder you to make the aforementioned investments to achieve this scenario?

Rebound effects from the scenario:

What are the main rebound effects (RE) for you and others that would have appeared if the scenario happened? Recall that the simplest illustration of the RE is: **"Buy a more fuel-efficient car, drive more."** (i.e. Jevons' paradox)

Minimum Scenario is completed!

WHY

Minimum Probable Plausible Ideal

Probable Scenario

WHY

Several urgent renovation and repair measures are necessary. First, you need to repair and replace the roof and the facade, as water leaks are affecting different neighbours. Second, the oil heating system needs to be replaced for a more efficient gas model (although it does not decarbonise 100%, there will be a reduction in emissions and probably savings on the bill). Thirdly, the installation of a lift would provide additional accessibility. These renovations cannot be undertaken simultaneously. For each case, please indicate which factors would motivate you to choose this option, and the order of prioritisation in which you would undertake the above-mentioned works.

(intrinsic/extrinsic) weighted causal determinants to happen: Probable Scenario

In your opinion, which are the internal (sticky note green) & external factors (sticky note blue) that would lead you to invest your time and resources in this scenario. Please, indicate the most relevant determining factors for you as an expert by using the post-its of different colors below. **Recall that you can use either abstract factors (environmental concern or peer pressure) or more specific real factors (worries about the future generations - e.g., your children- or for the peer pressure, your closest neighbour is everyday posting green actions in its social networks and you want imitate him).**

(in/extrinsic) Barriers to occur if it happens:

What are the main factors that would hinder you to make investments to achieve this scenario?

Rebound effects from the scenario:

What are the main rebound effects (RE) for you and others that would have appeared if the scenario happened? Recall that the simplest illustration of the RE is: **"Buy a more fuel-efficient car, drive more."** (i.e. Jevons' pa

Probable Scenario is completed!

WHY

Minimum

Probable

Plausible

Ideal

Plausible Scenario

WHY

At the last residents' meeting, the neighbourhood decided to renovate the building entirely to improve energy efficiency and comfort. The facade and roof will be insulated, air sealed, and waterproofed, and all the windows will be replaced with more efficient ones (for instance triple pane windows which can save you at least 3 % on your heating bill, more in colder regions without compromising the light). In addition, a lift is going to be installed. The government or a public authority may be granting aid to carry out comprehensive building renovations, giving you the opportunity to invest in the replacement of the old oil heating system for a modern heat pump system, or to connect to district heating.

(intrinsic/extrinsic) weighted causal determinants to happen: Plausible Scenario

In your opinion, which are the internal (sticky note green) & external factors (sticky note blue) that would lead you to invest your time and resources in this scenario. Please, indicate the most relevant determining factors for you as an expert by using the post-its of different colors below. **Recall that you can use either abstract factors (environmental concern or peer pressure) or more specific real factors (worries about the future generations - e.g., your children- or for the peer pressure, your closest neighbour is everyday posting green actions in its social networks and you want imitate him).**

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What are the main rebound effects (RE) for you and others that would have appeared if the scenario happened? Recall that the simplest illustration of the RE is: **"Buy a more fuel-efficient car, drive more."** (i.e. Jevons' pa

Plausible Scenario is completed!

WHY

Minimum

Probable

Plausible

Ideal

Ideal Scenario

You live in a new passive home. In addition to having first-class facade, roof and window insulation, an intelligent high COP heat pump supplies the dwelling with low heating needs and hot water. An energy management system controls the heat pump and some other devices, giving the system the potential to exchange thermal energy with the neighbours. You are very environmentally conscious so you prioritise saving energy, and are willing to sacrifice your comfort, especially in the context of the thermostat temperature. You try to optimise energy consumption. Which factors made you decide to live in this house? Why would you rent this house to others instead of living there? What would have made you undertake all the work to make that house passive or buy such a house?

(intrinsic/extrinsic) weighted causal determinants to happen: Ideal Scenario

In your opinion, which are the internal (sticky note green) & external factors (sticky note blue) that would lead you to invest your time and resources in this scenario. Please, indicate the most relevant determining factors for you as an expert by using the post-its of different colors below. **Recall that you can use either abstract factors (environmental concern or peer pressure) or more specific real factors (worries about the future generations - e.g., your children- or for the peer pressure, your closest neighbour is everyday posting green actions in its social networks and you want imitate him).**

(in/extrinsic) Barriers to occur if it happens:

What are the main factors that would hinder you to make investments to achieve this scenario?

Rebound effects from the scenario:

What are the main rebound effects (RE) for you and others that would have appeared if the scenario happened? Recall that the simplest illustration of the RE is: **"Buy a more fuel-efficient car, drive more."** (i.e. Jevons' pa

Ideal Scenario is completed!

Minimum

Probable

Plausible

Ideal

Thank you!

If you have any questions or comments, please drag and drop a sticky note(s).

We appreciate receiving additional relevant feedback, and will also take it into account.

APPENDIX

D

Coding of expert contributions by researchers

MOBILITY

	Minimum Scenario					Probable Scenario				
	Expert	RAW	Key Concept	Key Concept	Final Coding	Expert	RAW	Key Concept	Key Concept	Final Coding
Intrinsic Determinants	1	The need to adapt to the environment No conventional gas stations	Trends [1]	Environmental Concerns	**Environmental Concerns**	1	Remote work eliminates the need to travel to / from work	Trends	Frugality	**Cozyness**
	1	The belief in the right behavior - environmentally friendly traveling	Proseur [3]	Poseur	Poseur	1	Occasional use of your own vehicle: vehicle operating costs	Self-Satisfaction [4]	Added value	**Added value**
	1	The belief in the right behavior - caring for future generations	Own Significance [6]	Own Significance	Own Significance	1	Occasional use of your own vehicle: the unused vehicle wears out faster	Self-Satisfaction [7]	Added value	**Added value**
	2	The need to buy an electric vehicle (no gas stations, because they have been converted to charging stations)	Technical Fit [9]	Technical Fit	Technical Fit	2	Distance to work	Wellbeing [10]	Technical Fit	**Technical Fit**
	2	The need to change to an electric vehicle, because that's what everyone else does	Authority [11]	Trends	**Trends**	2	Less need to travel	Wellbeing [12]	Frugality	**Frugality**
	2			Cozyness	Cozyness	2	Traveling by bike is healthy	Self-Satisfaction [15]	Wellbeing	**Wellbeing**
	3	Self-efficacy: dopting this scenario is easy for me: it requires minimal personal behaviour change. I am a competent driver and know my way around	Own Competence [17]	Own Competence	Own Competence	2	Easy access to sharing services (no need to have your own vehicle)	Trends	Safety	**Safety**
	3	Self-perception: I would feel some sense of collective pride to live in a city/region where such a scenario has been realised, knowing that my city/region has a decarbonised transport system.	Support [19]	Support	Support	3	Self-perception: I am happy and proud that my city has much lower emissions than other cities.	Self-Satisfaction [20]	Self-Satisfaction	Self-Satisfaction
	3	Self-sufficiency and Individualism: I would buy my own electric car. This continues to give me the (perceived) freedom of deciding when and where to travel, without range anxiety and without sharing my private vehicle with other people.	Self-Satisfaction [22]	Autarky	**Autarky**	3	Self-efficacy: I know how to manage mobility apps for PT and ride-sharing which help me plan my trips.	Own Competence [23]	Own Competence	Own Competence
	3	Self-perception and virtue signalling: If I drive a nice new EV, then I feel and show that I am making a positive contribution to the climate by driving without emissions and pollution.	Support [25]	Brag	**Own Significance**	3	Self-determination: On occasion I am willing to sacrifice the comfort and privacy of a my own (or a shared/co-owned) motor vehicle, because I know it has a lower impact on the environment.	Environmental Concerns [26]	Frugality	**Frugality**
	3		[27]			3	Self-perception: I would feel a significant sense of collective pride to live in a city/region where such a scenario has been realised, knowing that my city/region has a decarbonised transport system and reduced private car use.	Environmental Concerns [28]	Support	**Support**
	3	Values: As some one with strong Environmental Concerns, I should lead by example, showing others that more environmentally-friendly behaviour is possible.	Authority [29]	Authority	Authority	3	Self-efficacy: I would combine PT with micro-mobility services for urban trips, use train for inter-city travel, and ride-/car-sharing for peri- or extra-urban trips.	Self-Satisfaction [30]	Knowledge	**Knowledge**
	3	Self-efficacy: Even when all transport modes are emission-free, I would continue to rely mainly on public transport, (folding) bicycle and bike-sharing; sometimes combining both modes to cover larger distances or get to my final destination more quickly.	Support [31]	Frugality	**Frugality**	3	Self-determination: I am an experienced and confident user of PT and (public) bikes. I want to and know how to get by without a private car. I plan accordingly and am willing to sacrifice the comfort and privacy of a private motor vehicle.	Self-Satisfaction [32]	Adherence	**Environmental Concerns**
	3	Self-determination: I am an experienced and confident user of public transport and bikes. I want to and know how to get by without a private car. I plan accordingly and am willing to sacrifice the comfort and privacy of a private motor vehicle.	Authority [33]	Adherence	**Environmental Concerns**	10	Do not want to differ from mainstream practices, climate friendly is the "mainstream"	Support [34]	Trends	**Trends**
	10	Personal care about the climate issues	Own Significance [35]	Poseur	**Environmental Concerns**	10	Pressure to feel that not owning any car (even electric) is better, therefore using public and shared transport modes shows care for climate concerns	Obligation - peer presure [36]	Peer-Pressure	**Peer-Pressure**
	10	Believe that this is the future anyway and available infrastructure supports the decision	Own Significance [37]	Trends	**Trust**					
	10	Feeling better as sensing the personal contribution to better and cleaner living environment, being part of the "climate community"	Own Significance [38]	Self-Satisfaction	**Own Significance**					
	Ruth	Despite I am confident that this behaviour is positive for the society I do not consider myself responsible of arrange any changes	Own Significance	Support	**Support**	Ruth	Still the investment of change my vehicle is to high	Credit Score	Credit Score	**Credit Score**

	Minimum Scenario					Probable Scenario				
	Expert	**RAW**	**Key Concept**	**Key Concept**	**Final Coding**	**Expert**	**RAW**	**Key Concept**	**Key Concept**	**Final Coding**
	Ruth	I see fuel and maintenance savings to happen in a long term	Profits	Profits	**Profits**	Ruth	Intensification of worries to the collateral effects of the climate change, such diseases and lack of supply	Environmental Concerns	Environmental Concerns	**Environmental Concerns**
	Ruth	I can't afford the investment	Credit Score	Credit Score	**Credit Score**		~~Change to teleworking~~			
	Omar Usmani	People can enjoy the innovative character of an electric car	Fun	Fun	**Fun**	Omar Usmani	Will people perceive these services as innovative?	Novelty	Novelty	**Novelty**
	Omar Usmani	By purchasing an electric car or switching to public transport feel they help fight climate change	Environmental Concerns	Environmental Concerns	**Environmental Concerns**	Omar Usmani	Will people see these services as helping fight climate change?	Environmental Concerns	Environmental Concerns	**Environmental Concerns**
	Omar Usmani	The experience (driving pleasure/ easy of fuel/charge) for switching car types, or the pleasure/hassle of the compared travel experiences for cars versus public transport	Poseur	Self-Satisfaction	**Self-Satisfaction**	Omar Usmani	People might see value in being able to get such services in stressful situations (being in an unknown place, having consumed alcohol at times/places where public transport is not available)	Trust	Added Value	**Added Value**
	Panagiotis	Self-perception. Decision is good for the society and the environment	Support	Support	**Support**	Omar Usmani	Such mobility services will provide a different experience from driving on your own (or in a cab). This holds both for the drive itself (including the interaction with the driver and the fact that people don't have to drive themselves) and for getting it (booking via an app, for example)	Self-Satisfaction	Own Significance	**Own Significance**
	Panagiotis	Lower fuel purchase costs	Frugality	Frugality	**Frugality**	Panagiotis	The decision is good for the society and the environment	Support	Support	**Support**
	Panagiotis	Contribution to climate change mitigation adn energy security (i.e. avoid reliance on Russian oil/gas)	Frugality	Autarky	**Autarky**	Panagiotis	Potential benefits outweigh the costs	Added value	Added value	**Added value**
						Panagiotis	Lack of adequate finance to buy own car	Credit Score	Credit Score	**Credit Score**
	1	Global policy for climate protection	Legal	Legal	Legal	1	Legal regulations in the field of micromobility	Legal [39]	Legal	Legal
	1	Incentives in the field of electromobility (subsidies for the purchase of vehicles)	Legal	Credit Score	**Credit Score**	1	Adapted public transport infrastructure (high availability)	Technical Fit	Technical Fit	**Technical Fit**
	1	Movement restrictions (zero emission zones)	Legal	Legal	Legal	1	Movement restrictions (zero emission zones)	Legal [42]	Legal	Legal
	2	Policy of action for climate protection	Legal	Legal	Legal	2	National regulations: Legal regulations in the field of micromobility	Legal [43]	Legal	Legal
	2	Energy price formation	Profits [44]	Risk Profile	**Risk Profile**	2	Global point of view: The scenario is in line with the general global trend of the sharing economy	Profits [45]	Trends	**Trends**
	2	Competitiveness of charging station operators in terms of energy prices (due to the excess of charging stations)	Profits [46]	Profits	Profits	2	Better for environment: Less passenger cars on the road (modal split of traffic change)	Environmental Concerns [47]	Environmental Concerns	Environmental Concerns
	3	Social proof: Most other people I know will probably also have substituted their ICE car for an EV. I would not want to be seen as the last on the block with a polluting car.	Support [48]	Trends	**Trends**	3	Peer pressure: I feel that people are looking at me whenever I drive my car through the inner city, and not in a nice way. This makes me uncomfortable.	Obligation - peer presure [49]	Peer-Pressure	**Peer-Pressure**
	3	Social norms: As a private car owner, I will not lose social status. I can still express my individuality through the choice of my car.	Rights and Duties [50]	Brag	**Brag**	3	Social norms: It no longer feels awkward to use an e-scooter to commute to work. No-one thinks it's odd or makes silly comments.	Legal [51]	Support	**Peer-Pressure**
	3	Social pressure: I've heard people in Germany use the term "Umweltsau" to call out ICE car users	Rights and Duties [52]	Peer-Pressure	**Peer-Pressure**	3	Social comparison: I hear from friends and colleagues that they use eHailing and ride-share services. They boast about it.	Brag [53]	Trends	**Trends**
	3	Social norms: If I do like most other people, than I will be as good as most other people. I can drive my EV free of guilt and judgement.	Trends [54]	Self-Satisfaction	**Trends**	3	Peer pressure might lead to a de facto banning of private motor vehicles from inner cities. People often show their annoyment with PMVs in pedestrianised streets	Obligation - peer presure [55]	Peer-Pressure	**Peer-Pressure**
	3	Social proof: Most other people will probably have substituted their ICE car for an EV. This will help with carbon emissions and local pollution (also noise), but will not change the mobility system significantly. It requires minimal change of habits to car owners.	Cost-Efficiency [56]	Adherence	**Cost-Efficiency**	3	If PT and micro-mobility is the social norm, the stigma that "only losers take the bus" would disappear.	Legal [57]	Support	**Safety**
ants	3	Social proof: Adopting this scenario is easy for most people: it requires hardly any personal behaviour change.	Cost-Efficiency [58]	Adherence	**Cost-Efficiency**	3	Collective civic pride of living in a person-centric, environmentally friendly city, with green and open public spaces.	Support [59]	Support	**Support**

	Minimum Scenario					Probable Scenario				
	Expert	RAW	Key Concept	Key Concept	Final Coding	Expert	RAW	Key Concept	Key Concept	Final Coding
Extrinsic Determina	3	Social norms are not demanding: The high social cost of continued private vehicle ownership is born by all citizens.	Rights and Duties [60]	Agreement	**Agreement**	10	"fashionable" to show trust in public transport mode and new mobility services, as this is the "common	Support [61]	Brag	**Brag**
	3	Social norms: As most people own a private vehicle (EV), there is usually no lack of offers for ride sharing. Most drivers are happy to share the cost of a trip with someone they know. They respect the choice not to own a car, but regard it as odd.	Agreement [62]	Frugality	**Frugality**					
	10	Policy and technology in coming years will favour strongly the purchase (or inhibit reverse decisions)	Legal [63]	Legal	Legal					
	10	Peer pressure (colleaguse and friends are already making similar decisions)	Peer-Pressure [64]	Peer-Pressure	Peer-Pressure					
	10	Social position requires personal decisions which reflect the policy directions (caring about the climate issues)	Proseur [65]	Brag	**Brag**					
	Ruth	Worries about the future generation, specially my children	Climate Protection	Climate Protection	Climate Protection	Ruth	My relatives and family demand me to change my habits	Peer-Pressure	Peer-Pressure	Peer-Pressure
	Ruth	I consider myself to be the change I want to see in society	Own Significance	Own Significance	**Own Significance**	Ruth	Deployments of of public transportation offers me to uptake this option	Technical Fit	Technical Fit	**Technical Fit**
	Ruth	I am working in the field of RE and I want to be recognized and gain social capital	Brag	Brag	Brag	Ruth	Worries about my own responsibility in climate change	Climate Protection	Climate Protection	Climate Protection
	Omar Usmani	Money: People process investment costs, and running costs separately and in a complex manner (such as loss aversion).	Cost-Efficiency	Risk Profile	**Risk Profile**	Omar Usmani	The pricing strategy (fee per journey, subscription, etc) and its levels need to be tailored to the market (different people react differently and sometimes in a complex manner)	Technical Fit	Profits	**Profits**
	Omar Usmani	(Some) people get value from being special/among the first to purchase something innovative or green.		Novelty	Novelty	Omar Usmani	(Some) people get value from being special/among the first to purchase something innovative or green.		Novelty	Novelty
	Omar Usmani	They also react to other people doing so (escalation: if my neighbour gets something, I have to get more/something better)	Poseur	Poseur	Poseur	Omar Usmani	They also react to other people doing so (escalation: if my neighbour gets something, I have to get more/something better)	Novelty	Poseur	Poseur
	Omar Usmani	(Some) people feel pressured to follow the norm.	Peer-Pressure	Peer-Pressure	**Peer-Pressure**	Omar Usmani	(Some) people feel pressured to follow the norm	Peer-Pressure	Peer-Pressure	**Peer-Pressure**
	Panagiotis	External recognition	Brag	Brag	Brag	Panagiotis	Social pressure,	Poseur	Peer-Pressure	Peer-Pressure
	Panagiotis	Social norms, social beliefs	Peer-Pressure	Trends	**Trends**	Panagiotis	Everyone is using the app, instead of more traditional cars,	Trends	Trends	**Trends**
	Panagiotis	Peer influence	Trends	Peer-Pressure	Peer-Pressure	Panagiotis	Sense of a modern community through car-pooling etc instead of the dominant private consumption mode	Support	Support	Support
	1	High cost of buying an electric car	Peer-Pressure	Credit Score	Credit Score	1	Lack of mutual synergy of various systems micromobility - system competitiveness	Trust	Technical Fit	Technical Fit
	1	High cost of battery replacement and / or disposal of an electric car	Profits	Profits	Profits	1	There are no regulations on the use of micromobility	Legal	Legal	Legal
	1	Limiting the number of charging points	Technical Fit	Technical Fit	Technical Fit	2	Lack of appropriate rules for moving with the use of micromobility causing chaos in transport systems	Clash [68]	Legal	Legal
	1	Energy infrastructure efficiency	Knowledge [70]	Technical Fit	**Technical Fit**	2	The need to establish cooperation between operators of various new forms of mobility	Clash [71]		**Technical Fit**
	2	High cost of an electric car	Credit Score [72]	Credit Score	Credit Score	3	Giving up the sense of total flexibility of PMV use, and having to plan ahead is cumbersome and tedious. I may not have a shared car available nearby when I need it.	Commitment	Adherence	Adherence
	2	A small number of people convinced to use an electric car	Knowledge [73]	Added value	**Added value**	3	I am not accustomed (and not willing to learn) to using apps for mobility services	Self-Satisfaction [74]	Knowledge	**Technical Fit**
	2	High cost of expanding the charging station network (infrastructure preparation)	Technical Fit	Technical Fit	Technical Fit	3	PT and other mob. services are usually paid for per use and immediately. Once the initial cost of PMV is overcome and the tank or battery is filled, its use appears free.	Profits [75]	Profits	Profits

	Minimum Scenario					Probable Scenario				
	Expert	RAW	Key Concept	Key Concept	Final Coding	Expert	RAW	Key Concept	Key Concept	Final Coding
Barriers	3	The initial cost of an EV is high. I might not be able to afford as nice a car as I would like.	Credit Score [77]	Credit Score	Credit Score	3	PT and mob. services should be widely available, reliable, comfortable and clean to gain wide adoption.	Wellbeing [78]	Trust	Trust
	3	Social norms are not demanding: The high social cost of continued private vehicle ownership is born by all citizens.	Rights and Duties	Agreement	**Agreement**	3	With a shared car, I'll never know what car I'll get and I don't feel as confident behind the wheel as in my own car. It feels awkward. I can't leave personal items behind	Commitment [79]	Own Competence	**Safety**
	3	If I want to go on holiday, I must plan stops at fast re-charging stations - they might not exist in other regions/countries.	Technical Fit [80]	Technical Fit	**Technical Fit**	3	Shared bikes and other micromob services show hiccups: no available bikes or spaces, malfunctions or vandalism, no transparent billing	Increase consumtion [81]	Trust	**Technical Fit**
	3	I have heard that the capacity of the battery declines over time and with use. That's a factor of uncertainty.	Technical Fit [82]	Risk Profile	**Risk Profile**	3	I don't like it that many eHailing services create terrible working conditions and false statutes of self-employment	Increase embodied [83]	Legal	**Legal**
	3	The same barriers that exist in the baseline: public transport is slow, will often not get you where you want at the time you want. It requires more planning and preparation. Sometimes you must rent a car or rely on others to help you out.	Technical Fit [84]	Autarky	**Autarky**	3	PT should offer higher frequency and longer operating hours in order to be a fully operational alternative to private mobility.	Commitment [85]	Trust	**Technical Fit**
	3	Initial investment in emission-free public transport is higher for municipal and private transport companies.	Risk Profile	Credit Score	**Credit Score**	3	Interoperationality between services (and between different cities) is barely existing: different swipe cards, apps etc	Commitment [86]	Cost-Efficiency	**Technical Fit**
	10	Trust into the technology requires sufficient information that may not be there for the prosumer	Knowledge [87]	Trust	**Trust**	3	The business case for car sharing and micromobility services is still fragile.	Risk Profile	Risk Profile	**Risk Profile**
	10	Price for owning and operating e/v or using public transport	Profits [88]	Added value	**Added value**	10	Ride sharing interferes with "my personal area" - trust for "strangers" needed	Trust	Trust	**Trust**
	10	Time (charging network/public transport has to be so effective in order not to lose time in moving around)	Technical Fit [89]	Technical Fit	Technical Fit	10	Time consideration for choosing alternative options for long distance travelling	Adherence [90]	Technical Fit	Cozyness
						10	Security and comfort issues, eg in travelling with kids, carrying a lot of luggage etc	Adherence [91]	Cozyness	**Cozyness**
	Ruth	Lack of trust on the concept of storage and its management	Knowledge	Trust	**Trust**	Ruth	Lack of support from my relatives	Own Competence	Peer-Pressure	**Peer-Pressure**
	Ruth	Lack of long term vision	Knowledge	Knowledge	**Knowledge**	Ruth	A sense of being the only one in my community adopting this changes	Own Significance	Peer-Pressure	**Peer-Pressure**
	Ruth	Behaviour based in individual profit	Profits	Profits	**Profits**	Ruth	Devaluation of my previous investment	Profits	Risk Profile	**Risk Profile**
	Omar Usmani	Habits: If gasoline/diesel cars are still an option, some will keep buying them out of habit. The same holds for keeping driving a car instead of switching to public transport	Frugality	Adherence	**Adherence**	Omar Usmani	Habits: Some people might not consider these new mobility services, since they already have a car (or would rebuy one) (or would keep using public transport)	Self-Satisfaction	Commitment	**Commitment**
	Omar Usmani	Can the people do their activities? For electric cars: Are the range and charging infrastructure perceived as being sufficient? For public transport: Do people see the frequency, timetables, and places reached sufficient?	Trust	Technical Fit	**Technical Fit**	Omar Usmani	Do these services have sufficient availability at the right time and right place so that people can keep doing their activities (i.e. do these mobility services restrict people's activities/male them harder)?	Technical fit	Technical fit	**Technical fit**
	Omar Usmani	Do people feel they know enough about electric vehicles/public transport to make a purchase decision?	Knowledge	Own Competence	**Knowledge**	Omar Usmani	Do people know enough about these mobility services?	Knowledge	Knowledge	**Knowledge**
	Omar Usmani	Can the people afford the necessary investment?	Credit Score	Credit Score	**Credit Score**	Omar Usmani	Will people feel safe with such mobility services (will they trust drivers)? This might be helped by a ratings system.	Trust	Safety	**Safety**
	Omar Usmani	Are there any availability issues (mostly for cars)?	Technical Fit	Technical Fit	**Technical Fit**	Panagiotis	Lack of knowledge about these new mobility options	Knowledge	Knowledge	**Knowledge**

	Minimum Scenario					Probable Scenario				
	Expert	RAW	Key Concept	Key Concept	Final Coding	Expert	RAW	Key Concept	Key Concept	Final Coding
	Panagiotis	Lack of knowledge on EVs, esp. For O&M	Knowledge	Knowledge	**Knowledge**	Panagiotis	Lack of trust in car- sharing or MaaS platforms	Knowledge	Trust	**Trust**
	Panagiotis	Lack of appropriate recharging infrastructure	Technical Fit	Technical Fit	**Technical Fit**	Panagiotis	Sense of ownership prevents adoption of MaaS options	Autarky	Autarky	**Autarky**
	Panagiotis	Confidence in the status-quo technologies	Trust	Trust	**Trust**					
Rebound effects	1	High use of individual eclectic vehicles will lead to: Increasing traffic congestion in cities, the parking problem, marginalize public transport, Increasing environmental pollution (e.g. electricity from coal	Increase consumption		**Environmental Concerns**	1	Private micromobility operators decide on transport accessibility - limiting accessibility	Clash		**Technical Fit**
	2	improved accessibility for electric cars (network of charging stations) will encourage their purchase. The more private electric cars: the greater the problem of congestion, the greater the land use by private cars, the greater difficulties for travel by public transport (further decline of public transport), the greater electric energy usage (depends on sources – for example based on fossil fuels)	Technical Fit		**Environmental Concerns**	1	Increase in accidents involving micromobility vehicles and pedestrians	Safety		**Wellbeing**
	2	Quiet passenger (electric) cars in city centers can reduce pedestrian safety	Wellbeing [92]		Wellbeing	2	Dependence on carsharing operators	Commitment [93]		Trust
	3	Since EVs are expensive to purchase and cheap to run (and fun to drive), there is a likelihood of increased (and guilt-free) car travel.	Increase consumption		Fun	2	A large number of e-hailing services can cause chaos	Clash		Trust
	3	I am less likelty to use Public Transport, because of the sunk cost in EVs.	Profits [94]		**Cost-Efficiency**	2	Unregulated offers of micromobility services (in particular the free-floating kind) have created urban clutter and waste.	Legal [95]		**Legal**
	3	Traffic jams and use of public space for parked cars will continue to be an issue. (That will still annoy me).	Technical Fit		**Trust**	3	Car sharing has been shown to substitute PT use, not private car ownership (1)	Trust		**Trust**
	3	Car-sharing schemes will help to overcome the financial investment in EVs, and hopefully lead to a more rational use of motor vehicles, public space and raw materials.	Profits [96]		**Environmental Concerns**	3	Micromobility services and in particular free-floating shared e-scooters tend to reduce more active modes of travel (which is less healthy and consumes more energy) and causes more clutter on the pavement.	Increase consumtion		**Wellbeing**
	10	Demand puts pressure on providers to increase the prosumer confidence into the technology and available infrastructure	Poseur [97]		**Trust**	3	As road congestion decreases, there is a renewed incentive for PMV use	Profits		**Profits**
						3	Ride hailing services have been shown to increase road traffic congestion as people abandon active modes of travel	Wellbeing [98]		Wellbeing
						3	High-speed trains may reduce plane travel but have cannibalised long- distance night trains and have used up public funds for upkeep of regional train services.	Increase consumtion [99]		Risk Profile
						3	eHailing (in particular Uber, Lyft etc) has moved from the social or sharing economy to the fiercely liberal-market, profit-driven gig economy.	Clash		Trust
						3	As more people opt for new services (e-haling, ride sharing...), less own their own car, also accessibility to the service is better as increased demand has pulled better offering and more service providers. This helps to deal with the "time issue" that is needed from getting point A to point B"	Trust		Cost-Efficiency

Minimum Scenario					Probable Scenario				
Expert	RAW	Key Concept	Key Concept	Final Coding	Expert	RAW	Key Concept	Key Concept	Final Coding
					10	May be opposite - more demand causes delays and inabilities in responding reflectively	Increase consumtion [100]		Technical Fit
Ruth	Sense of imposition	Rights and Duties			Ruth	Stratification of mobility along the week	Technical Fit		
Ruth	Difficulties in maintaining the public investments if the people do not use the current services	Clash			Ruth	Dependence on financial subsidies	Credit Score		
Ruth	Slow down the future investments	Profits			Ruth	Deployment of sharing systems instead of individual investments in EV	Technical Fit		
Omar Usmani	Simultaneous charging demand at critical moments can put a strain on the electricity network	Technical fit			Omar Usmani	The mobility services might trigger people to use these instead of public transport or other modes (walking/biking, etc.) because of their ease of use, thereby increasing energy use for transport	Technical Fit		
Omar Usmani	Lower running/energy costs can lead to higher use (people driving their car more or using it instead of public transport).	Frugality			Panagiotis	Use mobility services more often, as they are cheap	Technical Fit		
Panagiotis	Higher traffic due to increased mobility	Increase consumption			Panagiotis	Increase transport activity, traffic and noise in the cities	Increase consumption		
Panagiotis	Higher financial risks as larger investment is needed	Risk Profile			Panagiotis	Increased digitisation of the economy	Increase consumption		
Panagiotis	Jobs are lost in auto-maker industries	Clash							
80	79	78	79	79	74	75	73	73	74

	Plausible Scenario					Ideal Scenario				
	Expert	RAW	Key Concept I	Key Concept II	Final Coding	Expert	RAW	Key Concept I	Key Concept II	Final Coding
Intrinsic Determinants	1	Occasional use of your own vehicle - vehicle operating costs - the unused vehicle wears out faster	Profits [2]	Added value	**Added value**	1	Limitation of travel with the use of vehicles (acceptable time for pedestrians to reach the destination)	Rights and Duties	Technical Fit	**Technical Fit**
	1	One vehicle for a family - occasional trips	Self-Satisfaction [5]	Technical Fit	**Frugality**	1	Change of road infrastructure into pedestrian ways	Technical Fit	Technical Fit	Technical Fit
	2	Need to change life style: No possibility of using public transport (replaced by other forms of mobility)	Adherence	Adherence	Adherence	1	Development of the concept of green cities	Added value [8]	Technical Fit	**Technical Fit**
	2	Health point of view: Traveling by bike is healthy	Wellbeing	Wellbeing	Wellbeing	1	Elimination of environmental pollution resulting from vehicle traffic	Wellbeing	Technical Fit	**Wellbeing**
	2	No sharing services (need to have your own vehicle or use robotaxi)	Technical Fit [13]	Technical Fit	Technical Fit	1	Everything is close to home (15 minutes cities)	Cozyness	Technical Fit	**Cozyness**
	3	Self-perception: It's cool to be driven around in an autonomous vehicle.	Brag [16]	Brag	Brag	2	Good place to live: A pedestrian-friendly city – good for health	Wellbeing	Wellbeing	Wellbeing
	3	Self-perception: I feel good about myself when I use an electric robotaxi, because I know I do not pollute, it's safer than a driver, and I do not take up car parking space.	Own Significance [18]	Own Significance	Own Significance	2	Environmental friendly – much more quiet streets	Wellbeing	Wellbeing	Wellbeing
	3	Self-perception: It's nice to live in a city that is a lot more liveable with less noise and other pollution and more public space.	Wellbeing [21]	Wellbeing	Wellbeing	2	Everything is close to home (15 minutes cities)	Cozyness	Cozyness	Cozyness
	3	Self-perception: When I sit in my car in a traffic jam, I feel ashamed because I realise I am part of the cause.	Environmental Concerns [24]	Environmental Concerns	Environmental Concerns	2	Only small road traffic	Technical Fit	Technical Fit	Technical Fit
	10	Purchasing any car is not an option, as there is strong believe that it is more climate friendly if there is less need to produce any type of vehicle	Environmental Concerns	Environmental Concerns	Environmental Concerns	3	It's a delight living in a city free of traffic, healthy and safe, with lots of public spaces	Cozyness	Cozyness	Cozyness
						3	Self-determination: Walking everywhere is healthier for me. I easily get my 8000 steps a day.	Wellbeing	Wellbeing	Wellbeing
						3	Self-sufficiency: My kids can now safely walk or cycle to school and sports activities. I do not need to chauffeur them around everywhere.	Trust	Safety	**Safety**
						3	Convenience: Owning a car is inconvenient and costly: there is nowhere to park it or even drive it in or near the city centre. It would only be useful on holidays or for excursions	Profits	Profits	Profits
	Ruth	All my community is arranging this changes	Peer-Pressure	Peer-Pressure	**Peer-Pressure**	Ruth	I see that my behaviour contributes to fight climate change	Environmental Concerns	Environmental Concerns	**Environmental Concerns**

	Plausible Scenario					Ideal Scenario				
	Expert	RAW	Key Concept I	Key Concept II	Final Coding	Expert	RAW	Key Concept I	Key Concept II	Final Coding
	Ruth	I feel more comfortable since the are more options	Self-Satisfaction	Cozyness	**Cozyness**	Panagiotis	Good for the environment and society	Climate Protection	Climate Protection	**Climate Protection**
	Ruth	I finally convinced that this behaviour is positive for the society	Support	Support	**Support**	Panagiotis	Drastically reduce transport costs (economic benefits)	Frugality	Frugality	**Frugality**
	Omar Usmani	Will people perceive these services as innovative?	Novelty	Novelty	**Novelty**	Panagiotis	Improve quality of life and health in cities with more active transport modes and reduced traffic	Wellbeing	Wellbeing	**Wellbeing**
	Omar Usmani	Will people see these services as helping fight climate change?	Climate Protection	Climate Protection	**Climate Protection**					
	Omar Usmani	People might see value in being able to get such services in stressful situations (being in an unknown place, having consumed alcohol at times/places where public transport is not available)	Trust	Added Value	**Added Value**					
	Omar Usmani	Such mobility services will provide a different experience from driving on your own (or in a cab). This holds both for the drive itself (no driver interaction, which some people might prefer and the fact that people don't have to drive themselves) and for getting it (booking via an app, for example)	Self-Satisfaction	Own Significance	**Own Significance**					
	Panagiotis	Environmental awareness	Knowledge	Environmental Concerns	**Environmental Concerns**					
	Panagiotis	Financial resources for transport are limited, so income can be used for other purposes	Credit Score	Credit Score	**Credit Score**					
	Panagiotis	Expectations that transport costs will decline massively	Added value	Profits	**Profits**					
	1	Incentives for the use of robotaxi (preferential prices)	Profits	Profits	Profits	1	Supply chain integration for goods	Trust [40]	Technical Fit	Technical Fit
	1	Restrictions on moving your own vehicle (zero-emission zones)	Legal	Legal	**Legal**	1	integration of people traveling	Trust [41]	Technical Fit	**Technical Fit**
	2	National regulations: Legal regulations in the field of micromobility	Legal	Legal	Legal	2	Policy for the integration of travel chains	Legal	Legal	Legal
	2	Global point of view: The scenario is not in line with the general global trend of the sharing economy.	Trends	Trends	Trends	2	High level of transport accesability – always we may choose some menas of transport to pass anywhere	Technical Fit	Technical Fit	Technical Fit
	2	National regulations: Legal regulations in the field of robotaxi (autonomous cars)	Legal	Legal	**Legal**	2	National regulations: Legal regulations in the field of robotaxi (autonomous cars)	Legal	Legal	**Legal**
	3	Social Norms: Public transport is only used by people who can't afford using robotaxis. I do not want to meet or be seen with these people.	Socialising	Socialising	Socialising	3	Social norms: private cars are considered either antisocial or a hobby (e.g. classic cars)	Trends	Trends	Trends
	3	Peer pressure: Driving yourself is considered unsafe and antisocial behaviour.	Peer-Pressure	Rights and Duties	**Rights and Duties**					
	3	Social comparison: Many friends and colleagues arrive by eHailing and ride-share services when we meet up.	Peer-Pressure	Peer-Pressure	**Peer-Pressure**					
	10	Peer pressure and public and political will to reduce private vehicle uses, even if public transport and ride sharing is not along the personal willingness	Legal	Legal	**Legal**					
ants										

	Plausible Scenario					Ideal Scenario				
	Expert	RAW	Key Concept I	Key Concept II	Final Coding	Expert	RAW	Key Concept I	Key Concept II	Final Coding
Extrinsic Determin										
	Ruth	I see the change in the majority and I decide to follow	Peer-Pressure	Trends	Trends	Ruth	I am doing this for being coherent with my personal beliefs	Own Significance	Own Significance	Own Significance
	Ruth	My family is demanding me to arrange this changes	Peer-Pressure	Peer-Pressure	**Peer-Pressure**	Ruth	An improvement of life quality	Wellbeing	Wellbeing	**Wellbeing**
	Ruth	Finally I can see that in the long term, savings offset purchase pric	Profits	Profits	Profits	Ruth	My community recognizes my contributions	Brag	Authority	Authority
	Omar Usmani	The pricing strategy (fee per journey, subscription, etc) and its levels need to be tailored to the market (different people react differently and sometimes in a complex manner)	Technical Fit	Technical Fit	**Technical Fit**	Panagiotis	Social norms, peer pressure	Peer-Pressure	Peer-Pressure	**Peer-Pressure**
	Omar Usmani	(Some) people get value from being special/among the first to purchase something innovative or green.		Novelty	Novelty					
	Omar Usmani	They also react to other people doing so (escalation: if my neighbour gets something, I have to get more/something better)	Novelty	Poseur	Poseur	Panagiotis	Increase of the "community" feeling in superblocks	Support	Support	Support
	Panagiotis	Social pressure, Social norms	Peer-Pressure	Peer-Pressure	**Peer-Pressure**	Panagiotis	External recognition and judgement by others	Authority	Authority	**Authority**
	Panagiotis	Development of "mobility communities" instead of dominant private car paradigm	Poseur	Support	Support					
	Panagiotis	Air trips become out-of-fashion, as everyone travels by train	Trends	Trends	**Trends**					
	1	No Knowledgeabout robotaxi	Knowledge [66]	Knowledge	Knowledge	1	No Knowledge about 15 mins cities	Knowledge	Knowledge	Knowledge
	1	No trust in the concept of autonomous solutions	Trust [67]	Trust	Trust	1	No positive attitude towards new solutions - restriction of civil liberties	Commitment	Commitment	Commitment
	1	No positive attitude towards new technologies - restriction of civil liberties	Commitment [69]	Commitment	Commitment	1	The need to develop new technologies for travel planning and information transfer	Agreement	Own Competence	Own Competence
	2	Lack of appropriate rules for moving with the use of micromobility causing chaos in transport systems	Legal	Legal	**Legal**	2	Lack of appropriate rules for moving with the use of micromobility and private personal mobility causing chaos in transport systems	Legal	Legal	**Legal**
	2	Lack of proper rules of moving with the use of robotaxi	Legal	Legal	Legal	2	The need to build appropriate tools for travel planning and information transfer	Technical Fit	Technical Fit	Technical Fit
	2	The new solution (robotaxi) requires breaking the cognitive barrier (fear of autonomous vehicles)	Trust	Safety	**Safety**	2	Lack of integrated ticket	Technical Fit	Technical Fit	**Technical Fit**
	2	Need to own your own car despite the existence of many other forms like robotaxi ("private vehicles obsolete in cities and low density zones, but it is not possible to live without using them")	Commitment [76]	Autarky	Autarky	2	Improving the image of public transport	Authority	Authority	Authority

	Plausible Scenario					Ideal Scenario				
	Expert	RAW	Key Concept I	Key Concept II	Final Coding	Expert	RAW	Key Concept I	Key Concept II	Final Coding
Barriers	3	I don't trust computers to be safe drivers.	Trust	Trust	Trust	3	Many cities cannot be redesigned, because the car infrastructure has demolished it and stripped it of its character.	Technical Fit	Technical Fit	Technical Fit
	3	You never know who has been in the robotaxi before you. It feels dirty.	Trust	Trust	**Trust**	3	"Personal freedom" groups defend the right to a PMV and consider public and shared mobility solutions an unacceptable limitation. They are supported and funded by the car lobby, but also by big-box retailers (hypermarkets, IKEA...)	Commitment	Commitment	**Commitment**
	3	What if I want to go shopping and need to make several stops and carry bags or large items?	Technical Fit	Technical Fit	**Technical Fit**	3	Only the well-off can afford to live in these cities. Low-income families have to commute on PT	Credit Score	Credit Score	**Credit Score**
	3	I still need access to a PMV for visiting out-of-town relatives/friends or for work.	Technical Fit	Technical Fit	**Technical Fit**	10	Barriers may occur in travelling as using similar services and modes of mobility has to be standardised in order to have trust into them	Trust	Trust	**Trust**
	3	What if there's an accident with a robotaxi, who is responsible?	Safety	Legal	**Legal**					
	10	New modes of mobility have to be quick and effective (do not require too much planning ahead, quick access near to home, work, school etc..)	Cost-Efficiency	Cost-Efficiency	**Cost-Efficiency**					
	Ruth	Regulation of micro mobility systems inside cities	Legal	Legal	**Legal**	Ruth	Freedom to maintain my personal choices	Self-Satisfaction	Autarky	**Autarky**
	Ruth	Accessibility to the micro mobility systems due to the digital gap	Own Competence	Own Competence	**Own Competence**	Ruth	Regulation of city access	Legal	Legal	**Legal**
	Ruth	Ethical aspects consideration regarding new modes of mobility	Technical Fit	Own Significance	**Own Significance**	Ruth	Fiscality/ taxes systems	Trust	Profits	**Profits**
	Omar Usmani	Habits: Some people might not consider these robo-taxis, since they already have a car (or would rebuy one) (or would keep using public transport, or previous car schemes from the previous scenario)	Self-Satisfaction	Commitment	**Commitment**	Panagiotis	Resistance to the design of new superblocks	Self-Satisfaction	Risk Profile	**Risk Profile**
	Omar Usmani	People might not trust robots/ autonomous vehicles	Trust	Trust	**Trust**	Panagiotis	Lack of knowledge for new mobility practices	Knowledge	Knowledge	**Knowledge**
	Omar Usmani	People might not know enough about robo-taxis	Knowledge	Knowledge	**Knowledge**	Panagiotis	Reduced comfort for some parts of society that face challenges for active transport	Cozyness	Cozyness	**Cozyness**
	Omar Usmani	People might feel unsafe while alone in a car with no driver (different than trusting the car to drive itself)	Safety	Safety	**Safety**					
	Omar Usmani	People might worry about liability issues (which party is liable if there is an accident: would the person ordering the ride be responsible?)	Technical Fit	Legal	**Legal**					

MOBILITY

	Plausible Scenario					Ideal Scenario				
	Expert	RAW	Key Concept I	Key Concept II	Final Coding	Expert	RAW	Key Concept I	Key Concept II	Final Coding
	Omar Usmani	Do these services have sufficient availability at the right time and right place so that people can keep doing their activities (i.e. do these mobility services restrict people's activities/male them harder)?	Trust	Technical Fit	**Technical Fit**					
	Panagiotis	Lack of trust in robotaxis and new forms of mobility	Knowledge	Trust	**Trust**					
	Panagiotis	Lack of knowledge about these new mobility options	Knowledge	Knowledge	**Knowledge**					
	Panagiotis	Reduced comfort if rail services are not good	Cozyness	Cozyness	**Cozyness**					
Rebound effects	1	The increase in the number of autonomous vehicles may lead to the paralysis of the system, reducing safety,	Safety		**Safety**	1	Changing the city concept according to the 15 mins cities idea may lead to unsustainable development of individual districts in terms of: Economical, Economic, Social, Transport	Clash		**Trust**
	1	System collapse in the event of unplanned events (infrastructure and system failures, extreme weather conditions,)	Technical Fit		**Safety**	2	The coexistence of autonomous and traditional vehicles in one transport system can reduce safety	Safety		**Technical Fit**
	2	The coexistence of autonomous and traditional vehicles in one transport system can reduce safety	Safety		Technical Fit	2	The concept of 15-minute cities may limit the development in the future and the need to relocate residents depending on the place of employment, economic crisis in a given industry, etc.	Clash		Legal
	2	Robotaxi is not solution for congestion – more cars = more congestion problems	Technical Fit		Technical Fit	2	The habit of up to 15-minute cities can make it difficult for people to move outside of them in the future	Clash		Risk Profile
	3	Robotaxis crawl the streets constantly in search for a ride and because they have nowhere to park	Increase consumption		**Risk Profile**	3	At weekends, when everyone wants to leave the city, all transport modes are overbooked. It is impossible to rent a car to reach the mountains or some rural areas.	Increase consumtion		**Technical Fit**
	3	High-speed trains have reduced plane travel but have cannibalised long- distance night trains and have used up public funds for upkeep of regional train services.	Cost-Efficiency		**Risk Profile**	3	Cities have become infested by e-bike couriers and Amazon automatic delivery vans and drones.	Clash		**Trust**
	3	Urban PT, which is more energy- and space efficient, has been outcompeted by eHailing and robotaxis.	Technical Fit		**Technical Fit**	3	Tourism is limited to the massiffied areas as all other areas are difficult to reach.	Technical Fit		**Technical Fit**
	3	Robotaxis are slow because of the many traffic jams.	Increase consumption		**Technical Fit**	3	Rural areas have all but emptied out of people. It's just impossible to get around.	Clash		**Support**
	10	As private cars are "disappearing", public transport is quicker and more effective or again vice-versa - demand is bigger than making the services responsive and high quality enough	Technical Fit		Cost-Efficiency	3	Due to a healthier environment and more active lifestyles, life expectancy has shot up. There is no money to pay retired people, who are forced to work beyond 70.	Clash		Legal

MOBILITY

Plausible Scenario					Ideal Scenario				
Expert	RAW	Key Concept I	Key Concept II	Final Coding	Expert	RAW	Key Concept I	Key Concept II	Final Coding
Ruth	Widening the gap mobility between people with low mobility inside the cities	Wellbeing			Ruth	Massive prices lowrance	Profits		
Ruth	Cities centres transformations	Agreement			Ruth	Democratization of mobility systems	Rights and Duties		
Ruth	Difficulties in maintaining the attitude in favor of alternative transportation options	Adherence			Ruth	Population abandoning city centres and considering to live in low populated nucleus	Clash		
Omar Usmani	The mobility services might trigger people to use these instead of public transport or other modes (walking/biking, etc.) because of their ease of use, thereby increasing energy use for transport and possible cheaper costs	Increase consumption			Panagiotis	Challenging to travel outside your superblock	Commitment		
Panagiotis	Increased mobility and traffic in city centers	Clash			Panagiotis	Possibly increase societal divide with "good" and "bad" superblocks	Clash		
Panagiotis	Changes in economy structure towards more digitisation	Cost-Efficiency			Panagiotis	Reduced jobs in industries manufacturing cars	Legal		
Panagiotis	Limited travelling outside the country	Autarky							
63	63	62	63	63	46	46	46	46	46

	Minimum Scenario					Probable Scenario				
	Expert	RAW	Summary I	Summary II	Final Coding	Expert	RAW	Summary I	Summary II	Final Coding
Intrinsic Determinants	1	I will pay less in the electric bill	Profits	Profits	Profits	1	I can estimate the returns of the investment made for the renovation	Cost-Efficiency	Risk Profile	Knowledge
	1	I know that this change is good for the society and the environment	Self-Satisfaction	Own Significance	Own Significance	1	I think that my behaviour is positive for the society and that it will help other people to go forward in the same direction	Authority	Authority	Authority
	1	I feel better changing my behaviour because I know that I am contributing to the electric system	Support	Knowledge	Support	1	My behaviour and investment are contributing to fight climate change	Environmental Concerns	Climate Protection	Climate Protection
	4	Money: I am convinced that I can easily save some money by changing my behaviour	Profits	Profits	Profits	4	Self-interest: Most of the time during the day when the PV is generating I am at home (e.g. because of family). Therefore I am convinced that I have most of the benefit from the PV, whereas my neighbours pay the same investment, but have less benefit then I have.	Profits	Profits	Profits
	4	Gamification: I find it funny to play with the app and see when the prices are low and act accordingly.	Fun	Fun	Fun	4	Indifference: I already spend a lot of money in the renovation so I can also make the PV investment for a little extra money.	Added Value	Risk Profile	Cost-Efficiency
	4	Curiosity: I am interested to try something new in my everyday life	Novelty	Novelty	Novelty	4	Strong belief in renewable energy: I am convinced that I have to do everything I can to increase the share of renewable energy. I owe it to my children and the next generations.	Authority	Own Significance	Authority
	5	The longer I do it, the more I get practice and can automatize stuff (as soon as it gets boring)	Adherence	Adherence	Adherence	5	See an effect of ideas/work/planning i do	Own Competence	Own competence	Own Competence
	5	My action has direct effects and those are positive not only for me but for the people I live with, my children and society as a whole	Own Significance	Support	Support	5	Produce my own energy and thus be more independent from big companies	Autarky	Autarky	Autarky
	5	I contribute climate protection, so I feel better	Self-Satisfaction	Climate Protection	Environmental Concerns	5	Being proud of using few energy	Own Significance	Own competence	Own Significance
	5	I save money with only little investment of time which I can spend elsewhere	Profits	Cost-Efficiency	Cost-Efficiency	6	Consensus inside the family unit (prosumer motivation and agreement in priority in comparison to other investments)	Agreement	Agreement	Agreement
	5	Others will follow my example when I do that in a good way	Authority	Authority	Authority	6	I can understand practical advantages of measures, including life cycle of new installation	Knowledge	Knowledge	Knowledge
	5	I am good at managing that stuff and proud if I can organize that in a clever and efficient way	Own Competence	own competence	Own Competence	6	Intensity of militant engagement towards sustainability	Environmental Concerns	Trends	Trends
	6	Impact of energy costs in Family Budget	Profits	Profits	Profits	6	Habituation to use explicit ethical analysis (common good, deliberation process, normative, virtues)	Knowledge	Knowledge	Knowledge
	6	Consensus inside the family unit (no deep disagreement due to cultural influence of different members for political, professional, religious... ideals)	Agreement	Agreement	Agreement	9	Producing and consuming green energy will reduce my carbon footprint	Own Competence	Own Competence	Own Competence
	6	I can understand and verify practical advantages of adopted measures	Own Competence	Knowledge	Knowledge	9	I will be part of a prosumers community	Authority	Socialising	Socialising
	9	Energy savings result in reduced energy bills for my family	Profits	Profits	Profits	9	Desire to disconnect from the grid and avoid rising electricity prices, save money	Autarky	Profits	Autarky
	9	Having own control of the energy consumption	Adherence	Autarky	Own Competence	13	I want to do something good for the environment	Environmental Concerns	Environmental Concerns	Environmental Concerns
	9	Having a smart home is fancy, it is the future of the modern energy home	Trends	Trends	Trends	13	financial incentive to save money	Profits	Profits	Profits
	10	I feel better after this investment as I feel I am contributing to fight climate change	Climate Protection	Climate Protection	Climate Protection	13	I believe solar energy is a green energy source, and the future	Own Significance	Own Significance	Own Significance
	10	I am confident that this behaviour is positive for the society	Own Significance	Own Significance	Own Significance					
	10	Someone has to start doing this kind of decisions and then others will continue	Authority	Authority	Authority					
	13	financial incentive to save money	Profits	Profits	Profits					
	13	motivation to reduce my own energy consumption and thus, carbon footprint	Own Competence	Own Significance	Own Significance					
	13	I feel good about reducing my energy consumption	Own Competence	Own Competence	Own Competence					
	1	Other people are also changing the routine	Peer-Pressure	Trends	Trends	1	Social pressure in other neighborhoods they have made the same investment	Trends	Peer pressure	Peer-Pressure
	1	Depending on the technology that has each house, in winter it could be more difficult to change habits	Cost-Efficiency	Technical Fit	Technical Fit	1	Investments in green technologies grants you recognition	Authority	Brag	Brag
	1	Most of the people says that they are not going to make any change	Trends	Trends	Trends	1	There are many new laws that support those kind of actions	Legal	Legal	Legal
	1	A lot of fake news	Knowledge	Knowledge	Knowledge	4	Subsidies: Building integrated PV systems are highly subsidised , making people feel that they would throw away money if they wouldn't make use of the subsidy	Profits	Profits	Profits

FLEXIBILITY

Extrinsic Determinants	1	Family composition: not that easy to change habits having small children at home	Cost-Efficiency	Own Competence	Adherence	4	Strong local community: My neighbours who are also my friends might convince me to make the investment in PV or to join the energy community. This could be reason enough for making this investment	Poseur	Peer pressure	Peer-Pressure
	4	Social pressure to be sustainable: My social environment suggests that I need to act to tackle climate change	Peer-Pressure	Peer Pressure	Peer-Pressure	4	Promotion of high expectations: Energy communities are promoted by several stakeholders (media, government, experts, peers), promising that it has financial benefits for PV prosumers	Knowledge	Knowledge	Knowledge
	4	Advertising: The promotion of the energy supplier gives me a good feeling (green and financial savings)	Knowledge	Trends	Trends	5	Good advice from experts (without investing at that step)	Poseur	Role models	Trends
	4	Social recognition as a front-runner: I can brag when talking with my friends that I am doing something new, cool and green	Authority	Brag	Brag	5	People I know have made good experience with that	Poseur	Trends	Authority
	5	Peer pressure: There is a competition among the people living in the house to use energy most efficient	Authority	Peer Pressure	Peer-Pressure	5	Difficult discussion with owner/neighbours who does and pays what	Rights and Duties	Rights and Duties	Rights and Duties
	5	The amount of money that can be saved is high in relation to the investment of time, money and effort I have to do	Risk Profile	Cost - efficiency	Cost-Efficiency	6	Good atmosphere and mutual trust among neighbours and/or the property (MDU-Tenant)	Own Significance	Trust	Agreement
	5	The people I live with are passionate climate protectors, so I need to take part to get recognition	Authority	peer Pressure	Peer-Pressure	6	Opportunity to reinforce culture of community (MDU-Tenant)	Authority	Support	Support
	5	It is anyway a good idea to get control and Knowledgeover the energy usage of different appliances in the house	Knowledge	Autarky	Own Competence	6	Peer pressure (increased if MDU) and owner proposals (increased if tenant). Follower vs promoter role increased SFH- MDU-Tenant	Peer-Pressure	Peer pressure	Peer-Pressure
	6	Scientific consensus and pedagogy to transmit facts to lay people	Knowledge	Authority	Authority	6	Significant financial programs to incentivize and support the investment	Credit Score	Risk Profile	Credit Score
	6	Opportunity to reinforce culture of community (MDU-Tenant)	Support	Support	Support	9	Access to public grants for energy self-production	Credit Score	Knowledge	Credit Score
	6	Peer pressure (increased if MDU) and owner proposals (increased if tenant). Follower vs promoter role increased SFH-MDU-Tenant	Peer-Pressure	peer Pressure	Peer-Pressure	9	Net metering schemes	Profits	Profits	Profits
	6	Institutional campaigns for social normalization	Authority	Trends	Trends	13	I'm proud to produce renewable energy, and can "show-off" to others	Authority	Role models	Authority
	9	Public incentives for smart homes - tax deductions, discounts	Profits	Profits	Profits	13	other neighbours participate and I feel I have to do the same	Poseur	Peer pressure	Peer-Pressure
	9	Awareness raising campaigns on the benefits of monitoring energy consumption and saving energy	Knowledge	Knowledge	Knowledge	13	experts explained me how the whole concept will work	Knowledge	Knowledge	Knowledge
	10	I have read that people similar to me make the same investments	Poseur	Role models	Authority	13	reparations are needed anyway, so good chance to get this done	Cost-Efficiency	Cost-Efficiency	Cost-Efficiency
	10	This is something that sooner or later will have to be done	Cost-Efficiency	Cost - efficiency	Cost-Efficiency					
	13	my neighbours are already using the app	Trends	Role models	Authority					
	13	I feel good about being part of a movement of people using the app	Own Significance	Socialising	Socialising					
	13	people approached my and told me how to use the app	Peer-Pressure	Support	Support					
	13	I got informed about the app via the news	Knowledge	Knowledge	Knowledge					
	1	Lack of availability to change my behaviour	Cost-Efficiency	Cost-Efficiency	Cost-Efficiency	1	Lack of Knowledgeof other kind of opportunities	Knowledge	Knowledge	Knowledge
	1	Lack of Knowledgein the benefits that could this change have	Knowledge	Knowledge	Knowledge	1	Initial investment	Credit Score	Credit Score	Credit Score
	1	Lack of information of the change	Knowledge	Knowledge	Knowledge	1	Lack of motivation in the community	Own Competence	peer pressure	Peer-Pressure
	4	Diverging motivation within the family: only one family member is interested in reacting to ToU prices, whereas others don't want to change their behaviour (e.g. complaining that it is too cold due to smart thermostat)	Agreement	Agreement	Agreement	4	Personal efforts for joining a energy community or engage in building up the community are very high, regarding administrative work etc.	Commitment	Commitment	Commitment
	4	Financial disillusion: no long term behaviour change because of low financial benefit	Profits	Profits	Profits	4	Lack of trust: I don't want to rely on my neighbours when it comes to money, thus I don't want to join an energy community.	Trust	Trust	Trust
	4	Lack of endurance: funny in the beginning to watch the prices, but it gets boring after a while	Fun	Fun	Fun	4	Act of defiance: I might refuse to participate in the investment, because I might have the feeling that my neighbour wants to forceme to something I don't need and it's onlyfor his benefit	Peer-Pressure	Peer pressure	Peer-Pressure
	4	Lack of belief: Not convinced that my behaviour change can save the world	Trust	Cost-efficiency	Trust	5	Being afraid of failure	Safety	Safety	Safety
	4	Ecologic disillusion: I realise that sometimes prices are low in times of high fossil generation instead of high renewable generation.	Own Significance	Knowledge	Climate Protection	5	Hidden/unknown/additional costs	Risk Profile	Risk Profile	Risk Profile
	5	Few money to earn, few effect to see for huge time and money investments	Profits	Risk Profile	Risk Profile	5	I will not profit from the work and investment	Profits	Profits	Profits
	5	Cannot make it a daily routine, so loose interest	Fun	Adherence	Adherence	6	Normative uncertainty and instability that discourage investment	Legal	Legal	Legal
	5	People I live with are not interested in what I am doing, think it is ridicoulous	Agreement	Peer pressure	Peer-Pressure	6	Impact of investment in Family Budget	Risk Profile	Risk Profile	Risk Profile

FLEXIBILITY

Barriers	5	Conflicts arise because people I live with do not want to adapt their habits	Agreement	Agreement	Agreement	6	Internal disagreement due to cultural influence of different members for political, professional, religious... ideals)	Agreement	Agreement	Agreement
	6	Personal skills related to gadgets, apps...	Cost-Efficiency	Technical Fit	Own Competence	9	Not good location of the building, respectively, its roof - not enough sun, higher buildings planned to be built close to our building.	Added Value	Risk Profile	Technical Fit
	6	Real possibilities of relevant changes in behaviours	Adherence	Cost-Efficiency	Cost-Efficiency	9	Too complicated administrative procedures to form the energy community and to distribute the generated energy evenly.	Cost-Efficiency	Cost-Efficiency	Cost-Efficiency
	6	Time disponibility to be concentrated daily in the scenario	Credit Score	Cost-Efficiency	Cost-Efficiency	9	It might be the case that not all households living in the building agree to invest in renewable energy.	Agreement	Agreement	Agreement
	9	The installations in my home could be obsolete and controlling energy consumption through smart plugs and apps could be impossible	Technical Fit	Technical Fit	Technical Fit	13	If I don't own the house, I cannot decide myself on the panel & renovations	Rights and Duties	Rights and Duties	Rights and Duties
	9	Not being aware of the existing opportunities to monitor your energy use and adjusting consumption to the new tariff scheme	Knowledge	Knowledge	Knowledge	13	I don't have money to invest	Credit Score	Credit Score	Credit Score
	9	Inability to adjust my energy consumption to the new tariffs - I need to wash my clothes in the morning so they get dry by night, although the price at night is lower, etc.	Technical Fit	Own Competence	Adherence	13	I worry about the bureaucratic process	Legal	Legal	Legal
	10	There are not any public help or subsidies	Credit Score	Profits	Credit Score	13	I don't trust in the reliability of solar energy	Trust	Trust	Trust
	10	Lack of Knowledgeabout the opportunities	Cost-Efficiency	Knowledge	Knowledge	13	I don't go well along with my neighbours and don't want to join a project with them	Agreement	Agreement	Agreement
	13	I miss the technical Knowledgeto use the app	Cost-Efficiency	Knowledge	Knowledge					
	13	I didn't get informed about the scheme	Knowledge	Knowledge	Knowledge					
	13	too much work for me to use the app (time consuming)	Cost-Efficiency	Cost-Efficiency	Cost-Efficiency					
Rebound effects	1	Save money	Profits	Profits		1	More conscious consumption	Knowledge	Environmental concerns	
	1	More conscience about energy consumption	Knowledge	Environmental Concerns		1	Reduce the consumption	Own Competence	Own competence	
	4	Loss of efficiency: When the price is low, I turn up all my appliances, but in this way I am extremely inefficient (e.g. turning up the washing machine only for only two shirts, because right now power is cheap)	Loss of importance of energ	Cost-Efficiency		1	Save money	Profits	Profits	
	4	Easing my bad conscience: By having a ToU tariff I am already saving the world, so I don't need to care about other harmful things (like driving my car, travelling by plane, eating a lot of beef etc.)	GreenWashing	Own Significance		4	Energy efficiency becomes less important:I use more electricity in total because it comes from my own roof or from the community anyways	Loss of importance of ener	Environmental concerns	
	5	I have protected the climate, so I can cause more emissions elsewher (e.g. fly/drive car)	GreenWashing	Poseur		4	Oversizing: I build my PV too big, so I produce too much energy that can be used locally in the energy community, resulting in congestions somewhere in the LV grid	Overuse	Own competence	
	5	The additional appliances and the digitalization in the house cause more additional energy demand than I use	Increased energy consumtion / ... on cheap hours / ... of anciliary devices	Cost-efficiency		5	High resource/energy input for small energy output	Overuse	Cost-Efficiency	
	5	More dispatch required due to unexpected user behaviour	Increased energy consumtion / ... on cheap hours / ... of anciliary devices	Autarky		5	Spending the extra money I saved from energy on other energy-intensive products or actions	Increase of embodied energy	Profits	
	6	Success creates a new market for apps and gadgets with its own life-cycle analysis and logistic, quality and maintenance potential problems	Increase of embodied energy	Trends		5	Being less careful with saving energy since I produce my own	Loss of importance of ener	Environmental concerns	
	6	Initial success of Technology-based solutions can demotivate other individual or community approaches (reduction, behaviors, habits... oriented to reduce)	Clash with energy conservation actions	Knowledge		6	Success in savings leads to decrease awareness in reduction of energy usage	Clash with energy conservation actions	Cost-Efficiency	
	9	Start consuming more energy at low-tariff periods, just because of the low price, not because I need it.	Increased energy consumtion / ... on cheap hours / ... of anciliary devices	Profits		6	If there is a fast growing market, supplies, maintenance and life cycle problems may appear	Overuse	Technical Fit	
	10	The abuse of the instrument could make more difficult other actions more relevant for the energy transition	Clash with energy conservation actions	Technical Fit		9	Start consuming more energy	Increased energy consumtion / ... on cheap hours / ... of anciliary devices	Cost-Efficiency	
	13	I know when electricity use is cheapest and I care less to turn appliances off	Clash with energy conservation actions	Knowledge		13	I have now clean energy and need to take less care of my energy consumption - because all I consume is green	Loss of importance of ener	Cost-Efficiency	

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	13	I know I can make a lot of saving and thing care less about uses that are still influences by myself, e.g. turning off light when leaving the room	Clash with energy conservation actions	Own Significance						
	84		71		71	70		58		58

	Plausible Scenario					Ideal Scenario				
	Expert	RAW	Summary I	Summary II	Final Coding	Expert	RAW	Summary I	Summary II	Final Coding
Intrinsic Determinants	1	Time and money save	Risk Profile	Profits	Profits	1	Time and money save	Risk Profile	Cost-Efficiency	Profits
	1	I can estimate the returns of the investment	Cost-Efficiency	Cost-efficiency	Cost-Efficiency	1	My behaviour has benefits for the society and the environment	Own Significance	Support	Support
	1	My behaviour has benefits for the society and the environment	Environmental Concerns	Own Significance	Own Significance	1	Autonomy	Self-Satisfaction	Self-Satisfaction	Self-Satisfaction
	1	Easy to use and understand	Cost-Efficiency	Cost-efficiency	Cost-Efficiency	4	Feeling safe in a self sufficient high-tech neighbourhood	Safety	Safety	Safety
	1	My behaviour can foster the energy transition	Poseur	Own satisfaction	Environmental Concerns	4	I am looking for a meaningful option to invest my money into.	Poseur	Poseur	Profits
	4	Shared risk: It is easier to decide for an investment if it is a community project so I don't have all the cost and risk on my own	Risk Profile	Risk Profile	Risk Profile	4	Affinity to high tech solutions: Being interested in smart energy solutions because of a professional technical background	Self-Satisfaction	Self-Satisfaction	Self-Satisfaction
	4	Strong belief in renewable energy: as in the probable scenario	Own Significance	Own Significance	Own Significance	5	I have the ability to understand and handle all the components	Knowledge	Knowledge	Knowledge
	4	Self-interest: I feel that I only have a benefit from my PV if there is also a battery storage, because I am usually not at home during daytime	Profits	Profits	Profits	5	I like investing money	Added Value	Added Value	Added Value
	5	Doing good for society / children	Authority	Role models	Authority	5	I am convinced that this small scale storage is beneficial for the whole system	Knowledge	Knowledge	Knowledge
	5	Getting more independant of huge energy companies	Autarky	Autarky	Autarky	5	I am very interested in technology	Novelty	Novelty	Novelty
	5	Earning money by doing good	Profits	Cost-efficiency	Profits					
	6	Consensus inside the family unit (prosumer motivation and agreement in priority in comparison to other investments)	Agreement	Agreement	Agreement	6	I can understand practical advantages of this decision, especially when purchasing (less important if renting).	Knowledge	Knowledge	Knowledge
	6	I can understand practical advantages of measures, including life cycle of new installation (batteries)	Knowledge	Knowledge	Knowledge	6	I can understand contractual aspects of energy community and financial products	Risk Profile	Knowledge	Knowledge
	6	I can understand contractual aspects of energy community and financial products	Risk Profile	Legal	Legal	6	Intensity of militant engagement towards sustainability	Environmental Concerns	Poseur	Commitment
	9	To become part of an energy community	Support	Socialising	Socialising	6	Habituation to use explicit ethical vs economical analysis (common good vs own interest)	Knowledge	Adherence	Environmental Concerns
	9	Self-generating and consuming green energy - becoming part of the energy transition process	Support	Support	Support	9	My willingness to become completely independent from the grid and to move entirely to RES, covering all my energy needs all year long with RES energy	Autarky	Self-Satisfaction	Autarky
	9	The storage system will allow to disconnect from the grid and thus avoid the risk of increasing energy prices	Autarky	Profits	Autarky	9	Satisfaction with becoming part of energy community	Support	Support	Support
	13	I feel good about doing something good by implementing all the measures	Own Significance	Own satisfaction	Self-Satisfaction	9	Good practices examples from other neighbourhoods	Authority	Authority	Authority
	13	financial incentive to save money in the future	Profits	Profits	Profits	13	financial incentive to save money	Profits	Profits	Profits
	13	I see a health benefit to live in a cleaner house	Wellbeing	Wellbeing	Wellbeing	13	I want to do something good for the environment/ climate	Poseur	Poseur	Environmental Concerns
	13	I care about the environment / climate and saw the need to refurbish our building	Poseur	Environmental concerns	Environmental Concerns	13	I want to be energy independent	Autarky	Self-Satisfaction	Autarky
						13	I want to live a green lifestyle and feel good about it	Own Significance	Poseur	Self-Satisfaction
	1	Social pressure in other neighborhoods they have made the same investment	Peer-Pressure	Peer pressure	Peer-Pressure	1	Social pressure in other neighborhoods they have made the same investment	Peer-Pressure	Peer pressure	Peer-Pressure
	1	Investments in green technologies grants you recognition	Authority	Brag	Brag	1	Investments in green technologies grants you recognition	Authority	Brag	Brag
	1	The interest rate seems fair	Added Value	Profits	Profits	1	The interest rate seems fair	Added Value	Profits	Profits
	4	Price: The market prices for battery storage have dropped recently, which makes a good timing to invest now	Added Value	Risk Profile	Risk Profile	4	Prestige: Being an absolute frontrunner of the energy transition	Authority	Authority	Authority

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Extrinsic Determinants	4	Community pressure: My neighbours ask me if I would like to invest in this community storage. Although I am not entirely convinced I don't want to be the bad guy who is against green energy.	Peer-Pressure	Peer pressure	Peer-Pressure	4	Fear of dependence on a vulnerable energy system incentivises investments in energy autarky within my neighbourhood	Autarky	Autarky	Autarky
	4	Subsidies: Building integrated PV systems are highly subsidised , making people feel that they would throw away money if they wouldn't make use of the subsidy	Profits	Profits	Profits	5	I can easily find good advice for building and maintaining the system	Cost-Efficiency	knowledge	Knowledge
	4	Strong local community: My neighbours who are also my friends might convince me to make the investment in PV or to join the energy community. This could be reason enough for making this investment	Poseur	Peer pressure	Peer-Pressure	5	The big energy suppliers and policy do not do what I think is necessary for climate protection, so I try to do it small scale	Environmental Concerns	Climate Protection	Climate Protection
	4	Promotion of high expectations: Energy communities are promoted by several stakeholders (media, government, experts, peers), promising that it has financial benefits for PV prosumers	Knowledge	Knowledge	Knowledge	5	There is enough space for the storage etc.	Technical Fit	Techical fit	Technical Fit
	5	My neighbours are good to work with and the energy community enhances the connections in our community	Agreement	Socialising	Socialising	5	The technology is proven and works well	Trust	Trust	Trust
	5	I am not satisfied with the current energy contracts I have and the way the companies generate the electricity/heat	Commitment	Own Satisfaction	Commitment	6	Such big investment (when purchasing, less important if renting) needs good Impact and Risk analysis (both personal and community)	Risk Profile	Risk Profile	Risk Profile
	5	I have free time I would like to fill with meaningful things, where I can learn and contribute	Self-Satisfaction	Own Significance	Own Significance	6	Clearly stablished contractual aspects regarding energy costs, selling prices and conditions...	Legal	Legal	Legal
	6	Good atmosphere and mutual trust among neighbours and/or the property (MDU-Tenant)	Own Significance	Agreement / trust	Agreement	6	Significant financial programs to incentivate and support the investment	Credit Score	Risk Profile	Credit Score
	6	Opportunity to reinforce culture of community (MDU-Tenant)	Authority	Socialising	Socialising	9	Public support/ funding	Credit Score	Risk Profile	Credit Score
	6	Significant financial programs to incentivize and support the investment	Added Value	Risk Profile	Credit Score	9	The existence of already developed similar system in the neighbourhood	Trends	peer pressure	Authority
	6	Peer pressure (increased if MDU) and owner proposals (increased if tenant). Follower vs promoter role increased SFH-MDU-Tenant	Peer-Pressure	Authority	Peer-Pressure					
	9	Discounts for energy self-producers when buying electrical appliances - I am not sure if such schemes exist, but it would be cool and motivating. :)	Novelty	Profits	Novelty	13	reputation by other people that I live in such a house	Authority	Role model	Authority
	9	Good location of the building, with enough sunny hours and open space around the building	Profits	Technical Fit	Technical Fit	13	I invest because others do too	Peer-Pressure	peer pressure	Peer-Pressure
	13	I feel good about what others think about my smart house	Authority	Brag	Brag					
	13	others get me motivated to join the project	Poseur	Peer pressure	Peer-Pressure					
	13	experts informed me about how the house will function after the refurbishment (benefits etc.)	Knowledge	Knowledge	Knowledge					
	1	Lack of Knowledgeabout the opportunities	Knowledge	Knowledge	Knowledge	1	High initial investment	Risk Profile	Credit Score	Risk Profile
	1	High initial investment	Credit Score	Risk Profile	Risk Profile	1	Lack of Knowledgeof all the technologies and opportunities	Knowledge	Knowledge	Knowledge
	1	Lack of interest of the neighbors	Commitment	Environmental Concerns	Commitment	1	Lack of trust on new technologies	Trust	Trust	Trust
	4	Location: The battery storage would need to be located right next to my balcony and I don't like that (NIMBY effect)	Technical Fit	Technical Fit	Technical Fit	4	Highly complex domestic energy concept leads to an increasing risk of malfunctions that have a high impact on my personal comfort.	Safety	Safety	Safety
	4	Personal efforts for joining a energy community or engage in building up the community are very high, regarding administrative work etc.	Commitment	Cost-Efficiency	Cost-Efficiency	4	High costs that clearly exceed my personal benefit (long-term financial benefit, comfort benefit)	Profits	Cost-Efficiency	Cost-Efficiency
	4	Lack of trust: I don't want to rely on my neighbours when it comes to money, thus I don't want to join an energy community.	Trust	Trust	Trust	5	It might not make sense to do H2-small scale storage from an environmental/ressources point of view	Climate Protection	Environmental concern	Technical Fit
	4	Act of defiance: I might refuse to participate in the investment, because I might have the feeling that my neighbour wants to forceme to something I don't need and it's onlyfor his benefit	Peer-Pressure	Peer presure	Peer-Pressure	5	Complexity	Cost-Efficiency	Cost-Efficiency	Cost-Efficiency
	5	fear of conflicts with direct neighbours when working/financing together	Agreement	Agreement	Agreement	5	My neighbours are afraid of H2	Safety	Safety	Safety
	5	Fear of the complexity of the whole tasl (organisational/technical/financing)	Cost-Efficiency	Security	Cost-Efficiency	6	Normative uncertainty and instability that discourage investment	Legal	Legal	Legal
	5	High risks and investment costs	Risk Profile	Risk Profile	Risk Profile	6	Affordability of investment (less important if renting).	Credit Score	Credit Score	Credit Score

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Barriers	6	Normative uncertainty and instability that discourage investment	Legal	Security	Trust	6	Internal disagreement due to cultural influence of different members for political, professional, religious... ideals)	Agreement	Agreement	Agreement
	6	Impact of investment in Family Budget	Risk Profile	Credit Score	Credit Score	9	Any future plans to move to live in another place	Risk Profile	Added value	Added value
	6	Internal disagreement due to cultural influence of different members for political, professional, religious... ideals)	Agreement	Agreement	Agreement	9	Any doubts in the estimations for produced/ consumed energy and the overall functioning of the system	Trust	Trust	Trust
	9	At one moment some of the neighbours could give up the idea to participate	Commitment	Rights and Duties	Commitment					
	9	Not enough information on the feasibility and profitability of the project	Knowledge	Knowledge	Knowledge	13	smart housing issues may get more complex in a multi-family house?!	Agreement	Rights and Duties	Agreement
	9	The project has been developed by untrusty experts - I do not trust the experts and their predictions for energy generated and saved	Trust	Trust	Trust	13	a lot of financial money needed to get to such a state of house; likely high renting prices too	Credit Score	Credit Score	Credit Score
	13	cannot afford to rent /buy	Credit Score	Credit Score	Credit Score	13	I need to manage a lot of things in my house (time issues)	Cost-Efficiency	Cost-Efficiency	Cost-Efficiency
	13	I don't feel able to handle all the technical details	Knowledge	Own competence	Own Competence	13	I miss technical Knowledgeto understand my smart house	Knowledge	Knowledge	Knowledge
	13	I miss Knowledgeabout all the technical details	Knowledge	Knowledge	Knowledge	13	If I don't own the house, I'm not the one investing here	Rights and Duties	Rights and Duties	Rights and Duties
	13	If I don't own the house, I'm not the one investing here	Rights and Duties	Rights and Duties	Rights and Duties					
	13	I don't want to deal with my neighbours (in case I live in a multi-family home)	Agreement	Adherence	Agreement					
Rebound effects	1	More conscious consumption	Knowledge	Environmental concerns		1	Save money and time	Profits	Profits	
	1	Save money	Profits	Profits		1	Lack of professionals	Lack of professionals	Knowledge	
	1	Lack of professionals for the energy community	Lack of professionals	Knowledge		1	More conscious consumption	Clash with energy conservation actions	Environmental concerns	
	4	Battery "ensures autarky": I don't care about when I use energy because the battery makes sure the energy I use is always local and green. So I don't care about any consumption peaks anymore.	Loss of importance of ener	Autarky		4	Image rebound: As high-tech systems as described here require a significant amount of money to be invested, the domestic energy transition is perceived more as something only for the wealthy people and therefore discourages others to follow the frontrunners' lead.	Image rebound	Trends	
	5	High material consumption by using batteries on that small scale	Increase of embodied energy	Cost-Efficiency		5	high energy usage for producing inefficient small-scale storage	Increased energy consumption / ... on cheap hours / ... of ancilliary devices	Cost-Efficiency	
	5	non-efficient use of storage	Loss of importance of ener	Cost-Efficiency		5	storage of H2 and usage for electricity is inefficient	Increased energy consumtion / ... on cheap hours / ... of ancilliary devices	Cost-Efficiency	
	5	primary energy content of the insulation and other builiding material	Loss of importance of ener	Cost-Efficiency		5	additional energy demand for all the control elements	Increased energy consumtion / ... on cheap hours / ... of ancilliary devices		
	6	Success in savings leads to decrease awareness in reduction of energy usage	Loss of importance of ener	Environmental concerns		6	Profit perspective when selling energy can lead to negative impact strategies	Clash with energy conservation actions	Environmental concerns	
	6	If there is a fast growing market, supplies, maintenance and life cycle problems may appea	Increase of embodied energy	Technical Fit						
	13	I think my energy consumption is low and green, and I don't care about additional measure that could save energy consumption	Clash with energy conservation actions	Cost-Efficiency		13	I feel good about the efficiency and RE in my house and don't worry about my energy consumption	Loss of importance of	Own satisfaction	

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						13	I can afford to live in such a house and have generally moe appliances than other people	Increased energy consumtion / ... on cheap hours / ... of ancilliary devices	Brag	
	72		62		62	65		55		55

Minimum Scenario					Probable Scenario					
Expert	RAW	KEY CONCEPT I	KEY CONCEPT II	Final Key Concept	Expert	RAW	KEY CONCEPT I	KEY CONCEPT II	Final Key Concept	Expert
1	I can save some money from reduced energy costs	Profits	financial security, profits	Profits	1	**Lift:**				1
1	The effort it takes is minimal	Cost-Efficiency	Competence, cost-efficiency	Cost-Efficiency	1	Added comfort for inhabtitants (SFH, MUD)	Wellbeing	wellbeing	Wellbeing	1
1	It is within my own domain of possible actions	Self-Satisfaction	Autonomy, self-satisfaction	Self-Satisfaction	1	Preparing for worse health times (SFH, MDU)	Wellbeing	wellbeing	Wellbeing	1
1	I can feel the effects of my actions directly	Self-Satisfaction	Autonomy	Self-Satisfaction	1	Increasing the value of the building (MDU)	Added Value	added value	Added Value	1
1	Given the current developments it gives me a good feeling to be doing something to counteract them	Own Competence	Competence, meaning, environmental concerns	Own Significance	1	**Leaking roof:**				1
4	Environmental concern for protecting the climate	Climate Protection	Security/ Meaning, climate protection	Climate Protection	1	Obligation toward tenants (MDU)	Rights and Duties	Rights and Duties	Rights and Duties	1
4	Feeling of responsibility to do my part in protecting the climate	Environmental Concerns	Meaning, own significance	Environmental Concerns	1	Comfort requirements (MDU, SFH, Ten)	Wellbeing	Wellbeing	Wellbeing	4
4	Values of frugality and modesty, seeing myself as a person who is sensible about spending money	Frugality	Autonomy/ Competence/ Security - frugality	Frugality	1	Fear of additional damange to the bulding (MDU, SFH)	Safety	Safety	Safety	4
4	Health impairment: I get cold or sick easily	Wellbeing	Physicalness, security, wellbeing	Wellbeing	1	**Leaking roof**				4
5	Household income	Credit Score	financial security, profits	Profits	1	SFH: Most important				4
5	Energy and environmental awareness and sensitisation	Poseur	meaning, phsyicalness, wellbeing	Own Significance	1	MDU: Most important				4
9	Feeling that by small effort I can help in achieving decarbonisation	Own Competence	Autonomy/ Competence	Own Competence	1	Tenant: Important but no leverage				4
11	I like to do the righ thing	Own Significance	Meaning - own significance	Own Significance	1	**Gas heater:**				5
11	It is important for my health and my family health	Cozyness	Relatedness/ physicalness, wellbeing, cozyness	Cozyness	1	SFH: Second				5
12	I need to lower our energy costs ASAP, since they represent more than 15% of our family budget.	Profits	security - values financial security, frugality	Profits	1	MDU: Second				5
12	Responsible energy behaviour is an example for my kids, I expect from them to learn and behave green too.	Authority	Relatedness, rights and duties, security +meaning, climate protection	Authority	1	Tenant: Important but no leverage				9
12	I want to have healthier home (warmer during winter, cooler during summer.	Wellbeing	Physicalness, security, wellbeing	Wellbeing	1	**Lift:**				11
					1	SFH: Not relevant (in most cases)				11
					1	MDU:				11
					1	**Heater:**				12

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	Minimum Scenario					Probable Scenario					
	Expert	RAW	KEY CONCEPT I	KEY CONCEPT II	Final Key Concept	Expert	RAW	KEY CONCEPT I	KEY CONCEPT II	Final Key Concept	Expert
						1	Funding	Credit Score	financial security	Credit Score	12
						1	Added value to the building (MDU)	Added Value		Added Value	12
						1	Reduced costs (SFH, Ten)	Own Competence	financial security	Profits	
						1	Reduced CO2 emissions (all)	Own Competence	competence, meaning	Own Competence	
						1	Feeling to be contributing (all)	Support	Meaning; popularity	Support	
						1	Feeling to invest into a new technology (MDU, SFH)	Novelty	Stimulation	Risk Profile	
						1	Feeling to get rid of a "ancient technology" (MDU, SFH)	Trends	Popularity	Trends	
						4	Self-efficacy in planning and managing major construction work	Own Competence	competence, autonomy, security	Own Competence	
						4	Skills and experience in negotiating with and supervising craftsmen	Own Competence	competence, own competence	Own Competence	
						4	One-off investment in roof/heating/lift is not correctly discounted over the entire lifetime	Risk Profile	financial security - risk	Risk Profile	
						5	Energy and environmental sensitisation and awareness raising.	Poseur	popularity; meaning	Poseur	
						5	Comfort provided by the lift. Need for the lift by neighbours with reduced mobility.	Cozyness	physicalness; relatedness, cozy	Cozyness	
						9	Health issues - dampness may negatively impact my health	Wellbeing	physicalness; relatedness, wellbeing	Wellbeing	
						11	The comfort of my family (kids) are very important for me as mother	Cozyness	relatedness, physicalness, cozyness	Cozyness	
						11	It is important for the family to make savings on the energy bills	Profits	financial security-profit	Profits	
						12	It is becoming unbearably hot during summer months, new facade and insulated roof will prevent overheating.	Wellbeing	physicalness; security, wellbeing	Wellbeing	
						12	My green behaviour could be an example for the others - without any "preaching". I will post it in my social media.	Authority	popularity; competence, role model	Authority	
Dete						12	Lower energy costs will help me to lower living costs and to work part-time.	Profits	financial security - profits	Profits	
	1	Others feel the effects of my doing when visiting me (positive and negative)	Authority	Popularity, role model	Authority	1	**Lift:**				1
	1	Other might think I am "weak" for heating the rooms to higher degrees	Authority	relatedness, peer-pressure	Peer-Pressure	1	Visitors can appreciate the added comfort	Cozyness	cozyness	Cozyness	1
	1	It gives me a good opportunity to talk about the reasoning behind my actions, when people visit an realise the changes in temperature	Authority	Relatedness, socialising	Socialising	1	Positive feedback from others for added comfort	Cozyness	relatedness, support	Support	1

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	Minimum Scenario					Probable Scenario					
	Expert	RAW	KEY CONCEPT I	KEY CONCEPT II	Final Key Concept	Expert	RAW	KEY CONCEPT I	KEY CONCEPT II	Final Key Concept	Expert
	1	Other might think I am lavish for heating the rooms to higher degrees	Trends	peer-pressure	Peer-Pressure	1	Others migh percieve this as an upgrade to the building	Added Value	added value, popularity - trends	Added Value	1
	4	Expected savings in heating costs, in particular if I have a low income, or if I have to compensate rent increases by lowering heating costs	Profits	financial security, added value, frugality	Profits	1	**Leaking roof:**				4
	4	My children learned about energy saving in school and expect me to do my part	Authority	Relatedness, support/ Competence + meaning, environmental concerns	Authority	1	If others are aware of the issue, they might think the building is sub-standard	Poseur	peer pressure	Peer-Pressure	4
	4	Compensating for technical faults of the building, e.g. a undersized heating system	Added value	Competence/ autonomy, Technical fit	Technical Fit	1	**Heater:**				4
	5	Prices of materials	Profits	financial security, availability of money	Profits	1	Low gas prices (SFH, Ten)	Profits	profits	Profits	4
	5	Experiences of other people (neighbours, friends, etc.)	Agreement	Relatedness, agreement, support	Agreement	1	Oil heaters are perceived as backward technology	Novelty	stimulation, relatedness - peer-pressure	Trends	5
	9	I will reduce the heating costs	Profits	financial security, profits	Profits	4	Perceived urgency: neighbours demanding to fix the roof, upcoming season of cold temperatures or heavy rainfall, physical impairment (e.g. wheelchair, walking with a stick)	Wellbeing	popularity; security (safety); physicalness	Safety	5
	9	Showing others (friends, family) that I take actions to help decarbonise	Poseur	Relatedness, support	Authority	4	Availability of capital or access to bank credit	Credit Score	financial security, credit	Credit Score	5
	11	External recognition among neighbours	Authority	Popularity, role model/ Relatedness, agreement	Authority	4	Discount for gas heating offered by plumbing companies (as is the case in Austria)	Profits	finanical security	Profits	9
	11	Green fashion trend	Novelty	Stimulation, novelty, Popularity trends	Novelty	5	Regulations	Legal	legal	Legal	11
	11	Worries about future generations	Environmental Concerns	Meaning + Relatedness	Environmental Concerns	5	Rehabilitation aid	Credit Score	financial security, credit	Credit Score	11
	12	I understand that climate changes are serious threat that could be mitigated if all of us contribute.	Poseur	Competence, meaning, environmental concerns	Environmental Concerns	5	Tax relief	Credit Score	financial security -access to credit	Credit Score	12
	12	Being environmentally friendly is very important for my partner.	Agreement	relatedness, peer-pressure	Agreement	5	Access to finance	Credit Score	financial security- credit	Credit Score	12
	12	Being environmentally friendly is very cool among my friends, (and vice versa.)	Authority	Relatedness, peer-pressure	Brag	9	Helping other neighbours who may live in upper floors and may not be able to use the staircase	Cozyness	relatedness, support	Support	12
						9	Reducing the heating bill	Profits	profits	Profits	
						11	The desire to be an eco frindly consumer	Poseur	meaning; popularity	Poseur	
						12	This summer was hottest in last decade, we all need to contribute in climate change mitigation.	Cozyness	relatedness, environmental concerns	Environmental Concerns	
						12	I have seen that similar building installed new heating system - and they are very happy :)	Added Value	popularity, trends, financial, added	Authority	
Dete						12	I understand that energy efficient home has greater market value, and non-efficient ones will be penalized by the state.	Added Value	security, added value	Added Value	
	1	Small children	Cozyness	Relatedness/ Security, wellbeing	Wellbeing	1	**Lift:**				1

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Minimum Scenario					Probable Scenario					
Expert	RAW	KEY CONCEPT I	KEY CONCEPT II	Final Key Concept	Expert	RAW	KEY CONCEPT I	KEY CONCEPT II	Final Key Concept	Expert
1	Partner requireing higher temperatures	Cozyness	Relatedness/ Security, rights and duties	Rights and Duties	1	Additional operational costs for all regardless of use	Profits	financial security	Profits	1
1	Fear of becoming sick	Wellbeing	Physicalness, wellbeing	Wellbeing	1	Major change in the building structure and architecture	Technical Fit		Technical Fit	1
1	I might be seen by others as avaricious that I rather freeze than spend money on heating	Trends	Relatedness, frugality	Frugality	1	Limits in the building substance	Trust		Safety	1
4	Other household members may undermine my saving efforts	Brag	Relatedness, support	Support	1	**Leaking roof:**				1
4	Habits keep me from adapting my clothing to weather/season	Cost-Efficiency	Physicalness, cozyness	Adherence	1	Costs	Profits	financial security	Profits	1
5	Differences in perceptions of comfort	Wellbeing	physicalness, cozyness	Cozyness	1	It is a good option to get tenants out of the building	Rights and Duties		Rights and Duties	4
5	Lack of Knowledge in the use of equipment	Own Competence	Competence, knowledge	Knowledge	1	**Heater:**				4
9	Feeling that such small effort will not help	Own Competence	Competence, cost-efficiency	Cost-Efficiency	1	Still not the best eco-solution	Trust	rebound	Technical Fit	4
9	Knowledge that the individual decisions do not scale and my choice will not help	Own Competence	Competence, knowledge	Knowledge	1	Reluctance towards new technology	Trust	security, trust, rebound, lackof professional	Trust	4
11	The difficulties in changing habits regarding the heating of the house	Cost-Efficiency	autonomy, adherence	Adherence	1	Investment cost through technological transition	Profits	financial security	Credit Score	4
11	Fear of not causing health problems to family members by reducing the temperature	Safety	Security, safety; physicalness, wellbeing	Safety	1	Cost through exchange of equipments	Profits	financial security	Credit Score	5
12	I do not have time right now to do any measures...	Commitment	autonomy, commitment, adherence	Commitment	4	Public subsidies not available, because these would require to not just fix but insulate the roof, and to switch to a non-fossil heating system	Risk Profile	security; autonomy	Credit Score	11
12	There are so many informations on the internet that confuses me and prevent me to act.	Own Competence	Competence, knowledge	Knowledge	4	Tenant-landlord dilemma: the landlord may be obligated to repair the roof and install a lift because of legal requirements, but the landlord may replace with a cheap/unreliable/inefficient heating because the heating costs are carried by the tenant	Risk Profile	autonomy; security	Rights and Duties	11
					4	Short-term tenancy contract makes it more attractive to make quick superficial repairs or move out of the flat	Risk Profile	security; autonomy	Added Value	12
					5	Economic	Profits	profits	Profits	12
					5	Community decision-making process	Agreement	relatedness; stimulation	Agreement	12
					9	The change from oil to gas seems risky taking into account gas phase out in the near future	Risk Profile	security - risk	Risk Profile	
					11	The lack of financial funds	Credit Score	financial, credit	Credit Score	
					11	Difficulties in determining the right technical solution	Knowledge	competence, knowledge, rebound - lack of professionals	Knowledge	

	Minimum Scenario					Probable Scenario					
	Expert	RAW	KEY CONCEPT I	KEY CONCEPT II	Final Key Concept	Expert	RAW	KEY CONCEPT I	KEY CONCEPT II	Final Key Concept	Expert
						12	I do not have enough own money for the investments.	Credit Score	financial security, credit	Credit Score	
						12	New heating systems installation needs approval from 50% residents, I heard that most of them are against it.	Agreement	agreement, support	Agreement	
						12	Our building representative is not interested in any renovation measures, since the building is allegedly poor...	Agreement	agreement	Agreement	
arrie						12	I have heard that administrative procedure is complicated and expensive.	Legal	legal	Legal	
	1	Buy warmer clothes	Wellbeing	security, frugality	Frugality	1	**Lift:**				1
	1	Ventilate less offen - reduction in air quality	Wellbeing	Physicalness, wellbeing	Wellbeing	1	People don't walk stairs anymore → negative effects on health	Wellbeing	physicalness, wellbeing	Wellbeing	1
	1	Spend less time home due to uncomfortable situation	Wellbeing	physicallyness, cozyness	Wellbeing+ Cozyness	1	**Heater:**				4
	4	Compensatory behaviours: because I did my part in reducing heating consumption, I feel entitled to consume more in other domains	Profits	rebound, increase consumption, image rebound		1	Cheaper costs lead to higher heating energy consumptiom	Profits	financial security, profit	Profits	4
	5	Other people (neighbours, friends, etc.) wanting to operate in the same manner	Authority	Popularity, role model	Authority	1	**Leaking roof:**				5
	5	Appearance of dampness due to excessive stagnation.	Wellbeing	Physicalness, wellbeing	Wellbeing	1	Make full blown refurbishment and also build PV	Poseur	stimulation	Novelty	5
	9	I will buy more clothing that I need	Wellbeing	frugality	Frugality	4	Quick renovation of roof/façade and replacement of heating leads to lock-in and precludes an in-depth retrofit for better energy efficiency in the coming years	Brag	loss of importance in energy efficiency		9
	11	-				5	Increase in consumption due to the lift	Profits	increased embodied energy		11
	12	Why save, when it is just a drop in the sea. Industry is not doing its part.	Self-Satisfaction	greenwashing		5	Increased activity in the refurbishment sector.	Own Significance	relatedness, support		12
	12	Climate change is already happening and we cannot stop it by sealing our windows...	Self-Satisfaction	security, climate protection	Climate Protection	9	I will pay less attention to how much heating I use if my heating spending is down	Fun	increased consumption		12
						9	There will be more spending on electricity if a new lift is installed	Profits	increased embodied energy		12
						11	The money saved from the energy bills will be used to pay additional bills	Profits	security , profits	Profits	
						12	Who guarantees that new heating system will function well? The old one is at least heating us...	Trust	lack of professionals	Trust	
ınd e											
	58		48		48	97		64		64	67

BUILDINGS

Plausible Scenario					Ideal Scenario				
Expert	RAW	KEY CONCEPT I	KEY CONCEPT II	Final Key Concept	Expert	RAW	KEY CONCEPT I	KEY CONCEPT II	Final Key Concept
1	Feeling to improve the quality and longevity of my building	Added Value	Security	Added Value	1	**Live / Build:**			
1	Feeling to do something to full extend and not only partially	Own Competence	Competence, Autonomy	Own Competence	1	Ecological awareness	Poseur	Meaning, climate protection	Own Significance
1	Expectancy of reduced operation costs	Profits	Financial Security - added value	Profits	1	Feeling to be contributing	Own Competence	own competence	Own Competence
1	Good feeling about doing something to counteract climate change	Own Competence	meaning, competence	Environmental Concerns	1	Required money is available	Profits	financial security, profits	Profits
1	Chance to prettify the building	Added Value	security - added value	Added Value	1	Living in a modern house	Trends	physicalness, stimlation	Novelty
1	Increase in living quality	Wellbeing	security, physicalness	Wellbeing	1	Attractiveness to gadgets	Fun	stimulation	Fun
4	Environmental concern for protecting the climate	Climate Protection	security, meaning	Climate Protection	1	**Let others rent:**			
4	Feeling of responsibility to do my part in protecting the climate	Climate Protection	competence, meaning	Environmental Concerns	1	Viable business model	Profits	financial security, value added	Profits
4	Self-efficacy in planning and managing major construction work	Own Competence	effectiveness	Own Competence	1	Already have such a building myself	Self-Satisfaction	security, trust	Trust
4	Skills and experience in negotiating with and supervising craftsmen	Own Competence	effectiveness	Own Competence	1	Share possibilty with someone who cannot afford to buy such a building	Rights and Duties	relatedness	Rights and Duties
4	One-off investment in roof/heating/lift is not correctly discounted over the entire lifetime	Risk Profile	security - risk	Risk Profile	1	See it as my contribute to battle climate change	Poseur	meaning, climate protection	Own Significance
4	Coincidence of the renovation with other plans to adapt the home amenities or with changing conditions of domestic life (e.g. expanding rooms because more household members ove in, existing windows or heating system are already nearing the end of their lifetime)	Added Value	security - added value	Added Value	4	Environmental concern for protecting the climate	Poseur	meaning, competence, environmental concerns	Poseur
5	Home comfort	Wellbeing	phyicalness, security - Wellbeing	Wellbeing	4	Feeling of responsibility to do my part in protecting the climate	Environmental Concerns	relatedness, rights/duties	Environmental Concerns
5	Energy bill savings	Profits	financial security	Profits	4	Self-efficacy and skills in planning and constructing such a house	Own Competence	own competence, autonomy	Own Competence
5	Energy and environmental awareness and sensitisation	Poseur		Own Significance	4	Technophilia and affinity/interest in innovative technologies and applying these technologies with my own hands	Self-Satisfaction	competence, technical fit, stimulation	Self-Satisfaction
9	-				4	Skills and experience in negotiating with and supervising craftsmen	Own Competence	competence, own, knowledge	Own Competence
11	Being a common project, I submit to the majority	Peer-Pressure	popularity (peer pressure)	Agreement	5	High income	Profits	financial security, money availability	Profits
11	Joint projects generate a good understanding between neighbors	Agreement	relatedness, agreement	Agreement	5	Energy and environmental awareness and sensitisation	Poseur	meaning, phsyicalness, wellbeing	Poseur
11	The desire to live in a renovated building	Brag	stimulation, security	Brag	5	What factors induce you to live in this dwelling? i. Low/no energy consumption	Wellbeing	own competence	Own Competence
12	I want to do something with our home, this is the best way to contribute to mitigate climate changes.	Climate Protection	Autonomy, competence	Environmental Concerns	5	What factors induce you to live in this dwelling? ii. Comfort of the home		physicalness, wellbeing, cozyness	Cozyness
12	I have good feeling about this, most of the neighbours are supporting the renovation. This will help our local community to be stronger.	Agreement	relatedness, meaning	Agreement	9	-			

BUILDINGS

	Plausible Scenario					Ideal Scenario				
	Expert	RAW	KEY CONCEPT I	KEY CONCEPT II	Final Key Concept	Expert	RAW	KEY CONCEPT I	KEY CONCEPT II	Final Key Concept
	12	I am looking forward to much healthier home for all of us.	Wellbeing	physicalness (well-being)	Wellbeing	11	The desire to be 100% eco friendly	Poseur	popularity, relatedness, role model	Self-Satisfaction
						11	The desire to launch a positive sign in local communities and among friend	Poseur	role model	Authority
						11	Generating appropriate behavior among children	Authority	role model	Authority
						12	I always wanted to know more about passive houses, this is great opportunity.	Knowledge	stimulation, competence, knowledge	Knowledge
						12	It looked like big investment in the beginning but now I am very happy that we invested in passive house.	Added Value	cost-efficiency	Cost-Efficiency
						12	This is more economic, ecological and healthier home than it was before.	Profits	competence, meaning, envir. concerns, physicalness, wellbeing	Wellbeing
						12	I am very satisfied because I live what I "preach".	Authority	autonomy, self-satisfaction, meaning	Self-Satisfaction
Dete										
	1	Funding for the investments	Credit Score	security (added value)	Credit Score	1	**Live/Build:**			
	1	Others perceive the building as more modern and beautiful	Brag	popularity	Brag	1	Others will perceive me a ecological aware	Authority	popularity, trends	Trends
	1	Interest in others how the process is going	Trends	popularity, competence	Authority	1	Others will want to have what I have	Brag	popularity, brag	Brag
	1	Very visible approach → it will get recognised	Trends	popularity	Brag	1	I can show it to othters	Authority	relatedness, socialising, support	Socialising
	4	Expected savings in heating costs	Profits	financial security (saving)	Profits	1	Others will perceive it as a good investment for my money	Authority	competency, cost-efficiency	Cost-Efficiency
	4	Expected increase in property value	Added Value	security (added value)	Added Value	1	**Let other live:**			

BUILDINGS

	Plausible Scenario					Ideal Scenario				
	Expert	RAW	KEY CONCEPT I	KEY CONCEPT II	Final Key Concept	Expert	RAW	KEY CONCEPT I	KEY CONCEPT II	Final Key Concept
	4	Availability of capital or access to bank credit	Credit Score	financial security (access to credit)	Credit Score	1	Market for such buildings is increasing	Brag	financial security, added value, trust	Added Value
	4	Role Model of others in my social circle who have successfully completed a renovation	Authority	popularity, relatedness	Authority	1	Awareness is increasing	Environmental Concerns	autonomy, commitment, adherence	Environmental Concerns
	5	Energy training of the property manager	Adherence	competence	Knowledge	1	Being perceived as benevolent and ecologically aware	Authority	popularity, role model, own competence	Authority
	5	Public financial support for investment	Credit Score	financial security (added value)	Credit Score	4	High income and capital to afford to be able to own or rent such a house	Credit Score	financial security, profits	Credit Score
	5	Regulations	Knowledge		Legal	4	Achieving a higher property value	Added Value	profits, added value	Added Value
	9	-				4	Demonstrating my social status to my neighbours and friends	Brag	popularity, role model, own competence	Authority
	11	Joint projects generate a divergences between neighbors	Agreement	relatedness - obligation	Agreement	5	Regulations	Legal	security, legal security?	Legal
	11	The possibility of obtaining financing from the state is a strong point	Credit Score	financial security (added value)	Credit Score	5	Tax deductions	Credit Score	financial, reduced costs	Credit Score
	12	Beside long term savings, we need this renovation in order to keep the value of our real estate.This is good investment.	Added Value	added value	Added Value	9	-			
	12	State aid will help us, we need to use this opportunity. Who knows when will it happen again?	Credit Score	added value	Credit Score	11	Peer pressure	Authority	relatedness, peer-pressure, popularity, trends	Authority
	12	Every other building in the neighborhood did it so why don't we?	Novelty	popularity (trends)	Trends	11	Social norms	Trends	relatedness, obligation, duties	Peer-Pressure
						12	My kids will be grateful one day because this house will maintain great quality and value for a long time.	Added Value	physicalness, relatedness, financial, added value	Added Value
						12	My friends and family are impressed :) with this house.	Authority	popularity, role model, relatedness, support	Brag
						12	Private green image boosted my professional career.	Brag	competence, knowledge	Brag
Dete										
	1	Shortage in materials	Profits	Whole supply chain	Technical Fit	1	High costs	Profits	financial security, risk profile	Credit Score
	1	Old age of the residents that don't see the benefits	Knowledge	relatedness, obligation, popularity	Cost-Efficiency	1	Technological barriers	Knowledge	competence, knowledge	Knowledge
	1	Individual residents might change their mind	Agreement	rebound, loss of importance in EE	Adherence	1	Envy of others	Authority	relatedness, peer-pressure	Authority
	1	Lack of Money	Profits	financial security (lack of availability, risk of investment)	Credit Score	1	Lack of financial means	Credit Score	financial security, credit score/access	Credit Score
	1	Unforseen costs can occur	Profits	risk of investment	Risk Profile	1	Rumours that living quality is not the same or will suffer	Safety	rebound, image rebound	Trust

BUILDINGS

	Plausible Scenario					Ideal Scenario				
	Expert	RAW	KEY CONCEPT I	KEY CONCEPT II	Final Key Concept	Expert	RAW	KEY CONCEPT I	KEY CONCEPT II	Final Key Concept
	1	Fear of overboarding costs and efforts	Profits	risk profile	Risk Profile	4	Lack of external consulting for identifying appropriate products and services necessary for constructing such a house	Knowledge	rebound, lack of professionals	Knowledge
	4	Expected hassle during the construction phase: craftsmen disturbing my privacy, noise, dust, restrictions in opening windows or using the balcony, delays in the process	Wellbeing	competence (tech/NIMBY), relatedness (support)	Wellbeing	5	House prices	Profits	financial security	Profits
	4	Lack of resident participation in designing the new appearance of the building and in scheduling the construction process	Support	relatedness, security (trust)	Agreement	11	Limited financial resources	Credit Score	financial security, access to credit	Credit Score
	4	Strict minimum efficiency standards to be eligible for governing aid	Profits	added value	Credit Score	11	Technical difficulties	Knowledge	security, trust	Trust
	4	Tenant-landlord-dilemma: the landlord may refrain from this scenario or postpone it indefinitely because the heating costs are carried by the tenant	Risk Profile	relatedness (obligation/right sduties)	Rights and Duties	12	Very high initial costs.	Credit Score	risk profile	Credit Score
	4	Short-term tenancy contract keeps from investing in the building and from enduring the hassle of the construction phase	Risk Profile		Added Value	12	I do not need that much technology dependance, service and maintenance costs may be higher than expected.	Profits	financial security, frugality	Frugality
	5	Community decision-making process	Support	relatedness (agreement)	Agreement			Self-Satisfaction		
	11	Misunderstandings between neighbors	Agreement	agreement	Agreement					
	11	Inconveniences caused by the renovation proces	Wellbeing	security	Safety					
	12	Administrative procedure is so complicated, I do not know if I have the time or anybody else.	Cost-Efficiency	relatedness (support)	Cost-Efficiency					
	12	3% looks like small savings compared to investment. Payback period may be too long.	Profits	Risk Profile	Risk Profile					
	12	We have to buy a new car, so this is too big investment for us.	Profits	Financial security (access)	Risk Profile					
arrie										
	1	Learning time to adapt to the new heating situation	Adherence	competence (knowledge)	Knowledge	1	Investment into additional gadgets that consume more resources and energy	Profits	Rebound, increased embodied energy	
	1	Due to the lift, people don't walk stairs anymore → negative effects on health	Wellbeing	physicalness	Wellbeing	1	Less aware livestyle sind everything is ecological anyway	Profits	Rebound, greenwashing	

BUILDINGS

Plausible Scenario					Ideal Scenario				
Expert	RAW	KEY CONCEPT I	KEY CONCEPT II	Final Key Concept	Expert	RAW	KEY CONCEPT I	KEY CONCEPT II	Final Key Concept
4	Gentrification: rents may be increased to re-finance the renovation investment, pushing low-income renters to lower-quality housing	Safety	security	Safety	4	Compensatory behaviours: because I live in a perfect building, I feel entitled to consume more in other domains	Profits	Rebound, image rebound	
4	Compensatory behaviours: because I did my part in renovating the building, I feel entitled to consume more in other domains	Profits	rebound		4	Oversized: because of low energy consumption per square meter floor area, I might build the house bigger than I actually need	Profits	Rebound, overuse	
5	Increased activity of the rehabilitation sector	Own Significance		Own Significance	4	Building in a suburban location with a big garden may increase total land consumption, increase surface sealing and increase energy consumption for everyday trips	Profits	Rebound, increased consumption	
5	Replication of other neighbouring buildings	Novelty	popularity (trends)	Trends	5	Reduction in the activity of energy companies	Own Significance	self-sufficency	
9	-				9	-			
11	-				11	-			
12	Now when we have smaller heating and electricity bills we spend more on car transport	Profits	rebound		12	Materials used for thermal insulation are very energy intensive, so the actual overall savings are questionable.	Risk Profile	Circular economy (LCA) concerns?	Trust
12	If we connect to the district heating, how we will know how much we consume?	Profits	competence (knowlege lack)	Knowledge	12	The smart home concept is very complicated and not user friendly and intuitive.	Knowledge	competence, knowledge,	Knowledge
12	New materials installed for the insulation might be toxic...	Wellbeing	security (safety)	Safety	12	I cannot repair anything by myself because it is hightech.	Self-Satisfaction	Rebound, lack of professionals, Competence knowledge	Knowledge
67		54		54	70		53		53

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APPLIANCES

	Minimum Scenario					Probable Scenario				
	Expert	RAW	Key Concept I	Key Concept II	Final Coding	Expert	RAW	KEY CONCEPT	Coding II	Final Coding
Intrinsic Determinants	1	My opinion that behaviour change does more than investing in new technology is a barrier to investment	Adherence	Knowledge	Knowledge	1	Knowledgeabout additional functions / properties of the possible solution (f	Knowledge	Knowledge	Knowledge
	1	Increasing one's own satisfaction through sustainable action	Own Competence	Self-Satisfaction	Self-Satisfaction	1	Expense of the exchange (other than financial)	Safety	Added value	Added value
	1	Frugality - I do not have to incur initial costs to achieve savings.	Frugality	Frugality	Frugality	1	Equipment with production for combination (e.g. magnetic pots and pans for induction fields)	Cost-Efficiency	Technical Fit	Technical Fit
	1	Role model function for fellow human beings / children	Authority	Authority	Authority	2	Self-efficacy: observable impacts of changed behaviour yield economic, ecological and social benefits	Own Competence	Environmental Concerns	Own Competence
	1	Doubt that the resources needed for new products can be recouped.	Risk Profile	Knowledge	Trust	2	Topical proficiency increases due to increased general interest and specific preoccupation with certain topics	Poseur	Trends	Own Significance
	2	Personal preconditions, personality: the decision to change is made affecting a general determination to adapt basic forms of energy relevant behaviour	Own Significance	Self-Satisfaction	Adherence	2	Individual norms regarding consumption of goods and services (buying the best available, buying the most sustainable, etc.)	Self-Satisfaction	Knowledge	Own Competence
	2	level of Knowledgehas increased: based on interactions among the immediate social peer groups positively affects sensitivity towards energy behaviour		Trends	Peer-Pressure	2	changing consumption type: increased willingness to act and ability to act in a sustainable way	Own Competence	Own Competence	Own Competence
	2	Need for self-improvement as motivation to adapt to changed circumstances and external social pressure	Own Competence	Peer-Pressure	Peer-Pressure	4	Environmental concern	Poseur	Environmental Concerns	Environmental Concerns
	4	Environmental concern / attitudes	Poseur	Environmental Concerns	Environmental Concerns	4	Knowledgeabout the available alternatives	Knowledge	Knowledge	Knowledge
	4	Frugality	Frugality	Frugality	Frugality	4	future time perspective	Environmental Concerns	Cost-Efficiency	Environmental Concerns
	4	Feeling to do something good	Own Significance	Own Significance	Own Significance	BSG1	I deserve some new and modern things, i work hard	Brag	Trends	Brag
	BSHG 1	Inner change -I would think buying new appliances wouldn't make my house greener if my everyday habits remained the same (not green)	Adherence	Knowledge	Adherence	BSG1	Trying something completely ney like induction, exit comfort zone	Novelty	Novelty	Novelty
	BSHG 1	Feeling safe using my old appliances (and choices that turned out to be good) that i know exactly how they work and i am satisfied with the results	Safety	Cost-Efficiency	Cost-Efficiency	BSG1	Environmental concern	Poseur	Environmental Concerns	Environmental Concerns
	BSHG 1	Saving money while also being greener	Profits	Profits	Profits	BSHG2	I am aware of all the benefits that induction technology provides	Knowledge	Knowledge	Knowledge
	BSHG 2	Feel good with myself because I contribute to protect the environment	Climate Protection	Self-Satisfaction	Climate Protection	BSHG2	The joy of buying something new, more technologically advanced and with more capabilities than the device than my old appliance	Novelty	Novelty	Novelty
	BSHG 2	Feel that I am part of something bigger than myself, that I'm giving back to the earth and the community	Own Significance	Support	Own Significance	BSHG2	That nice feeling that I´ m protecting the environement	Climate Protection	Climate Protection	Climate Protection
	BSHG 2	Feel that I can protect the environment so that future generations can enjoy it also	Climate Protection	Climate Protection	Climate Protection	BSHG2	Since I'm bying a new device, it might as well be environment friendly and with many new technologies	Brag	Environmental Concerns	Brag
	BSHG 3	I will enhance my quality of life.	Brag	Wellbeing	Wellbeing	BSHG3	I will protect the environment since my new appliance is energy efficient.	Climate Protection	Climate Protection	Climate Protection
	BSHG 3	I will protect the environment and feel good with myself by doing it.	Climate Protection	Climate Protection	Climate Protection	BSHG3	I will expand my Knowledgeabout induction.	Knowledge	Knowledge	Knowledge
	BSHG 4	Feel good with myself because I contribute to environment protection	Own Competence	Climate Protection	Climate Protection	BSHG4	~~I will protect the environment since my new appliance is energy efficient.~~	Climate Protection		
	BSHG 4	Feel that I can protect the environment for future generations	Climate Protection	Authority	Climate Protection	BSHG4	~~That nice feeling that I´ m protecting the environement~~	Climate Protection		
	BSHG 5	I need to do something to help against global warming. Everybody should help with little things that cost nothing.	Environmental Concerns	Poseur	Environmental Concerns	BSHG4	~~I will expand my Knowledgeabout induction.~~	Knowledge		
	BSHG 5	I feel it is good to educate my children about good practices that save energy, by discussing about them and adopting them	Authority	Authority	Authority	BSHG5	It is a good oportunity to buy a better hob now that the old broke down		Cost-Efficiency	Cost-Efficiency
	BSHG 6	Environment protection	Climate Protection	Climate Protection	Climate Protection	BSHG5	I like making smart purchases and this hob is good for me and the enviroment.	Own Competence	Own Competence	Own Competence

APPLIANCES

	Minimum Scenario: Expert	RAW	Key Concept I	Key Concept II	Final Coding	Probable Scenario: Expert	RAW	KEY CONCEPT	Coding II	Final Coding
	BSHG 6	Better way of life	Brag	Wellbeing	Wellbeing	BSHG6	New innovative appliance	Novelty	Novelty	Novelty
	BSHG 9	Learning about saving energy by practising on daily life	Knowledge	Knowledge	Knowledge	BSHG6	Environment protection	Climate Protection	Climate Protection	Climate Protection
	BSHG 9	Interested in results (how much energy is saving at the end)	Knowledge	Novelty	Own Competence	BSHG9	I know the real benefits of induction	Knowledge	Knowledge	Knowledge
						BSHG9	Easy to find cookware combatible with induction	Cost-Efficiency	Cost-Efficiency	Cost-Efficiency
						BSHG9	I want to invest money	Added value	Credit Score	Credit Score
Extrinsic Determinants	1	Social dependency: The scenario relies heavily on improving user behaviour. If not all residents of the household or building participate, the effect is small.	Agreement	Agreement	Agreement	1	Cash availability - higher costs now vs. savings during life time span	Credit Score	Credit Score	Credit Score
	1	Energy costs low - impact of actions therefore monetarily low	Profits	Profits	Profits	1	Barriers associated with the habit of using the old product	Adherence	Adherence	Adherence
	2	Peer pressure: social reference groups increasingly adapt their energy behaviour towards increased sustainability	Peer-Pressure	Peer-Pressure	Peer-Pressure	2	Accessible expert information and Knowledgebefore purchase and in stores including	Knowledge	Authority	Knowledge
	2	Sensitization through information: increased public awareness due to changed public discourse on energy relevant behaviour and technologies	Poseur	Trends	Trends	2	External perception and social status associated with energy efficient appliances and sustainable consumption behaviour	Authority	Trends	Trends
	2	Cost and household structure: the potential to save costs (even if only long-term) is becoming a factor in the context of new purchases among lower income households	Profits	Profits	Profits	2	Societal "climate" and changing social norms towards pro-environmental behaviour and consumption (social rewards and status)	Poseur	Support	Support
	4	Devices which offer a complete disconnect		Credit Score	Technical Fit	4	Availability of energy efficient alternatives (I need the appliance now and need to buy what is available)	Knowledge	Technical Fit	Technical Fit
	4	Injunctive social norms from family (most important) and friends	Poseur	Authority	Authority	4	competent seller	Knowledge	Trends	Knowledge
	4	Descriptive norms		Support	Support	4	Incentive programs	Credit Score	Credit Score	Credit Score
	BSHG 1	Global sensitivity for environment	Poseur	Environmental Concerns	Environmental Concerns	4	Social influence (injunctive norms, descriptive norms)	Poseur	Trends	Trends
	BSHG 1	Disappointed by the majority of people, so I will make a change to make a start for general improvement	Self-Satisfaction	Poseur	Own Significance	BSHG1	If i don't change broken things, people may think I am poor or that i don't care for better quality in life	Trends	Peer-Pressure	Peer-Pressure
	BSHG 1	Satisfaction in being perceived by others as a good example	Authority	Authority	Authority	BSHG1	Look cool while cooking with induction	Brag	Brag	Brag
	BSHG 2	I will make a good impression on others that will think that I'm trying to protect the environment	Authority	Brag	Brag	BSHG1	Make an investment that is worthy and will be externally appreciated as a greener choice	Added value	Cost-Efficiency	Cost-Efficiency
	BSHG 2	My peers are doing it so I want to do it to	Trends	Peer-Pressure	Peer-Pressure	BSHG2	Convince my friends to also buy new appliances, more energy saving than the ones they had	Authority	Authority	Authority
	BSHG 2	Saving energy is the No1 priority nowadays	Poseur	Trends	Trends	BSHG2	Induction is the new trend in hobs	Trends	Trends	Trends
	BSHG 3	Climate change is one of the most important things nowadays and its impact is getting more obvious.	Poseur	Trends	Trends	BSHG2	Prestige: I now have an new appliance that many of my peers want	Authority	Brag	Brag
	BSHG 3	My friends are changing their environmental behavior.	Trends	Peer-Pressure	Trends	BSHG3	A friend of mine has also the same appliance and is very satisfied.	Authority	Authority	Authority
	BSHG 4	My family members are also willing to change their practices	Authority	Peer-Pressure	Authority	BSHG4	Convince my friends and relatives to also buy new appliances formore energy saving	Authority	Authority	Authority
	BSHG 4	~~My friends are changing their environmental behavior.~~				BSHG5	The energy label marking on the appliance is pushing me to spend more on higher efficiency appliances	Knowledge	Cost-Efficiency	Cost-Efficiency
	BSHG 5	~~My other family members are also willing to change their practices~~				BSHG5	Shefs prefer gas or induction hobs! Probably they cook better.	Authority	Authority	Authority
	BSHG 5	We were trainned about envirometally good practices at work	Own Competence	Knowledge	Knowledge	BSHG6	Induction is the future	Knowledge	Trends	Trends
	BSHG 5	Climate change is in focus in the media and I feel that I have personally to do something about it	Poseur	Own Significance	Trends	BSHG6	Better cooking impressing my friends	Authority	Brag	Brag

	Minimum Scenario					Probable Scenario				
	Expert	RAW	Key Concept I	Key Concept II	Final Coding	Expert	RAW	KEY CONCEPT	Coding II	Final Coding
	BSHG 6	Persuading close environment to follow me	Authority	Authority	Authority	BSHG9	I could affect my friends	Authority	Authority	Authority
	BSHG 6	Energy saving is one of the top priorities	Poseur	Trends	Trends	BSHG9	Radiant cooktops are significantly decreased		Technical Fit	Technical Fit
	BSHG 9	My close environment could do the same with me	Authority	Support	Authority					
	BSHG 9	Energy saving products are still expensive to invest for	Risk Profile	Added value	Risk Profile					
Barriers	1	Requirements for energy efficiency / use of renewable technologies from the legislator	Knowledge	Legal	Legal	1	Availability of spare parts	Knowledge	Technical Fit	Technical Fit
	1	Low energy prices	Profits	Profits	Profits	1	Cost of spare parts vs. complete new product	Profits	Cost-Efficiency	Cost-Efficiency
	1	Lack of information concerning energy behaviour	Knowledge	Knowledge	Knowledge	1	Substitute products (e.g. microwave instead of hotplate)	Knowledge	Technical Fit	Technical Fit
	2	Lack of public discourse: contradictory public statements, disruptive public figures and opinions	Poseur	Trust	Support	2	Availability of energy efficient appliances and involved costs (i.e. if only high-end appliances are energy efficient, etc.)	Knowledge	Cost-Efficiency	Technical Fit
	2	Lack of easily accessible information on ways to adapt individual activities of daily living	Knowledge	Knowledge	Knowledge	2	Ambiguous or missing markings and identification of sustainable products, appliances and goods	Knowledge	Knowledge	Knowledge
	2	Lack social peer-group pressure or lack available and accepted Role Model increases changes to fall back to old behavioural patterns	Authority	Peer-Pressure	Peer-Pressure	2	Negative feedback from peer groups and political discourse ("the classic model is the best, no need for change"),	Trends	Peer-Pressure	Peer-Pressure
	4	Habits/ routines	Adherence	Adherence	Adherence	2	Market leaders and brands do not "jump" on new and sustainable developments or delay market introduction	Trends	Trends	Trends
	4	Mismatch with hygiene practices (washing at lower temperature feels unclean)	Wellbeing	Technical Fit	Safety	4	Incompatibility with existing infrastructure	Adherence	Technical Fit	Technical Fit
	4	Convenience, e.g. when disconnecting devices	Cost-Efficiency	Cost-Efficiency	Cost-Efficiency	4	Brand loyalty (if the preferred brand does not offer an energy efficient solution)	Trends	Own Significance	Own Significance
	4	Having to coordinate with other household members who might not agree (in a way negative social norms)	Rights and Duties	Agreement	Agreement	4	Lack of money for upfront investment (even if it pays of in the longer run)	Risk Profile	Credit Score	Credit Score
	4	Incompatibilities with daily practices (e.g., using the dishwasher when it fits the daily schedule)	Adherence	Technical Fit	Adherence	BSHG1	Money	Profits	Credit Score	Credit Score
	BSHG 1	More time to complete washing clothes or dishes	Cost-Efficiency	Cost-Efficiency	Cost-Efficiency	BSHG1	Very specific installation requirements	Knowledge	Technical Fit	Technical Fit
	BSHG 1	Start determined but end up soon bored and tired from everyday life	Novelty	Adherence	Adherence	BSHG1	Someone says to me that induction hobs are not worthy and not bring favourable results	Authority	Authority	Authority
	BSHG 1	No great significant change in money or energy saving soon, seems like there is no point	Profits	Profits	Profits	BSHG2	New energy saving appliances are quite expensive	Profits	Credit Score	Credit Score
	BSHG 2	Others may think that I'm cheap and don't want to spend some money to buy new energy efficient machines	Frugality	Frugality	Frugality	BSHG2	You need some time to get used to the new appliance	Knowledge	Adherence	Adherence
	BSHG 2	I don't know all the tips in order to save energy	Knowledge	Knowledge	Knowledge	BSHG2	Maybe the hob is not compatible with my oven	Knowledge	Technical Fit	Technical Fit
	BSHG 2	Sometimes it is hard to keep in mind all the things that you have to do every day in order to save energy	Knowledge	Knowledge	Knowledge	BSHG3	Is more expesive and probably I cannot afford it.	Credit Score	Credit Score	Credit Score
	BSHG 2	You cannot always follow the energy saving practices due to limited time e.g. you are expecting friends for dinner so you need to start the dishwasher even though it is not fully loaded, so that you have enough clean dishes for them to use	Cost-Efficiency	Technical Fit	Adherence	BSHG3	Not compatible with my other appliances.	Knowledge	Technical Fit	Technical Fit
	BSHG 3	By not updating my home appliances people may think that I am "old-fashioned" and I do not follow the latest trends.	Trends	Trends	Trends	BSHG4	~~Is more expesive and probably I cannot afford it.~~	Credit Score		
	BSHG 3	I will have to spend more time on a daily basis in order to accomplish it. For example, i may not have the time to air-dry my clothes and i will have to use my old dryer.	Cost-Efficiency	Technical Fit	Adherence	BSHG4	~~Maybe the hob is not compatible with my oven~~	Knowledge		
	BSHG 4	By not updating my home appliances people may think that I am "old-fashioned" and I do not follow the latest trends.	Trends	Trends	Trends	BSHG4	~~You need some time to get used to the new appliance~~	Knowledge		
	BSHG 4	Sometimes it is hard to keep in mind all the things that you have to do every day in order to save energy	Knowledge	Knowledge	Knowledge	BSHG5	Maybe it is a big invest with low benefit for 1 person household	Risk Profile	Risk Profile	Risk Profile

APPLIANCES

	Minimum Scenario					Probable Scenario				
	Expert	RAW	Key Concept I	Key Concept II	Final Coding	Expert	RAW	KEY CONCEPT	Coding II	Final Coding
	BSHG 5	Some habits are difficult to change	Adherence	Adherence	Adherence	BSHG5	It is much more expensive than a conventional one	Profits	Credit Score	Credit Score
	BSHG 6	Prices of energy saving products are still high	Profits	Profits	Profits	BSHG5	If I move to a new home, will it be ok for it? In terms of dimensions/design?	Knowledge	Technical Fit	Technical Fit
	BSHG 6	Used in a different way of life		Technical Fit	Technical Fit	BSHG6	Prices of energy saving products are still high	Profits	Credit Score	Credit Score
	BSHG 6	It's a long term „investment"	Added value	Credit Score	Risk Profile	BSHG6	Not many choices yet	Self-Satisfaction	Risk Profile	Technical Fit
	BSHG 9	I don't know all the tips for saving energy	Knowledge	Knowledge	Knowledge	BSHG9	Not combatible cookware	Knowledge	Technical Fit	Technical Fit
	BSHG 9	How to measure the real saving	Knowledge	Trust	Trust	BSHG9	Not big enough assortment to choose from	Knowledge	Risk Profile	Technical Fit
						BSHG9	Very expensive price	Profits	Credit Score	Credit Score
Rebound effects	1	Lower revenues for energy suppliers and grid operators	Profits			1	More usage of the new product due to lower energy demand	Profits		
	1	Energy-efficient appliances make my user behaviour less relevant	Cost-Efficiency			1	Friends are impressed by new product and also want to buy it	Authority		
	2	Changing individual values affect social reference groups yielding a multiplication effect	Poseur			1	I eat more and get fatter - then I move less and drive more :-)	Wellbeing		
	2	Public discourse among social sub-groups change towards topics of energy and sustainability	Poseur			2	Increased consumption and demand of energy efficient appliances affects main brands and market leaders on which not yet sensitized consumers rely on, in turn increasing the consumer base for these appliances	Trends		
	2	The issue increases in political and societal relevance	Poseur			4	Moral licencing (I have done my share)	Self-Satisfaction		
	4	Moral licencing -> feeling free to use more in other domains	Self-Satisfaction			4	Buying a larger appliance than before (e.g. fridge)	Knowledge		
	4	Money saved might be used on more energy intensive activities, but not much money can be saved anyway with these activities	Profits			BSHG1	My old hob gets recycled - green again!			
	4	There might be positive spillover to other behavioural domains	Own Competence			BSHG1	All my peers buy induction hobs, seller company becomes richer	Authority		
	BSHG 1	Waste time trying, while newer appliances might do the job easier and faster without me trying	Cost-Efficiency			BSHG1	I am not satisfied with my choice, i lose interest in become greener at all	Self-Satisfaction		
	BSHG 1	Grow abilities and Knowledgeconcerning the house cleaning and maintaining	Knowledge			BSHG2	Save money since the new appliance is more energy efficient	Profits		
	BSHG 1	People around me can be influenced for better	Authority			BSHG2	Use my new appliance more	Own Competence		
	BSHG 2	Save money	Profits			BSHG2	Manufacturers try to develop to new energy saving appliances			
	BSHG 2	My peers can learn from my experience and mimic me, therefore contribute to protecting the environment	Authority			BSHG3	Save money from my electricity bills.	Profits		
	BSHG 2	We can all share useful tips on how to save energy	Support			BSHG4	Save money since the new appliance is more energy efficient	Profits		
	BSHG 2	Manufacturers may see this as a way to make their machines more energy efficient by developing new technologies and programs, as well as giving energy saving tips to the consumers for their new machines or the existing ones	Profits			BSHG5	Induction hobs are super fast	Knowledge		
	BSHG 3	I could share my methods with my friends and family.	Authority			BSHG5	I like cooking with friends and my friends will be thrilled!	Authority		
	BSHG 3	I will save money.	Profits			BSHG6	More innovation – more ease	Knowledge		
	BSHG 3	I may join a voluntary organization which deals with energy efficiency to contribute more.	Support			BSHG6	Saving money in long term	Profits		
	BSHG 4	Save money	Profits			BSHG9	Cook more with induction	Adherence		

APPLIANCES

Minimum Scenario					Probable Scenario				
Expert	RAW	Key Concept I	Key Concept II	Final Coding	Expert	RAW	KEY CONCEPT	Coding II	Final Coding
BSHG 4	I could share my methods with my friends and family.	Authority			BSHG9	Manufacturers put all inovation technologies on induction	Knowledge		
BSHG 4	We can all share useful tips on how to save energy	Rights and Duties							
BSHG 5	Savings in electricity bills.	Profits							
BSHG 5	Friend may follow my example	Authority							
BSHG 6	Money saving	Profits							
BSHG 6	More energy saving promotion by manufactures	Profits							
BSHG 6	Influence more people	Authority							
BSHG 9	My friends could learn from my experience	Authority							
BSHG 9	Manufactures could put "tips" for energy saving in their user manuals	Knowledge							
107		74		78	101		79		75

APPLIANCES

	Plausible Scenario					Ideal Scenario				
	Expert	RAW	KEY CONCEPT	Key Concept II	Final Coding	Expert	RAW	KEY CONCEPT	Key Concept II	Final Coding
	Expert	RAW	KEY CONCEPT	Key Concept II	Final Coding	Expert	RAW	KEY CONCEPT	Key Concept II	Final Coding
Intrinsic Determinants	1	Socialising - meeting others in the laundry	Rights and Duties	Socialising	Socialising	1	Social aspect - more visits to my house	Socialising	Socialising	Socialising
	1	Convenience - way to laundry	Cost-Efficiency	Cost-Efficiency	Cost-Efficiency	2	Pro-environmental behaviour: knowledge, values and new behavioural patterns are on a high level, barriers preventing learning and lack of incentivisation have been overcome	Own Significance	Trends	Own Significance
	1	Social aspect - owning vs. buying incl. payment aspect (ongoing payment vs. one-off payment)	Trends	Credit Score	Trends	2	Participatory and cooperative values and competences increase willingness to engage in associations	Support	Agreement	Support
	2	Individual norms and values: shared services and appliances including mobility is connected to attitudes towards access over ownership	Self-Satisfaction	Cost-Efficiency	Own Significance	2	Normative and hedonic motives for sharing and participation: sustainability as lifestyle, enjoy associations and cooperation, being at the forefront of technological and social advancements	Fun	Agreement	Socialising
	2	Individual participatory behaviour and ability to engage in peer-to-peer models of appliance usage and services	Support	Agreement	Agreement	4	environmental concern	Poseur	Environmental Concerns	Environmental Concerns
	2	Socio-demographic background and usage segmentation: specific user types engage in different forms of participatory behaviour or are more likely to engage, however willingness to participate may nevertheless be high in heterogeneous groups (those dependent on cheaper solutions compared ownership, those associating it with their lifestyle)				4	economic savings	Profits	Profits	Profits
	4	Environmental concern	Poseur	Environmental Concerns	Environmental Concerns	4	Access to a larger selection of professional tools	Knowledge	Cost-Efficiency	Cost-Efficiency
	4	perceived efficiency	Knowledge	Cost-Efficiency	Cost-Efficiency	4	social belonging ("sharing is caring :-)")	Rights and Duties	Agreement	Socialising
	4	economic gain	Profits	Profits	Profits	BSG1	Need to connect more with people I live with in the same building	Agreement	Agreement	Agreement
	BSG1	Take up a new habit - walking to the laundry is also good for me.	Adherence	Self-Satisfaction	Adherence	BSG1	Maybe some of them know better than me, what would make a better purchase	Authority	Knowledge	Authority
	BSG1	Save money and effort, doing everything on my own	Own Competence	Profits	Own Competence	BSG1	If something breaks, i wouldn't be the only one responsible for repairing it or buying a new one	Rights and Duties	Rights and Duties	Rights and Duties
	BSG1	No commitments made - if i don't like the laundry place i change it, if i make a wrong purchase is hard to undo it.	Commitment	Commitment	Commitment	BSHG2	I don't need to buy a new machine by my own and don't need to spend money on service on my own. I share the expenses with others	Profits	Cost-Efficiency	Profits
	BSHG2	I don't need to buy a new machine and don't need to spend money on service	Profits	Cost-Efficiency	Cost-Efficiency	BSHG2	No need for many machines just one that will be operated by many people, therefore we are all saving energy	Cost-Efficiency	Environmental Concerns	Cost-Efficiency
	BSHG2	Usually the machines that the laundy and drying services have are quite easy to operate	Cost-Efficiency	Knowledge	Cost-Efficiency	BSHG3	The enthusiasm of starting a new initiative.	Novelty	Novelty	Novelty
	BSHG2	I don't have another appliance at home that spends energy	Knowledge	Profits	Frugality	BSHG3	It will be a great step to energy saving.	Own Competence	Environmental Concerns	Own Competence
	BSHG3	I do not need to spend time searching for a new machine.	Cost-Efficiency	Cost-Efficiency	Cost-Efficiency	BSHG3	Great opportunity to expand my social skills.	Socialising	Socialising	Socialising
	BSHG3	Commercial machines might be the more powerful and higher performing machines. So, I will have better cleaning results.	Knowledge	Added value	Added value	BSHG4	~~It will be a great step to energy saving.~~	Own Competence		
	BSHG3	Commercial washing machines have much greater capacity than the domestic ones. That is an energy efficient solution.	Knowledge	Profits	Profits	BSHG4	~~Great opportunity to expand my social skills.~~	Socialising		
	~~BSHG4~~	~~Commercial machines might be the more powerful and higher performing machines. So, I will have better cleaning results.~~	Knowledge			BSHG5	I enjoy inspiring others to do something good together	Authority	Authority	Authority
	~~BSHG4~~	~~Commercial washing machines have much greater capacity than the domestic ones. That is an energy efficient solution.~~	Knowledge			BSHG5	If I am an 1 person household it makes more sence to share appliances with others instead of buying everything	Cost-Efficiency	Cost-Efficiency	Cost-Efficiency
	BSHG5	I don't want to spend money now in buying new appliances	Profits	Cost-Efficiency	Frugality	BSHG6	Service cost sharing	Profits	Profits	Profits
	BSHG5	I enjoy sozializing at the laundry service	Socialising	Socialising	Socialising	BSHG6	Purchase save money	Profits	Profits	Profits

APPLIANCES

	Plausible Scenario					Ideal Scenario				
	Expert	RAW	KEY CONCEPT	Key Concept II	Final Coding	Expert	RAW	KEY CONCEPT	Key Concept II	Final Coding
	BSHG6	No need to buy new appliance	Profits	Cost-Efficiency	Frugality	BSHG9	Initiate something new and interesting	Novelty	Novelty	Novelty
	BSHG6	More free space at home		Added value	Added value	BSHG9	Save money when purchase	Profits	Profits	Profits
	BSHG9	Not enough space in my house		Technical Fit	Technical Fit					
	BSHG9	Peace of mind concerning maintainance of appliance	Cost-Efficiency	Cost-Efficiency	Cost-Efficiency					
	BSHG9	Saving of individual energy consumption	Profits	Profits	Profits					
Extrinsic Determinants	1	Opinion of others when I don't have a washing machine on my own	Trends	Peer-Pressure	Peer-Pressure	1	Scepticism from other users to use my basement at any time	Rights and Duties	Trust	Trust
	2	Social status and external reception and a high level of prestige associated partaking in sharing economy in certain societal sub-groups	Authority	Brag	Brag	2	Mainly social status and societal perception associated with community leaders and sustainability-focussed initiatives, as economic factors could be secondary in this scenario, especially for the leading characters	Authority	Poseur	Authority
	2	Positive feedback and reinforcement due to Role Model and social peer groups	Authority	Authority	Authority	2	Self-efficacy: affecting both, the market place and general sustainability on a larger scale beyond the initial initiative, the potential for multiplication and influence, establishing a movement		Own Competence	Own Competence
	4	social norms	Poseur	Support	Support	4	good maintenance procedures	Knowledge	Cost-Efficiency	Knowledge
	4	good availability of the washing service / high flexibility	Cost-Efficiency	Cost-Efficiency	Cost-Efficiency	4	Easy to handle storage space with access control	Cost-Efficiency	Technical Fit	Technical Fit
	4	Service offers activities to do during the waiting time (e.g. an office space / good and free internet access)	Fun	Added value	Fun	4	Strong social bonds in the neighbourhood	Agreement	Agreement	Agreement
	BSHG1	Socialize - meet new people	Socialising	Socialising	Socialising	4	Good socio-demographic neighbourhood structure	Agreement	Support	Agreement
	BSHG1	Inspire others to try and find more options/solutions than either buy a new one or repair the old one	Authority	Authority	Authority	BSHG1	Make wiser use of the resources of the building	Cost-Efficiency	Cost-Efficiency	Cost-Efficiency
	BSHG1	Support local businesses rather that multinationals	Support	Support	Support	BSHG1	Neighbors are meant to have good relationships for better living experience - sharing appliances serve that	Agreement	Support	Agreement
	BSHG2	Covince other people to use these type of services	Authority	Authority	Authority	BSHG1	Being a good example and make a start so more and more people become greener, help them think in my way	Authority	Authority	Authority
	BSHG2	Meet new people	Socialising	Socialising	Socialising	BSHG2	Create a stronger bond with the people in my community	Socialising	Support	Socialising
	BSHG3	Maybe a place to meet new people.	Socialising	Socialising	Socialising	BSHG2	Learn how to cooperate better and easier with my peers	Knowledge	Agreement	Agreement
	BSHG4	Covince other people to use these type of services	Authority	Authority	Authority	BSHG3	I will have the chance to cooperate with other community members.	Agreement	Support	Agreement
	BSHG6	Meeting new people	Socialising	Socialising	Socialising	BSHG4	~~Create a stronger bond with the people in my community~~	Socialising		
	BSHG6	Support local business	Support	Support	Support	BSHG5	My neighbors seem to share the same values with me and it is easy for me to get along with them	Agreement	Agreement	Agreement
	BSHG9	Expand concept also to other categories (e.g.Cooking together in common kitchen)	Socialising	Knowledge	Socialising	BSHG6	Getting closer with neighbours	Socialising	Support	Socialising
						BSHG6	More people may follow my example	Authority	Authority	Authority

APPLIANCES

	Plausible Scenario					Ideal Scenario				
	Expert	RAW	KEY CONCEPT	Key Concept II	Final Coding	Expert	RAW	KEY CONCEPT	Key Concept II	Final Coding
						BSHG9	Friends of mine could be affected from this	Authority	Support	Authority
Barriers	1	Visit to the laundry in the lockdown not possible	Cost-Efficiency	Legal	Legal	1	Insecurity - other people have access to my cellar	Safety	Trust	Safety
	1	Using ecologic detergents	Poseur	Environmental Concerns	Environmental Concerns	2	Lack of organizational skills and structures limit uptake within communities	Knowledge	Own Competence	Own Competence
	2	Availability, accessibility and usability of needed services (when open, costs, ease of use, etc.)	Cost-Efficiency	Technical Fit	Technical Fit	2	Limited transparency of processes interfere with intended participation levels	Knowledge	Trust	Trust
	2	Information is lacking or not easily accessible regarding shared services and appliances (there maybe existing services in the vicinity, but only a limited	Knowledge	Knowledge	Knowledge	2	Lack of legal and structural preconditions increas liabilities for individuals and community leaders	Knowledge	Legal	Legal
	2	Negative social feedback and association (i.e. association with low-income milieus and lack of status symbols)	Trends	Peer-Pressure	Peer-Pressure	4	Diffusion of responsibility to maintain / repair tools	Rights and Duties	Agreement	Rights and Duties
	4	inconvenience	Cost-Efficiency	Technical Fit	Technical Fit	4	Lack of being able to express one's personality/self through possessions	Self-Satisfaction	Poseur	Brag
	4	perceived lack of security when washing at night for example	Safety	Safety	Safety	4	Inflexibility of use (everyone wants to cut the grass the same day)	Cost-Efficiency	Agreement	Technical Fit
	4	lack of flexibility	Adherence	Technical Fit	Adherence	4	Complicated upfront financing (who buys what and pays how much?)	Risk Profile	Credit Score	Credit Score
	4	negative social stigma	Authority	Peer-Pressure	Peer-Pressure	4	More difficult to protect against vandalism / stealing	Safety	Safety	Safety
	BSHG1	Inconvenience - Bad weather/ bad mood to go out	Cost-Efficiency	Cost-Efficiency	Cost-Efficiency	4	Hygiene aspects (COVID!)	Wellbeing	Safety	Safety
	BSHG1	Peers say that this looks pathetic and I should have my own appliances as an adult	Authority	Peer-Pressure	Peer-Pressure	BSHG1	Bad communication and co-operation	Agreement	Agreement	Agreement
	BSHG1	Covid-19 closes down everything, so I can no longer use this service	Cost-Efficiency	Legal	Legal	BSHG1	Lack of willingness from the neighbors	Agreement	Commitment	Commitment
	BSHG2	The same machine is also used by others/strangers	Agreement	Trust	Trust	BSHG1	Uncertainty about availability of spare parts for the next ten years	Knowledge	Trust	Trust
	BSHG2	I don't really know how well maintened and clean the machine actually is	Knowledge	Trust	Trust	BSHG2	The same machine is also used by others/strangers	Rights and Duties	Trust	Trust
	BSHG3	The fact that others use the same machines is quite concerning.	Rights and Duties	Trust	Trust	BSHG2	The machine may be occupied by others and therefore not available for use for when you need it	Cost-Efficiency	Technical Fit	Technical Fit
	BSHG3	It can also be inconvenient having to drop off and pick up your laundry.	Cost-Efficiency	Cost-Efficiency	Cost-Efficiency	BSHG2	Someone has to undertake the maintenance of the appliance	Knowledge	Knowledge	Knowledge
	BSHG3	There is always the possibility that your laundry can be stolen. That's why you have to spend time waiting there till is done.	Safety	Safety	Safety	BSHG3	The fact that others use the same machines is quite concerning.	Rights and Duties	Trust	Trust
	BSHG4	The fact that others use the same machines is quite concerning.	Agreement	Trust	Trust	BSHG3	Might be difficult to convince other community members get out of their comfort zone.	Agreement	Commitment	Commitment

APPLIANCES

	Plausible Scenario					Ideal Scenario				
	Expert	RAW	KEY CONCEPT	Key Concept II	Final Coding	Expert	RAW	KEY CONCEPT	Key Concept II	Final Coding
	BSHG5	The more the family members, the less convenient it is to go to laundry service	Cost-Efficiency	Cost-Efficiency	Cost-Efficiency	BSHG4	~~The same machine is also used by others/strangers~~	Rights and Duties		
	BSHG5	I have hygienic concerns about washing in a public laundry service	Wellbeing	Trust	Wellbeing	BSHG4	~~Someone has to undertake the maintenance of the appliance~~	Knowledge		
	BSHG5	Maybe at the end it costs more...	Profits	Profits	Profits	BSHG5	Care/cleaning of the appliances can create disagreements	Agreement	Agreement	Agreement
	BSHG6	Waste of time	Cost-Efficiency	Cost-Efficiency	Cost-Efficiency	BSHG5	In order to make a purchase everybody has to agree on it	Agreement	Agreement	Agreement
	BSHG6	Common use of appliance	Agreement	Trust	Trust	BSHG5	An appliance may not be availlable when I need it	Cost-Efficiency	Technical Fit	Technical Fit
	BSHG9	Common use with others	Agreement	Trust	Agreement	BSHG6	Common use	Rights and Duties	Trust	Trust
	BSHG9	Enough number of machines (waiting time)	Cost-Efficiency	Cost-Efficiency	Cost-Efficiency	BSHG6	Waste of time	Cost-Efficiency	Cost-Efficiency	Cost-Efficiency
						BSHG6	Lack of cooperation	Agreement	Agreement	Agreement
						BSHG9	Common use with others	Rights and Duties	Trust	Trust
						BSHG9	Risk of mishandling	Safety	Safety	Safety
						BSHG9	Acountability for the functionality of the machine	Knowledge	Own Competence	Knowledge
	1	Buying another energy-intensive appliance with the money that was reserved for the purchase of the washing machine	Profits			1	Creation of new sharing ideas due to higher social contacts	Socialising		
	1	Consumption for internet streaming while waiting in the laundry	Profits			1	Higher awareness of other sustainability aspects	Poseur		
	2	Multiplication among peer groups, increasing demand for shared solutions, expansion towards other services and appliances	Authority			2	Increased market for shared appliances and peer-to-peer services in other life domains and economic and societal sectors (mobility, gardening, care, housing, etc.) among the community and greater society.	Added value		
	2	Increased uptake and participation yields potential to expand sharing concepts towards new services	Support			4	More / larger tools than necessary are bought and used	Risk Profile		
	4	More frequent washing because the large amounts need to be filled	Cost-Efficiency			4	Things that were done by hand before (in lack of tools) are now done by tools	Cost-Efficiency		
	4	More clothes to bridge longer competent seller intervals				4	Community experience might foster positive spill-over to other domains	Support		
	4	Transportation of washing by car	Cost-Efficiency			BSHG1	Lower bills paid from the whole building	Profits		
	4	Activities conducted while waiting are carbon intensive	Poseur			BSHG1	More fights and problems caused while sharing - opposite results	Agreement		
	BSHG1	Extra space in my house from moving the washer out				BSHG1	Lower sales for the appliances company	Profits		
	BSHG1	Peers learn from my experience and they do that too	Authority			BSHG2	Convince others to follow my example	Authority		
	BSHG1	Laundry place become richer, buys better equipment	Added value			BSHG2	Save money	Profits		
	BSHG2	Save money	Profits			BSHG2	Manufactures may be convinced to develop machines with bigger capacity			
	BSHG2	The laundy and drying services can install more energy efficient appliances	Added value			BSHG3	We get to know each other better while using the same appliances and organize	Socialising		
und effects	BSHG3	I will save money and I could invest them somewhere else.	Profits			BSHG3	Save money.	Profits		

APPLIANCES

	Plausible Scenario					Ideal Scenario				
	Expert	RAW	KEY CONCEPT	Key Concept II	Final Coding	Expert	RAW	KEY CONCEPT	Key Concept II	Final Coding
Rebou	BSHG3	Influence my friends to do the same.	Authority			BSHG3	Spread the word to other neighborhoods and convince them to do the same.	Authority		
	BSHG4	I will save money and I could invest them somewhere else.	Profits			BSHG4	Convince others to follow my example	Authority		
	BSHG5	Friends frome the neighborhood may join me	Authority			BSHG4	Save money.	Profits		
	BSHG6	Save money	Profits			BSHG5	Cost savings for all of us	Profits		
	BSHG6	Time to meet friends	Socialising			BSHG6	Save money	Profits		
	BSHG9	"A place to meet" with friends while washing	Socialising			BSHG6	Good or bad communication	Agreement		
						BSHG9	Share your laundry	Rights and Duties		
	88		65		65	92		70		66

APPENDIX

E

Workshop Bilbao: Mapping Archetypes of Europe

E.1 Methodology and results

In the framework of the H2020-WHY (WHY-Consortium, 2021b), H2020-PARITY (Parity-Consortium, 2021), SmartLivingEPC (SmartLiving-Consortium, 2021) and H2020-ATELIER (ATELIER-Consortium, 2021; ATELIER-Consurtium, 2021) projects, an hybrid-multidisciplinary workshop session is organised to better understand which are the most predominant factors that affect the decision-making in stereotypical households regarding investment decisions toward the energy transition in the EU .

Following the workshop steps described in Section 10.3 which in a nutshell are the following:

1. Read the four scenarios of the energy aspects.
2. Break down the experts in a group per energy aspect.
3. Warm up. The instructor guided the group through the material.
4. Individual phase. First approach, sorting determinants into stages per archetype.
5. Collective phase. The experts moved to a different room to discuss.
6. Wrap up. The moderator of each session presented their main results.

Originally, this activity was planned to be carried out in-person and collaboratively, but for reasons beyond our control, it had to be carried out online as well, which required extra effort to develop an online template for synchronous work and the implementation of moderators to assist the experts during the session.

For the online session, the experts were divided into two working groups, but despite the best efforts of the moderators and the experts, there was not enough time to discuss a minimum of 3-4 archetypes, as expected; for this reason, an online template was designed to allow the experts to work asynchronously to complete this activity.

E.1.1 Individual mappings

In this stage, the experts were asked to sort the determinants into the different stages of the TTM per archetype according to their knowledge and expertise. Physical experts have been asked to sort the cards in a thread while the online participant does the same in a Miro board. Several rules were put into place:

1. Not all the determinants affect all the archetypes equally. So each archetype will only have a subset of 15 out of the 32 determinants.
2. In this stage, once a determinant is used in one stage of a behaviour model based on stages, it cannot be used in another stage.

The results of the individual mappings are the following:

Group	Moderator	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5
A	Macarena Larrea	Christian Klockner	Bram Vanacker	Afrodita Lioudaki	Uliana Torkunova	Chris Merveille
F	Carlos Quesada	Peru Sasia	Peter Conrady	Andrzej Ceglarz	Roberto Alvaro	Leire Astigarraga
FF (online)	Diego Casado	Sebastian Seebauer	Guntram Preßmair	Ismini Dimitriadou	Johannes Thema	Julio Elarre
M (online)	Amanda Schibline	Grzegorz Sierpinski	Marcin Staniek	Evgenia Kapassa	Oscar Pulido	Roberto Barrella

Table E.1: Grouping of experts and assignment of moderators for the collective mapping activity

E.1.2 **Collective mappings**

After the individual phase, we started the collective mappings. A moderator was appointed to help all to discuss and compare the determinants per stage of each archetype. In these sessions, the groupings were as follows (Table 4):

First, the experts discuss on each panel their individual assessments. Then, the moderator will collect the agreements and disparities. For each disparity, the moderator will ask the relevant expert to provide a reason for each assignment. If after a short discussion, no consensus is found, the moderator will ask the different experts involved to write in a sticky note a summary of the discussion and will proceed. Figures E.1 and E.2 show some pictures of the discussion and the end result of the physical activity. Figures E.3 and E.4, show the same for the online activity.

The overall opinion of all the participants was positive, even though it was difficult to carry out. Participants liked the materials provided (card decks, strings, pins, miro boards, etc.). Another positive view was that it has been possible to carry out the event in an hybrid format, with both physical and online attendance providing valuable outcomes. Finally, the most cited strength mentioned was the healthy discussion it raised with a lot of different points of view. Nevertheless, during the wrap-up session, several comments were made by the experts:

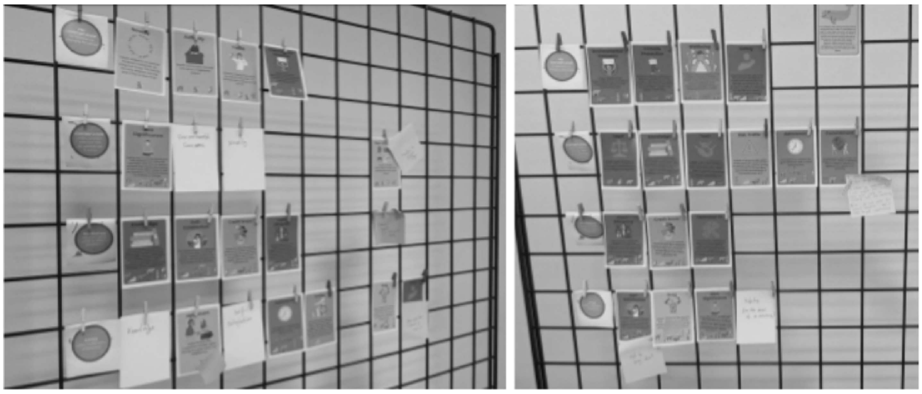


Figure E.1: Sorting determinants board: In-person discussion and one of the results

Figure E.2: Expert sorting determinants: In-person discussion and one of the results

Figure E.3: Online templates for sorting determinants into TTM stages

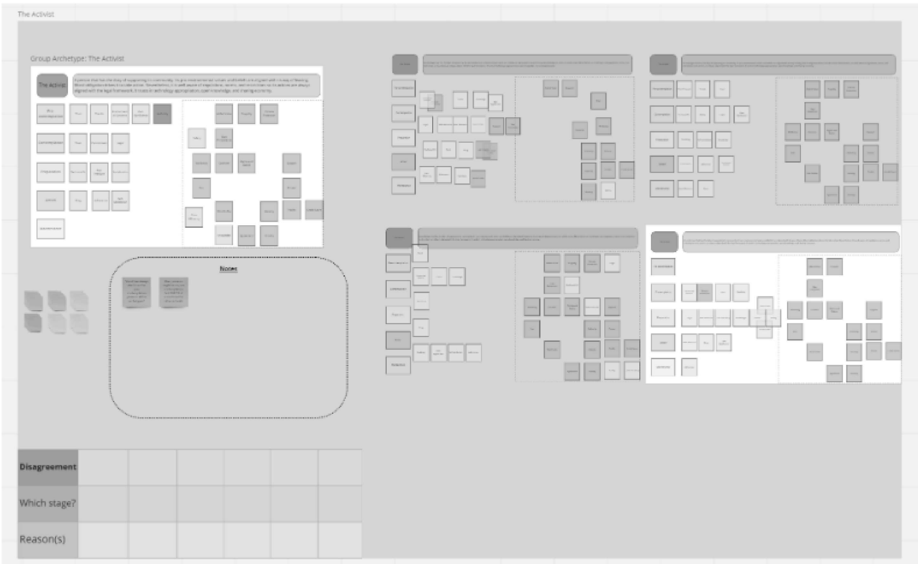


Figure E.4: Online templates for sorting determinants into TTM stages

- It was expected that each group will discuss a minimum of 3-4 archetypes to have at least 2 sets of consensus agreements per archetype. Given the amount of discussion produced, only 10 archetypes have been discussed (of the 32 we were hoping). This means that only 2 archetypes have more than one collective answer. **Several experts agree that in order to reach any conclusion it is needed 3 or 4 of such repetitions. They explicitly mention that no conclusion or action should be made until this amount of information is collected.**
- Several experts raised concerns about the lack of practitioners from the public sector. Several practitioners participated in the workshop but they have to leave early and their contributions have not been extensive.

In order to overcome these challenges a list of follow-up activities is planned:

- The activity is being replicated in Latin American contexts. This would allow us to compare if there is a significant difference between the results in Europe and in the Global South.
- It is being planned to repeat the workshop with public authorities from different regions of Spain late in the year. Unfortunately, it was not possible to set dates for them in a reasonable amount of time so the activity was transformed into a survey (WHY-Consortium, 2021a) where the participants have to select the determinants that are more important to make a decision from their point of view for the different archetypes at each stage of the TTM. No answer has been received so far.
- In order to retrieve more information from the experts, online meetings were tried to be established. Unfortunately, it was not possible to set dates for them in a reasonable amount of time so the activity was transformed into an online asynchronous task. The individual contributions of all the experts were assessed and the overall consensus where provided. Table 2 provides this consensus where green cells means that more than 50% experts agreed; red cells, between 25-50% agreement and grey cells means that less than 25% experts agreed. Experts were requested to discuss the red cells providing a comment with the reasons. If any other expert has already provided a comment,

it was requested to reply in the same thread. In any case, experts were requested to provide feedback on grey and green cells providing their reasons. This activity has just finished and the results have not been assessed yet.

E.2 Activity: Causal modelling based on expert panel agreements

The following steps show how the final causal model of each archetype was built from the collective mapping results.

1. **Summarising consensus**. Figs E.5, E.6, E.7, and E.8 show the consensus reached in each group (MX, CO, CL, SV) on the factors that make up an archetype and the TTM phase in which they should arise. Figure E.9 summarizes the consensus of the four groups, where the factors and all the MTT stages associated with each factor are marked with the number of groups agreeing on them. The TTM stage with the highest agreement value, and candidate to be the final one, is highlighted in green.
   Fig E.11 shows how many archetypes a given factor appears in (on the left) as well as the stages of the MTT model in which a factor may arise.
2. **Filtering factors by consensus**. Factors with less than 50% consensus (by groups) will not be considered further for their archetype. For instance, a factor cited by only one of the three groups will be ignored.
3. **Weighting of agreements-degree**. Based on the filtered factor (table 9), the agreement degree per factor was weighted (weight = total groups / agreement degree). The following cases help to assign the final TTM stages where a factor is placed.

   (a) **Case 1**: The cell of a factor with the highest weight stands for its final TTM stage.

   (b) **Case 2**: Equal agreement degrees. The highest weight is found by spatial autocorrelation: This technique analyses the spatial relationships between neighbouring cells. Cells with similar values tend to be assigned higher weights, capturing the spatial pattern of the data.

Fig E.12 shows the final archetypes and the describing factors, including the TTM stage in which they appear, marked with a cross (X). Table 11 also shows (1) some squares with a lighter border, those indicating the ignored factors by filtering, (2) the final factor counts by TTM stage, and (3) the factors that were removed.

E.3 **Activity: Crafting the causal graphs of investment profiles**

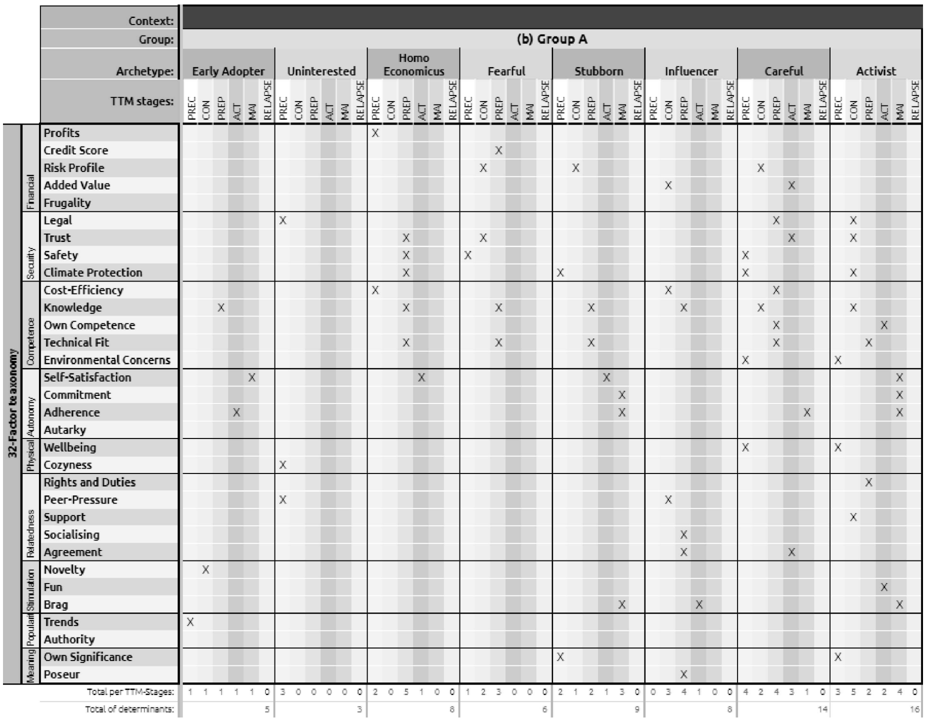
This activity is carried out by researchers based on the results of Section E.2 (Causal modelling). In this activity, the factors of a given archetype are placed in a DAG following the structure described in Section 10.2 as is shown in Fig 10.2

Eight Causal Graphs or Directed Acyclic Graphs (DAG) of Europe are introduced, representing the causal relationships between the factors of the archetypes (Figure E.12). The absence of determinants at some stage of change (TTM) implies that archetypes are advancing directly to the next stage of the decision-making process. For example, the Early Adopter advances (Fig E.13 directly from *contemplation* to *reparation* stage. Figs E.13, E.14, E.15, E.16, E.17, E.18, E.19, and E.20 show the causal graphs of the European archetypes.

	Context:	European Archetypes & TTM stages per group																							
	Group:	(a) Group F																							
	Archetype:	Early Adopter						Uninterested						Homo Economicus						Fearful					
	TTM stages:	PREC	CON	PREP	ACT	MAI	RELAPSE	PREC	CON	PREP	ACT	MAI	RELAPSE	PREC	CON	PREP	ACT	MAI	RELAPSE	PREC	CON	PREP	ACT	MAI	RELAPSE
32-Factor taxonomy: Financial	Profits				X									X			X								
Financial	Credit Score			X												X						X			
Financial	Risk Profile															X					X				
Financial	Added Value														X										
Financial	Frugality																								
Security	Legal								X						X	X					X				
Security	Trust														X						X				
Security	Safety										X					X				X			X		
Security	Climate Protection																			X					
Competence	Cost-Efficiency			X						X					X	X						X			
Competence	Knowledge			X	X									X	X						X				
Competence	Own Competence																								
Competence	Technical Fit									X						X						X			
Competence	Environmental Concerns	X	X												X					X					
Autonomy	Self-Satisfaction			X	X						X						X						X		
Autonomy	Commitment																				X				
Autonomy	Adherence				X						X										X				
Autonomy	Autarky																								
Physical	Wellbeing								X											X					
Physical	Cozyness										X														
Relatedness	Rights and Duties							X																	
Relatedness	Peer-Pressure							X																	
Relatedness	Support																								
Relatedness	Socialising																								
Relatedness	Agreement				X																				
Stimulation	Novelty	X	X																						
Stimulation	Fun															X									
Stimulation	Brag																						X		
Popularit	Trends	X								X															
Popularit	Authority	X								X															
Meaning	Own Significance		X						X							X							X		
Meaning	Poseur																								
	Total per TTM-Stages:	4	3	4	5	0	0	2	3	4	4	0	0	2	6	8	2	0	0	4	6	3	4	0	0
	Total of determinants:						16						13						18						17

	Archetype:	Stubborn						Influencer						Careful						Activist					
	TTM stages:	PREC	CON	PREP	ACT	MAI	RELAPSE	PREC	CON	PREP	ACT	MAI	RELAPSE	PREC	CON	PREP	ACT	MAI	RELAPSE	PREC	CON	PREP	ACT	MAI	RELAPSE
Financial	Profits																								
Financial	Credit Score															X									
Financial	Risk Profile		X													X									
Financial	Added Value																								
Financial	Frugality																								
Security	Legal																								
Security	Trust														X										
Security	Safety		X											X											
Security	Climate Protection																								
Competence	Cost-Efficiency																								
Competence	Knowledge			X						X						X									
Competence	Own Competence	X														X									
Competence	Technical Fit																					X			
Competence	Environmental Concerns													X											
Autonomy	Self-Satisfaction														X								X		
Autonomy	Commitment																	X					X		
Autonomy	Adherence																								
Autonomy	Autarky																								
Physical	Wellbeing																								
Physical	Cozyness																								
Relatedness	Rights and Duties																								
Relatedness	Peer-Pressure								X																
Relatedness	Support																								
Relatedness	Socialising									X															
Relatedness	Agreement																								
Stimulation	Novelty																								
Stimulation	Fun																								
Stimulation	Brag										X														
Popularit	Trends																								
Popularit	Authority							X																	
Meaning	Own Significance							X																	
Meaning	Poseur										X														
	Total per TTM-Stages:	1	2	1	0	0	0	2	1	2	2	0	0	2	2	4	0	1	0	0	0	1	2	0	0
	Total of determinants:						4						7						9						3

Figure E.5: F group consensus on the factors that make up an archetype and the phase of the TTM in which they should emerge.



	Context:																																																
	Group:	(b) Group A																																															
	Archetype:	Early Adopter						Uninterested						Homo Economicus						Fearful						Stubborn						Influencer						Careful						Activist					
32-Factor taxonomy	TTM stages:	PREC	CON	PREP	ACT	MAI	RELAPSE	PREC	CON	PREP	ACT	MAI	RELAPSE	PREC	CON	PREP	ACT	MAI	RELAPSE	PREC	CON	PREP	ACT	MAI	RELAPSE	PREC	CON	PREP	ACT	MAI	RELAPSE	PREC	CON	PREP	ACT	MAI	RELAPSE	PREC	CON	PREP	ACT	MAI	RELAPSE	PREC	CON	PREP	ACT	MAI	RELAPSE
Financial	Profits													X																																			
	Credit Score																					X																											
	Risk Profile																				X						X												X										
	Added Value																																X								X								
	Frugality																																																
Security	Legal							X																																X					X				
	Trust															X					X																				X				X				
	Safety															X				X																		X											
	Climate Protection															X										X												X							X				
Competence	Cost-Efficiency													X																			X							X									
	Knowledge			X												X						X						X						X					X						X				
	Own Competence																																							X							X		
	Technical Fit															X						X						X												X						X			
	Environmental Concerns																																					X						X					
Autonomy	Self-Satisfaction					X											X												X																			X	
	Commitment																													X																		X	
	Adherence				X																									X												X						X	
	Autarky																																																
Physical	Wellbeing																																					X						X					
	Cozyness							X																																									
Relatedness	Rights and Duties																																													X			
	Peer-Pressure							X																									X																
	Support																																												X				
	Socialising																																	X															
	Agreement																																	X							X								
Stimulation	Novelty		X																																														
	Fun																																														X		
	Brag																													X					X													X	
Popularity	Trends	X																																															
	Authority																																																
Meaning	Own Significance																									X																		X					
	Poseur																																	X															
	Total per TTM-Stages:	1	1	1	1	1	0	3	0	0	0	0	0	2	0	5	1	0	0	1	2	3	0	0	0	2	1	2	1	3	0	0	3	4	1	0	0	4	2	4	3	1	0	3	5	2	2	4	0
	Total of determinants:						5						3						8						6						9						8						14						16

Figure E.6: A group consensus on the factors that make up an archetype and the phase of the TTM in which they should emerge.

		Context:																								
		Group:	(c) Group FF																							
		Archetype:	Early Adopter						Uninterested						Homo Economicus						Fearful					
		TTM stages:	PREC	CON	PREP	ACT	MAI	RELAPSE	PREC	CON	PREP	ACT	MAI	RELAPSE	PREC	CON	PREP	ACT	MAI	RELAPSE	PREC	CON	PREP	ACT	MAI	RELAPSE
32-Factor teaxonomy	Financial	Profits													X											
		Credit Score																					X			
		Risk Profile																			X					
		Added Value														X										
		Frugality														X										
	Security	Legal								X												X				
		Trust															X					X				
		Safety															X				X					
		Climate Protection																								
	Competence	Cost-Efficiency																			X					
		Knowledge			X										X								X			
		Own Competence																								
		Technical Fit							X								X						X			
		Environmental Concerns	X																							
	Autonomy	Self-Satisfaction					X																			
		Commitment																								
		Adherence				X																				
		Autarky																								
	Physical	Wellbeing								X												X		X		
		Cozyness							X																	
	Relatedness	Rights and Duties																								
		Peer-Pressure		X																						
		Support																								
		Socialising																								
		Agreement																								
	Stimulation	Novelty	X																							
		Fun																								
		Brag				X																				
	Popularity	Trends	X																							
		Authority										X														
	Meaning	Own Significance																								
		Poseur																								
		Total per TTM-Stages:	3	1	1	2	1	0	2	2	0	1	0	0	2	2	3	0	0	0	3	3	3	1	0	0
		Total of determinants:						8						5						7						10

		Context:																								
		Group:	(c) Group FF																							
		Archetype:	Stubborn						Influencer						Careful						Activist					
		TTM stages:	PREC	CON	PREP	ACT	MAI	RELAPSE	PREC	CON	PREP	ACT	MAI	RELAPSE	PREC	CON	PREP	ACT	MAI	RELAPSE	PREC	CON	PREP	ACT	MAI	RELAPSE
32-Factor teaxonomy	Financial	Profits																								
		Credit Score														X										
		Risk Profile													X											
		Added Value																								
		Frugality																								
	Security	Legal																				X				
		Trust													X						X	X				
		Safety													X											
		Climate Protection													X											
	Competence	Cost-Efficiency														X		X	X							
		Knowledge			X											X										
		Own Competence															X									
		Technical Fit														X							X			
		Environmental Concerns													X						X					
	Autonomy	Self-Satisfaction					X											X						X		
		Commitment															X					X				
		Adherence					X									X								X		
		Autarky														X										
	Physical	Wellbeing														X		X	X							
		Cozyness																								
	Relatedness	Rights and Duties																								
		Peer-Pressure								X													X			
		Support																								
		Socialising																					X			
		Agreement									X															
	Stimulation	Novelty																								
		Fun																								
		Brag										X												X		
	Popularity	Trends																			X					
		Authority							X												X					
	Meaning	Own Significance																			X					
		Poseur																								
		Total per TTM-Stages:	0	0	1	0	2	0	1	1	1	1	0	0	5	7	2	3	2	0	5	3	3	3	0	0
		Total of determinants:						3						4						19						14

Figure E.7: FF group consensus on the factors that make up an archetype and the phase of the TTM in which they should emerge.

32-Factor taxonomy	Context:																								
	Group:	(d) Group M																							
	Archetype:	Early Adopter						Uninterested						Homo Economicus						Fearful					
	TTM stages:	PREC	CON	PREP	ACT	MAI	RELAPSE	PREC	CON	PREP	ACT	MAI	RELAPSE	PREC	CON	PREP	ACT	MAI	RELAPSE	PREC	CON	PREP	ACT	MAI	RELAPSE
Financial	Profits																								
	Credit Score																								
	Risk Profile																								
	Added Value																								
	Frugality																								
Security	Legal																								
	Trust																								
	Safety																								
	Climate Protection																								
Competence	Cost-Efficiency																								
	Knowledge																								
	Own Competence																								
	Technical Fit																								
	Environmental Concerns																								
Autonomy	Self-Satisfaction																								
	Commitment																								
	Adherence																								
	Autarky																								
Physical	Wellbeing																								
	Cozyness																								
Relatedness	Rights and Duties																								
	Peer-Pressure																								
	Support																								
	Socialising																								
	Agreement																								
Stimulation	Novelty																								
	Fun																								
	Brag																								
Popularity	Trends																								
	Authority																								
Meaning	Own Significance																								
	Poseur																								
	Total per TTM-Stages:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total of determinants:						0						0						0						0

32-Factor taxonomy	Context:																								
	Group:	(d) Group M																							
	Archetype:	Stubborn						Influencer						Careful						Activist					
	TTM stages:	PREC	CON	PREP	ACT	MAI	RELAPSE	PREC	CON	PREP	ACT	MAI	RELAPSE	PREC	CON	PREP	ACT	MAI	RELAPSE	PREC	CON	PREP	ACT	MAI	RELAPSE
Financial	Profits											X													
	Credit Score									X								X							
	Risk Profile													X											
	Added Value																								
	Frugality																								
Security	Legal																								
	Trust																	X			X				
	Safety														X									X	
	Climate Protection		X												X										
Competence	Cost-Efficiency			X		X					X											X			
	Knowledge	X							X							X					X				
	Own Competence	X													X										
	Technical Fit			X																		X			
	Environmental Concerns		X																	X					
Autonomy	Self-Satisfaction				X																		X		
	Commitment					X												X						X	
	Adherence					X											X							X	
	Autarky																X								
Physical	Wellbeing			X	X									X											
	Cozyness																								
Relatedness	Rights and Duties																								
	Peer-Pressure								X												X				
	Support											X													
	Socialising									X		X											X		
	Agreement																								
Stimulation	Novelty							X																	
	Fun									X															
	Brag										X														
Popularity	Trends					X		X												X					
	Authority																								
Meaning	Own Significance																								
	Poseur										X														
	Total per TTM-Stages:	2	2	3	2	4	0	2	2	3	3	3	0	2	3	1	2	3	0	2	3	2	2	3	0
	Total of determinants:						13						13						11						12

Figure E.8: M group consensus on the factors that make up an archetype and the phase of the TTM in which they should emerge.

(h) Europe - Archetypes & TTM stages
Summary of the groups: F, A, FF, and M

Number of groups: **4**

	Number of panels:	3						3						3						3					
	Archetype	Early Adopter						Uninterested						Homo Economicus						Fearful					
	TTM Stages	PREC	CON	PREP	ACT	MAI	RELAPSE	PREC	CON	PREP	ACT	MAI	RELAPSE	PREC	CON	PREP	ACT	MAI	RELAPSE	PREC	CON	PREP	ACT	MAI	RELAPSE
Financial	Profits				1									3			1								
Financial	Credit Score			1												1						3			
Financial	Risk Profile															1				1	2				
Financial	Added Value														2										
Financial	Frugality														1										
Security	Legal							1	2						1	1					2				
Security	Trust														1	2					3				
Security	Safety										1					3				3			1		
Security	Climate Protection															1				1					
Competence	Cost-Efficiency			1						1				1	1	1				1		1			
Competence	Knowledge			3	1									2	1	1					1	2			
Competence	Own Competence																								
Competence	Technical Fit							1		1						3						3			
Competence	Environmental Concerns	2	1												1					1					
Autonomy	Self-Satisfaction			1	1	2					1						2						1		
Autonomy	Commitment																				1				
Autonomy	Adherence				3						1										1				
Autonomy	Autarky																								
Physicality	Wellbeing								2											1	1		1		
Physicality	Cozyness							2			1														
Relatedness	Rights and Duties							1																	
Relatedness	Peer-Pressure		1					2																	
Relatedness	Support																								
Relatedness	Socialising																								
Relatedness	Agreement				1																				
Stimulation	Novelty	2	2																						
Stimulation	Fun															1									
Stimulation	Brag				1																		1		
Popularity	Trends	3								1															
Popularity	Authority	1								1	1														
Meaning	Own Significance		1						1							1							1		
Meaning	Poseur																								
	Tot. num. of factors:	4	4	4	6	1		5	3	4	5	0		3	7	11	2	0		6	7	4	5	0	
						19						17						23						22	

	Number of panels:	4						4						4						4					
	Archetype	Stubborn						Influencer						Careful						Activist					
	TTM Stages	PREC	CON	PREP	ACT	MAI	RELAPSE	PREC	CON	PREP	ACT	MAI	RELAPSE	PREC	CON	PREP	ACT	MAI	RELAPSE	PREC	CON	PREP	ACT	MAI	RELAPSE
Financial	Profits											1													
Financial	Credit Score									1					1	1		1							
Financial	Risk Profile		2											2	1	1									
Financial	Added Value								1								1								
Financial	Frugality																								
Security	Legal															1					2				
Security	Trust													1	1		1	1		1	3				
Security	Safety		1											3	1									1	
Security	Climate Protection	1	1											2	1						1				
Competence	Cost-Efficiency			1		1			1		1				1	1	1	1				1			
Competence	Knowledge	1		3					1	2					2	2					2				
Competence	Own Competence	2													1	3							1		
Competence	Technical Fit			2											1	1						4			
Competence	Environmental Concerns		1											3						3					
Autonomy	Self-Satisfaction				2	1									1		1						3	1	
Autonomy	Commitment					2										1		2			1		1	2	
Autonomy	Adherence					3									1		1	1					1	2	
Autonomy	Autarky														1		1								
Physicality	Wellbeing			1	1									2	1		1	1		1					
Physicality	Cozyness																								
Relatedness	Rights and Duties																					1			
Relatedness	Peer-Pressure								4												1	1			
Relatedness	Support											1									1				
Relatedness	Socialising									3		1										1	1		
Relatedness	Agreement									2							1								
Stimulation	Novelty							1																	
Stimulation	Fun									1													1		
Stimulation	Brag					1					4												1	1	
Popularity	Trends					1		1												2					
Popularity	Authority							2												1					
Meaning	Own Significance	1						1												2					
Meaning	Poseur									1	2														
	Tot. num. of factors:	4	4	4	2	6		4	4	6	3	3		6	13	8	8	6		6	7	5	7	5	
						20						20						41						30	

32-Factor taxonomy

Agreement

Figure E.9: Summarized the consensus of the four LATAMs: MX, CO, CL, and SV; agreements on the factors and the TTM stages where the factors may arise.

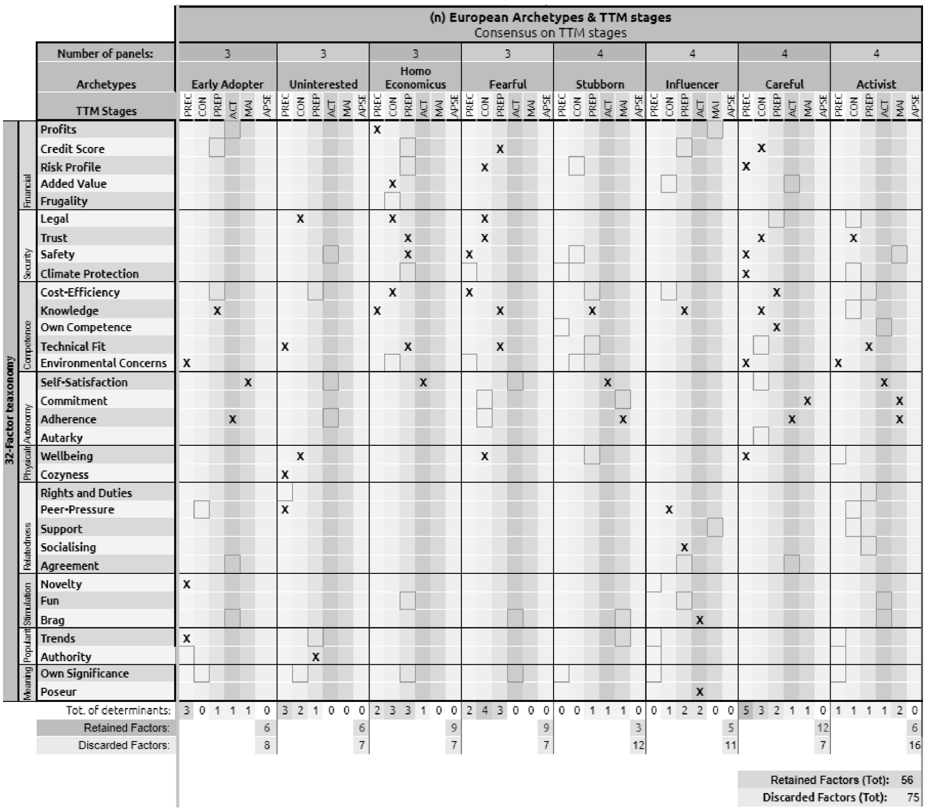


Figure E.10: Factors versus archetypes and TTM stages in which they may arise.

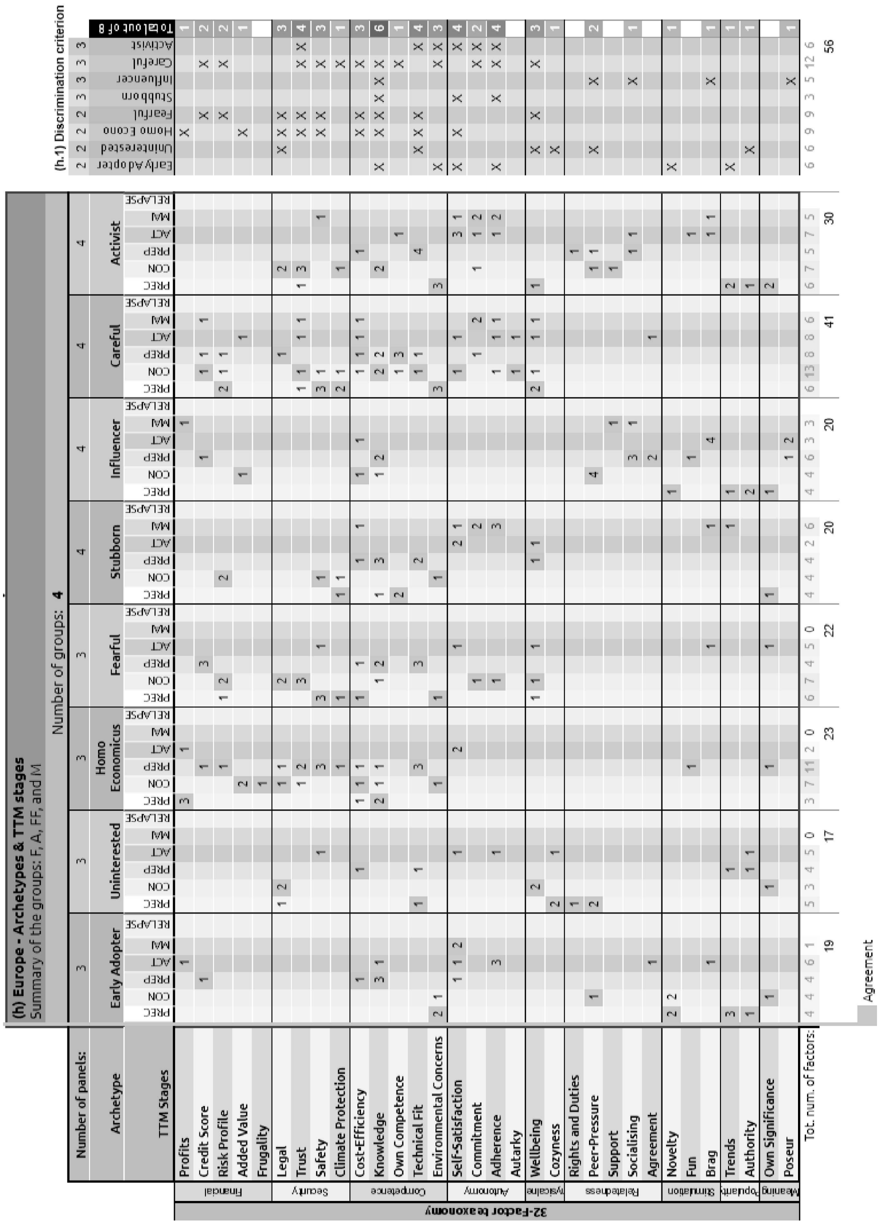


Figure E.11: Filtering factors by discrimination criterion: Select factors with proportions greater than 50% (100 / Number of panels).

(n) European Archetypes & TTM stages
Consensus on TTM stages

32-Factor teaxonomy	Number of panels:	3						3						3						3					
	Archetypes	Early Adopter						Uninterested						Homo Economicus						Fearful					
	TTM Stages	PREC	CON	PREP	ACT	MAI	APSE	PREC	CON	PREP	ACT	MAI	APSE	PREC	CON	PREP	ACT	MAI	APSE	PREC	CON	PREP	ACT	MAI	APSE
Financial	Profits													x											
	Credit Score																					x			
	Risk Profile																				x				
	Added Value														x										
	Frugality																								
Security	Legal								x						x						x				
	Trust															x					x				
	Safety															x				x					
	Climate Protection																								
Competence	Cost-Efficiency														x					x					
	Knowledge			x										x								x			
	Own Competence																								
	Technical Fit							x								x						x			
	Environmental Concerns	x																							
Autonomy	Self-Satisfaction					x											x								
	Commitment																								
	Adherence				x																				
	Autarky																								
Physical	Wellbeing								x												x				
	Cozyness							x																	
Relatedness	Rights and Duties																								
	Peer-Pressure							x																	
	Support																								
	Socialising																								
	Agreement																								
Stimulation	Novelty	x																							
	Fun																								
	Brag																								
Popularit	Trends	x																							
	Authority									x															
Meaning	Own Significance																								
	Poseur																								
	Tot. of determinants:	3	0	1	1	1	0	3	2	1	0	0	0	2	3	3	1	0	0	2	4	3	0	0	0
	Retained Factors:						6						6						9						9
	Discarded Factors:						8						7						7						7

32-Factor teaxonomy	Number of panels:	4						4						4						4					
	Archetypes	Stubborn						Influencer						Careful						Activist					
	TTM Stages	PREC	CON	PREP	ACT	MAI	APSE	PREC	CON	PREP	ACT	MAI	APSE	PREC	CON	PREP	ACT	MAI	APSE	PREC	CON	PREP	ACT	MAI	APSE
Financial	Profits																								
	Credit Score														x										
	Risk Profile													x											
	Added Value																								
	Frugality																								
Security	Legal																								
	Trust														x						x				
	Safety													x											
	Climate Protection													x											
Competence	Cost-Efficiency															x									
	Knowledge			x						x					x										
	Own Competence															x									
	Technical Fit																					x			
	Environmental Concerns													x						x					
Autonomy	Self-Satisfaction				x																		x		
	Commitment																	x						x	
	Adherence					x											x							x	
	Autarky																								
Physical	Wellbeing													x											
	Cozyness																								
Relatedness	Rights and Duties																								
	Peer-Pressure								x																
	Support																								
	Socialising									x															
	Agreement																								
Stimulation	Novelty																								
	Fun																								
	Brag										x														
Popularit	Trends																								
	Authority																								
Meaning	Own Significance																								
	Poseur										x														
	Tot. of determinants:	0	0	1	1	1	0	0	1	2	2	0	0	5	3	2	1	1	0	1	1	1	1	2	0
	Retained Factors:						3						5						12						6
	Discarded Factors:						12						11						7						16

Retained Factors (Tot): 56
Discarded Factors (Tot): 75

Figure E.12: Archetypes and the final factors that compose them sorted in TTM stages.

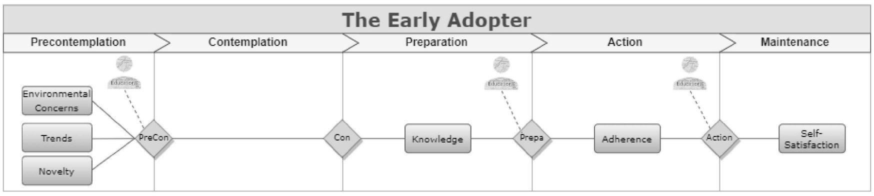


Figure E.13: Causal graph of The Early Adopter archetype.

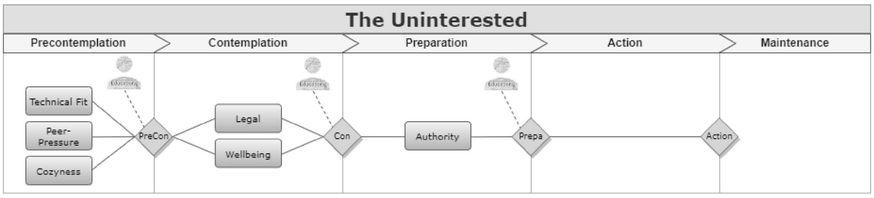


Figure E.14: Causal graph of The Uninterested archetype.

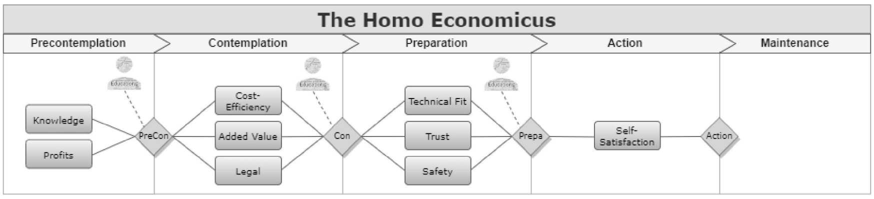


Figure E.15: Causal graph of The Homo Economicus archetype.

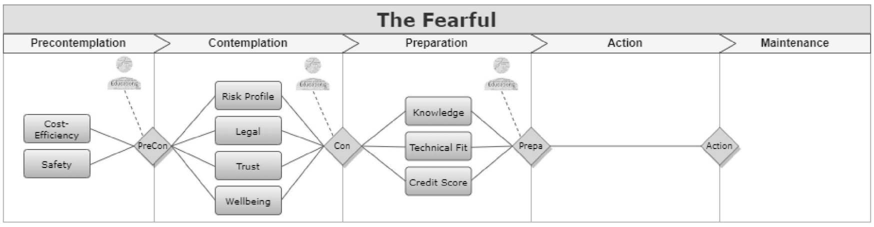


Figure E.16: Causal graph of The Fearful archetype.

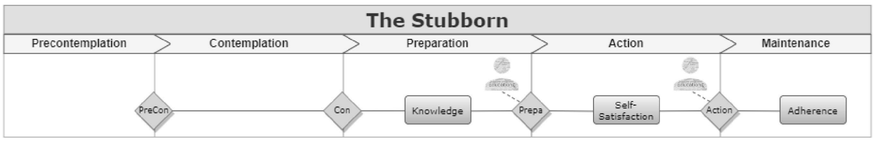


Figure E.17: Causal graph of The Stubborn archetype.

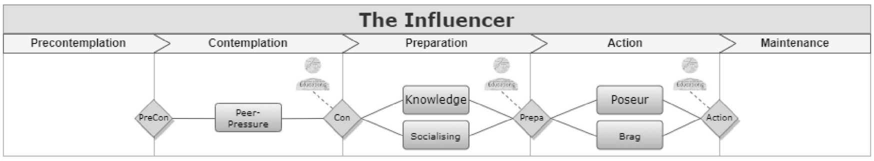


Figure E.18: Causal graph of The Influencer archetype.

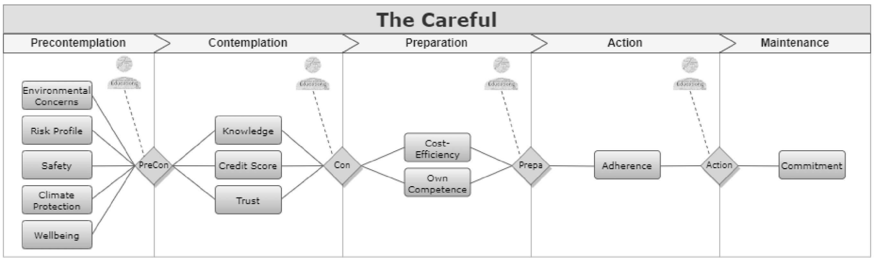


Figure E.19: Causal graph of The Careful archetype.

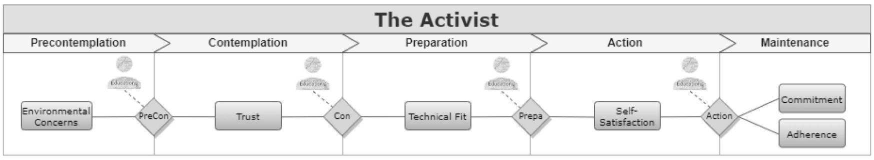


Figure E.20: Causal graph of The Activist archetype.

APPENDIX

F

Materials for Shaping Archetypes in LATAM

Why project (H2020)

Validación de flujos causales

WHY

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Human behaviour modelling

Causal diagrams based on expert knowledge

CLIMBING THE CAUSALITY LADDER TO UNDERSTAND
THE ENERGY DEMAND ON THE RESIDENTIAL SECTOR

Junio/2023

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 891943

WHY

1. Proyecto WHY (H2020)

Introducción

WHY

Climbing the causality ladder to understand and project the energy demand of the residential sector

Projecto WHY

Los **modelos de sistemas energéticos** (ESM) son herramientas que ayudan a los **expertos en energía** y a los **responsables políticos** a **describir** racionalmente los sistemas energéticos y a **evaluar** sistemáticamente los **impactos** de los **escenarios energéticos** a largo plazo. Los actuales ESM **carecen** de la **precisión** necesaria para captar adecuadamente **el uso de la energía en los hogares.**

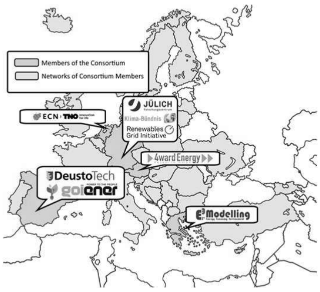
WHY desarrolla un nuevo **modelo causal** combinado con un innovador enfoque de **elaboración de perfiles** para **analizar** la **toma de decisiones** humanas en el consumo de energía y las **reacciones** humanas a los cambios en la **política energética.**

Fuente: https://www.why-h2020.eu/who-we-are

Projecto WHY

- **WHY** ha desarrollado una metodología innovadora para la previsión de la carga a corto y largo plazo en el sector residencial.
- El conjunto de herramientas WHY (**WHY toolkit**) se utilizará para evaluar varios escenarios que simulan diferentes medidas políticas.
- Todos los resultados serán de código abierto para maximizar su aceptación, y se difundirán ampliamente a diversos públicos.

Fuente: https://www.why-h2020.eu/who-we-are



¿Quiénes somos?

WHY

- Socios que cubren toda la cadena de valor de la innovación
  - 1 University,
  - 3 RTOs (Research and Technology Organizations),
  - 1 SME (Small and Medium-size Enterprise),
  - 1 Industry and
  - 2 NGOs (Non-Governmental Organization)
- Distribuidos geográficamente en toda Europa y con varios miembros del consejo asesor en todo el mundo

Basic Research → Development → Validation → Uptake

DeustoTech, ECN › TNO innovation for life, Climate Alliance, 4ward Energy Research GmbH, goiener, JÜLICH Forschungszentrum, E3Modelling Energy Economy Environment, Renewables Grid Initiative

Objetivo clave de WHY

WHY

Mejorar la evaluación de las **tendencias de consumo de energía eléctrica en los hogares** mediante la inclusión de **modelos causales** en los principales modelos de sistemas energéticos (ESM) centrados en:

- Eficiencia energética (Energy efficiency, EE)
- Generación distribuida (Distributed generation, DG)
- Respuesta a la demanda (Demand response, DR)
- Electrificación de los servicios (Electrification of services, ES)

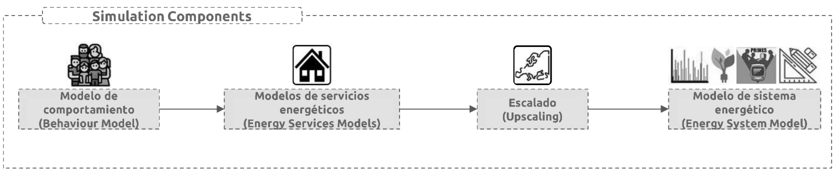
www.why-h2020.eu

Colaboración con otros proyectos

En este contexto, el proyecto **H2020-WHY** (why-h2020.eu) ha unido fuerzas con otros tres proyectos financiados por Europa que versan igualmente con estrategias para la transición energética.

- **H2020-PARITY** (parity-h2020.eu/) sobre mercados de flexibilidad energética
- **H2020-SMARTLIVINGEPC** (cordis.europa.eu/project/id/101069639) sobre un nuevo modelo de certificación energética de edificios
- **H2020-ATELIER** (smartcity-atelier.eu) que versa sobre los nuevos modelos de ciudad o áreas urbanas para una mejora de su eficiencia energética.

Concepto I:
Simulación de consumo energético basada en el comportamiento humano



Concepto II:
Componentes de nuestro trabajo

- Modelo de comportamiento para el consumo energético de los hogares
  – Uso de metodologías innovadoras (FFORMA* y modelos causales)
- Modelos de servicios energéticos
  – Aparatos y modelos generales de eficiencia energética, respuesta a la demanda, generación distribuida y electrificación de la calefacción y el transporte
- Escalado
  – Utilización de sistemas de agentes múltiples con el medio ambiente para ampliar la escala de una casa a un país
- Modelos de sistemas energéticos
  – Plugins para tres de los modelos de sistemas energéticos más importantes (Times, Primes y Prometheus)

*Feature-based FORecast Model Averaging

Casos de uso

Escenarios	Geo.	Temp.	ESM	Objetivo
Gniebing Microgrid Operation	City	Hourly / Yearly	Load Profile Generator	• Mejorar la previsión de la carga en funcionamiento normal • Crear perfiles de carga en caso de apagón
Energy Cooperative O&P	Regional	Hourly / Yearly	Own Model	• Mejorar la previsión de la carga en condiciones normales de funcionamiento • Probar el impacto de las nuevas políticas/tarifas en la empresa de servicios públicos
Energy Community	City	Hourly / Yearly	Load Profile Generator	• Crear una herramienta para dimensionar los diferentes componentes y definir los modelos de negocio y gobernanza • Ayudar a diseñar intervenciones que aumenten la participación en la comunidad energética
2030 & 2050 European energy strategy	European	2030 / 2050	PRIMES	• Crear diferentes perfiles de carga bajo diferentes intervenciones para fomentar la EE, la DG, la DR y la ES • Evaluar el impacto de diferentes campañas de EE
Global energy scenario	Worldwide	2100	TIAM-ECN	• Crear diferentes perfiles de carga bajo diferentes intervenciones para fomentar la EE, la DG, la DR y la ES • Proyectar el consumo de energía habitual

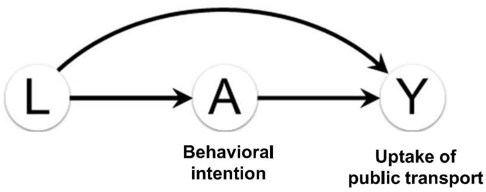
Modelado causal con Grafos Acíclicos Dirigidos (DAG)

WHY

- Un DAG es un modelo de cómo creemos (supuestos) que funciona una realidad (Transición energética)
- El **diagrama causal** es una herramienta gráfica para representar nuestro **conocimiento cualitativo experto** y nuestras **suposiciones a priori** sobre el problema estudiado y la red causal que vincula el tratamiento, el resultado y otras variables.
- En situaciones complejas, será crucial ser **explícito** sobre **lo que sabemos** y **lo que suponemos** acerca de las **variables** relevantes para nuestro problema de inferencia causal particular.
- Un DAG representa un Modelo Causal Estructural (MCE) subyacente

Ejemplo: Factores relacionados con la utilización del transporte público, supuesto 3

WHY



L	values
Hing cost	1
Low cost	0

A	values
Willing	1
Unwilling	0

Y	values
Person who uptake PT	1
Person who **no** uptake PT	0

WHY

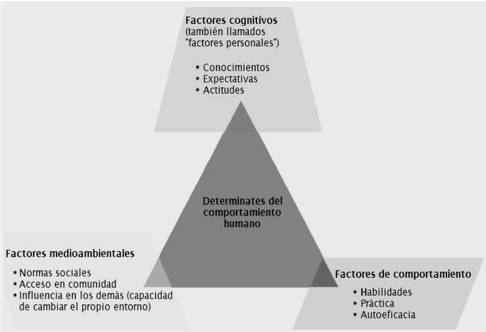
2. Comportamiento humano
Factores determinantes

WHY

La teoría cognitiva social como guía para entender los determinantes que esperamos

La **Teoría del Aprendizaje Cognitivo Social** (Social Cognitive Learning Theory) reconoce la constante *interacción* que existe entre *el individuo y su entorno*, tanto *estructural* como *social*, para moldear el comportamiento.
Hay tres factores cognitivos personales que se ven afectados por el entorno y que influyen en el comportamiento:

- **Aprendizaje observacional** (Observational learning): Los individuos son más propensos a realizar una conducta deseada si observan que otros modelan esa conducta y experimentan las consiguientes recompensas positivas.
- **Expectativas de resultados** (Outcome expectations): Es más probable que los individuos practiquen una conducta deseada si creen que los beneficios de realizarla son mayores que los costes.
- **Autoeficacia** (Self-efficacy): Es más probable que los individuos practiquen un comportamiento deseado si perciben que tienen las habilidades y la capacidad necesarias para hacerlo (Bandura, 2001; Glanz & Rimer, 2005).



…La teoría cognitiva social

Según la bibliografía existente, parece que los ***factores internos***, como las *creencias*, los *valores* o la *preocupación por el medio ambiente*, son los **principales impulsores de un cambio en el comportamiento diario** de las personas para **invertir** *tiempo y esfuerzo* en la **reducción de la huella de carbono** y de energía en su **vivienda personal**. Además, los ***factores externos dominantes*** para que se produzca este comportamiento proambiental parecen ser la *presión de los compañeros, la comparación social y las normas sociales.*

Entonces… ¿Cómo podemos codificar los determinantes reunidos (en EU) teniendo en cuenta la motivación que hay detrás?

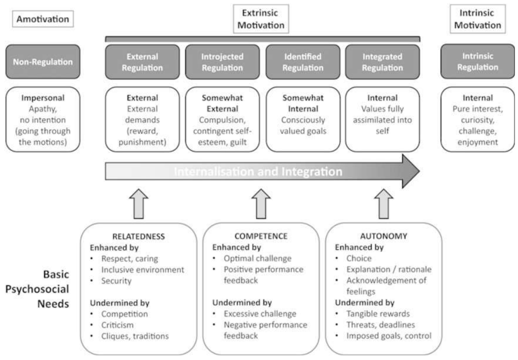
Teoría de la autodeterminación: comprender los determinantes según la motivación

Teoría de la autodeterminación (Self-determination theory, SDT) es una teoría empírica derivada de la motivación y la personalidad humanas en contextos sociales, que diferencia la motivación en términos de autonomía y control.

Aborda las necesidades psicológicas universales fundamentales que son esenciales para el crecimiento, la integridad y el bienestar.

La SDT sugiere que las personas están motivadas para crecer y cambiar satisfaciendo sus necesidades psicológicas universales.

Deci, E. L., & Ryan, R. M. (2012). Self-determination theory. In P. A. M. Van Lange, A. W. Kruglanski, & E. T. Higgins (Eds.), Handbook of theories of social psychology (pp. 416–436). Sage Publications Ltd. https://doi.org/10.4135/9781446249215.n21



3. Obtención de conocimiento experto

Metodo Delphi

Tarea ejecutada en EU

Metodo Delphi

Nadie tiene una bola de cristal, pero, por fortuna se puede aprovechar la **experiencia que los profesionales y especialistas** poseen para obtener información útil de cara al futuro.

Dicho de otra forma, el **método Delphi** se basa en el hecho de que las *decisiones en grupo* tienden a ser más precisas que las individuales. Este método es un procedimiento iterativo diseñado para *ayudar a un panel de expertos a alcanzar un consenso sobre un tema*.

Actividad 1: Generación de escenarios futuros

Tarea ejecutada en EU

Base	Estos escenarios tratan de reflejar la situación actual de los aspectos. Intentan ser una descripción general de la realidad en los hogares de Latinoamérica.
Minimum	Estos escenarios incluyen el esfuerzo mínimo necesario para mejorar el escenario base hacia la descarbonización del aspecto concreto. La mayoría de las veces, se dirigen a un cambio de comportamiento más que a una decisión de inversión monetaria.
Probable	Estos escenarios son la descripción más probable de la realidad en Latinoamérica dentro de varios años.
Plausible	Estos escenarios son menos probables que el anterior, pero podrían ser incubadoras de innovación en Latinoamérica.
Ideal	Estos son los escenarios ideales, pero es muy improbable que ocurran debido a la enorme innovación social necesaria.

Movilidad: Escenarios futuros en Europa

WHY

Tarea ejecutada en EU

Escenario ideal

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Escenario plausible

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Escenario probable

\- - -

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Escenario mínimo

\- - -

Todos
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recarga
compor

Escenario base

\- - -

Usted vive en un área metropolitana donde casi todo el mundo tiene al menos un coche de combustión. El coche se utiliza mucho, incluso para destinos a los que se puede llegar fácilmente a pie o con dispositivos de movilidad personal (por ejemplo, bicicletas). El transporte público en los desplazamientos de corta distancia se utiliza poco, ya sea por personas que no poseen vehículo o para desplazarse a zonas donde es difícil encontrar aparcamiento. El transporte público está parcialmente electrificado, aunque sigue dependiendo de los combustibles fósiles. Los desplazamientos a pie o en movilidad personal son habituales en algunas regiones, pero están lejos de ser el medio de transporte típico. Las grandes distancias se recorren normalmente en transporte público o en coche privado de forma más o menos uniforme. En las zonas de baja densidad de población la única opción viable es el coche, ya que el transporte público es inexistente y las distancias a recorrer son demasiado grandes para ser cubiertas por otros medios de transporte.

Flexibilidad: Escenarios futuros de Europa

WHY

Tarea ejecutada en EU

Escenario ideal (Ideal scenario)

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mayo

Escenario plausible (Plausible scenario)

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genera
energé
tambié
sistem
largo p

Escenario probable (Probable scenario)

Se han
vecinos
está bie
la oport
en la fot
una com

Escenario mínimo (Minimum scenario)

\- - -

Se ha
varias
tenga
alta pu
cada
incluye
cargas
que la

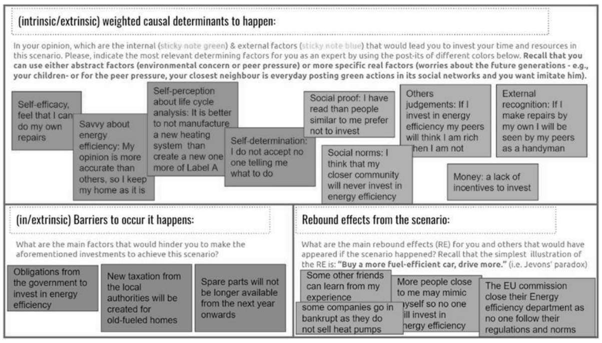
Escenario base (Base scenario)

\- - -

Vive en una vivienda mal ventilada No dispone de mecanismos para generar o almacenar energía. Los electrodomésticos son poco eficientes y no existe un sistema de gestión de la energía. Su tarifa eléctrica no incluye tarifas por tiempo de uso, por lo que no se preocupa de cuándo utilizar los electrodomésticos. Simplemente, cuando los necesitas, los enchufas y los utilizas.

Identificación de determinantes

Tarea ejecutada en EU



Plantilla entregada al experto para recuperar los determinantes (intrínsecos/extrínsecos), las barreras y los efectos de rebote previstos

Entonces… ¿Cómo podemos codificar los determinantes reunidos teniendo en cuenta la motivación que hay detrás?

Teoría de la autodeterminación: comprender los determinantes según la motivación

WHY

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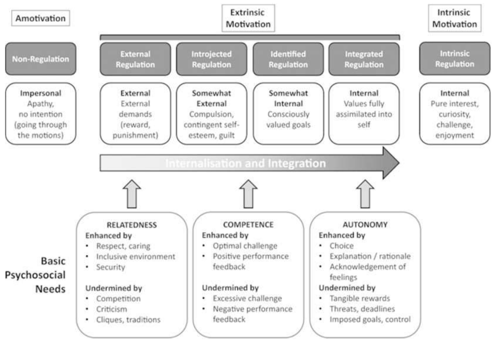
Aborda las necesidades psicológicas universales fundamentales que son esenciales para el crecimiento, la integridad y el bienestar.

La SDT sugiere que las personas están motivadas para crecer y cambiar satisfaciendo sus necesidades psicológicas universales.

Deci, E. L., & Ryan, R. M. (2012). Self-determination theory. In P. A. M. Van Lange, A. W. Kruglanski, & E. T. Higgins (Eds.), Handbook of theories of social psychology (pp. 416–436). Sage Publications Ltd. https://doi.org/10.4135/9781446249215.n21



WHY

¿Cuáles son entonces esas necesidades psicológicas?

Autonomía (Autonomy)

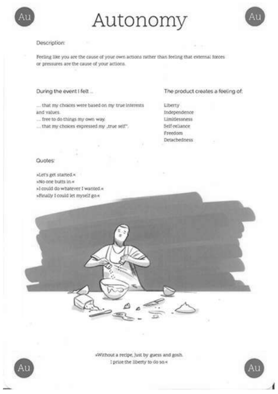
Sentir que eres la causa de tus propias acciones en lugar de sentir que las fuerzas o presiones externas son la causa de tus acciones.

Durante el evento me sentí...

...que mis elecciones se basaran en mis verdaderos intereses y valores.

...libre de hacer las cosas a mi manera.

...que mis elecciones expresan mi.,verdadero yo.



WHY

Seguridad (Security)

Sentirse seguro y en control de su vida en lugar de sentirse inseguro y amenazado por sus circunstancias.

Durante el evento me sentí...

... que mi vida fuera estructurada y predecible.

...contento de tener un conjunto de rutinas y hábitos cómodos.

... a salvo de amenazas e incertidumbres.

Estimulación (Stimulation)

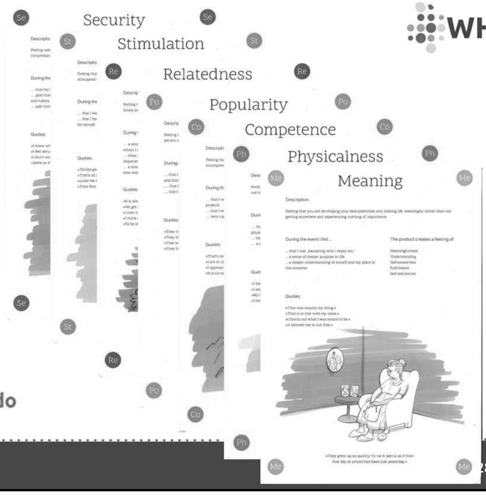
Relación/Conexión (Relatedness)

Popularidad (Popularity)

Competencia (Competence)

Apto fisicamente (Physi

Sentido/Significado (Meaning)



WHY

Acuerdo sobre las contribuciones recibidas,

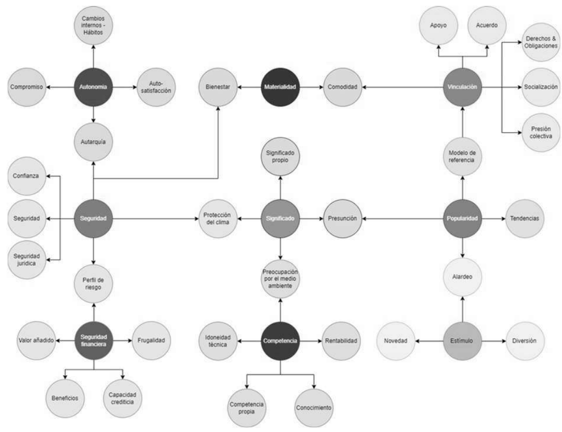
Tarea ejecutada en EU

Tras recibir todas las aportaciones de los expertos sobre cada uno de los diferentes aspectos de la transición energética y por cada uno de los escenarios futuros que se les han presentado, se ha llegado a un acuerdo sobre la codificación de los datos.

Codificación por parte de dos investigadores. El consenso del panel de expertos generó una lista de determinantes, que se agruparon, según la teoría del aprendizaje cognitivo en factores cognitivos personales que se ven afectados por la influencia del entorno (Trabajo en pares)

● **Una tercera homogeneización**. Ronda llevada a cabo por un tercer experto, el objetivo fue confirmar/modificar la primera codificación de consenso, y resolver conflictos para los determinantes en los que no hubo consenso en la primera ronda. Esta ter ronda dió lugar a la codificación final

archivo fuente



Visión general de los determinantes

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Lista de determinantes

Tarea ejecutada en EU

La lista de determinantes que surgieron de la fase de codificación y sus descripciones incluyen los conceptos más importantes se tomaron de la investigación de Hassenzah [1] donde se describe una lista de necesidades psicológicas, que pueden ser una fuente de experiencias positivas, también cuando se interactúa con productos técnicos o futuros potenciales.

- WHY-Lista de determinantes [2]

[1] http://www.experienceandinteraction.com/tools
[2] https://drive.google.com/file/d/1y2jWQFS2909fUQKQTNMf3zMCjAeszER6/view?usp=sharing

Peso que tienen los determinantes en cada uno de los escenarios

la **Competencia (Competence).** Sentirse muy capaz y eficaz en sus acciones, es el determinante de mayor peso en tres de los cuatro aspectos así como en la media de todas las respuestas.

En el aspecto de Edificios (Buildings), parece que las **necesidades financieras (financial)** son más relevantes que otras. Esto es posiblemente debido, principalmente, al hecho de que la inversión en construcción infraestructura es más cara que la de los otros verticales, Es muy importante destacar que los aspectos financieros están siempre presentes en todos los aspectos siendo en promedio el segundo de mayor importancia según el conocimiento de los expertos conocimiento de los expertos.

En tercer lugar encontramos el **Relación (Relatedness)**, que es un constructo relacionado con la relación entre los compañeros y la importancia que los demás tienen en las decisiones.

	Flexibility	Appliances	Building	Mobility	TOTAL
Financial	**18%**	**13%**	**32%**	**15%**	**20%**
Security	10%	11%	10%	**24%**	13%
Competence	**26%**	**29%**	**15%**	**25%**	**24%**
Autonomy	7%	6%	4%	5%	5%
Physicalness	0%	1%	5%	4%	2%
Relatedness	**24%**	**21%**	**18%**	12%	**19%**
Stimulation	3%	4%	3%	1%	3%
Popularity	7%	10%	8%	7%	8%
Meaning	5%	6%	6%	5%	6%

WHY

4. Creación de los arquetipos de toma de decisiones

WHY

¿Cómo contribuir como miembro de nuestro consejo consultor en Latinoamérica?

1. **Una sesión de inducción** (1 hora). Indicanos la fecha y hora para enviarte la invitación por google meeting.
2. **Una actividad individual online** (90 min), contribuye en remoto acerca de los arquetipos en el contexto de EL Salvador de la transición energética.
3. **Una sesión colaborativa presencial** con todos los expertos (1 día, enero 13, 2023). Extiende tu red de contactos. Participa en el trabajo colaborativo. Consolidar conocimiento experto que utilizaremos como base para diseñar modelos causales que serían la base de una plataforma de software (WHY toolkit). Al estar basado en un modelo causal, el kit de herramientas será capaz de modelar correctamente el impacto que las diferentes acciones tendrán sobre los patrones de demanda en el sector residencial.

arquetipos de toma de decisiones

Existen diferentes métodos para crear **personajes** o **arquetipos** basados en datos. Las personas son personajes ficticios que se pueden crear a partir de un trabajo de investigación para representar a los diferentes **tipos de usuarios** que podrían **tomar una decisión** de **inversión en un hogar**.

La creación de Personas siempre ayudará a comprender mejor las necesidades, experiencias, comportamientos, objetivos y obstáculos de los usuarios finales. Puede ayudar a reconocer que diferentes personas tienen diferentes necesidades y expectativas, y también puede ayudar a identificarse con el usuario para el que estamos diseñando.

…arquetipos de toma de decisiones

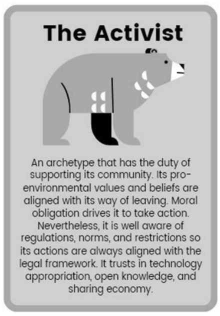
- Los **arquetipos** creados con este enfoque de **Personas** deben entenderse como aproximaciones de casos de usuarios -individuos reales- que pueden identificarse en cualquier proyecto relacionado con la energía que tenga que ver con las viviendas.
- Los arquetipos de **personas** que se presentan aquí están basados en datos revisados sobre el cuerpo de conocimiento y el **conocimiento experto** del equipo de investigación de DEUSTO y sus colaboradores. Así, una combinación de un enfoque inductivo y deductivo que nos llevó a identificar los siguientes ocho usuarios finales típicos con características específica

WHY

¿Cuáles arquetipos construimos?

WHY

arquetipos
(EU archetypes)



arquetipos
(EU archetypes)

WHY

El temerosos
The Fearful

Una persona con una conciencia medioambiental media que es capaz de entender la necesidad de realizar cambios de cualquier importancia (legal, económica, personal, etc.). Sin embargo, suele tener pereza o miedo al cambio por la cantidad de riesgo y tiempo que conlleva. Por lo tanto, su única motivación para realizar un cambio sustancial será la falta de confianza en la situación actual que puede afectar a su seguridad personal. Su conocimiento de la materia, su competencia personal y su deseo de mantener el bienestar les ayudarán a realizar los cambios necesarios y significativos. La adhesión a su decisión les llevará a ser capaces de emprender la acción final. Sólo la falta de acceso a la financiación, o que la tecnología no esté disponible o no pueda instalarse, les disuadirá de su empeño.

El obstinado
The Stubborn

Una persona muy comprometida con los temas medioambientales. Esta persona está angustiada o enfadada por la situación actual del medio ambiente y quiere emprender acciones significativas. Su principal objetivo es proteger el medio ambiente y esto les lleva a actuar cueste lo que cueste. La ambición de las acciones que emprenderá dependerá de su competencia, de la satisfacción personal que le produzca, de las capacidades de la tecnología y del acceso a la financiación.

El cuidadoso
The Careful

Una persona cuya principal prioridad es su bienestar y seguridad personal o de sus compañeros. Cualquier tipo de decisión que tomen está fuertemente influenciada por su percepción de seguridad y confianza en la acción. El principal motor de su comportamiento es su satisfacción personal o de grupo, en particular el mantenimiento de su comodidad física y mental y la de sus allegados. Las decisiones se tomarán en función de su competencia y conocimientos. La ambición de las acciones a realizar dependerá del grado de autosuficiencia y de los beneficios que quiera obtener para sí mismo y para la comunidad a la que pertenecen. Sólo la falta de financiación o los problemas técnicos les impedirán llevar a cabo sus esfuerzos.

Influencee / Influencer
Influencee / Influencer

Es una persona con un alto capital social que se deja influir fácilmente por sus compañeros o por las tendencias del grupo o que disfruta influyendo en sus compañeros. Su principal motivación para emprender cambios es cumplir con lo que el grupo espera de ellos, ya sea por las normas sociales o porque es una obligación para ellos. El sentimiento de pertenencia o su voluntad de apoyar a la comunidad es lo que les impulsa a actuar. Dependiendo de si estas personas quieren establecerse como una autoridad en su comunidad o si simplemente están cumpliendo con las normas sociales, sus acciones se verán reforzadas en mayor o menor medida. Sólo la falta de financiación o los problemas técnicos les impedirán actuar.

arquetipos y sus determinantes

WHY

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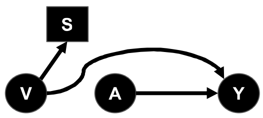
5. Creación de los Diagramas Causales por arquetipo según la TTM

(The Transtheoretical Model)



Creación de los Diagramas Causales por arquetipo según la TTM

Una vez identificados los siete arquetipos, los investigadores decidieron hacer un ejercicio para asignar los determinantes más relevantes de *la toma de decisiones de inversión* a cada arquetipo utilizando el Modelo Transteórico (TTM)

La TTM caracteriza el cambio de comportamiento como un proceso que se desarrolla en el tiempo, una transición no lineal a través de una secuencia de etapas cualitativamente distintas. En cada etapa hay fuentes individuales de resistencia al cambio, propias de cada etapa, que pueden mantener a las personas atascadas en una etapa inicial durante un largo periodo de tiempo, por lo que se necesitan habilidades y estrategias específicas.

El éxito de la transición a través de las etapas se refleja en una mayor disposición al cambio.

¿Cómo contribuir como miembro de nuestro consejo consultor en Latinoamérica?

WHY

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Modelo Transteórico

WHY

En pocas palabras, el TTM se basa en seis etapas o estadios de cambio:

1. **Precontemplación**
2. **Contemplación**
3. **Determinación**
4. **Acción**
5. **Mantenimiento**
6. **Recaida**

WHY

5. Expertos

Tarea a realizar

WHY

Preguntas?

Contatos

WHY

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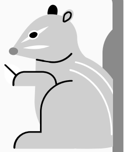
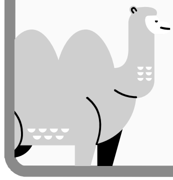
WHY

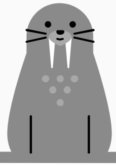
CLIMBING THE CAUSALITY LADDER TO UNDERSTAND
THE ENERGY DEMAND ON THE RESIDENTIAL SECTOR

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 891943



Arquetipos



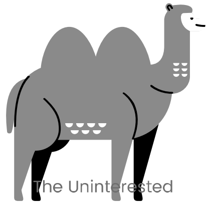


Adoptante temprano

Early Apdopter

Un arquetipo que siempre se ve afectado e impulsado por la novedad. Siempre quiere estar a la última y ser el primero en hacer cambios en su casa o en su vida personal (sobre todo cuando la tecnología punta está en la ecuación). Sus motivaciones son principalmente técnicas, pero no por ello deja de preocuparse por el medio ambiente. Su disfrute y emoción por lo que hace son factores predominantes para sus acciones. Tiene un estatus social que mantener y sus compañeros esperan que se comporte así. Puede darse el caso de que en determinadas situaciones le guste presumir o intente ser percibido como una autoridad.

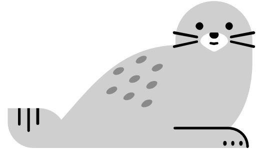
El desinteresado



The Uninterested

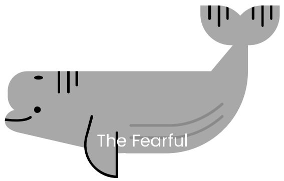
Un arquetipo que no presta especial atención a la información externa ni a los incentivos para realizar algún tipo de mejora en el hogar o en su vida personal. El mantenimiento de la comodidad es lo que predomina en su vida diaria a la hora de tomar decisiones. Suele aplicar atajos para la toma de decisiones, como seguir las tendencias de sus compañeros y aplicar valores predeterminados. Raramente aceptará cambios sin resistencia.

Homo Economicus



Un arquetipo que tiene un grado medio-alto de conocimientos sobre economía y/o transición energética. Sus motivaciones para emprender cualquier actividad son meramente económicas, ya sea para obtener beneficios o para reducir gastos. Estará más o menos interesado en realizar nuevas inversiones en función de su percepción del riesgo, la confianza en la situación actual de los mercados, las tendencias de las ventas y el acceso a los fondos. El valor añadido es el motor de sus elecciones.

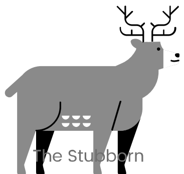
El temeroso



The Fearful

Un arquetipo con una conciencia medioambiental media que es capaz de comprender la necesidad de realizar cambios legales, económicos o personales. Sin embargo, suele tener tanto miedo o pereza que conlleva la inacción por la cantidad de riesgo y tiempo que conlleva. La falta de confianza en la situación actual, que puede afectar a su seguridad y bienestar personal, será un motor para la toma de decisiones urgentes y duraderas.

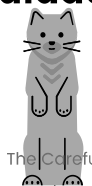
El obstinado



The Stubborn

Un arquetipo que está muy comprometido con las cuestiones medioambientales. Sin embargo, esta situación le hace sentirse angustiado, ansioso o enfadado. Por lo tanto, pretende realizar acciones significativas en cualquier momento y lo que sea necesario para aliviar su malestar. La ambición y el grado de sus acciones dependerán de su competencia, su satisfacción personal, las capacidades de la tecnología, el presupuesto o/y el acceso a los fondos.

El Cuidadoso



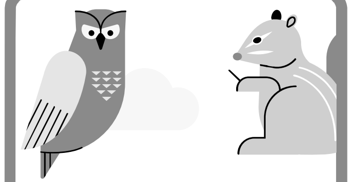
The Careful

Un arquetipo que tiene como objetivo maximizar el bienestar y la seguridad personal, colectiva y del ecosistema. Cada decisión que toma está fuertemente influenciada por la seguridad percibida, la autocompetencia, el impacto en el medio ambiente y la confianza en los resultados de la acción. La satisfacción personal o grupal es el principal motor de la acción. En particular, a la hora de mantener la comodidad física y mental de los allegados en relación con la ansiedad climática.

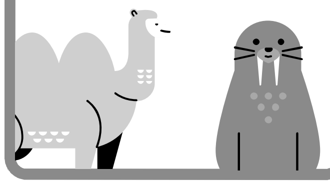
El Influencer

INFLUENTEE / INFLUENCER

Un arquetipo al que le gusta influir en sus compañeros. Busca siempre un valor añadido a sus acciones, ya sea monetario, de autoridad o de aumento del capital social. Cumplir con lo que el grupo espera de él se convierte en una obligación.



Financiero

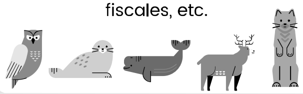


Beneficios

Todo tipo de ganancias y pérdidas económicas, incluyendo los flujos de ingresos directos (como la venta de energía o las flexibilidades a la red) a la reducción de las pérdidas (como la reducción de las facturas de calefacción) por llevar a cabo las acciones (no por invertir en terceros).

Credito

Acceso a la financiación (por ejemplo, acceso a préstamos), inversión directa en tecnología (mediante crowdfunding, por ejemplo, o uso de capital real), subvenciones u otros instrumentos fiscales, etc.



Perfil de riesgo

Todo tipo de riesgos económicos relacionados con la inversión realizada (como, por ejemplo, largos periodos de amortización, incertidumbres sobre los flujos de caja, comportamiento desconocido a largo plazo de las infraestructuras, etc.).

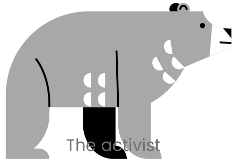
Valor añadido

Otras ganancias económicas indirectas relacionadas con las inversiones realizadas (como el aumento del valor inmobiliario de un bien).

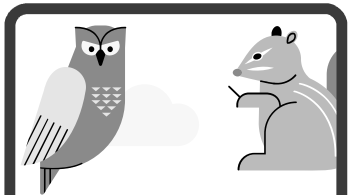
Frugalidad

Valores para reducir voluntariamente el consumo y los gastos incluso a costa de reducir la calidad de vida (incluyendo a las personas que valoran el dinero por encima de todas las cosas)

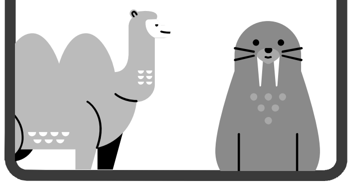
El activista

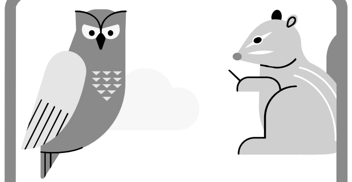


Un arquetipo que tiene el deber de apoyar a su comunidad. Sus valores y creencias en favor del medio ambiente están alineados con su forma de partir. La obligación moral le impulsa a actuar. Sin embargo, es consciente de las regulaciones, normas y restricciones, por lo que sus acciones están siempre alineadas con el marco legal. Confía en la apropiación de la tecnología, el conocimiento abierto y la economía colaborativa.

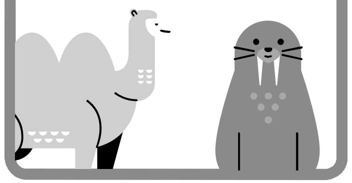


Significado





Seguridad



Protección del clima

Todas las acciones relacionadas con la protección o la lucha por mejorar el estado del clima. El mensaje importante es que el clima está en peligro y hay que tomar medidas para mantenerlo en su estado actual o pasado.

Legal

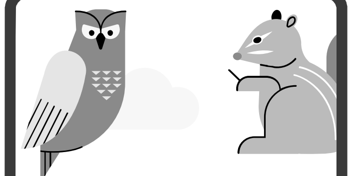
Todos los aspectos legales que permiten (o no) llevar a cabo una determinada acción (incluyendo las incertidumbres dadas por los cambios en la legislación).

Confianza

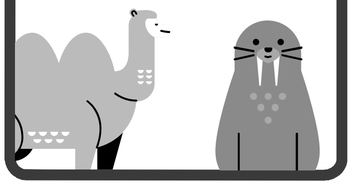
Grado de confianza en las instituciones (por ejemplo, acceso a las subvenciones, disponibilidad de fondos, creación de leyes basadas en el interés de las empresas y no de los ciudadanos), en las personas (por ejemplo, en relación con el comportamiento de los vecinos) y en la tecnología (por ejemplo, su rendimiento real, el apoyo futuro de la tecnología, etc.).

Protección

Valores relacionados con la seguridad de las infraestructuras y todo tipo de acciones que puedan alterarla (por ejemplo, aumentando el riesgo de daños estructurales), incluyendo también la seguridad de las personas (por ejemplo, riesgo de robo o de contraer una enfermedad infecciosa).



Popularidad



Tendencias

Capacidad de ser influenciable por terceros externos (como la publicidad o las normas sociales abstractas).

Autoridad

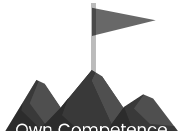
La gente quiere seguir las indicaciones y los consejos de los expertos legítimos.

Competencia

Rentabilidad

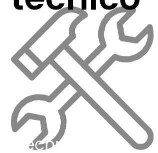
Valores reflexivos relacionados con la evaluación de las actividades/inversiones a realizar en función de diferentes criterios (por ejemplo, tras considerar los pros y los contras de la inversión la persona decide no realizarla por falta de valor añadido, o por grandes riesgos).

Competencia propia



Conocimiento práctico de la tarea en cuestión (que aumenta la autoestima porque se hace de forma correcta). Esto incluye la familiaridad con las tecnologías y valores similares

Idoneidad técnico

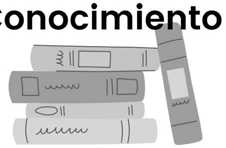


Cuestiones técnicas de todo tipo que favorecen o dificultan la adopción de las tecnologías, como el espacio para su despliegue, el acceso a instaladores cualificados o el tiempo de espera, pero también la estabilidad de la red o la falta de acceso a la misma, etc.

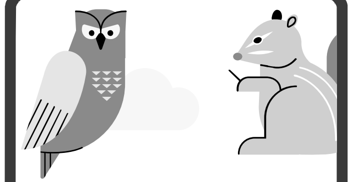
Preocupacion por el medio ambiente

Valores relacionados con la responsabilidad de nuestras propias acciones hacia el clima y la perspectiva de futuro.

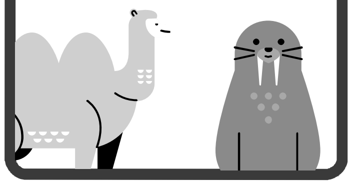
Conocimiento



Conocimiento interno de la persona o capacidades/contactos personales para recuperar los conocimientos necesarios para resolver una tarea. El conocimiento que se considera aquí es sobre todo desde un punto de vista teórico (para el conocimiento práctico, véase Competencia propia). También se consideran aquí las noticias falsas o el bombo y platillo (como anticonocimiento).

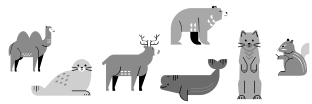


Autonomía



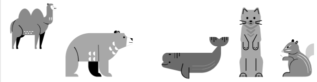
Autosatisfacción

La felicidad de sentir que eres la causa de tus propios actos. Emociones relacionadas con la libertad y la realización de la esencia interior del individuo.



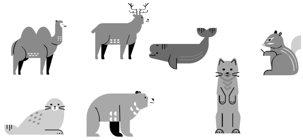
Compromiso

La voluntad de dedicar tu tiempo y energía a un trabajo, actividad o algo en lo que crees. Además, está relacionado con una decisión firme de hacer algo.

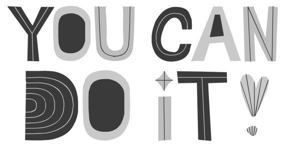


Adhesión

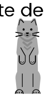
La capacidad de mantener un determinado comportamiento, tarea o acción durante el tiempo.

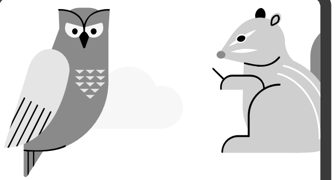


Autarky

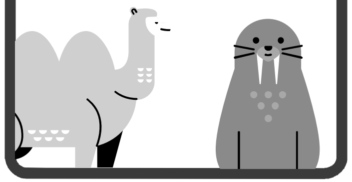


La autarquía está relacionada con la autosuficiencia del pueblo. Tener el propio control de las cosas, y producir sus propios bienes para sentirse independiente de las empresas



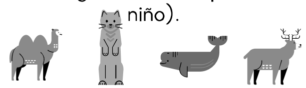


Materialidad
(Relacionado a la salud físia)



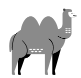
Bienestar

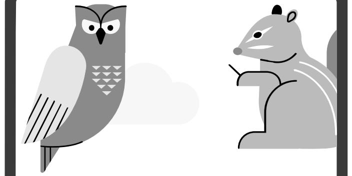
Relacionado con el bienestar del individuo: cualquier cuestión relacionada con la salud, y con el impacto en el bienestar físico de las personas (Por ejemplo, tener un hogar adecuado para un niño).



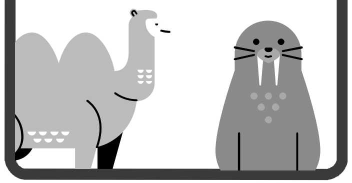
Comodidad

Relacionado con la comodidad de vivir. Implica el aspecto emocional de estar en casa con los seres queridos y sentirse cómodo y feliz en el hogar.

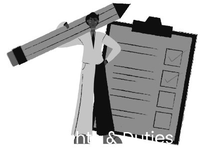




Vinculación

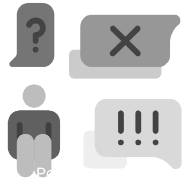


Derechos y obligaciones

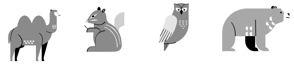


Relacionado con cuestiones específicas que pueden aparecer al vivir en una comunidad: obligaciones y normas de los barrios o de los inquilinos/propietarios, y también los beneficios y derechos que conlleva.

Presión de los compañeros



Capacidad de ser influenciable por los compañeros que realmente hacen cumplir las normas sociales.



Apoyo

Está relacionado con la idea de contribuir a la comunidad (o a cualquier otra causa social) y de hacer lo mejor posible por la mejora de la sociedad (a cualquier nivel).

Socialización

La idea de tener un contacto íntimo y regular con personas que se preocupan por ti, en lugar de sentirte solo y desatendido. Sentirse conectado a otras personas y formar parte de una comunidad.

Acuerdo

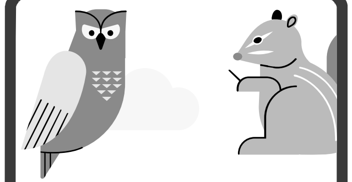
Entendimiento y cooperación entre pares entre cualquier tema (por ejemplo, los vecinos).

Arrogancia

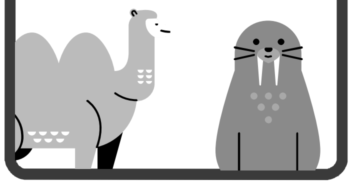
Los sentimientos, las actitudes y las acciones están influidos por factores externos (dinero, popularidad) y no se deben a una motivación interna. Por ejemplo, aceptar y seguir tendencias que no son inherentes o verdaderamente representativas del individuo.

Significado propio

Sentir que está desarrollando sus mejores potenciales y haciendo que la vida tenga sentido, en lugar de no llegar a ninguna parte y no experimentar nada importante. Ideas relacionadas con su propio significado y factores internos como emociones o sentimientos.



Estimulación



Novedad

Valores relacionados con el mecanismo de retroalimentación positiva para hacer cosas nuevas. Entre ellos se encuentran los adoptadores tempranos y la falta de miedo a lo nuevo.

Diversión

Valores relacionados con el disfrute (o lo contrario) de realizar una actividad o invertir en algo.

Alardear

Valores relacionados con las personas que creen activamente en las actividades que realizan y hacen proselitismo o se jactan de el

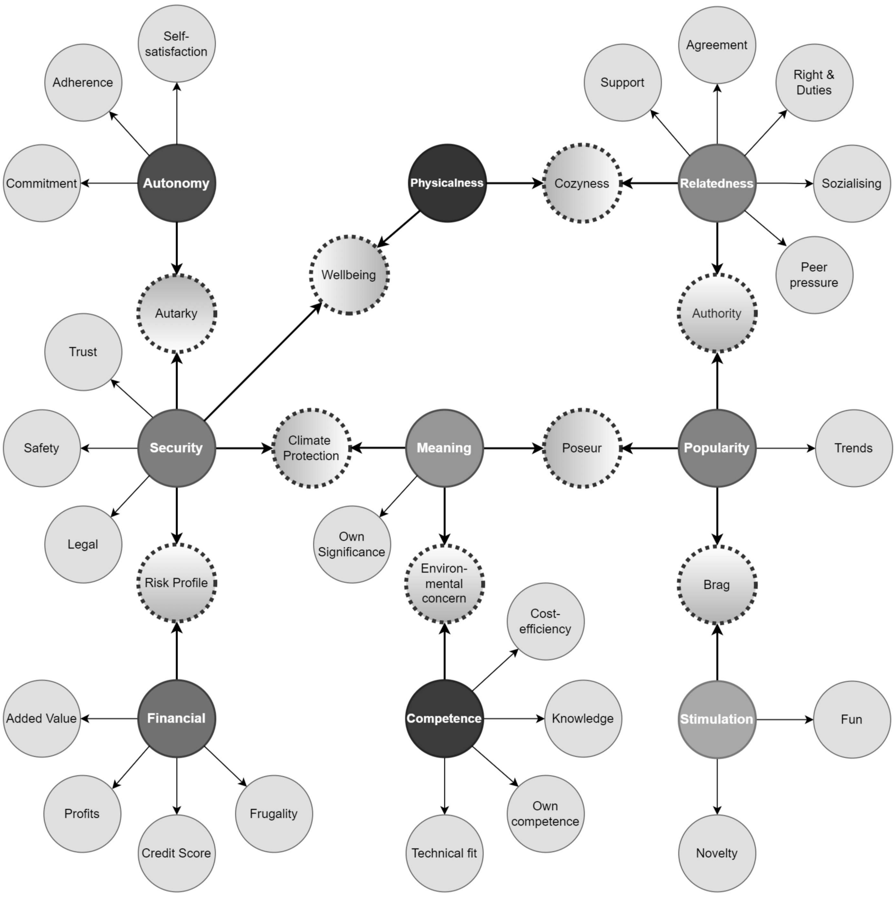


Figure F.1: The 32-factor taxonomy: Nine psychological needs at the top tier (dark colours) and 32 behavioural factors at the bottom tier (light colours); factors associated with more than one need are shown in the dashed border.

1. European Archetypes Icons Section (Information): This section provides information on icons representing European archetypes, offering visual references and context.
2. Instructions for Experts on Template Usage (Information): Here, experts will find detailed instructions on how to effectively use the template, ensuring clarity and consistency in their input.

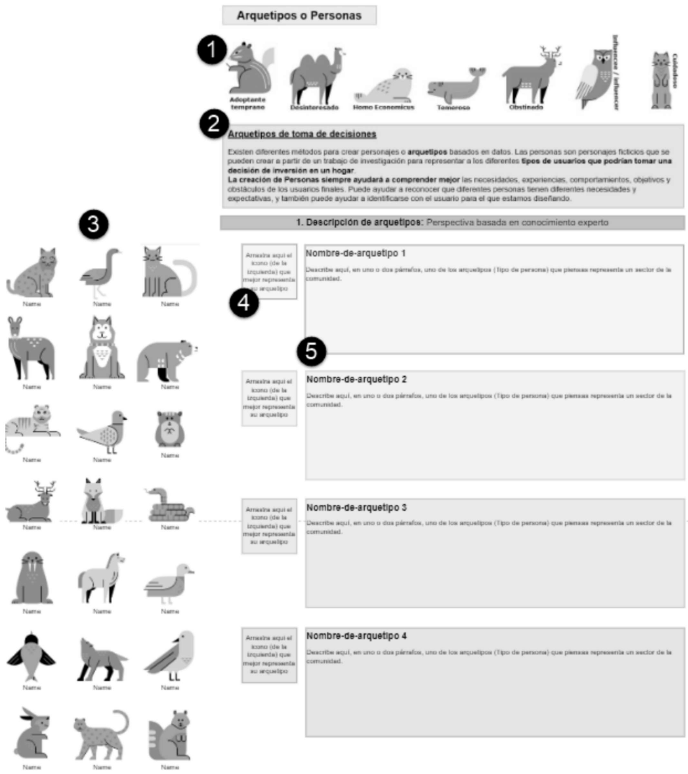


Figure F.2: Activity-1 template version-1 for individual contributors on archetypes.

3. Archetypes Icons (Information): This part contains information about various archetype icons, which aids experts in understanding and identifying different archetypes.
4. Icon Placement for Described Archetype (Workspace): In this area, experts are encouraged to place the icon that they believe best represents the archetype they have described.
5. Section for Archetype Description (Workspace): This workspace is designated for experts to provide a written description of the archetype, detailing its characteristics and relevance.

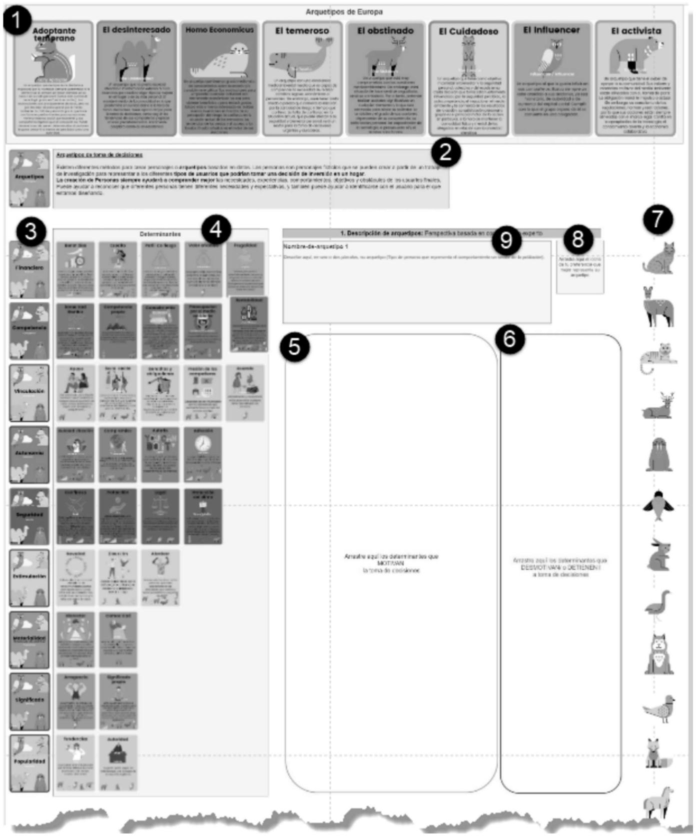


Figure F.3: Activity-1 template version-2 for individual contributors on archetypes.

1. Section on European Archetypes Cards (Information): This section provides experts with detailed information on European archetypes.
2. Instructions for Experts on Template Usage (Information): This segment offers comprehensive guidelines on how experts should utilize the provided template.
3. Section on Psychological Needs Cards (Information): This part contains information about various psychological needs, essential for understanding the archetypes.

4. Section on the 32-Factor Cards (Interactive Elements): Here, experts can interact with drag-and-drop elements related to the 32-factor taxonomy, facilitating a more dynamic engagement.
5. Section for Identifying Facilitative Determinants (Workspace): In this area, experts are encouraged to place the factors that they believe aid the decision-making process.
6. Section for Identifying Barrier Determinants (Workspace): This space is dedicated to identifying and placing factors that act as barriers in the decision-making process.
7. Archetypes Icons (Interactive Elements): This interactive section contains drag-and-drop elements representing different archetypes.
8. Section for Icon Placement of Described Archetype (Workspace): Experts can use this area to place the icon that best represents the archetype they have described.
9. Section for Descriptive Text of the Archetype (Workspace): This is a designated area where experts can elaborate in words on the archetype they have described.

1. Precontemplación

Las personas **no tienen intención** de actuar durante un breve periodo de tiempo (seis meses) y pueden estar en esta etapa porque **no están bien informadas** sobre las consecuencias de su comportamiento o porque han intentado cambiar varias veces y se han desmoralizado.

2. Contemplación

Las personas **intentan cambiar** su comportamiento en los próximos seis meses. Son más conscientes de los **pros** del cambio, pero también son muy conscientes de los **contras**. Este equilibrio entre los pros y los contras puede producir una profunda **ambivalencia** y mantiene a las personas atrapadas en la contemplación durante largos períodos de tiempo.

3. Preparación para el cambio o Determinación

La gente **tiene la intención de actuar pronto**, normalmente en los próximos seis meses. Por lo general, **ya** han dado algún **paso significativo** hacia el comportamiento en el último año y tienen un plan de acción.

4. Acción

Etapa en la que las personas **han realizado cambios concretos** y **manifiestos en su estilo de vida** en los últimos seis meses. Se nota el proceso de cambios. No todos los cambios de comportamiento cuentan como acción en este modelo, deben cumplirse ciertos criterios que los científicos y los profesionales consideran suficientes.

5. Mantenimiento

Las personas han realizado modificaciones concretas y manifiestas en su estilo de vida y trabajan para **evitar recaídas**, no aplican los procesos de cambio con tanta frecuencia como las personas en acción. Cada vez tienen más confianza en que pueden continuar con los cambios.

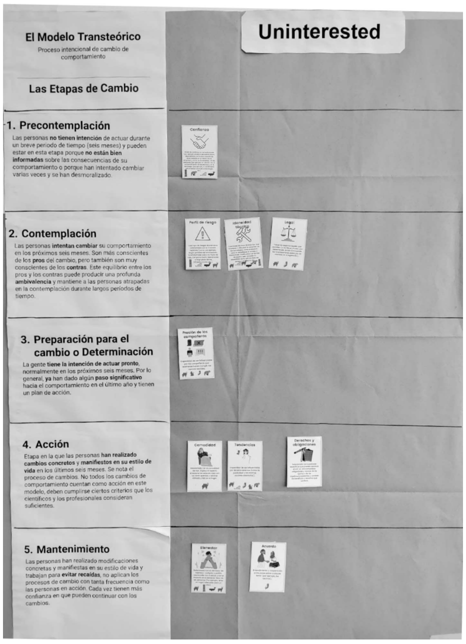


Figure F.4: Template for sorting determining factors of an archetype into the TTM stages

APPENDIX

G

Expert Panels in LATAM

Table G.1: Composition of the panel of experts.

Num	Partner	Sector	Expertise	Job position	Organization	Country
			Expert Panel in México			
1	Ady Patricia Carrera Hernández	Government	Public Policy, Government, Public Management, Local Governments	Researcher	Universidad Popular Autónoma del Estado de Puebla (UPAP)	Mexico
2	Anabel Martínez Guzmán	Academy	Economist, Projects on Mexican agribusiness, public sector research at INECC, analysis of environmental norms, circular economy in plastics industry	Lecture	Tecnológico de Estudios Superiores de Coacalco (TESCo)	Mexico

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Nun	Partner	Sector	Expertise	Job position	Organization	Country
3	Elvira Maribel Flores Rodríguez	Academy	Lawyer, Lecture, Productivity measurement, intellectual capital model design, Gender Equity	Lawyer and Lecture	TESCo	Mexico
4	José René Gómez Pérez	Industry	Expert in UPS and Cooling solutions, focus on residential and industrial solutions	Director General (REMERGY), Commercial Executive	REGEMERY, TEMPEL GROUP	Mexico
5	Juana Karina Vargas Hernández	Academy	International Relations, Master's in Direction and specialization in Logistics and Supply Chain Management	Lecture, Residence counsellor, Trainee counsellor, Liaison officer	TESCo / CBT No.4 Tecamac	Mexico
6	Luis Enrique Sucar	Academy	International Relations, Master's in Direction and specialization in Logistics and Supply Chain Management	Senior Research Scientist	National Institute of Astrophysics, Optics, Electronics - INAOE	Mexico
7	Nubia Lilian Páez Bello	Civil Society	Academic Coordinator, Emotional Education Management	Academic Coordinator	Colegio Andrés Escobar	Mexico
8	Shafia Sucar Succar	Civil Society	Degree in Industrial Psychology, HR management, payroll, recruitment, and personnel development	Payroll Analyst	ADAM Human Center Management	Mexico
9	Xochitl Iveth Aguayo Mendoza	Government	Demographic and epidemiological change management, international and national initiatives, administrative-organizational models for public health	Psychologist	UMAE "Dr. Victorio de la Fuente Narváez", Instituto Mexicano del Seguro Social	Mexico
			Expert Panel in Colombia			
1	Alejandro Lombana Pérez	Industry	Master in Innovation Management(UK), Electronics Engineer	Desarrollador de software	Soft Mas SAS	CO

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Nun	Partner	Sector	Expertise	Job position	Organization	Country
2	Camilo Andrés Arias Henao	Academy	University District Francisco José de Caldas graduate, with expertise in inspection and monitoring through Law 1746 of 2014 and Law 30 of 1992	Investigador Docente de planta (PhD Ingeniería Energética)	Universidad Distrital	CO
3	Cristhian Eduardo Garzon Barajas	Industry	Telecommunication Engineer, Electrical Technician, Electromechanical Technologist	Director de proyectos de energía y telecommunications	—	CO
4	Eduardo Rodríguez Arape	Academy	Energy	PhD Candidate	Universidad EAN	CO
5	Federico Lopez Muñoz	Academy	Doctor en Ciencias del Deporte	Profesor Titular	U. Santo Tomas	CO
6	Fernando Guio Gutierrez	Academy	Environmental management and compliance specialist with experience in environmental and corporate risk management	Ingeniero Ambiental	Morelco	CO
7	Juan Pablo Gil Londoño	Industry	PhD Candidate in Sports Sciences	Professor	UniCafam	CO
8	Julian Londoño Rodríguez	Industry	Electrical Technician, Telecommunication Engineer	Technitian	Secretaria Distrital de Salud de Bogotá	CO
9	Miguel Angel Gallego Garcia	Industry	Telecommunication Engineer, Electrical Technician	Tecnico operative	UniCafam	CO
10	Rafael Antonio Vargas Vargas	Academy	PhD Candidate in Physiology Science	Researcher	Nueva Granada Military University Faculty of Medicine and Health Sciences	CO
			Expert Panel in El Salvador			

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Nun	Partner	Sector	Expertise	Job position	Organization	Country
1	Alejandro Xavier Najarro Mancia	Civil Society	Student, with basic knowledge of green technologies	Student	Universidad Centroamericana "José Simeón Cañas" (UCA)	SV
2	Carlos Armando Torres Paniagua	Civil Society	Student, with basic knowledge of green technologies	Student	UCA	SV
3	Carlos Mario Flores Lazo	Academy	M.Sc. in Production Engineering, expertise in renewable energy and e-mobility	Director of Energy Engineering	UCA	SV
4	Faranz Manrique Quijada Campos	Government	Engineer, working in energy policy change at the governmental level	Staff	Dirección General de Energía, Hidrocarburos y Minas	SV
5	Jacqueline Valeria Cortez Bolaños	Civil Society	Student, with basic knowledge of green technologies	Student	UCA	
6	Jaime Fernando Zepeda Quintanilla	Commercial Sector	Engineer in industrial and commercial sectors, entrepreneur in charge of designing green technology	Entrepreneur	Dissetti Green Engineering	SV
7	Jakelin Marcela Jacobo Morales	Civil Society	Student, with basic knowledge of green technologies	Student	UCA	SV
8	Jorge Emilio Barrientos Guzmán	Civil Society	Student, with basic knowledge of green technologies	Student	UCA	SV
9	Luis Aarón Martínez Figueroa	Academy	Experience as researcher and consultant on energy efficiency and renewable energy	Engineering Department	UCA	SV
10	María Guadalupe Pineda Montesinos	Civil Society	Student, with basic knowledge of green technologies	Student	UCA	SV

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Nun	Partner	Sector	Expertise	Job position	Organization	Country
11	Óscar Funes Engelhard	Commercial Sector	Engineer, with experience in industrial and commercial sectors, entrepreneur in charge of a company that distributes green technologies	Entrepreneur	Enersys	SV
12	Paola Alexandra González Alfaro	Civil Society	Student, with basic knowledge of green technologies	Student	UCA	SV
13	René Iván Ariza Rodríguez	Academy	B.S. Mechanical Engineering, experience in energy efficiency in industry, Professor of Mechanical Engineering	Professor of Mechanical Engineering	UCA	SV
14	Rigoberto Contreras Vásquez	Government	Engineer, expert in electrical markets, experience in electric sector regulating bodies	Regulator	Superintendenc General de Electricidad y Telecomunicaciones	SV
			Expert Panel in Chile			
1	Andrés Víctor Ulloa Oliva	Academy	Master of Sciences and PhD(c) in Agricultural and Natural Resource Economics	Head of Economics Department	Universidad Católica de la Santísima Concepción	CL
2	Ernesto Alex Guerra Vallejos	Academy	Ph.D. and M.Sc. in Agriculture Resource Economics, University of California Berkeley. Consultant in Artificial Intelligence, Algorithm Development	Assistant Professor	Universidad Católica de la Santísima Concepción	CL
3	Rodrigo Fernando Díaz Valenzuela	Academy	Ingeniero Civil Industrial	Lecture	Universidad Católica de la Santísima Concepción	CL
4	Guillermo Ramírez Arias	Academy	Ph.D. in Electrical Engineering, with a focus on Electrical Engineering	Head of Department of Electrical Engineering	Universidad Católica de la Santísima Concepción	CL

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Num	Partner	Sector	Expertise	Job position	Organization	Country
5	Leonardo Manriquez Mendez	Academy	Data engineering and machine learning specialist with extensive experience in developing predictive models, econometrics, statistical models and artificial intelligence	Part-time academic and freelance econometrician	Universidad Católica de la Santísima Concepción	CL
6	Cristian Marcelo Guzmán Cofré	Academy	Microeconomic Analysis, Introduction to Econometrics, Analysis of the Microeconomic Environment II	Director of Postgraduate and Lifelong Learning	Universidad Católica de la Santísima Concepción	CL
7	Angela Cristina Gutierrez	Civil Society	Business Consultant in Cultural Mobilisation of Change Processes and Leadership	Strategic Consultant	Freelance	CL
8	María Valentina Benito Rocha	Industry	User experience designer, with a master's degree in design and sustainability	Diseñadora UX/UI	Lenio labs y Taxfix	CL
9	Paulina Andrea Cordova Gatica	Legal	Director of Legal and Compliance Department	Directora Legal	CV Consultores	CL

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APPENDIX

H

Cross-Sectorial Survey

H.1 Consent Form

Background

Energy system models (ESMs) have been used by experts to project and describe the long-term impacts of interventions on energy systems. While ESMs have yielded useful results in simulating energy supply, there is a lack of accuracy in simulating energy consumption, especially in the residential sector, where diversity of dwellings and human behaviours produce a broad spectrum of consumption patterns. To address this issue, the EU-funded project WHY will quantitatively analyse people's daily decisions regarding energy consumption and their reactions to specific policy-driven interventions. Furthermore, the project will examine how these daily behaviours translate into electricity consumption with the help of causal modelling. In the context of the project, interventions are external stimuli that have an impact on private settings such as changes in funding schemes, changes in policies, changes in taxes or subsidies, etc.

What do we expect from you?

In the framework of the H2020-WHY (why-h2020.eu), H2020-PARITY (parity-h2020.eu/), H2020-SMARTLIVINGEPC (cordis.europa.eu/project/id/101069639) and H2020-ATELIER (smartcity-atelier.eu) projects, we are assessing the determinants (factors) that lead consumers to participate in the energy transition in four different aspects: flexibility markets (e.g. PV panels), energy efficiency (e.g. building insulation), mobility (e.g. electric vehicles) and energy conservation (e.g. sharing economy). Our objective is to build a set of archetypes (a very typical example of a certain person which is present in the collective unconscious) that characterise as much as possible the European population in order to create better policies for them. To this end, your core contribution to this research consists of self-assessing how much you agree with a set of 32 statements.

Rights as Stakeholder

- Your participation in this project is voluntary and no costs are derived for you. You have the right to withdraw at any point during the activity, for any reason, and without any prejudice.
- No personal data will be collected.
- All your contributions will be used only for the sole purpose of research (e.g. dissemination, outreach, etc.).
- Data contained in this survey will be kept at least until 5 years after the end of the project for auditing or reporting purposes by request of the funding agencies. A copy of your answers could be collected at the end of the survey following the steps provided by the system.
- The researchers in charge of this activity are Cruz E. Borges (cruz.borges@deusto.es) and Diego Casado-Mansilla (dcasado@deusto.es). You can contact them to solve any question related to this survey.

Consent form

By hitting the next button, you acknowledge that:

- Your participation in the action is voluntary.
- You are at least 18 years of age.
- You have read the background information that provides enough details about the project (purpose, expected duration and procedures of the study).
- You have been informed about your right to refuse to participate or to leave the activity at any moment without any justification.
- You have been notified of the contact persons, in the case you have questions or doubts during the activity.
- You have been informed how to get a copy of the consent form and your answers.
- You have had enough time to decide on your participation in the study.
- You have been informed about the questionnaire that you have been asked to complete.
- You have been informed about the storage procedures of the study data.
- You allow experts involved in the study under confidentiality agreements to utilize the information for the purpose of the study and only for this.

*** I agree to participate in the study.**

H.2 Survey - Which are the critical factors that influence investment decisions on the energy transition?

H.2.1 Personal characterization

1. In which country do you reside?
    - (List of countries)
    - No answer
2. In which type of town do you live?
    - Rural
    - City
    - Residential area

- I prefer not to answer

3. How old are you?
    - 18-30
    - 31-55
    - 56+
    - I prefer not to answer
4. Which of the following most accurately describes you?
    - Male
    - Female
    - Non-binary
    - Other
    - I prefer not to answer
5. Do you live alone or do you share your household with others? (Please, check all the answers that apply to you and your personal situation)
    - I live alone
    - I live with friends or other non-family persons
    - I live with my partner
    - I live with my childs (or other minors under my responsibility)
    - I live with other adults under my responsibility
    - I live with other persons who are either family or relatives
    - I live with my pet
    - I prefer not to answer
6. How many people live in the house?
    - Numeric
7. What is the highest level of education you have completed?
    - Primary or no studies
    - High school
    - Vocational training/ Trade School
    - University

- I prefer not to answer

8. What is your approximate individual yearly income (netto)?
   - More than 100.000 €
   - Between 50.000 € and 100.000 €
   - Between 30.000 € and 50.000 €
   - Between 15.000 € and 30.000 €
   - Less than 15.000 €
   - I prefer not to answer
9. In a typical month, how much of your salary is saved?
   - I manage to save more than 20
   - I manage to save between 10 and 20
   - I manage to save less than 10
   - Nothing, I am using my savings lately
   - I prefer not to answer

H.2.2 **Household Characterization**

10. In which type of housing do you live?
    - Flat / Apartment
    - Semi-Detached / Townhomes
    - Single-Family Home / Chalet
    - In a multi-family house
    - Others
    - I prefer not to answer
11. Do you own the place where you live?
    - Yes
    - No
    - I prefer not to answer
12. How much usable area does your house have?

- Less than 80 m²
- Between 80 and 120 m²
- More than 120 m²
- No answer

13. Is your house properly insulated?
    - Yes (it has been built or refurbished with energy efficiency in mind),
    - No (it has built without energy efficiency in mind and has not been completely refurbished),
    - I do not know,
    - I prefer not to answer
14. In which climate zone do you live?
    - Atlantic
    - Mediterranean
    - Continental
    - Alpine or Nordic
    - Arid or semi-arid
    - I do not know
    - I prefer not to answer

H.2.3 **Behaviour modelling (self-assessment)**

15. On a scale of 0-5, where 0 is "Climate change does not exist" and 5 is "I am a climate change expert/activist", how would you assess your level of awareness of climate change?
16. On a scale of 0-5, where 0 is "Climate change does not exist" and 5 is "They are climate change experts/activists", how would you assess the level of awareness of climate change of your peers or relatives?
17. On a scale of 0-5, where 0 is "It is the first time I hear about it" and 5 is "I am an expert or activist", how would you assess your level of awareness about the energy transition?

18. On a scale of 0-5, where 0 is "It is the first time they hear about it" and 5 is "they are experts or activists", how would you assess the level of awareness about the energy transition of your peers or relatives?

A. Scenarios

19. Rank, in order of priority for you (where 1 is the highest priority and 4 is the lowest) in which scenario you will be willing to live or to contribute/invest to make it possible. Those are ideal scenarios for making the energy transition a reality. We understand that not all may apply to you or that you may think they are futuristic, but please try to rank them according to your personal preference or situation

    (a) Scenario #1 - Appliances: One of the appliances you use occasionally (e.g. the oven for baking, the washing/drying machine, a drill or the vacuum cleaner) breaks down again. In order to contribute to the climate neutrality objectives, you decide not to buy a new piece of equipment for individual use but to propose its purchase to your community for shared and common use (and that way you can buy a top energy efficiency one). To do this, you convince your entire community of your building to share these household appliances for common everyday use. Luckily, you have space in the basement to accommodate them and you propose to your community to adhere to this initiative when they have to replace their equipment and not before.

    (b) Scenario #2 - Insulation: You live in a new or highly refurbished passive house(`(https://en.wikipedia.org/wiki/Passive_house)`). In addition to having first-class facade, roof and window insulation, an intelligent and highly efficient heating/air conditioning system supplies the dwelling with your heating, cooling and hot water needs. An energy management system controls the heating/air conditioner system giving to it the potential to share energy with the neighbours building a "distributed district heating". Moreover, you are very environmentally conscious so you prioritise saving energy with any kind of investment of money or time, and you are always willing to sacrifice some comfort when setting the thermostat temperature.

(c) Scenario #3 - Electricity: You live in a new or highly refurbished passive house ((https://en.wikipedia.org/wiki/Passive_house)). You have solar panels integrated into the building and a battery system that allows you to store excess daily energy to consume at night. The generation system is slightly oversized, and in summer, you have a surplus of energy generated that is used at the community electrolyzer that generates and stores hydrogen. This hydrogen is later used in a highly efficient community cogeneration system (a.k.a. technology that produces electricity and thermal energy) to power a low-temperature district heating that provides the heating/cooling and hot water demand of the community. All these components could be controlled by an energy management system in which you can invest, not only to optimise its performance but also to allow you to trade energy between neighbours or with the energy provider.

(d) Scenario #4 - Mobility: The city where you live has been re-designed in a way that all services are at foot distance (for example, following the idea of 15 mins cities (https://en.wikipedia.org/wiki/15_minute_city). A series of agreements between the government and companies, aligned with investments in behaviour change from the citizens' side, ensures that teleworking is mandatory at least three days a week. In your city, the number of vehicles is drastically reduced due to several incentives to embrace low-emissions mobility vehicles (e.g., bikes, e-bikes, e-scooters, etc.) and facilities to take public transport. Indeed, a combination of public or private personal mobility, robotaxis (a.k.a. self-driving taxi or a driverless taxi) and electric public transport supply the rest of travel needs (inter and intra city). For these reasons, traffic jams are something from the past and the air is again breathable. Long distance transport of passengers and goods is only made using trains and the amount of travel by plane is drastically reduced to intercontinental travel.

B. Determinantes

20. **As you can see, these ideal yet futuristic scenarios would only be possible if citizens, enterprises, and public authorities collaborate. In the following, you will be presented with a list of factors that may influence your decision making when it comes to contributing to make this scenario possible (e.g., change your daily behaviour, take investment decisions with money or time or decide who to vote for to make the scenarios a reality). Please rate each of them,** THINKING ON THE SCENARIO YOU HAVE SELECTED AS THE PRIORITY FOR YOU, in a scale being the left-side of the slider "Not at all relevant for you" **and the right-side of the slider** "drastically important to you".

    i. **Profits**: Profits are what guide my decision-making. I always prefer to earn or save money with every decision I take.
    ii. **Credit Score**: Access to funding (my own savings, deductions, exemptions, and/or credits) is the main factor that allows/hinders me to make an investment decision.
    iii. **Risk Profile**: The evaluation of the risks of my investment(s) is what will always guide my final decision.
    iv. **Added value**: I will only do an investment if my actions have an impact beyond the monetary gain/losses.
    v. **Frugality**: I am a thrifty person, so I only invest in actions that allow me to reduce my cost/impact/expenditures.
    vi. **Climate Protection**: Every decision I take serves to foster the planet's preservation. If my choice might harm the environment, I will always avoid taking this action.
    vii. **Legal**: Having a complete certainty that my actions comply with the legal, tax and administrative regulations is what guide my actions.

viii. **Trust**: I only make decisions if I trust all the parties involved (e.g., public administration, neighbours) and on the technology that is needed to accomplish my goal.

ix. **Safety**: I only make decisions if the outcome of them ensures or improves my safety or the ones of my relatives.

x. **Cost-Efficiency**: I always review and assess the pros and cons of my decisions looking for the most cost-effective one.

xi. **Knowledge**: I do not make a decision if I do not have enough knowledge of the subject of matter.

xii. Own Competence: Feeling that I am competent to make an investment is what guides my decision making.

xiii. **Technical Fit**: I carefully check that the technology, the equipment or the goods fits my lifestyle or the technical requirements before making an investment decision.

xiv. **Environmental Concerns**: I always review and assess the pros and cons of my decisions in relation to the environment before taking one.

xv. **Self-Satisfaction**: I will only take a decision if I feel satisfied with the action and the expected outcome.

xvi. **Commitment**: I only take a decision if I feel personally committed with the action and the expected outcome.

xvii. **Adherence**: I will only take a decision if I feel that I can sustain it throughout time.

xviii. **Autarky**: Self-sufficiency and individual sovereignty is what guide my decisions. I will only make a decision if I feel that the investment will improve my control of all circumstances and potential outcomes.

xix. **Wellbeing**: I will only make a decision if it improves my well-being or the well-being of my relatives.

xx. **Cosiness**: I will only make a decision if it improves my comfort or the comfort of my relatives.

xxi. **Rights and Duties**: I firmly believe that we live in a society where we have to adhere to regulations, laws and community agreements by all means, so my investment decision has to agree with this vision.

xxii. **Peer-Pressure**: My investment decisions are influenced by the opinions of others (such as my peers, relatives or family).

xxiii. **Support**: I will only make an investment decision if it has the approval or support of the community I belong to.

xxiv. **Socialising**: I will only make an investment decision if it improves my possibilities to socialise with my peers and relatives.

xxv. **Agreement**: I will only make an investment decision if it has the agreement of the people affected by it (for example, my relatives, peers or the community).

xxvi. **Novelty**: I love to test new ideas and cutting-edge technology so novelty is what drives my investment decisions.

xxvii. **Fun**: Having fun is important to me. Therefore, I will only make a decision if it would be enjoyable and amusing for me.

xxviii. **Brag**: I am interested in that my decisions lead to increased status for me and I can show others what I achieved.

xxix. **Trends**: I usually follow the trends when making a decision. In particular, I usually find myself sticking to the ads I see, the recommendations of people I admire, or what I read in magazines or blogs I follow.

xxx. **Authority**: I only take a decision if it helps me to improve my position as an expert on the subject matter.

xxxi. **Poseur**: I only take a decision if it helps me to improve the opinion of others about me even if this decision is not always what I would do if it was only for myself.

xxxii. **Own Significance**: I only take a decision if the action has a personal and inner meaning for me (beyond any economic gain).

C. Self-assessment

21. In Scenario 1: How much money will you be willing to invest deploying a fair booking system for the shared appliances that can be inclusively used for all the neighbours irrespective of their digital literacy?
    (a) Number in €
    (b) No answer
22. What is the maximum time of return on investment (ROI) you are willing to accept for this scenario?
    (a) Number in years
    (b) No answer
23. In Scenario 2: How much green taxes will you be willing to invest in deploying a public incentivisation scheme that allows neighbours to perform deep refurbishings of their house or buildings to drastically reduce their energy consumption?
    (a) Number in €
    (b) No answer
24. What is the maximum time of return on investment (ROI) you are willing to accept for this scenario?
    (a) Number in years
    (b) No answer
25. In Scenario 3: How much money will you be willing to invest deploying an energy management system that allows neighbours to sell and buy energy that each can generate?
    (a) Number in €
    (b) No answer
26. What is the maximum time of return on investment (ROI) you are willing to accept for this scenario?
    (a) Number in years

(b) No answer

27. In Scenario 4: How much green taxes will you be willing to invest per year to help local governments to make the scenario a reality (e.g., maintain the robotaxis and e-vehicles fleet)?

    (a) Number in €
    (b) No answer

28. What is the maximum time of return on investment (ROI) you are willing to accept for this scenario?

    (a) Number in years
    (b) No answer

29. Select the statement that best represent yourself when you are taking a decision related to this scenario:

    (a) I prefer to not make a decision. I rather try to continue doing the same every time without thinking and prioritise following my daily routines.
    (b) I prefer to do things with the lowest physical and mental effort. I am concerned about the environment, but I am usually too busy to think twice before acting.
    (c) I prefer to think carefully about my decisions overall if they impact the climate. I know what I want and take my time to evaluate my options.
    (d) I prefer not to answer

30. Select the statement that best represent yourself when you are taking a decision related to this scenario:

    (a) I am an environmentally conscious and a well-informed consumer.
    (b) I am concerned about the environment, but I always prioritise comfort.
    (c) I am concerned about the environment, but I lack awareness of my impacts to act differently.
    (d) I am rather materialist and the impact on the environment of my decisions is beyond my personal responsibility.

(e) Society or my peers influence me, so I usually follow what others suggest to me.
(f) I am indifferent to environmental concerns.
(g) I prefer not to answer

31. Select the statement that best represent yourself when you are taking a decision related to this scenario:
    (a) I consider myself as an early adopter, so I enjoy following the latest trends even if it means taking some risks or impacts on the environment.
    (b) I am not really interested in new equipment, technology or environmental actions, so I just use/do the one that I am used to.
    (c) My main interest is taking the most cost-effective decision. I am an informed person and I always make some calculations before making any decision.
    (d) I'd only invest in the energy transition if it helps to improve my safety and that of my relatives.
    (e) I'd only invest in the energy transition if it helps me to reduce my environmental impact in any form.
    (f) I'd only invest in the energy transition if it helps me to increase my social status (i.e., the opinion of others about me) or if it is the social norm of my colleagues, friends and family.
    (g) I'd only invest in the energy transition if it helps to maximise my comfort/well-being and that of my relatives.
    (h) I prefer not to answer.

H.3 **Online survey**

The following contents show the online participant´s consent form and the complete survey.

Which are the critical factors that influence investment decisions on the energy transition?

Fields marked with * are mandatory.

Pages Background Scenarios Determinants Further Information

1 Consent Form

Background

Energy system models (ESMs) have been used by experts to project and describe the long-term impacts of interventions on energy systems. While ESMs have yielded useful results in simulating energy supply, there is a lack of accuracy in simulating energy consumption, especially in the residential sector, where diversity of dwellings and human behaviours produce a broad spectrum of consumption patterns. To address this issue, the EU-funded project WHY will quantitatively analyse people's daily decisions regarding energy consumption and their reactions to specific policy-driven interventions. Furthermore, the project will examine how these daily behaviours translate into electricity consumption with the help of causal modelling. In the context of the project, interventions are external stimuli that have an impact on private settings such as changes in funding schemes, changes in policies, changes in taxes or subsidies, etc.

What do we expect from you?

In the framework of the H2020-WHY (why-h2020.eu), H2020-PARITY (parity-h2020.eu/), H2020-SMARTLIVINGEPC (cordis.europa.eu/project/id/101069639) and H2020-ATELIER (smartcity-atelier.eu) projects, we are assessing the determinants (factors) that lead consumers to participate in the energy transition in four different aspects: flexibility markets (e.g. PV panels), energy efficiency (e.g. building insulation), mobility (e.g. electric vehicles) and energy conservation (e.g. sharing economy). Our objective is to build a set of archetypes (a very typical example of a certain person which is present in the collective unconscious) that characterise as much as possible the European population in order to create better policies for them. To this end, your core contribution to this research consists of self-assessing how much you agree with a set of 32 statements.

Rights as Stakeholder

- Your participation in this project is voluntary and no costs are derived for you. You have the right to withdraw at any point during the activity, for any reason, and without any prejudice.
- No personal data will be collected.
- All your contributions will be used only for the sole purpose of research (e.g. dissemination, outreach, etc.).
- Data contained in this survey will be kept at least until 5 years after the end of the project for auditing or reporting purposes by request of the funding agencies. A copy of your answers could be collected at the end of the survey following the steps provided by the system.
- The researchers in charge of this activity are Cruz E. Borges (cruz.borges@deusto.es) and Diego Casado-Mansilla (dcasado@deusto.es). You can contact them to solve any question related to this survey.

Consent Form

By hitting the next button, you acknowledge that:

- Your participation in the action is voluntary.
- You are at least 18 years of age.
- You have read the background information that provides enough details about the project (purpose, expected duration and procedures of the study).
- You have been informed about your right to refuse to participate or to leave the activity at any moment without any justification.
- You have been notified of the contact persons, in the case you have questions or doubts during the activity.
- You have been informed how to get a copy of the consent form and your answers.
- You have had enough time to decide on your participation in the study.
- You have been informed about the questionnaire that you have been asked to complete.
- You have been informed about the storage procedures of the study data.
- You allow experts involved in the study under confidentiality agreements to utilize the information for the purpose of the study and only for this.

*

☐ I agree to participate in the study

Next

Which are the critical factors that influence investment decisions on the energy transition?

Fields marked with * are mandatory.

Pages | Background | Scenarios | Determinants | Further Information | Investment decisions | Household Characterization

2 Scenarios for energy transition

2.1 Rank in order of priority, from top to bottom, in which scenario you will be willing to live or to contribute/invest to make it possible. The higher up you rank a scenario, the more priority it has (the scenario at the top is the highest priority and the scenario at the bottom is the lowest). Please note that we understand that not all apply to you or that you may think they are futuristic, but please try to rank them according to your personal preference or situation.

Use drag&drop or the up/down buttons to change the order or accept the initial order.

Scenario a. One of the appliances you use occasionally (e.g. the oven for baking, the washing/drying machine, a drill or the vacuum cleaner) breaks down again. In order to contribute to the climate neutrality objectives, you decide not to buy a new piece of equipment for individual use but to propose its purchase to your community for shared and common use (and that way you can buy the highest energy efficiency option). To do this, you convince your entire building community to share these household appliances for common everyday use. Luckily, you have space in the basement to accommodate them and you propose to your community to adhere to this initiative when they have to replace their equipment and not before.

Scenario b. You live in a new or highly refurbished passive house (https://en.wikipedia.org/wiki/Passive_house). In addition to having first-class facade, roof and window insulation, an intelligent and highly efficient heating/air conditioning system supplies the dwelling with your heating, cooling and hot water needs. An energy management system controls the heating/air conditioner system giving to it the potential to share energy with the neighbors building a "distributed district heating". Moreover, you are very environmentally conscious so you prioritize saving energy with any kind of investment of money or time, and you are always willing to sacrifice some comfort when setting the thermostat temperature.

Scenario c. You live in a new or highly refurbished passive house (https://en.wikipedia.org/wiki/Passive_house). You have solar panels integrated into the building and a battery system that allows you to store excess daily energy to consume at night. The generation system is slightly oversized, and in summer, you have a surplus of energy generated that is used at the community electrolyzer that generates and stores hydrogen. This hydrogen is later used in a highly efficient community cogeneration system (a.k.a. technology that produces electricity and thermal energy) to power a low-temperature district heating that provides the heating/cooling and hot water demand of the community. All these components could be controlled by an energy management system in which you can invest, not only to optimize its performance but also to allow you to trade energy between neighbors or with the energy provider.

Scenario d. The city where you live has been re-designed in a way that all services are at foot distance (for example, following the idea of 15 mins cities - https://en.wikipedia.org/wiki/15_minute_city). A series of agreements between the government and companies, aligned with investments in behavior change from the citizens' side, ensures that teleworking is mandatory at least three days a week. In your city, the number of vehicles is drastically reduced due to several incentives to embrace low-emissions mobility vehicles (e.g., bikes, e-bikes, e-scooters, etc.) and facilities to take public transport. Indeed, a combination of public or private personal mobility, robotaxis (a.k.a. self-driving taxi or a driverless taxi) and electric public transport supply the rest of travel needs (inter and intra city). For these reasons, traffic jams are something from the past and the air is again breathable. Long distance transport of passengers and goods is only made using trains and the amount of travel by plane is drastically reduced to intercontinental travel.

Imaging that you have inherited a large amount of money or an institution has provided you a credit in very good conditions (e.g. 250 k€). How much money (in percentage) would you be willing to spend on each of the scenarios provided in the previous question? Please answer this question in the following 5 boxes (2.2 to 2.6) taking into consideration that there is one box (2.6) to be used if you do not want to invest all your money but to save some. Finally, bear in mind that you should allocate all the money in the 5 boxes, namely, the sum of all figures provided in boxes 2.2 to 2.6 below should add to 100.

2.2 Percentage spend for scenario a)

Only values of at most 100 are allowed

%

2.3 Percentage spend for scenario b)

Only values of at most 100 are allowed

%

2.4 Percentage spend for scenario c)

Only values of at most 100 are allowed

%

2.5 Percentage spend for scenario d)

Only values of at most 100 are allowed

%

2.6 Percentage saved

Only values of at most 100 are allowed

[ ] %

2.7 Imaging that you have bought a new house that needs a complete refurbishment, how much money (in €) will you be willing to invest in improving the efficiency of the house (like including energy efficient appliances, improving the insulation, installing solar panels, purchasing an electric car or several of the previous ones together)?

Only values of at most 1000000 are allowed

[ ] €

2.8 Now assume that the government gives you an interest free credit with a long term payment period for the total cost of the refurbishment. How much will you be willing to invest in that case?

Only values of at most 1000000 are allowed

[ ] €

2.9 Assume that the supply of electricity suffers frequent but short interruptions in your neighborhood due to a bad grid infrastructure. This way, **only a small number of houses are affected and the general communication and service infrastructure is still working.** The utility provider has a partial solution to temporarily provide a limited local electricity supply that cannot support all the normal loads. So they are asking which services you would prefer in order to estimate the resulting loads. Please, rank the following energy services from 0 to 10 stars where 0 stars means it is extremely low priority for you and 10 stars is absolutely needed for you:

Ensure that drinking water is available in my home.	☆☆☆☆☆☆☆☆☆☆
Allow me to cook.	☆☆☆☆☆☆☆☆☆☆
Allow me to commute long distances.	☆☆☆☆☆☆☆☆☆☆
Allow me to communicate with my family and peers.	☆☆☆☆☆☆☆☆☆☆
Allow me to clean the house.	☆☆☆☆☆☆☆☆☆☆
Allow me to heat my house.	☆☆☆☆☆☆☆☆☆☆
Allow me to cool my house.	☆☆☆☆☆☆☆☆☆☆
Allow me to move goods.	☆☆☆☆☆☆☆☆☆☆
Allow me to work at home.	☆☆☆☆☆☆☆☆☆☆
Provide me and the family with entertainment.	☆☆☆☆☆☆☆☆☆☆
Allow me to light up my house.	☆☆☆☆☆☆☆☆☆☆
Allow me to operate a Home Energy Management system.	☆☆☆☆☆☆☆☆☆☆
Allow me to operate the washing machine, dishwasher, etc.	☆☆☆☆☆☆☆☆☆☆
Allow me to keep the food refrigerated.	☆☆☆☆☆☆☆☆☆☆
Allow me to generate hot water for the appliances.	☆☆☆☆☆☆☆☆☆☆
Allow me to generate hot water for showering and cleaning.	☆☆☆☆☆☆☆☆☆☆
Allow me to operate home security systems.	☆☆☆☆☆☆☆☆☆☆
Allow me to operate my smart home devices (automatic window openers, shutters, etc.)	☆☆☆☆☆☆☆☆☆☆
Allow me to operate ventilation.	☆☆☆☆☆☆☆☆☆☆

2.10 Assume that full black-outs could occur in your region. This mean **the entire region** (and possibly even beyond) **is without electricity supply for at least a day or two.** Please note that in this situation **several services are not working or working** only in a very limited way (like cellular network, internet, television, etc.). The utility provider has a partial solution to provide limited local electricity supply but cannot support the electricity supply all the normal loads so they are asking which loads they should prioritize. Please, rank the following energy services from 0 to 10 stars where 0 stars means it is extremely low priority for you and 10 stars is absolutely needed for you:

Ensure that drinking water is available in my home.	☆☆☆☆☆☆☆☆☆☆
Allow me to cook.	☆☆☆☆☆☆☆☆☆☆
Allow me to commute long distances.	☆☆☆☆☆☆☆☆☆☆
Allow me to communicate with my family and peers.	☆☆☆☆☆☆☆☆☆☆
Allow me to clean the house.	☆☆☆☆☆☆☆☆☆☆
Allow me to heat my house.	☆☆☆☆☆☆☆☆☆☆
Allow me to cool my house.	☆☆☆☆☆☆☆☆☆☆

Allow me to move goods.	☆☆☆☆☆☆☆☆☆☆
Allow me to work at home.	☆☆☆☆☆☆☆☆☆☆
Provide me and the family with entertainment.	☆☆☆☆☆☆☆☆☆☆
Allow me to light up my house.	☆☆☆☆☆☆☆☆☆☆
Allow me to operate a Home Energy Management system.	☆☆☆☆☆☆☆☆☆☆
Allow me to operate the washing machine, dishwasher, etc.	☆☆☆☆☆☆☆☆☆☆
Allow me to keep the food refrigerated.	☆☆☆☆☆☆☆☆☆☆
Allow me to generate hot water for the appliances.	☆☆☆☆☆☆☆☆☆☆
Allow me to generate hot water for showering and cleaning.	☆☆☆☆☆☆☆☆☆☆
Allow me to operate home security systems.	☆☆☆☆☆☆☆☆☆☆
Allow me to operate my smart home devices (automatic window openers, shutters, etc.)	☆☆☆☆☆☆☆☆☆☆
Allow me to operate ventilation.	☆☆☆☆☆☆☆☆☆☆

2.11 Select the statement that best represents yourself when you are taking a decision related to the **scenario you selected as the highest priority in the previous question**:

- ○ b. I prefer to do things with the lowest physical and mental effort. I am concerned about the environment, but I am usually too busy to think twice before acting.
- ○ d. None of the above.
- ○ e. I prefer not to answer.
- ○ a. I prefer to not make a decision. I rather try to continue doing the same every time without thinking and prioritize following my daily routines.
- ○ c. I prefer to think carefully about my decisions overall if they impact the climate. I know what I want and take my time to evaluate my options.

2.12 Select the statement that best represents yourself when you are taking a decision related to the **scenario you selected as the highest priority in the previous question**:

- ○ f. I am indifferent to environmental concerns.
- ○ a. I am an environmentally conscious and a well-informed consumer.
- ○ d. I am rather materialist and the impact on the environment of my decisions is beyond my personal responsibility.
- ○ e. Society or my peers influence me, so I usually follow what others suggest to me.
- ○ g. None of the above.
- ○ h. I prefer not to answer.
- ○ c. I am concerned about the environment, but I lack awareness of my impacts to act differently.
- ○ b. I am concerned about the environment, but I always prioritize comfort.

2.13 Select the statement that best represents yourself when you are taking a decision related to the **scenario you selected as the highest priority in the previous question**:

- ○ d. I'd only invest in the energy transition if it helps to improve my safety and that of my relatives.
- ○ h. None of the above.
- ○ a. I consider myself as an early adopter, so I enjoy following the latest trends even if it means taking some risks or impacts on the environment.
- ○ e. I'd only invest in the energy transition if it helps me to reduce my environmental impact in any form.
- ○ i. I prefer not to answer.
- ○ f. I'd only invest in the energy transition if it helps me to increase my social status (i.e., the opinion of others about me) or if it is the social norm of my colleagues, friends and family.
- ○ b. I am not really interested in new equipment, technology or environmental actions, so I just use/do the one that I am used to.
- ○ g. I'd only invest in the energy transition if it helps to maximize my comfort/well-being and that of my relatives.
- ○ c. My main interest is taking the most cost-effective decision. I am an informed person and I always make some calculations before making any decision.

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Which are the critical factors that influence investment decisions on the energy transition?

Fields marked with * are mandatory. ✖

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3 Determinants (factors)

3.1.1 As you can see, these ideal yet futuristic scenarios presented in the previous section would only be possible if citizens, enterprises, and public authorities collaborate. In the following, you will be presented with a list of statements describing factors that may influence your decision making when it comes to contributing to make this scenario possible (e.g., change your daily behavior, take investment decisions with money or time or decide who to vote for to make the scenarios a reality). Please rate each of them, **based only on the situation you selected as the highest priority in the previous question**, in a scale being the left-side of the slider "Not at all important for you" and the right-side of the slider "Drastically important to you"**.**

3.1.1.13 m. I carefully check that the technology or equipment fits my lifestyle or the technical requirements before making an investment decision.
Move the slider or accept the initial position.

Not at all relevant for me | Drastically important to me

50

0 | 100

3.1.1.29 ac. I usually follow the trends when making a decision. In particular, I usually find myself sticking to the ads I see, the recommendations of people I admire, or what I read in magazines or blogs I follow.
Move the slider or accept the initial position.

Not at all important for me | Drastically important to me

50

0 | 100

3.1.1.17 q. I will only make a decision if I feel that I can sustain it throughout time.
Move the slider or accept the initial position.

Not at all important for me | Drastically important to me

50

0 | 100

3.1.1.19 s. I will only make a decision if it improves my well-being or the well-being of my relatives.
Move the slider or accept the initial position.

Not at all important for me | Drastically important to me

50

0 | 100

3.1.1.7 g. Having complete certainty that my actions comply with the legal, tax and administrative regulations are what guide my actions.
Move the slider or accept the initial position.

Not at all important for me | Drastically important to me

50

0 | 44% | 100

3.1.1.30 ad. I only make a decision if it helps me improve my position as an expert on the subject matter.
Move the slider or accept the initial position.

Not at all important for me | Drastically important to me

50

0 | 100

3.1.1.24 x. I will only make an investment decision if it improves my possibilities to socialise with my peers and relatives.
Move the slider or accept the initial position.

Not at all important for me | Drastically important to me

50

0 | 100

3.1.1.2 b. Access to funding (my own savings, deductions, exemptions, and/or credits) is the main factor that allows/hinders me to make an investment decision.
Move the slider or accept the initial position.

Not at all important for me | Drastically important to me

50

0 | 100

3.1.1.1 a. Profits are what guide my decision making, I always prefer to earn or save money with every decision I take.
Move the slider or accept the initial position.

Not at all important for me | Drastically important to me

50

0 | 100

3.1.1.26 z. I love to test new ideas and cutting-edge technology so novelty is what drives my investment decisions.
Move the slider or accept the initial position.

Not at all important for me | Drastically important to me

50

0 | 100

3.1.1.8 h. I only make decisions if I trust all the parties involved (e.g., public administration, neighbors) and that I trust the technology that is needed to accomplish my goal.
Move the slider or accept the initial position.

Not at all important for me | Drastically important to me

50

0 | 100

3.1.1.9 i. I only make decisions if the outcome of them ensures or improves my safety or the ones of my relatives.
Move the slider or accept the initial position.

Not at all important for me | Drastically important to me

50

0 | 44% | 100

3.1.1.14 n. I always review and assess the pros and cons of my decisions in relation to the environment before making a decision.
Move the slider or accept the initial position.

Not at all important for me　Drastically important to me

50

0　100

3.1.1.10 j. I always review and assess the pros and cons of my decisions looking for the most cost-effective option.
Move the slider or accept the initial position.

Not at all important for me　Drastically important to me

50

0　100

3.1.1.15 o. I will only make a decision if I feel satisfied with the action and the expected outcome.
Move the slider or accept the initial position.

Not at all important for me　Drastically important to me

50

0　100

3.1.1.20 t. I will only make a decision if it improves my comfort or the comfort of my relatives.
Move the slider or accept the initial position.

Not at all important for me　Drastically important to me

50

0　100

3.1.1.4 d. I will only invest if my actions have an impact beyond the monetary gain/losses.
Move the slider or accept the initial position.

Not at all important for me　Drastically important to me

50

0　100

3.1.1.23 w. I only make an investment decision if it fulfill a social need or improve the society as a whole.
Move the slider or accept the initial position.

Not at all important for me　Drastically important to me

50

0　100

3.1.1.22 v. My investment decisions are influenced by the opinions of others (such as my peers, relatives or family).
Move the slider or accept the initial position.

Not at all important for me　Drastically important to me

50

0　100

3.1.1.31 ae. I only make a decision if it improves my peers' opinions about me, even if this decision is not always what I would do only for myself.
Move the slider or accept the ini osition.

Not at all important for me | Drastically important to me

50

0 | 100

3.1.1.27 aa. Having fun is important to me. Therefore, I will only make a decision if it would be enjoyable and amusing for me.
Move the slider or accept the initial position.

Not at all important for me | Drastically important to me

50

0 | 100

3.1.1.18 r. Self-sufficiency and individual sovereignty is what guide my decisions. I will only make a decision if I feel that the investment will improve my control of all circumstances and potential outcomes.
Move the slider or accept the initial position.

Not at all important for me | Drastically important to me

50

0 | 100

3.1.1.6 f. Every decision I take serves to foster the planet's preservation. If my choice might harm the environment, I will always avoid taking this action.
Move the slider or accept the initial position.

Not at all important for me | Drastically important to me

50

0 | 100

3.1.1.32 af. I only make a decision if the action has a personal, inner meaning for me (beyond any economic gain).
Move the slider or accept the initial position.

Not at all important for me | Drastically important to me

50

0 | 100

3.1.1.5 e. I am a thrifty person, so I only invest in actions that allow me to reduce my cost/impact/expenditures.
Move the slider or accept the initial position.

Not at all important for me | Drastically important to me

50

0 | 100

3.1.1.11 k. I do not make a decision if I do not have enough knowledge of the subject matter.
Move the slider or accept the initial position.

Not at all relevant for me | Drastically important to me

50

0 | 100

3.1.1.25 y. I will only make an investment decision if the people affected by it (for example, my relatives, peers or the community) agree with the decision cohesively.

Move the slider or accept the initial position.

Not at all important for me Drastically important to me

50

0 100

3.1.1.12 l. Feeling that I am competent to make an investment is what guides my decision making.

Move the slider or accept the initial position.

Not at all important for me Drastically important to me

50

0 100

3.1.1.21 u. I firmly believe that we live in a society where we have to adhere to regulations, laws and community agreements by all means, so my investment decision has to agree with this vision.

Move the slider or accept the initial position.

Not at all important for me Drastically important to me

50

0 100

3.1.1.28 ab. I make investment decisions that lead to my increased status and I can show others what I achieved.

Move the slider or accept the initial position.

Not at all important for me Drastically important to me

50

0 100

3.1.1.16 p. I only make a decision if I feel personally committed to the action and the expected outcome.

Move the slider or accept the initial position.

Not at all important for me Drastically important to me

50

0 100

3.1.1.3 c. The evaluation of the risks of my investment(s) is what will always guide my final decision.

Move the slider or accept the initial position.

Not at all important for me Drastically important to me

50

0 100

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Which are the critical factors that influence investment decisions on the energy transition?

Fields marked with * are mandatory.

Disclaimer
The European Commission is not responsible for the content of questionnaires created using the EUSurvey service - it remains the sole responsibility of the form creator and manager. The use of EUSurvey service does not imply a recommendation or endorsement, by the European Commission, of the views expressed within them.

Anonymous mode
The anonymous option has been activated. As a result, your contribution to this survey will be anonymous as the system will not save any personal data such as your IP address.

4 Socio-economic description

4.1 Have you understood so far the questions we have made?

- ◯ Car
- ◯ Yes, it has been easy so far.
- ◯ 0
- ◯ No, the survey is quite difficult to answer.
- ◯ It is an average survey.
- ◯ -1000 * 23 ^27

* 4.2 Do you have a Prolific ID? (if you don't know what this is, just answer no)

No

4.4 I which country do you reside?

4.5 How old are you?

- ◯ 18-30 years
- ◯ 31-55 years
- ◯ +56 years
- ◯ I prefer not to answer

4.6 What is the highest level of education you have completed?

- ◯ Primary or no studies
- ◯ High school
- ◯ Vocational training / Trade school
- ◯ University
- ◯ I prefer not to answer

* 4.7 If you have 15 minutes more, we would be delighted if you could answer some questions about investment decission.

- ◉ Yes, I have some more time.
- ◯ No, I would like to end my contributions here.

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Which are the critical factors that influence investment decisions on the energy transition?

Fields marked with * are mandatory. ✖

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5 Investment decisions

In the following questions, you will be asked about specific prices of potential purchases-decisions related to the four scenarios we explained at the beginning of the survey. Please, answer them as honestly as possible consistently with the answer that best fit your lifestyle.

5.1 Appliances:

5.1.1 How much do you think a regular refrigerator costs for personal use?

Only values of at most 20000 are allowed

[ ] €

5.1.2 How much do you think an *energy efficient* (e.g., "A" label or similar) refrigerator costs for personal use?

Only values of at most 20000 are allowed

[ ] €

5.1.3 If your refrigerator suddenly brokes tomorrow, will you buy the energy efficient option?

- ◯ Yes
- ◯ No
- ◯ I prefer not to answer

5.2 Insulation:

5.2.1 How much do you think **updating to a state of the art insulation for your façade** (without changing windows) of your house cost? (for multifamily buildings, please think on how much per household costs)

Only values of at most 20000 are allowed

[ ] €

5.2.2 If your façade needs to be painted soon, will you invest to update the insulation of your household as well?

- ◯ Yes
- ◯ No
- ◯ I prefer not to answer

5.3 Energy Generation:

5.3.1 How much do you think a **solar photovoltaic system costs**? (for multifamily buildings, please think on how much per household costs)

Only values of at most 20000 are allowed

[ ] €

5.3.2 Are you willing to pay this amount to install a solar photovoltaic system?

- ◯ Yes
- ◯ No
- ◯ I prefer not to answer

5.4 Energy Storage:

5.4.1 How munch do you think an energy storage system (like batteries) costs? (for multifamily buildings, please think on how much per houshold costs?

Only values of at most 20000 are allowed

€

5.4.2 Are you willing to pay this amount to install an energy storage system?

- Yes
- No
- I prefer not to answer

5.5 Heating:

5.5.1 How much do you think a gas boiler costs? (for multifamily buildings with central heating, please think on how much per household costs)

Only values of at most 100000 are allowed

€

5.5.2 How much do you think an energy efficient heating system (e.g., a heat pump) costs?

Only values of at most 100000 are allowed

€

5.5.3 If your heating system suddenly brokes tomorrow, will you buy the energy efficient option?

- Yes
- No
- I prefer not to answer

5.6 Mobility:

5.6.1 On average, how many kilometers do you travel in a typical day? Please provide the round trip amount.

Only values of at most 200 are allowed

km

5.6.2 Which travel options do you typically use? Please select all that apply to you

- a. Private vehicle
- b. Public Transport
- c. Walking / Bicycling / Electric Scooter / Other personal mobility devices
- d. Others
- e. I prefer not to answer

5.6.3 How much do you think a **diesel or gasoline mid-range brand new car** costs (in €)?

Only values of at most 100000 are allowed

€

5.6.4 How much do you think a **mid-range brand new electric car** costs?

Only values of at most 100000 are allowed

€

5.6.5 If your car suddenly broke, are you willing to buy an electric car?

- Yes
- No
- I prefer not to answer

Previous Next

Which are the critical factors that influence investment decisions on the energy transition?

Fields marked with * are mandatory.

6 Household Characterization

6.1 Please select zero

- ◯ Two
- ◯ Ten
- ◯ Zero
- ◯ Six

6.2 What type of area do you live in?

- ◯ Rural
- ◯ City
- ◯ Residential area
- ◯ I prefer not to answer

6.3 Which of the following most accurately describes you?

- ◯ Male
- ◯ Female
- ◯ Non-binary
- ◯ Other
- ◯ I prefer not to answer

6.4 Do you live alone or do you share your household with others? (Please check all the answers that apply to you and your personal situation)

- ☐ a. I live alone.
- ☐ b. I live with friends or other non-family persons.
- ☐ c. I live with my partner.
- ☐ d. I live with my child/children (or other minor/s under my responsibility).
- ☐ e. I live with other adult/s under my responsibility.
- ☐ f. I live with other person/s who are either family or relative/s.
- ☐ g. I live with my pet/s.
- ☐ h. I prefer not to answer.

6.5 How many people live in the household?

Only values of at most 20 are allowed

6.6 What is your approximate individual yearly income (neat)?

- ◯ More than 100.000 €
- ◯ Between 50.000 € and 100.000 €
- ◯ Between 30.000 € and 50.000 €
- ◯ Between 15.000 € and 30.000 €
- ◯ Less than 15.000 €
- ◯ I prefer not to answer

6.7 In a typical month, how much of your salary is saved?

- ◯ I manage to save more than 20% of the monthly salary.
- ◯ I manage to save between 10 and 20 % monthly.
- ◯ I manage to save less than 10 % monthly.
- ◯ Nothing, I am using my savings lately.
- ◯ I prefer not to answer.

6.8 In which type of housing do you live?

- ◯ Flat / Apartment
- ◯ Semi-Detached / Townhomes
- ◯ Single-Family Home / Fully detached house
- ◯ In a multi-family house
- ◯ Other type of household
- ◯ I prefer not to answer

6.9 Are you the owner / co-owner of the place where you live?

- ◯ Yes
- ◯ No
- ◯ I prefer not to answer

6.10 How much usable area does your house have?

- ◯ Less than 80 m²
- ◯ Between 80 and 120 m²
- ◯ More than 120 m²
- ◯ Not sure
- ◯ I prefer not to answer

6.11 Is your house properly insulated?

- ◯ Yes - it has been built or refurbished with energy efficiency in mind.
- ◯ No - it has been built without energy efficiency in mind or has not been completely refurbished.
- ◯ I do not know.
- ◯ I prefer not to answer.

6.12 In which climate zone do you live?

- ◯ Atlantic
- ◯ Mediterranean
- ◯ Continental
- ◯ Alpine or Nordic
- ◯ Arid or semi-arid
- ◯ I do not know
- ◯ I prefer not to answer

6.13 On a scale of 0-10, where 0 is “Climate change does not exist” and 10 is “I am a climate change expert/activist”, how would you assess your level of awareness of climate change?

Move the slider or accept the initial position.

Climate change does not exist | 5 | I am a climate change expert/activist

0 | 10

6.14 On a scale of 0-10, where 0 is “Climate change does not exist” and 10 is “They are climate change experts/activists”, how would you assess the level of awareness of climate change of **your peers or relatives**?

Move the slider or accept the initial position.

Climate change does not exist | 5 | They are climate change experts/activists

0 | 10

6.15 On a scale of 0-10, where 0 is “It is the first time I hear about it” and 10 is “I am an expert or activist”, how would you assess your level of awareness about the energy transition?

Move the slider or accept the initial position.

It is the first time I hear about it | 5 | I am an expert or activist

0 | 10

6.16 On a scale of 0-10, where 0 is “It is the first time they hear about it” and 10 is “They are experts or activists”, how would you assess the level of awareness about the energy transition of **your peers or relatives**?

Move the slider or accept the initial position.

It is the first time they hear about it

They are experts or activists

0

10

6.17 Please provide below any additional feedback about the survey you could give us.

Previous

Submit

APPENDIX

I

Publications

I.1 Indexed journal articles

Aguayo-Mendoza A, Irizar-Arrieta A., Casado-Mansilla D. Cruz E. Borges. (2024) "Understanding the factors that affect households' investment decisions required by the energy transition" in PLOS ONE,
DOI: https://doi.org/10.1371/journal.pone.0297222

Nacht, T., Pratter, R., Ganglbauer, J., Schibline, A., Aguayo, A., Fragkos, P., & Zisarou, E. (2023). Modeling Approaches for Residential Energy Consumption: A Literature Review. Climate 2023, Vol. 11, Page 184, 11(9), 184.
DOI: https://doi.org/10.3390/CLI11090184

I.2 Datasets

Borges, C. E., Quesada, C., Casado-Mansilla, D., & Aguayo-Mendoza, A. (2022). Characterization of investments profiles on the energy transition for european citizens.

Zenodo. https://doi.org/10.5281/ZENODO.7383018

Cruz E. Borges, Carlos Quesada, Diego Casado-Mansilla, & Armando Aguayo-Mendoza. (2022). Characterization of investments profiles on the energy transition for european citizens. Zenodo. https://doi.org/10.5281/ZENODO.8407117

Borges Hernández, C. E., Casado-Mansilla, D., Irizar Arrieta, A., Larrea Basterra, M., Schibline, A., & Aguayo-Mendoza, A. (2024). Microdata used to construct the Causal Diagrams to model investment decisions related to the energy transition. https://doi.org/10.5281/ZENODO.11236053

Corina Bolintineanu, Armando Aguayo, Thomas Natch, Chris Merveille, Axel Veitengruber, Francesco Dalla Longa, Panagiotis Fragkos, Amanda Schibline, & Antina Sander. (2021). Inventory of Policy Interventions related to Energy and Transport Behaviours. https://doi.org/10.5281/ZENODO.4743705

I.3 Conferences

Armando Aguayo-Mendoza, Cruz E. Borges, Diego Diego Casado-Mansilla, Melany Melany Hebles, & Carlos Quesada. (2023). Causal Models of Human Behavior from Human Experts. INAOE - CaDis – Workshop on Causal Discovery (19-21 June). https://cadisworkshop.com.mx/

Casado-Mansilla, D, & Aguayo-Mendoza, A. (2023). How to define an intervention strategy to foster the energy transition in EU households? In ECEMP 2023 – European Climate and Energy Modelling Forum. https://www.ecemf.eu/ecemp/ecemp-2023/

Armando Aguayo-Mendoza. (2022). Preliminary results of a combination of change of electricity tariff and nudge-based interventions to foster energy conservation and demand response behaviour in a Spanish energy cooperative. In EEDAL-LS-2022: International Conference on Energy Efficiency in Domestic & Light Sources

(Ed.), Conference| EEDAL-LS-2022: International Conference on Energy Efficiency in Domestic & Light Sources (01-03, June). https://build-up.ec.europa.eu/en/news-and-events/events/conference-eedal-ls-2022-international-conference-energy-efficiency-domestic

Cruz E. Borges, Armando Aguayo-Mendoza, Carlos Quesada, D. Casado-Mansilla, M. Larrea Basterra, & A. Schibline & A. Ceglarz. (2022). What are the most relevant factors that affect households' investment decisions on the energy transition? In ECEMP 2022 – European Climate and Energy Modelling Forum - Acting on the ambitions to a net-zero EU: roadblocks, challenges, and opportunities. https://www.ecemf.eu/ecemp/ecemp-2022

Armando Aguayo-Mendoza. (2021, October 28). Skills Workshop 08: How to model citizens‘ behaviour? EMP-E 2021: Re-Energising Sustainable Transitions in Europe Energy System Modelling, Methods & Results to Support the European Green Deal (26 - 28 October). https://www.ecemf.eu/ecemp/ecemp-2021

Armando Aguayo-Mendoza. (2022). Causal Model. In Desuto Summer School (2022). https://www.deusto.es/en/landing/deusto-summer-school

Armando Aguayo-Medoza, & Diego Casado-Mansilla. (2023). Identificar la Idiosincrasia de los Hogares para Definir Incentivos y Estrategia a Medida con el Fin de Promover la Transición Energética Justa en la Unión Europea. Deusto Ingeniería, 48–49.

I.4 International presentations

Armando Aguayo-Mendoza, & Carlos Quesada-Granja. (2023). Workshop: Análisis Expliratorio de Datos usando Herramientas de IA. In Facultad de Ciencias Económic as y Administrativas. Universidad Católica de la Santisima Concepción. Concepción, Chile

Armando Aguyo-Mendoza. (2023). Artificial Intelligence - Causal models of human behaviour based on human expert knowledge. In Universidad Autónoma Metropolitana - Seminario del Cuerpo Académico Sistemas de Telecomunicaciones. Universidad Autónoma Metropolitana, Unidad Azcapotzalco. Cidad de México, México.

Armando Aguayo-Mendoza. (2022). New Engineering Trends - Nuevas Tendencias de la Ingeniería. In Jornada de Seminario de Tendencias 2022-1. Universidada UniCafam - Facultad de Ingeniería. Bogota, Colombia.

Aguyo-Mendoza, A., Cruz E. Borges, Luis Enrique Sucar, & José Isaías Salas Hernández. (2021). Why project (H2020). In Universidad Autónoma Metropolitana - Seminario del Cuerpo Académico Sistemas de Telecomunicaciones. Universidad Autónoma Metropolitana, Unidad Azcapotzalco. Unidad Azcapotzalco. Cidad de México, México.

Declaration

I, Armando Aguayo Mendoza, herewith declare that this dissertation is my own original work, carried out as a doctoral student at the University of Deusto. All assistance received and notions from other sources have been identified as such, acknowledging their correspondent contributions and citing them properly.

This work contains no material which has been presented in identical or similar form to any examination board, except where due acknowledgement is made in the dissertation.

This dissertation was finished writing on July 22th, 2018.