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V2G-QUESTS Integrating Vehicle-to-Grid Technologies for Equitable and Sustainable Transitions in Positive Energy Districts

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Abstract: *The Vehicle to Grid for Equitable Zero-Emission Transitions in positive energy districts (V2G-QUESTS) project is presented as a pioneering and crucial initiative in the context of a fair and equitable digital transition. In a world where technological development faces the challenge of mitigating environmental degradation caused by climate change, V2G-QUESTS stands out in preventing the unequal or harmful development of technologies such as Vehicle-to-Grid (V2G) in urban environments, particularly in socially disadvantaged communities, betting on social equity in the adoption of advanced technologies.*

The essence of V2G-QUESTS lies in its holistic approach that integrates social sciences to understand how technological innovations impact and are shaped by social, economic, and cultural structures. The project commits to ensuring that the transition to sustainable energy systems and mobility technologies is not only environmentally sustainable but also socially just and accessible to all strata of society.

To discern the impact of the urban transition to this new technological model, an urban simulation environment based on Multi-Agent Systems will be developed, which will replicate social behavior at different degrees and case studies across the European territory. This approach allows an interdisciplinary analysis of the interactions and the impact of V2G technology in different social and technical spheres, enabling regional organizations and institutions to adapt to the future needs of their inhabitants.

This task involves integrating into a multi-agent system a detailed model of the electrical energy system, as well as a model of daily transportation needs, a model of transportation mode selection that includes driving behavior and the interaction of drivers with V2G technologies, and a model of social impact on the various agents involved. Orchestrating all these models will allow capturing the complexity of the interactions between different agents, such as energy providers, electric vehicle users, and network operators to ensure that the simulations reflect realistic *scenarios and provide valuable insights into how users can interact with the V2G system.*

To achieve these objectives, it is necessary to specify the main characteristics to be embodied in each scenario to be specified, considering the three urban dimensions; society, economy and technical infrastructure. The present study focuses its efforts on specifying these vital characteristics for the specification of the scenarios.

Keywords: *V2G, Equitable electric transport, electric mobility, energy-efficient districts, energy transition*

1 Introduction

Cities, home to over half of the world's population, are at a crucial crossroads (World Bank, 2022). On one hand, they are engines of economic growth, innovation, and social development. On the other hand, they face pressing challenges such as traffic congestion, air pollution, dependence on fossil fuels, and uncontrolled urban sprawl (IPCC, 2022).

The current urban development model, based on private car dependence and fossil fuels, is unsustainable in the long term. Urban transportation carbon emissions significantly contribute to climate change, while air pollution affects public health and quality of life (WHO, 2023).

A paradigm shift towards a more sustainable urban development model is urgent, prioritizing efficient urban mobility, renewable energy integration, and social equity (UN, 2023). This shift must be comprehensive, encompassing economic, social, environmental, and technological aspects.

In this context, new technologies such as electric vehicles (EVs) and vehicle-to-grid (V2G) technology emerge as tools for urban transformation (Deloitte, 2024). EVs offer a cleaner and more efficient transportation alternative, while V2G technology allows bidirectional energy integration between EVs and the electrical grid, enabling more efficient energy use and renewable sources integration.

However, like any technological transition, the adoption of the V2G model is not without risks. Its implementation will impact urban fabric in economic, social, and technical dimensions, making it crucial to evaluate its effects in each dimension without omitting any.

This study is part of the V2G-QUESTS project, which aims to model the urban environment with its potential V2G development. This modeling will allow anticipating and preventing risks of marginalization or social exclusion that could arise from improper management of the technical-economic resources associated with V2G technology.

In this context, the study focuses on defining the characteristics that the V2G-QUESTS project's model must consider in each case study to be analyzed. Specifying these characteristics is essential to better understand the social, economic, and technical dynamics that influence the adoption of the V2G model, identifying areas where V2G model implementation could generate risks of social marginalization or exclusion, as well as regions with the greatest potential for positive impact on urban society.

These models, and their results, will enable the development of intervention strategies and public policies that minimize these risks and promote a fair and inclusive transition towards a more sustainable energy model. Therefore, defining the characteristics to consider in each case study is a fundamental step. The study's results will enable the V2G-QUESTS project team to develop a more precise and robust model, which in turn will contribute to informed decision-making on the implementation of the V2G model in cities.

2 Methodology

In line with the previously established foundations, a series of collaborative work sessions and detailed analysis have been conducted, providing a framework for the exhaustive exploration of essential characteristics to be considered. These sessions, designed to foster idea generation and knowledge exchange, have been conducted under an informal brainstorming approach, thus facilitating the identification and evaluation of key elements relevant to the specification of variables in the context of V2G technology within the urban environment.

The outcome of these working sessions and discussions has been the development of a list of critical aspects that define and delimit the scope of application of the project in question. This list, based on the practical experience and specialized knowledge of the participants, serves as a solid and coherent foundation for the precise definition of distinctive characteristics that will guide scenario modeling and strategy formulation in the V2G-QUESTS project. During these sessions, special attention was paid to the identification and categorization of both agent and environmental attributes considered essential to the project's objectives. Through collaborative analysis, these sessions facilitated the detection and prioritization of key variables that will shape the modeling and implementation phases of the V2G-QUESTS project, ensuring a comprehensive and robust approach to addressing urban mobility challenges.

3 Characterisation of ABM

Characterizing the multi-agent model involves characterizing three types of assets; the active agents, the passive agents and the environment in which they act. For this purpose, and after developing a series of workshop sessions, the characteristics to be defined are considered to be the following:

Active Agent Characterization: These attributes comprise demographic and socioeconomic variables that characterize the individuals participating in the urban environment. Among them are:

- Age. Influences transportation preferences and willingness to adopt new technologies.
- Presence of children under their care. They may require access to specific services, such as schools or child care facilities.
- Existence of dependent relatives. May influence mobility decisions and the availability of time and resources to participate in V2G and urban transportation activities.
- Available private transport. Affects mobility choices and participation in public or shared transport initiatives, while influencing traffic congestion.
- Available public transport. Directly impacts mobility options and the willingness to adopt alternatives, especially for those without access to private transportation.
- Employment status. Affects mobility patterns, including travel times and destinations.
- Working days. Influence the demand for transportation and participation in work-related activities, which affects the use of transportation.
- Distance to POIs. Distances to places such as work or schools, impacts transportation needs and patterns.
- Daily to-do lists. Reflect activities and commitments that require mobility, influencing transportation decisions and patterns.

Passive Agent Characterization: These attributes encompass the structural components and operational characteristics of public transportation systems within the urban environment. Key features include:

- Public transport. It includes details on transportation infrastructure, such as routes, stops and services available (e.g., buses, streetcars, trains), as well as vehicle capacity and frequency to meet the demand for public transportation.

- Regulatory Framework. Includes regulations related to safety, accessibility, fares, and other aspects that affect the operation and provision of public transportation services in the urban environment.
- Energy Management Systems (EMS). Crucial in the context of public transportation systems, especially when considering emerging technologies such as V2G. This feature addresses energy management systems used to optimize energy consumption in public transport vehicles, as well as the integration of clean and renewable energy technologies in the operation of these systems.

Understanding active and passive agent's aspects allows for a more precise segmentation of the population and facilitates the design of interventions and specific policies for particular demographic groups.

Environment Characterization: These attributes relate to the temporal and contextual characteristics that can influence the behavior of agents at any given time. They include variables such as;

- Workday/non-workday, weekend. This variable distinguishes between working and non-working days, as well as weekends, which can influence mobility patterns and transport demand in the urban environment.
- Special events. Demonstrations or sporting events, can modify the normal flow of traffic and affect mobility in the urban environment, which should be considered in the modeling of the transportation system.
- Weather conditions. Weather conditions, such as rain, snow or temperature, can influence the choice of transport modes and the operational efficiency of public transport systems.
- Seasonality. Affects mobility patterns and transportation demand throughout the year, with changes in travel preferences and user behavior, which must be considered for effective urban transportation planning and management.

Considering these temporal and contextual factors is crucial for capturing the dynamics and variability of agent behavior over time and for informing effective planning and management of urban mobility.

4 Defined Hypotheses

The V2G-QUESTS project proposes to use an agent-based model (ABM) to model urban behavior. This model will determine the urban areas with the greatest potential for energy exchange through V2G, maximizing the benefits of this technology. In order to understand the impact of the implementation of this type of technology, a series of hypotheses or aspects to be tested are developed. After several working sessions, the following have been defined:

- **Implementation Focus:** The evaluation will determine whether infrastructure (ville) or social behavior (cité), as two key elements of the urban environment, has more potential to contribute to a successful scenario (Richard Sennett, 2019). Key Performance Indicators (KPIs) will be used to compare scenarios where infrastructure is fixed and social behavior is modified, and vice versa.
- **Remote Work:** The impact of telecommuting on the population's needs and interests regarding electric mobility will be evaluated. Will the need for travel decrease, and consequently, the demand for electric vehicles?
- **Renewable Technology Placement:** Scenarios with in-situ (within the urban environment, like rooftop solar panels) and ex-situ (connected to the substation, such as distant wind or solar parks) implementations of renewable sources will be evaluated.
- **Feasibility/Profitability of Energy Storage Systems (ESS):** The viability and profitability of installing ESS in the urban environment, whether in-situ or ex-situ, will be assessed.
- **Typology of Energy Storage Systems (ESS):** Different types of ESS, including seasonal ones (capable of storing energy for long periods) like hydrogen batteries, will be analyzed to understand their impact on the system.
- **Charging Point Reliability:** Reliability profiles will be defined, considering scenarios with different reliability profiles of charging points and analyzing how failures and inoperability affect the system.
- **Location/Existence of Ultra-Fast Charging Systems:** The impact of ultra-fast chargers on social and urban behavior will be studied. How would the speed of charging, similar to traditional gas stations, affect the usage patterns of electric vehicles?
- **Autonomous Vehicles:** Aspects of the behavior of autonomous transport vehicles (similar to taxis), such as reaching the customer and transporting them to their destination, will be defined. Their impact on the electrical system will be assessed.
- **Shared Cars:** Car-sharing behavior will be modeled similarly to public transportation, analyzing its impact on the demand for electric vehicles and the electrical grid.

These scenarios will allow the analysis of the combined effect of various variables on the impact of electric vehicles and V2G technology in the urban environment. The selection of specific scenarios will be based on an analysis of future trends, data availability, and relevance to the selected case studies.

5 Conclusions

The V2G-QUESTS project stands out as a crucial and innovative initiative in the transition to equitable and sustainable urban development by integrating Vehicle-to-Grid (V2G) technologies into positive energy districts. Its holistic approach combines social science with technological innovation to ensure a transition to sustainable energy and mobility systems that are both environmentally responsible and socially just. Using multi-agent system simulations, the project specifies vital characteristics in the urban dimensions of society, economy and technical infrastructure, enabling an understanding of how V2G technology impacts and is shaped by social and economic structures. The detailed characterization of active and passive agents, together with environmental factors, informs the formulation of hypotheses and the evaluation of scenarios that address aspects such as the influence of telework on electric mobility, the feasibility of energy storage systems, and the impact of autonomous vehicles and car sharing on the electric system and urban behavior. These actions seek to promote a fair and inclusive transition towards a more efficient and environmentally friendly urban mobility model.

References

Deloitte (2024) The Deloitte Research Monthly Outlook and Perspectives. Issue 88. Available at: https://www2.deloitte.com/cn/en/pages/about-deloitte/articles/deloitte-research-issue-88.html

European Commission (2021) Mobility Strategy. Available at: https://transport.ec.europa.eu/transport-themes/mobility-strategy_en

Intergovernmental Panel on Climate Change (IPCC) (2022). Climate Change 2022: Impacts, Adaptation and Vulnerability.

International Energy Agency (IEA) (2021). Sustainable and Smart Mobility Strategy. Available at: https://www.ipcc.ch/report/ar6/wg2/

Sennett, R. (2019) *Building and Dwelling: Ethics for the City*. New York: Farrar, Straus and Giroux.

United Nations (UN) (2023) *Sustainable Development Goals: Goal 11: Sustainable Cities and Communities*. Available at: https://www.un.org/sustainabledevelopment/cities/

World Bank (2023) *Urban Development Overview*. Available at: https://www.worldbank.org/en/topic/urbandevelopment/overview

World Health Organization (WHO) (2023) *Air quality, energy and health*.

Data Sources

V2G-QUESTS Project. 2024. Retrieved March 05, 2024. (https://v2g-quests.eu/)

Abbreviations

- **EMS:** Energy Management Systems
- **EV:** Electric Vehicle
- **POI:** Point of Interest
- **V2G:** Vehicle to Grid

Notes

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