Business Case Analysis

Project deliverable D3.3

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1.1 Legal Disclaimer

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2 About the SCALE project

SCALE (Smart Charging Alignment for Europe) is a three-year Horizon Europe project that explores and tests smart charging solutions for electric vehicles. It aims to advance smart charging and Vehicle-2-Grid (V2G) ecosystems to shape a new energy system wherein the flexibility of EV batteries' is harnessed. The project will test and validate a variety of smart charging and V2X solutions and services in 13 use cases in real-life demonstrations in 7 European contexts: Oslo (NO), Rotterdam/Utrecht (NL), Eindhoven (NL), Toulouse (FR), Greater Munich Area (DE), Budapest/Debrecen (HU) and Gothenburg (SE). Going further, project results, best practices, and lessons learned will be shared across EU cities, regions, and relevant e-mobility stakeholders. SCALE aims to create a system blueprint for user-centric smart charging and V2X for European cities and regions.

SCALE's consortium comprises 29 cutting-edge European e-mobility actors covering the entire smart charging and V2X value chain (equipment and charging manufacturers, flexibility service providers, research and knowledge partners, public authorities, consumer associations, etc.) It is led by ElaadNL, one of the world's leading knowledge and innovation centres in smart charging and charging infrastructure.

SCALE partners

List of participating cities:

- Oslo (NO)
- Rotterdam & Utrecht (NL)
- Eindhoven (NL)
- Toulouse (FR)
- Greater Munich Area (GER)
- Budapest & Debrecen (HU)
- Gothenburg (SE)

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3 Introduction to the Business Case Analysis in SCALE

Business Case Analysis

The D3.3 deliverable of the SCALE project presents an in-depth analysis of the business cases for Vehicle-to-Everything (V2X) technologies, with a particular emphasis on Vehicle-to-Grid (V2G) solutions across diverse European settings. The report builds on the other deliverables (D3.1 and D3.2) in WP3. The business case analysis is based on 2 selected uses cases per the 4 innovation clusters of SCALE. This document focuses not on quantitative financial modelling (only in 1 use case), which is addressed in Deliverable 5.1, but rather on exploring viable business models and the ecosystem conditions required for their success. To achieve this, the report employs a combination of qualitative and semi-quantitative methodologies, leveraging insights from real-world use cases tested under the SCALE project in cities such as Eindhoven and Gothenburg, as well as pilots involving utilities and operators like Stedin.

To structure the analysis, the research team applied the Business Model Canvas framework, which provides a comprehensive view of how value is created, delivered, and captured by different actors within the V2G ecosystem. This framework allowed for a structured exploration of key components such as customer segments, revenue streams, cost structures, key partnerships, and value propositions. The Value Proposition Canvas was further used to assess how specific V2G solutions meet stakeholder needs and address pain points, particularly for fleet operators, charge point operators (CPOs), aggregators, and energy system actors. These insights were contextualized within the broader stakeholder landscape using a Stakeholder Matrix, which categorized and mapped stakeholder influence and interest across the deployment value chain—from EV users and manufacturers to public authorities and DSOs.

Beyond these qualitative tools, the analysis also incorporated an experimental Multi-Criteria Weighted Cost-Benefit Analysis (MCWCBA) to support comparative evaluation of different business models. This method allowed to assess business case viability not only through financial metrics but also by factoring in regulatory risk, technology readiness, scalability, and societal value. Weights were assigned to these criteria based on expert input and policy relevance, enabling a nuanced understanding of how business models perform under various national and regional conditions. For instance, a model that scores highly on financial profitability in one country may rate poorly on scalability or policy alignment in another due to regulatory fragmentation or differing energy market structures. This method was evaluated on Use Case D2.

The methodology was grounded in empirical data from use cases, but real-world operational parameters, such as battery sizes, charge/discharge cycles, participation in ancillary markets, and actual revenue streams are limited in this report. The quantitative Stedin use case (Den Haag), for example, demonstrated the greater financial viability of vans with large battery capacities participating in frequency regulation markets. It also highlighted how volatile electricity prices can severely affect annual savings per vehicle, revealing a need for more stable and predictable market mechanisms and regulatory frameworks.

Overall, this deliverable illustrates that the success of V2G business models is highly context-dependent, requiring careful alignment of technical enablers, regulatory frameworks, and stakeholder incentives. It argues for the necessity of adaptable business model design tailored to national market conditions, and it provides a robust foundation for policy and industry actors looking to scale V2X technologies across Europe. In doing so, it complements the financial modelling presented in D5.1 by offering the strategic, systemic view necessary for long-term market integration and ecosystem development.

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4 List of abbreviations and acronyms

Acronym	Meaning
AC	Alternating Current
ACER	Agency for the Cooperation of Energy Regulators
AFIR	Alternative Fuels Infrastructure Regulation
aFRR	Automatic Frequency Restoration Reserve
B2B	Business-to-business
B2C	Business-to-Consumer
BEMS	Building Energy Management System
BESS	Battery Energy Storage System
BM	Business Model
BRP	Balance Responsible Party
BSP	Balancing Service Provider
CCS	Combined Charging System
CP	Charge Point
CPMS	Charging Point Management System
CPO	Charge Point Operator
DC	Direct Current
DSO	Distribution System Operator
EC	European Commission
EM	Energy Manager
EMS	Energy Management System
eMSP	e-Mobility Service Provider
EPBD	Energy Performance of Buildings Directive
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
FCR	Frequency Containment Reserves
FSP	Flexibility Service Provider
GA	Grant Agreement
GDPR	General Data Protection Regulation
HEMS	Home Energy Management System
IC	Innovation Cluster
KoM	Kick-off Meeting
KPI	Key Performance Indicator
LDV	Light duty vehicle
MCWCBA	Multi-Criteria Weighted Cost-Benefit Analysis
OCPI	Open Charge Point Interface protocol
OCPP	Open Charge Point Protocol
OEM	Original Equipment Manufacturer
PV	Photovoltaic
SCALE	Smart Charging Alignment for Europe
SoC	State-of-Charge
ToU	Time-of-Use
TSO	Transmission System Operator
V1G	Vehicle-One-Grid
V2B	Vehicle-to-Business
V2D	Vehicle-to-Depot
V2G	Vehicle-to-Grid
V2H	Vehicle-to-Home
V2P	Vehicle-to-Public
V2X	Vehicle-to-Everything
WP	Work Package

5 Methodology

5.1 Case study methodology

The transition to a sustainable and electrified energy ecosystem requires innovative approaches to integrating electric vehicles (EVs) and vehicle-to-everything (V2X) technologies into energy systems. V2X, which includes vehicle-to-grid (V2G), vehicle-to-home (V2H), and vehicle-to-building (V2B), has emerged as a critical enabler of grid flexibility, energy optimization, and decarbonization. This methodology is designed to systematically analyse and evaluate V2X use cases, with the aim of identifying their potential benefits, challenges, and financial viability across diverse stakeholders and operational scenarios.

Purpose of the Methodology

The primary purpose of this methodology is to provide a standardized framework for analysing V2X use cases in the context of their technical, economic, regulatory, and social implications. By applying a consistent and structured approach, this methodology allows stakeholders—such as energy providers, distribution system operators (DSOs), aggregators, EV manufacturers, policymakers, and site owners—to understand the feasibility and impact of specific V2X-enabled services.

Key objectives include:

1. **Identifying Value Propositions**: Highlighting the unique benefits that V2X technologies can deliver to different stakeholders, including cost savings, revenue generation, environmental benefits, and operational efficiency.
2. **Understanding Market Conditions**: Assessing market dynamics, including demand for V2X services, price volatility, and competition, to evaluate the commercial viability of use cases.
3. **Clarifying Economic Conditions**: Determining cost structures and revenue streams to estimate financial outcomes for stakeholders involved in the implementation of V2X technologies.
4. **Assessing Regulatory Assumptions**: Analysing the stability and maturity of regulatory frameworks to ensure compliance and identify opportunities for policy-driven incentives.
5. **Evaluating Technological Readiness**: Examining the readiness of V2X technologies and local site conditions to facilitate smooth deployment and scalability.

Why This Methodology is Needed

Despite the significant potential of V2X technologies, their deployment faces several barriers, including regulatory complexities, high upfront costs, and a lack of standardization in evaluation processes. This methodology addresses these challenges by:

- **Creating a Uniform Framework**: Ensuring consistency in evaluating use cases across different geographies, markets, and technological contexts.
- **Bridging Knowledge Gaps**: Providing stakeholders with a clear understanding of the financial, technical, and societal impacts of V2X technologies.
- **Enabling Decision-Making**: Generating actionable insights that can guide investments, policy development, and business model innovation.
- **Facilitating Collaboration**: Encouraging partnerships among stakeholders by identifying shared value and opportunities for mutual benefit.

Outputs of the Methodology

The application of this methodology delivers several key outputs, including:

1. **Detailed Use Case Profiles**: Comprehensive documentation of individual use cases, including boundary conditions, stakeholder roles, and operational parameters.
2. **Value Proposition Analysis**: A ranked assessment of the most critical benefits delivered by each use case, customized to the needs of stakeholders.
3. **Economic and Financial Insights**: A breakdown of cost structures, revenue streams, and financial viability for stakeholders involved in V2X-enabled services.
4. **Market and Regulatory Scenarios**: Insights into how market trends, regulatory conditions, and policy environments influence the success of V2X technologies.
5. **Scalability and Feasibility Analysis**: Identification of factors that enable or hinder the large-scale deployment of V2X services.
6. **Recommendations for Stakeholders**: Actionable recommendations for policymakers, companies, and site owners to overcome barriers and leverage opportunities in the V2X ecosystem.

Expected Impact

The adoption of this methodology is expected to accelerate the deployment of V2X technologies, enabling:

- **Grid Stability**: Through enhanced flexibility and support services.
- **Energy System Decarbonization**: By maximizing renewable energy integration and minimizing reliance on fossil fuels.
- **Economic Viability**: By unlocking new revenue streams and reducing operational costs for stakeholders.

Social and Environmental Benefits: Through improved energy access, reduced emissions, and community resilience.

5.1.1 Description of use cases

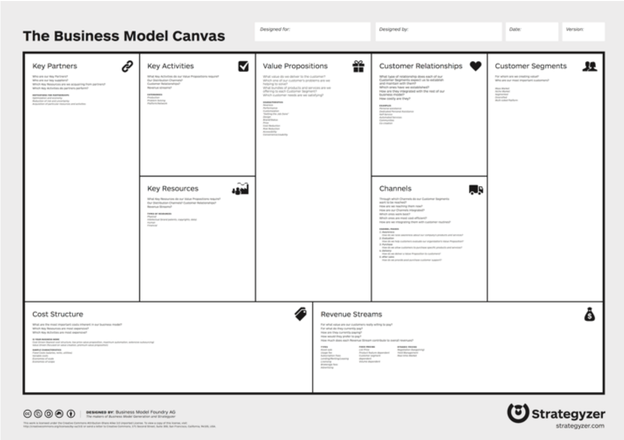
- **Use Case Name**: Enter the specific name of the V2X use case. Brief, general description (from use case setup report)
- **Objective:** Business objectives of the use case.
- **Boundary conditions:**
    - **Geographical Scope**: Define the geographical boundaries for each case study to ensure context-specific analysis. Which country, region, city, etc. Relevance of geographical split depends on use case.
    - **Time Frame**: Establish the time frame over which the case studies will be analysed to ensure consistency.
- **Technological assumptions**
    - **Technology Readiness:** Assumptions regarding the maturity and adoption rates of V2X technologies outlook.

- **Interoperability:** Assumptions about the compatibility between different V2X systems, vehicles, and grid infrastructures.

- **V2X type:** (V2H, V2B, V2G, etc.)
- **Conditions on site:**
  - **Grid Conditions**: The current state and capacity of the local grid infrastructure – e.g., existing connection, capacity of connection, ~~metering technology~~.
  - **Renewable Energy Penetration**: The level of renewable energy integration in the grid.
- **Selection of Energy Management Services:**
  - **Local Behind-the-Meter Optimization**: Optimize PV self-consumption, peak shaving, dynamic grid tariffs, emergency power supply (i.e., backup power).
  - **Congestion Management**: Long-term flexibility agreement, grid-serving power range, market-based redispatch, power quality control. Balancing Responsibility: Spot market trading (a.k.a. wholesale market price arbitrage), market-oriented price signal (i.e., Intraday portfolio optimization).

Balancing Services: Operating reserve (i.e., FCR; aFRR; mFRR)

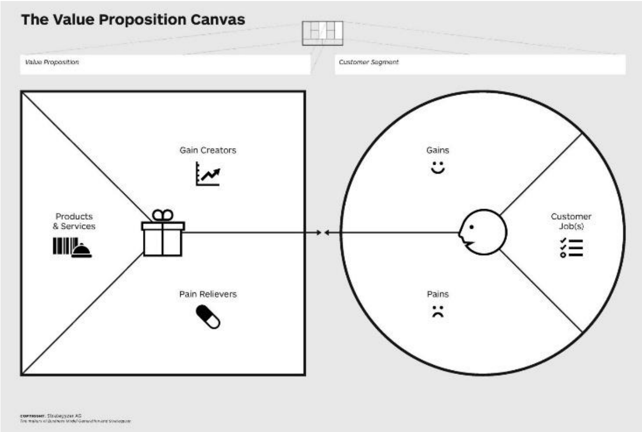
5.1.2 Business Model Canvas Methodology



The Business Model Canvas (BMC) was used to analyse and visualise the underlying value creation logic of each use case. The BMC framework, originally developed by Osterwalder and Pigneur (2010), was adapted to reflect the specific dynamics of the energy and mobility sectors. Each canvas was co-developed with project partners through structured interviews and iterative validation workshops, ensuring that all nine building blocks—key partners, key activities, value propositions, customer relationships, customer segments, key resources, channels, cost structure, and revenue streams—were contextualised for smart charging and V2X services. This approach facilitated a holistic comparison across diverse use cases and business models, enabling the identification of replicable patterns, revenue mechanisms, and value delivery strategies within the European e-mobility ecosystem.

5.1.3 Value Proposition Canvas Methodology

The Value Proposition Canvas (VPC) was employed to systematically identify, assess, and communicate the specific customer value embedded in each smart charging use case. The methodology builds on the framework introduced by Osterwalder et al. (2014), mapping the interaction between product/service offerings and customer needs. The canvas was structured around three analytical layers: "Products & Services," "Gains" and "Pain Relievers" on the value map side, and "Customer Jobs," "Gains" and "Pains" on the customer profile side. Information was gathered through direct partner input, technical documentation, and expert elicitation, focusing on charge point operators, fleet operators, energy suppliers, and public authorities as key user segments. This framework supported the identification of core value drivers such as cost savings, operational efficiency, grid services monetisation, and environmental compliance, and allowed for cross-case synthesis of recurring value mechanisms and their enablers and barriers.



5.1.4 Stakeholder Matrix Methodology

The stakeholder analysis followed a structured mapping approach to identify and assess the influence, interest, and importance of stakeholders involved in each use case. Stakeholders were categorised into five broad groups: End Users & Operators, Government & Regulatory Bodies, Industry & Financial Actors, and Infrastructure & Energy Market Players. For each stakeholder, three dimensions were evaluated: level of interest (ranging from passive to active involvement), influence (capacity to influence the outcome), and importance (relevance to the success or failure of the project). Scores were assigned on a 1–10 scale based on expert judgment, project documentation, and partner consultations. This quantitative stakeholder matrix enabled the visual comparison of actor constellations across use cases, highlighting potential enablers, blockers, and coordination challenges. It further informed the governance and implementation feasibility analysis at local and European levels.

5.2 Multi-Criteria Weighted Cost-Benefit Analysis (MCWCBA)

This section presents an in-depth description of the methodology designed to evaluate stakeholder interactions within the Emobility Solutions (EMS) Vehicle-to-Grid (V2G) use case in Budapest. The methodology integrates a **Multi-Criteria Weighted Cost-Benefit Analysis (MCWCBA)** with a **network graph visualization** to systematically assess the multifaceted relationships among stakeholders.

This approach ensures a comprehensive evaluation that captures both tangible outcomes (e.g., financial impacts) and intangible benefits (e.g., sustainability and innovation), aligning with the project's dual objectives of economic feasibility and environmental sustainability. Below, the methodology is elaborated in seven detailed steps, each accompanied by its purpose, execution process, and rationale.

Step 1: Selection of Evaluation Criteria

The first step involves defining a set of evaluation criteria to assess stakeholder interactions holistically. Six criteria were carefully selected to reflect the diverse dimensions of the V2G ecosystem, ensuring relevance to the EMS use case and the broader V2G context in Budapest. Each criterion is assigned a weight based on its relative importance, determined through expert consultation and stakeholder input. The criteria and their detailed descriptions are as follows:

- **Monetary Impact (Weight: 25%)**

    - **Description**: Measures the direct financial implications of each stakeholder interaction, including costs (e.g., infrastructure setup, maintenance) and revenues (e.g., grid service payments, energy trading profits).
    - **Rationale**: Economic sustainability is a cornerstone of V2G project success. The high weight reflects the priority of financial viability for scaling the initiative.
    - **Examples**: Costs of charging station deployment, income from demand response programs.
- **Regulatory Compliance Burden (Weight: 15%)**
    - **Description**: Evaluates the effort, time, and cost required to comply with local, national, and EU regulations affecting the interaction.
    - **Rationale**: Regulatory hurdles can significantly influence project timelines and feasibility, particularly in a highly regulated energy sector. This criterion ensures these challenges are accounted for.
    - **Examples**: Costs of obtaining certifications, compliance with Budapest's grid codes.
- **Operational Dependency (Weight: 20%)**
    - **Description**: Assesses the degree to which one stakeholder relies on another for operational success, considering both enabling factors (e.g., access to resources) and constraints (e.g., limited autonomy).
    - **Rationale**: V2G systems depend on seamless coordination, making this criterion vital for understanding operational dynamics. Its weight reflects the complexity of these dependencies.
    - **Examples**: EMS's reliance on grid operators for market participation.
- **Market Impact (Weight: 20%)**
    - **Description**: Analyses the potential of each interaction to enhance market opportunities, such as revenue growth or entry into new energy markets.
    - **Rationale**: Long-term success hinges on market expansion, justifying its significant weighting.
    - **Examples**: Partnerships enabling access to flexibility markets.
- **Sustainability Impact (Weight: 10%)**
    - **Description**: Quantifies the environmental and social benefits, such as reduced emissions or improved grid resilience, stemming from the interaction.
    - **Rationale**: Sustainability is a core driver of V2G adoption, though its lower weight reflects its secondary role relative to immediate economic and operational priorities.
    - **Examples**: Contribution to renewable energy integration.
- **Innovation and Scalability (Weight: 10%)**
    - **Description**: Gauges how the interaction supports technological advancements or the potential for replication in other regions.
    - **Rationale**: As an emerging technology, V2G benefits from innovation, making this criterion essential for future-proofing the project.
    - **Examples**: Development of scalable V2G protocols.

Weighting Rationale: The weights (totalling 100%) were determined through a combination of expert judgment and feedback from key stakeholders. Financial and operational factors (45% combined) are prioritized to ensure short-term viability, while sustainability and innovation (20% combined) support long-term strategic goals. This balanced approach aligns with the EMS project's dual focus.

Step 2: Scoring System

A standardized scoring system is applied to evaluate each criterion across all stakeholder interactions. Scores range from **-3 to +3**, defined as follows:

- **-3**: Highly negative impact (e.g., substantial financial loss, severe operational constraint).
- **-2**: Moderately negative impact.
- **-1**: Slightly negative impact.
- **0**: Neutral or no significant impact.
- **+1**: Slightly positive impact.
- **+2**: Moderately positive impact.
- **+3**: Highly positive impact (e.g., significant revenue gain, major sustainability benefit).

Execution: For each interaction (e.g., EMS to EV Driver), a score is assigned to each criterion based on its assessed impact.

Rationale: This symmetrical scale allows for a nuanced assessment, capturing both the magnitude and direction (positive or negative) of impacts. It prevents bias by treating benefits and drawbacks with equal granularity, ensuring a fair and detailed evaluation.

Step 3: Data Collection and Stakeholder Input

Data to inform the scoring process is gathered through a multi-source approach to ensure accuracy and robustness:

- **Document Analysis**: Examination of EMS project documentation, including the V2G use case description, business model canvas, and prior stakeholder analyses.
- **Expert Judgment**: Contributions from specialists in V2G technology, energy markets, and regulatory frameworks to provide informed estimates.
- **Stakeholder Workshops**: Interactive sessions with key stakeholders to gather qualitative insights, validate assumptions, and refine scores.

Execution: Data is synthesized into a scoring matrix, where each interaction is evaluated against the six criteria.

Rationale: Combining empirical data with expert and stakeholder perspectives ensures that scores reflect both objective realities and practical experiences, enhancing the methodology's credibility and relevance.

Step 4: Calculation of Final Interaction Scores

The final score for each stakeholder interaction is computed as a weighted sum of the individual criterion scores, using the formula:

$$Final\ Score = \sum_{i=1}^{6} \text{Criterion Score}_i \times Weight_i$$

Example Calculation (EMS to EV Driver):

- Monetary Impact: +2 (revenue from services) × 0.25 = 0.50
- Regulatory Compliance Burden: -1 (minor compliance costs) × 0.15 = -0.15
- Operational Dependency: +1 (driver participation enables grid services) × 0.20 = 0.20
- Market Impact: +1 (expanded customer base) × 0.20 = 0.20
- Sustainability Impact: +3 (significant emissions reduction) × 0.10 = 0.30
- Innovation and Scalability: +1 (scalable model) × 0.10 = 0.10
- **Final Score**: 0.50 - 0.15 + 0.20 + 0.20 + 0.30 + 0.10 = **1.15**

Execution: This calculation is repeated for all identified interactions.

Rationale: The weighted sum consolidates diverse impacts into a single, comparable metric, enabling prioritization and strategic decision-making.

Step 5: Network Graph Construction

A network graph is constructed to visualize the stakeholder ecosystem:

- **Nodes**: Represent stakeholders (e.g., EMS, National Regulators, EV Drivers).
- **Directed Edges**: Indicate interactions, with arrows showing the direction of value flow (e.g., EMS → EV Driver).
- **Edge Weights**: Reflect the final scores, with visual cues such as thickness (magnitude) and colour (positive = green, negative = red) enhancing interpretability.

Execution: Python's NetworkX was used to generate the graph based on the calculated scores.

Rationale: This visualization highlights key relationships, central stakeholders (e.g., EMS as a hub), and areas of concern (e.g., negative scores to regulators), facilitating a systemic understanding of the ecosystem.

Step 6: Sensitivity Analysis and Validation

To test the methodology's robustness, a sensitivity analysis is performed:

- **Process**: Weights and scores are varied within plausible ranges (e.g., ±10%) to assess their impact on final scores.
- **Validation**: Results are reviewed with stakeholders to ensure consistency with observed realities and project priorities.

Execution: Multiple scenarios are modelled, and key findings are cross-checked.

Rationale: This step confirms the reliability of conclusions, reducing the risk of over-reliance on specific assumptions and enhancing confidence in the results.

Step 7: Interpretation and Strategic Recommendations

The final step translates the analysis into actionable insights:

- **High-Scoring Interactions**: Strengthen and leverage (e.g., EMS-EV Driver collaboration).
- **Low-Scoring Interactions**: Develop mitigation strategies (e.g., lobbying for regulatory simplification).
- **Missing Interactions**: Propose new relationships (e.g., EMS to Flexibility Service Aggregators) to fill gaps.

Execution: Recommendations are documented and prioritized based on their potential impact.

Rationale: This ensures the methodology delivers practical outcomes, guiding stakeholder management and project optimization.

6 Innovation Cluster B - case study B2: Future proof energy management and V2G pilot at Duna Auto, a multi brand car dealership (Budapest)

6.1 Use Case Overview

The following sections provide an overview of the case study boundary conditions, stakeholder roles, and corresponding data that underpin the V2G pilot at Duna Auto in Budapest. Tables and figures summarize key parameters such as technology maturity, regulatory constraints, and projected market developments. Each parameter is evaluated with respect to its influence on the viability and scalability of the Vehicle-to-Grid demonstration. These data points offer the foundation for subsequent analysis of risks, benefits, and overall alignment with the project's innovation objectives. By highlighting critical factors such as connection capacity, local infrastructure conditions, market assumptions, and economic indicators, the tables serve as a reference for understanding the practical and theoretical constraints within which the use case operates.

Use Case Overview	
Use case name	Future proof energy management and V2G pilot at Duna Auto, a multi brand car dealership (Budapest)
Objective	One of the main goals is to increase the self-consumption of the onsite solar PV through V1G and V2G technology. Through V1G CP, this is achieved by charging the EV when there is excessive PV production. Using the V2G CP, this is achieved by saving the extra power of solar PV at sunny time by charging the EV and realizing the energy (discharging the EV) when required in the building at peak time.
Use case leader	Emobility Solutions
Use case leader organization type	Charge point operator

6.2 Case study boundary conditions

The below table provides an overview about the boundary conditions considered in this case study analysis. The boundary conditions reflect a theoretical scenario, as regulatory and technological prevent real life demonstration as of the timeline of the implementation of the project.

General Conditions	
Country	Hungary
Time Frame	5-10 years
V2X Type	V2G
Technological Assumptions	
Technology Maturity Level	Emerging (1)
Adoption Rate Outlook	Low (1)
Interoperability Compatibility Level	Poor (1)
Conditions on Site	
Existing Connection Capacity	Low Capacity(1)
Ability to Facilitate Selected V2X	Partial
Connection Capacity Category	Needs Upgrade (3)
Local Infrastructure Condition	Fair (2)
Potential to Increase Renewable Capacities	Medium (2)
Selection of Energy Management Services	
EMS Optimization Cluster	Local Behind-the-Meter
Energy Management Service	Optimize PV self-consumption
Market Assumptions	
Market Size and Growth	4: Significant Growth
Demand for Electric Vehicles	4: Above Expectations
Grid Services Demand	5: High
Competitive Landscape	2: Dominant
Innovation Rate	3: Expected
Electricity Price Fluctuations	3: Moderately Volatile
Expected Price Changes in the Next 5 Years	Increase
Impact on V2X Profitability	5: Positive

Value Proposition (TOP 5)	
1. Cost Savings 2. Revenue Generation 3. Optimized Asset Utilization 4. Enhanced Customer Experience 5. Operational Efficiency	
Regulatory Assumptions	
Policy Environment Stability	1: Unstable
Commercial Exploitation Allowance	2: Limited Market
Availability of Incentives	No
Level of Incentives	Poor
Effectiveness	Ineffective
Economic Conditions	
EVSE Purchase Cost	Moderately Higher Price
Installation Costs	Moderately Higher Price
Metering Equipment Costs	Moderately Higher Price
Additional Hardware/Software Costs	Moderately Higher Price
EV Purchase Costs	Moderately Higher Price
EV Operation Costs	Neutral Price
Organizational and Administrative Efforts	Extremely Higher Price Premium
Business model	4. Energy Savings Sharing
Environmental Benefits	
Social Benefits	

6.3 Stakeholder Analysis

This section examines the primary stakeholders involved in the V2G pilot at Duna Auto, focusing on their levels of interest, influence, and strategic importance in enabling or constraining the deployment. The analysis categorizes stakeholders into four groups—End Users & Operators, Government & Regulatory

Bodies, Infrastructure & Energy Market Players, and Industry, Manufacturers & Financial—according to their roles and influences in the project's ecosystem. Each stakeholder's significance is determined by its ability to shape investment decisions, influence policy and regulatory frameworks, and drive technology adoption at the dealership.

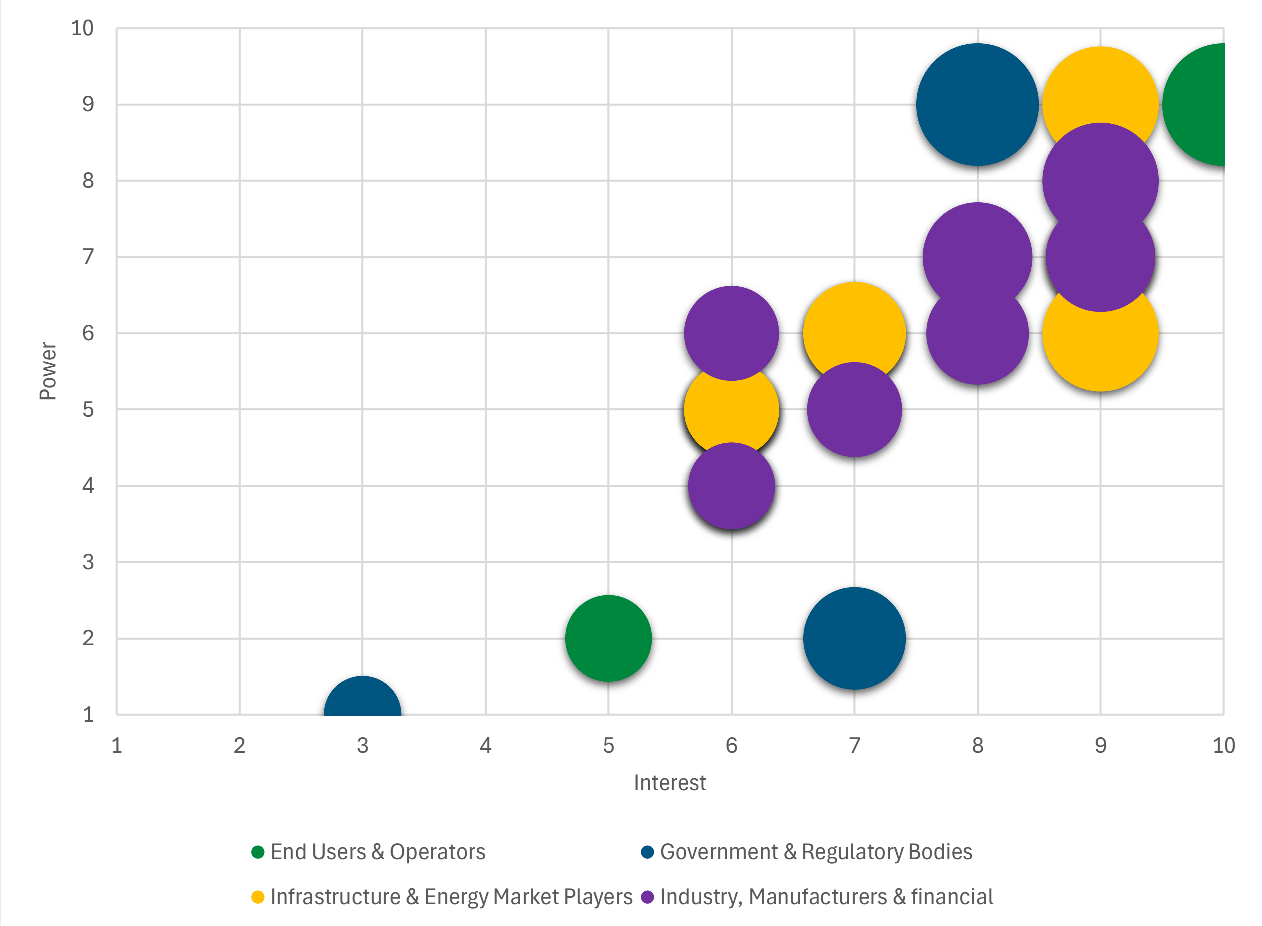


Figure 1: Stakeholder matrix for use case B2

The table below outlines these considerations in detail, assigning numerical values to interest, influence, and importance. These metrics illustrate how certain groups, such as site owners and energy management service providers, possess higher leverage due to their direct control over operational aspects, while others, including local authorities and standardization bodies, exercise a more indirect but nonetheless critical influence through policy and compliance requirements. The associated graph visually represents each stakeholder's position in the influence-interest matrix, highlighting where collaboration, negotiation, or compliance efforts are most needed to ensure successful implementation and long-term viability of the V2G pilot.

Type	Stakeholder types	Identified stakeholder in the use case	Interest	Influence	Importance
End Users & Operators	Electric vehicle driver	Customers and staff using the EVs at Duna Auto	5	2	5
	Fleet operators	Potential fleet customers using dealership charging infrastructure	6	5	6
	Site owner	Duna Auto (owns the dealership infrastructure)	10	9	10

Government & Regulatory Bodies	Local and regional authorities	Budapest Municipality	3	1	4
	European and national regulators	Hungarian Energy and Public Utility Regulatory Authority, European Commission	8	9	10
	Standardization organization	ISO15118 working group, Hungarian standards bodies	7	2	7
Infrastructure & Energy Market Players	Charge point operator	EMS (operating the smart charging system)	9	6	9
	eMobility service provider	EMS (providing energy management solutions)	7	6	7
	Energy Management Service provider	Enervalis (developing and managing the EMS)	9	9	9
	Distribution system operator	E.ON Hungary or other local DSO	9	7	8
	Transmission system operator	MAVIR (Hungarian TSO)	6	5	6
	Energy supplier	Partner energy providers for Duna Auto's grid connection	7	6	7
	Balance responsible party	N/A	6	5	6
Industry, Manufacturers & financial	Aggregator and flexibility service provider	Enervalis (potentially aggregating V2G resources)	9	7	8
	Validation data provider	EMS, Enervalis, and project researchers	6	4	5
	Electric vehicle manufacturer	Various brands at Duna Auto, V2G-compatible EV providers	8	7	8
	Battery manufacturer	Suppliers of stationary storage used at the site	7	5	6
	Charge point manufacturer	ABB (providing the bidirectional chargers)	9	8	9
	Financial institution	Potential investors or grant providers for the project	6	6	6
	RTOs and universities	N/A	6	4	5
	PV manufacturer	Suppliers of the 400 kW rooftop solar PV system	8	6	7

In interpreting the results, particular attention should be paid to stakeholders whose high interest is matched by substantial influence, since they can either accelerate or impede progress depending on whether their objectives align with the project's goals. Examples include the dealership site owner, who has the authority to approve infrastructure upgrades and new operational practices, and relevant regulatory bodies, whose policy frameworks directly impact the commercial exploitation of V2G technology. Likewise, stakeholders with moderate levels of influence but high interest—such as fleet operators or charge point operators—may emerge as champions for the initiative, facilitating broader adoption of the technology in other commercial settings. Balancing these perspectives is essential to building effective partnerships, ensuring regulatory compliance, and achieving widespread acceptance of V2G solutions.

6.4 Value Proposition Canvas

This section presents an in-depth examination of how the V2G case study at Duna Auto addresses stakeholder needs, challenges, and opportunities. The Value Proposition Canvas captures the essential drivers behind the selected energy management service—optimizing PV self-consumption—and the chosen business model of energy savings sharing. In the table, “Gain Creators” and “Pain Relievers” offer mechanisms for reducing reliance on the grid, generating additional revenue, and stabilizing energy prices. Specific products and services, such as energy management software and bidirectional chargers, highlight the integrative approach necessary for balancing vehicle availability, dealership operations, and grid requirements. The “Customer Profile” complements this analysis by illustrating the expected gains for stakeholders—ranging from cost savings and sustainability benefits to improved customer experiences—and the pains they face when confronting regulatory, technical, and financial uncertainties. The table also categorizes drivers and barriers for the top three value propositions—cost savings, revenue generation, and optimized asset utilization—providing clarity on the incentives and challenges likely to influence stakeholder engagement.

Selected Energy Management Service: Optimize PV self-consumption		**Selected Business Model:** Energy Savings Sharing	
Value Map		**Customer Profile**	
Gain Creators (Ways the Smart Charging Ecosystem Creates Value)	**Products & Services (Specific Offerings Provided within the Smart Charging Ecosystem)**	**Gains (Expected Benefits for Stakeholders)**	**Pains (Challenges or Problems Faced)**
Peak Demand Reduction: Smart scheduling shifts charging and discharging to minimize high grid tariffs. Flexibility Market Participation: Dealerships can monetize their energy flexibility through demand response services. Renewable Energy Optimization: Maximizes onsite PV consumption, reducing reliance on the grid and energy costs. Energy Monitoring & Analytics: Real-time insights help dealerships track savings, vehicle readiness, and charging efficiency. Interoperability & Standardization: Ensures compatibility with multiple EV brands and charging networks using protocols like OCPP and ISO 15118.	Smart Charging & V2G Infrastructure: AC and DC bidirectional chargers designed for peak shaving and self-consumption optimization. Energy Management Software (EMS): Optimization platform for load balancing, demand response, and revenue tracking. Grid Services Integration: Participation in ancillary services such as frequency regulation and demand flexibility. Digital Charging & Billing Platform: Real-time monitoring, automated billing, and customer-facing insights. Regulatory & Market Advisory Services: Ensuring compliance with evolving V2G policies and energy-sharing frameworks.	Cost Reduction: Lower electricity bills for dealerships through optimized PV self-consumption and smart charging strategies. Revenue Sharing: Dealerships earn a share of energy savings and flexibility market participation. Optimized Asset Utilization: Vehicles in inventory serve as temporary energy storage to enhance grid and site energy efficiency. Operational Efficiency: Smart charging aligns with dealership operations, ensuring vehicles are ready for sale or customer use. Sustainability Gains: Increased self-consumption of renewable energy reduces CO_2 emissions and dependence on grid electricity. Enhanced Customer Experience: Educates customers about EV technology and benefits, improving dealership attractiveness.	Fluctuating Energy Prices: Dealerships face high operational costs due to peak grid tariffs and fluctuating electricity prices. Regulatory Barriers: Uncertainty around V2G policies, incentives, and market access hinders widespread adoption. Interoperability Issues: Lack of standardization across different EV brands and energy management systems complicates implementation. Limited Vehicle Availability: The availability of parked EVs in inventory varies, affecting energy storage reliability. Battery Degradation Concerns: Dealerships may be hesitant to use inventory vehicles as energy storage due to potential battery lifespan reduction.
Pain Relievers (Solutions That Mitigate Stakeholders’ Challenges)		**Customer Jobs (Tasks or Activities Stakeholders Need to Perform)**	

Smart Energy Management System (EMS): Optimization to ensure charging is cost-efficient and aligned with dealership schedules. Revenue Sharing Model: Allows dealerships to benefit financially from energy savings without major upfront investments. Regulatory Alignment: Advocates for supportive policies and compliance frameworks to enable V2G and demand-side participation. Dynamic Load Balancing: Adjusts energy usage dynamically based on real-time grid conditions to prevent costly demand spikes. Customer Training & Support: Educates dealership personnel on V2G and smart charging to improve adoption and ease of use.			Dealership Owners / Operators: Optimize energy usage to reduce costs while maintaining vehicle readiness for sales and customer use. Fleet Operators: Align fleet charging with energy savings strategies and maximize efficiency for vehicle deployment. Energy Suppliers & Grid Operators: Balance local energy demand and supply, utilizing dealership energy flexibility for grid stability. Policy Makers & Regulators: Ensure incentives and regulations align with enabling business models like energy savings sharing for V2G and smart charging.	

Drivers and barriers of TOP3 value propositions

Value Proposition	Drivers	Barriers
Cost Savings	• Availability of onsite renewable energy (e.g., solar PV) reduces reliance on expensive grid electricity. • Smart energy management enables peak shaving, lowering demand charges. • Dynamic load management reduces energy waste and optimizes usage during off-peak periods.	• High upfront costs for installing V2G chargers, solar PV systems, and integrating EMS infrastructure. • Lack of regulatory frameworks to encourage cost-sharing mechanisms between stakeholders. • Battery degradation concerns may limit willingness of EV owners to participate in V2G programs
Revenue Generation	• Opportunity to earn revenue from providing grid services (e.g., peak shaving, frequency regulation). • Increasing demand for flexible grid services, driven by renewable energy penetration • Potential for revenue from carbon credits or sustainability programs aligned with green energy goals.	• Dependence on volatile electricity prices and uncertain ancillary service revenues • Limited access to markets for ancillary services in regions with underdeveloped flexibility markets. • Difficulty in convincing site owners and stakeholders of tangible revenue opportunities.

Optimized Asset Utilization	• Idle EVs and dealership inventory vehicles can function as dynamic energy storage assets • Increased utilization of chargers and batteries lowers per-unit costs and improves efficiency. • Leveraging battery storage and renewable energy aligns with long-term operational sustainability goals.	• Vehicles may not always be available due to operational needs (e.g., sales, test drives, maintenance). • Poor interoperability between chargers, vehicles, and EMS systems creates operational inefficiencies. • Limited V2G-compatible EVs in inventory may restrict.

By combining these elements into a cohesive framework, the Value Proposition Canvas underscores how the pilot aligns technological innovation with commercial viability, drawing attention to the interdependencies that must be managed for a successful project outcome.

Value Proposition Summary

EMS's Energy Savings Sharing business model at Duna Auto, Budapest enables dealerships to optimize PV self-consumption, reduce electricity costs, and participate in energy flexibility markets. Through V2G and smart charging, EMS ensures that dealerships benefit from cost savings, revenue generation, and sustainability improvements while maintaining vehicle readiness and operational efficiency. By integrating renewable energy, demand-side response, and real-time energy monitoring, EMS creates a scalable and financially sustainable model that supports energy efficiency, EV adoption, and dealership profitability.

6.5 Business Model Canvas

The Business Model Canvas elaborates on how the project's stakeholders and resources come together to create, deliver, and capture value in the context of the V2G pilot. It outlines key partners—including charge point manufacturers, energy suppliers, and dealership management—and demonstrates how their collaboration forms the backbone of the energy savings sharing model. The table emphasizes how essential activities, such as dynamic energy optimization and the integration of solar PV, produce clear value propositions: cost reduction, revenue sharing, and enhanced operational efficiency. The relationships with customers and other user segments, such as vehicle manufacturers and local grid operators, hinge on transparent communication of benefits, revenue models, and real-time data insights. In particular, the shared revenue arrangement for energy optimization services reinforces a cooperative framework that incentivizes both the dealership, and the charge point operator to enhance system performance. The text also details the types of resources—bidirectional chargers, onsite PV capacity, and cloud-based EMS software—needed to deliver these gains. Cost structures centre on hardware installation, software development, and regulatory compliance, while revenue streams primarily involve shared cost savings, grid service payments, and the potential monetization of carbon offsets.

Selected Energy Management Service: Optimize PV self-consumption	**Selected Business Model:** Energy Savings Sharing			**Selected Stakeholder Perspective:** Charge point operator
Key Partners	**Key Activities**	**Value Propositions**	**Customer Relationships**	**Customer Segments**
Car Manufacturers: Partner with multi-brand manufacturers to ensure V2G compatibility for dealership inventory and vehicles. Dealership Management: Collaborate closely with dealership management to align energy strategies with operational schedules and vehicle availability. Technology Providers: Suppliers of V2G chargers, battery storage systems, and EMS software. Local Grid Operators: Coordination for utilizing energy flows during peak and off-peak times and balancing grid loads. Regulators and Policymakers: Advocacy for regulatory frameworks that enable V2G services for temporary inventories in dealerships. Energy Suppliers: Collaborate for off-peak electricity procurement and monetization of stored energy.	Energy Optimization with Dynamic Availability: Align EMS with the dealership's operational schedule to optimize energy flows considering variable vehicle availability. Integration of Temporary Battery Storage: Treat parked inventory cars as temporary, dynamic storage assets for energy optimization and grid services. Scenario-Specific EMS Development: Develop EMS algorithms to accommodate unpredictable availability of vehicles (e.g., vehicles being sold or picked up). Savings Analysis and Sharing: Calculate energy savings and share revenues with the dealership based on operational constraints. Monitoring and Reporting: Provide dealership-specific analytics to optimize energy efficiency while meeting operational requirements (e.g., vehicle readiness for customers). Customer Engagement: Train dealership staff and customers on the benefits of energy optimization and V2G technology.	Cost Savings: The dealership benefits from reduced energy bills by utilizing the inventory cars for energy optimization without impacting operational workflows. Revenue Generation: Shared savings model creates new revenue streams for both the dealership and the CPO through V2G services. Optimized Asset Utilization: Temporary availability of batteries (e.g., unsold inventory or parked cars) is leveraged to provide grid services and optimize renewable energy usage. Operational Alignment: The EMS is tailored to ensure dealership operations (e.g., vehicle readiness, maintenance schedules) are not disrupted. Environmental Benefits: Increased renewable energy self-consumption and reduced reliance on grid power align with sustainability goals. Enhanced Customer Experience: Educate dealership customers about V2G benefits, improving their understanding of EV capabilities.	Revenue Sharing Agreements: Flexible, operationally aligned contracts with dealerships to share cost savings from energy optimization. Operational Support: Continuous engagement to ensure energy optimization aligns with dealership workflows and vehicle availability. Staff Training and Education: Train dealership employees on how to use V2G chargers and explain their benefits to customers. Customer Outreach: Engage dealership customers to highlight the sustainability and operational benefits of V2G and energy savings.	Dealership Owners/Operators: Primary customers benefiting from energy cost savings and additional revenue streams without disrupting vehicle sales or operations. Car Manufacturers: Secondary beneficiaries via enhanced operational efficiency for dealerships and showcasing V2G capabilities in vehicles. Fleet Operators (if applicable): Leverage the dealership infrastructure for energy optimization when their fleet vehicles are parked at the site. Local Grid Operators: Indirect customers benefiting from grid services (e.g., peak shaving, load balancing) provided by the dealership's inventory vehicles.
	Key Resources		**Channels**	

	Vehicle Inventory as Energy Assets: Vehicles temporarily parked on-site function as dynamic storage resources. EMS System with Dynamic Scheduling: Sophisticated software capable of managing energy flows based on the fluctuating availability of vehicles. V2G Chargers: Bidirectional chargers capable of integrating with dealership operations and EMS. Solar PV System: 400 kW rooftop solar PV system to generate renewable energy for on-site consumption. Battery Storage: Industrial-scale storage as a fallback option for periods with low vehicle availability. Workforce: Skilled personnel for charger maintenance, system operation, and customer engagement.		Dealership Energy Management: Integration of energy-saving services directly into the dealership's operational processes. EMS User Interface: Provide dealership management with easy-to-use interfaces to monitor savings, vehicle availability, and energy flows. Customer Communication: Offer transparent updates to customers on how their vehicles contribute to sustainability and cost savings during their time at the dealership. Marketing Campaigns: Use success stories from the dealership to promote the business model to other potential clients (e.g., other dealerships, fleets).	

Cost Structure	**Revenue Streams**
Hardware Costs: Installation of V2G chargers and integration with dealership infrastructure. Software Development: Development and maintenance of EMS algorithms customized for fluctuating vehicle availability. Operational Costs: Maintenance of V2G chargers and battery storage systems. Administrative Costs: Managing revenue-sharing agreements and compliance with dealership operational requirements. Regulatory Advocacy Costs: Engagement with policymakers to address challenges related to energy sharing models in dealerships.	Shared Energy Savings Revenue: Percentage of cost savings achieved by optimizing energy use shared between the CPO and dealership. Grid Services Revenue: Payments from grid operators for providing services such as peak shaving, frequency regulation, and demand response. Solar PV Optimization Revenue: Monetizing increased utilization rates of renewable energy generated by the dealership's solar PV system. Customer Retention Revenue: Improved dealership operations and sustainability practices may attract more EV customers, indirectly increasing revenue. Carbon Credits: Potential revenue from achieving sustainability targets and selling carbon offsets.

By highlighting these interlocking components, the Business Model Canvas clarifies how a balance of partnership, technology, and financial strategy underpins a sustainable approach for V2G adoption in a dealership environment.

Business Model Summary

The business model for EMS focuses on leveraging energy management strategies to optimize dealership energy use, integrate vehicle-to-grid (V2G) technology, and create shared savings models. EMS collaborates with automotive dealerships to integrate its energy management system (EMS) into dealership operations, using parked vehicles as temporary energy storage assets. The system dynamically manages energy flow, scheduling EV charging when electricity prices are low and discharging stored energy during peak periods to reduce dealership electricity costs. EMS also integrates with on-site renewable energy sources, such as solar PV, to maximize self-consumption and minimize grid dependence.

Through dynamic load management, EMS prevents dealership peak demand surges by shifting charging times based on real-time grid pricing and vehicle availability. Dealerships benefit from direct cost reductions on electricity bills, while EMS generates revenue through a shared energy savings model where cost reductions are split between the dealership and the EMS provider. Additionally, EMS enables dealerships to participate in grid service markets by offering demand response, frequency regulation, and peak shaving services, creating additional revenue streams.

A cloud-based platform provides dealership operators with real-time insights into energy savings, vehicle availability, and operational efficiency. EMS also trains dealership staff on V2G operations, ensuring smooth integration of smart charging and vehicle energy management. As dealerships transition to electric vehicle operations, EMS enhances sustainability by reducing CO_2 emissions and improving grid interaction. The model is scalable across multiple dealership locations, allowing EMS to expand its service offerings and establish a replicable business case in energy savings and vehicle-grid integration.

6.6 Key financial indicators

The final section presents the key financial indicators used to assess the profitability and investment feasibility of the V2G solution at Duna Auto. The table categorizes revenue parameters and cost parameters to reveal how income can be generated through load shifting, solar PV self-consumption, and the provision of ancillary services to the grid. For instance, load-shifting revenue depends on time-of-use price differentials, while grid-service payments hinge on the dealership's capacity to offer demand response or frequency regulation. The indicators further capture the magnitude of infrastructure investments, including the costs associated with purchasing bidirectional EV chargers, upgrading connections, and deploying energy management software. Other cost drivers involve regulatory compliance, maintenance requirements, and potential battery degradation expenses. Taken together, these metrics establish the economic foundation for the pilot, showing the interplay between up-front investments and long-term cost savings or revenue gains. They also facilitate scenario-based analyses, enabling stakeholders to assess assumptions regarding electricity market volatility, EV adoption rates, or evolving policy incentives. The quantitative analysis of these use cases is worked out in Deliverable 5.1 of the SCALE project.

Revenue Parameters	Cost Parameters
Energy Optimization	**Infrastructure Investment**
Load Shifted (kWh)	EVSE Purchase Cost
Time-of-Use Price Differentials	Installation Costs
Revenue from Solar PV Self-Consumption	Infrastructure Upgrade Costs
Energy Storage Capacity (kWh)	**Software and Technology**
"Battery Utilization Rate (%)	Metering Equipment Costs
Grid and Market Services	Additional Hardware/Software Costs
Grid Service Payments	Regulatory Compliance Costs
Ancillary Services Revenue	**Operational and Maintenance**
Incentives from Regulators	Operation and Maintenance Costs
Carbon Credits Revenue	Customer Incentive Costs
"Customer Revenue	Program Administration Costs
Customer Participation Fees	Electricity Procurement Costs
Number of V2G Cars	Marketing and Recruitment Costs
	Battery Degradation Costs

7 Innovation Cluster B - case study B4: V2G chargers at office and residential buildings (Gothenburg)

7.1 Use Case Overview

This use case focuses on installing V2G chargers at office and residential buildings in Gothenburg, with Chalmers University of Technology acting as the main coordinator. The pilot leverages a living lab environment to integrate bidirectional charging into an existing building energy management system (EMS). By coupling electric vehicles with onsite renewable generation, the project evaluates how V2G can reduce energy costs, optimize solar PV self-consumption, and inform future research on advanced energy solutions in real-world conditions. The primary objective is to develop a repeatable framework that other campuses, residential complexes, or commercial facilities can adopt, ultimately promoting sustainable electrification strategies across Sweden and beyond.

Use Case Overview	
Use case name	V2G chargers at office and residential buildings (Gothenburg)
Objective	The use case will take place at Chalmers University of Technology, Gothenburg, Sweden. One of the chargers will be installed in a living lab where novel energy solutions can be demonstrated and tested. The use case will include the EV into the existing building EMS to assess the potential gain from V2G.
Use case leader	Chalmers University
Use case leader organization type	Energy Management Service provider

7.2 Case study boundary conditions

The boundary conditions illustrate the readiness of the Swedish market and infrastructure to support V2B (Vehicle-to-Building) applications in a near-term timeframe of two to three years. Although the technology maturity level is still developing, adoption rates are projected to be high, supported by strong policy backing and good interoperability among charging standards. Onsite conditions at Chalmers reflect moderate to sufficient connection capacity, enabling the integration of V2G chargers without extensive network upgrades. Market assumptions remain favourable, given the significant growth in EV demand and a rapidly innovating sector. With highly stable regulations and effective incentives in Sweden, this environment offers a strong platform for real-time energy management initiatives. Economic considerations reveal moderately higher purchase and installation costs for V2G equipment, reflecting the emerging nature of the technology. Nonetheless, stable policies, growing EV penetration, and a focus on decarbonization bolster the prospects for achieving substantial cost savings, enhanced energy independence, and new revenue streams through flexible energy services.

General Conditions	
Country	Sweden
Time Frame	2-3 years
V2X Type	V2B
Technological Assumptions	
Technology Maturity Level	Developing (2)
Adoption Rate Outlook	High (3)
Interoperability Compatibility Level	Good (3)
Conditions on Site	
Existing Connection Capacity	Moderate Capacity
Ability to Facilitate Selected V2X	Yes
Connection Capacity Category	Sufficient (4)
Local Infrastructure Condition	Good (3)
Potential to Increase Renewable Capacities	Medium (2)
Selection of Energy Management Services	
EMS Optimization Cluster	Local Behind-the-Meter
Energy Management Service	Optimize PV self-consumption
Market Assumptions	
Market Size and Growth	4: Significant Growth
Demand for Electric Vehicles	5: High
Grid Services Demand	4: Above Expectations
Competitive Landscape	4: Competitive
Innovation Rate	5: Fast
Electricity Price Fluctuations	4: Volatile
Expected Price Changes in the Next 5 Years	Increase
Impact on V2X Profitability	5: Positive

Value Proposition (TOP 5)	
1. Cost Savings 2. Increased Energy Independence 3. Enhanced Grid Stability 4. Optimized Asset Utilization 5. Revenue Generation	
Regulatory Assumptions	
Policy Environment Stability	5: Highly Stable
Commercial Exploitation Allowance	4: Developed Market
Availability of Incentives	Yes
Level of Incentives	Very Good
Effectiveness	Effective
Economic Conditions	
EVSE Purchase Cost	Moderately Higher Price
Installation Costs	Moderately Higher Price
Metering Equipment Costs	Moderately Higher Price
Additional Hardware/Software Costs	Moderately Higher Price
EV Purchase Costs	Moderately Higher Price
EV Operation Costs	Moderately Higher Price
Organizational and Administrative Efforts	Moderately Higher Price
Business model	7. Real-Time Energy Management
Environmental Benefits	
Social Benefits	

7.3 Stakeholder Analysis

The stakeholder analysis for this V2G pilot in Gothenburg outlines diverse groups with varying levels of interest and influence. End-users, including electric vehicle drivers and building occupants, demonstrate a strong personal stake in accessing cost-effective and reliable charging solutions, though their capacity to influence large-scale decisions is generally lower. By contrast, infrastructure owners, such as Akademiska Hus, hold considerable sway over deployment and operational procedures, given their authority over building infrastructure and campus facilities. Regulatory bodies at local, national, and European levels, including the Swedish Transport Agency and the European Commission, have substantial influence to shape the legal and policy framework, making their support critical for commercial-scale adoption.

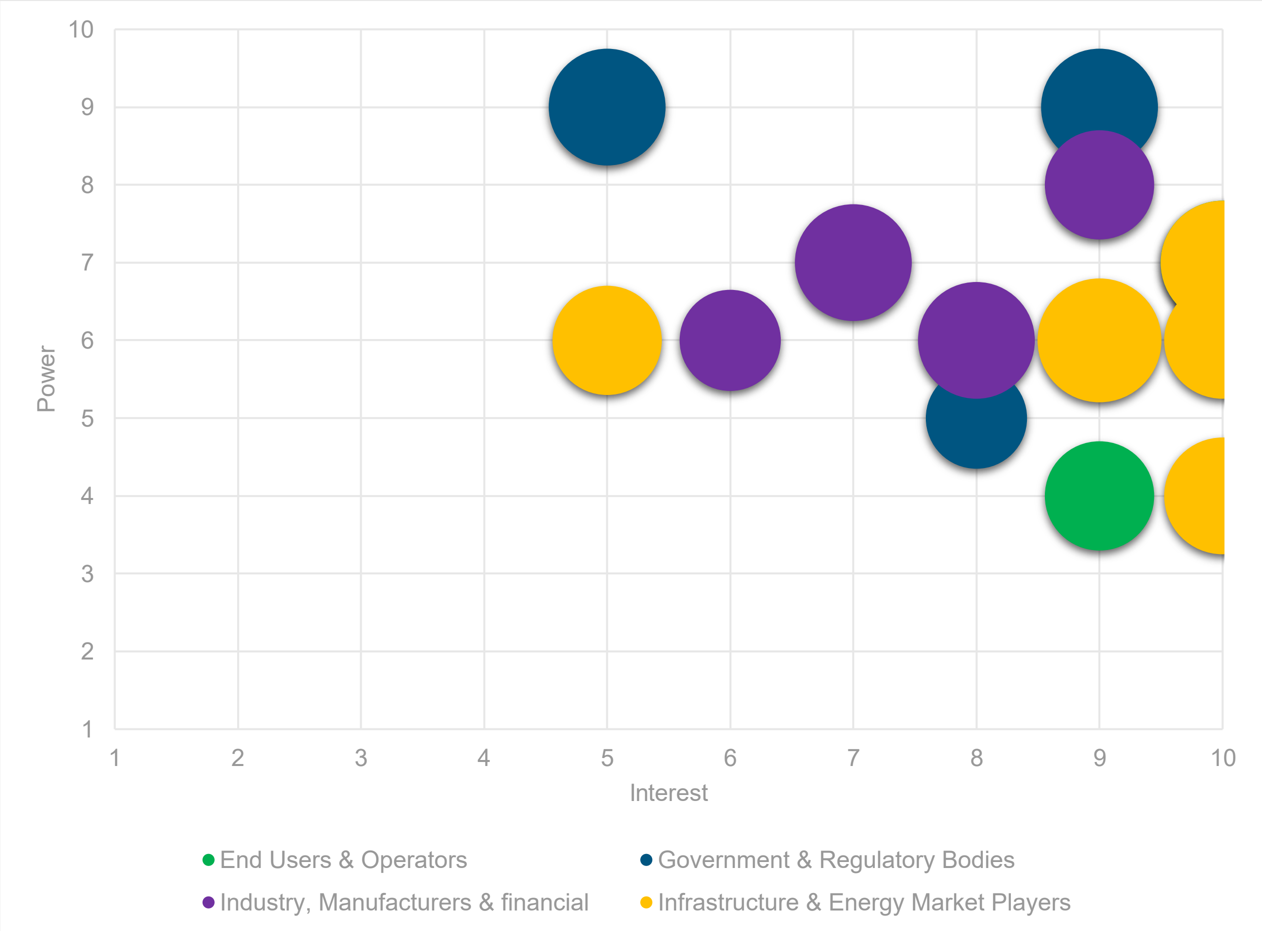


Figure 2: Stakeholder matrix for use case B4

Private-sector participants, encompassing charge point manufacturers, energy suppliers, and vehicle manufacturers like Polestar, contribute technological expertise and innovative products. Their role in ensuring seamless integration, interoperability, and user-friendly charging experiences is essential for long-term viability. Academic and research entities, represented by Chalmers University of Technology, lend valuable insights into system performance, user behaviour, and potential improvements.

Type	Stakeholder types	Identified stakeholder in the use case	Interest	Influence	Importance
End Users & Operators	Electric vehicle driver	Users of the EVs at HSB Living Lab and Chalmers campus	9	4	7
End Users & Operators	Site owner	Akademiska Hus (owns campus infrastructure)	10	7	9
Government & Regulatory Bodies	European and national regulators	Swedish Transport Agency, European Commission	5	9	8
Government & Regulatory Bodies	Local and regional authorities	Gothenburg Municipality, Swedish Energy Agency	9	9	8

Government & Regulatory Bodies	Standardization organization	ISO15118 working group	8	5	6
Industry, Manufacturers & financial	Charge point manufacturer	DC charger supplier (not specified in text)	7	7	8
Industry, Manufacturers & financial	Electric vehicle manufacturer	Polestar (providing V2G-capable EVs)	8	6	8
Industry, Manufacturers & financial	RTOs and universities	Chalmers University of Technology	9	8	7
Industry, Manufacturers & financial	Validation data provider	Chalmers University, project researchers	6	6	6
Infrastructure & Energy Market Players	Charge point operator	Akademiska Hus (managing testbed)	10	4	8
Infrastructure & Energy Market Players	Distribution system operator	Göteborg Energi	9	6	9
Infrastructure & Energy Market Players	Energy Management Service provider	Chalmers University (developing EMS)	10	7	9
Infrastructure & Energy Market Players	Energy supplier	Göteborg Energi	10	6	8
Infrastructure & Energy Market Players	Transmission system operator	Svenska Kraftnät	5	6	7

This melding of policy influence, infrastructural control, and research capabilities underpins the collaborative effort needed to refine and scale the V2G concept, highlighting that a successful rollout depends on shared objectives, regulatory clarity, and ongoing technological innovation.

7.4 Value Proposition Canvas

The Value Proposition Canvas illustrates how integrating Vehicle-to-Building (V2B) solutions within a living lab environment addresses both end-user requirements and broader energy management challenges. Gain creators emerge through intelligent EMS optimisation that aligns charging and discharging with solar PV availability and real-time energy price signals, while pain relievers take the form of standardisation protocols, flexible charging options, and sophisticated battery degradation monitoring.

Selected Energy Management Service: Optimize PV self-consumption

Selected Business Model: Real-Time Energy Management

Value Map

Gain Creators (Ways the Smart Charging Ecosystem Creates Value)

Intelligent EMS Optimization: Dynamic scheduling to align charging/discharging cycles with energy price fluctuations and demand peaks.

V1G and V2G Integration: Smart charging and bidirectional energy flow to maximize solar PV self-consumption.

Cost-Effective Operations: Reduction of peak load charges and demand-based electricity tariffs.

Seamless User Experience: Plug-and-charge solutions with enhanced automation for user convenience.

Research and Innovation Hub: Living lab setup at Chalmers University enables real-life testing of future energy solutions.

Pain Relievers (Solutions That Mitigate Stakeholders' Challenges)

Battery Degradation Analysis: Data-driven insights to balance financial gains from V2G with battery wear costs.

ISO 15118-20 Implementation: Standardized communication protocols for better system interoperability.

Flexible Charging Mechanisms: Combination of V1G (unidirectional) and V2G (bidirectional) to cater to different EV compatibility levels.

Regulatory Alignment: Collaboration with policymakers to develop supportive frameworks for V2G adoption.

Products & Services (Specific Offerings Provided within the Smart Charging Ecosystem)

Smart Charging and V2G-Enabled Infrastructure: Installation of bidirectional AC and DC chargers integrated with an EMS.

Energy Optimization Algorithms: Software solutions that enhance self-consumption and grid participation strategies.

Real-Time Monitoring Platform: Web-based interface for tracking energy usage, cost savings, and environmental impact.

Stakeholder Collaboration: Partnerships with energy suppliers, grid operators, and building owners for seamless energy management.

Revenue-Sharing Models: Monetization of flexibility services, demand response participation, and cost savings distribution.

Customer Profile

Gains (Expected Benefits for Stakeholders)

Cost Reduction: Lower electricity bills through smart charging and peak shaving.

Optimized Renewable Energy Use: Maximized self-consumption of onsite solar PV energy.

Grid Flexibility: Improved grid stability by delivering power back to the distribution system operator (DSO).

Sustainability Goals: Reduced carbon footprint by integrating renewable energy with EV charging.

Energy Independence: Less dependency on the grid, allowing better control over energy costs.

Interoperability: Compliance with ISO 15118-20 ensures seamless integration across different systems.

Revenue Generation: Financial incentives through participation in flexibility markets.

Customer Jobs (Tasks or Activities Stakeholders Need to Perform)

Charge Management: Optimize EV charging schedules to align with solar PV production and electricity price fluctuations.

Grid Services Participation: Provide bidirectional energy transfer to support grid balancing and peak shaving.

Battery Health Monitoring: Evaluate the economic viability of V2G based on battery degradation analysis.

Policy Compliance: Ensure adherence to national and European regulatory standards for V2G operations.

User Engagement: Encourage EV drivers to participate in smart charging programs through incentives and clear communication.

Pains (Challenges or Problems Faced)

Limited V2G-Compatible EVs: Public access to bidirectional charging is constrained due to a lack of compatible vehicles.

Battery Degradation Concerns: Uncertainty regarding the long-term impact of V2G on EV battery lifespan and economics.

Complexity of Implementation: Need for sophisticated energy management systems (EMS) and communication protocols.

Regulatory Uncertainty: The evolving policy landscape for V2G services may impact business viability.

Technical Barriers: Compatibility challenges between different charging standards (OCPP 1.6, ISO 15118-2, and MQTT protocols).

Market Uncertainty: Difficulty in assessing financial benefits due to fluctuating electricity tariffs and demand response pricing.

EMS-Backed Load Management: Optimized energy flow to reduce grid dependence and mitigate demand spikes.				

The most notable gains relate to cost reductions through peak shaving, revenue generation by participating in grid services, and the improved sustainability that results from higher self-consumption of renewable energy. At the same time, users and site owners confront pains such as initial equipment costs and potential complexity in building automation systems. Effective mitigation strategies include transparent regulatory support, robust communication standards, and data-driven battery health monitoring. By tailoring charging schedules to coincide with off-peak tariffs and peak solar production, the V2B model maximises renewable energy use and minimises electricity expenses. This convergence of technological readiness, policy stability, and user engagement underscores the potential of real-time energy management to scale V2G across multiple building types and user profiles.

Drivers and barriers of TOP3 value propositions

Value Proposition	Drivers	Barriers
Cost Savings	• Energy Price Volatility: High energy price differences between peak and off-peak hours create financial incentives for users to optimize energy use via V2G. • High Tariff Charges for Peak Load: Increasing costs for peak demand provide building owners a direct benefit from peak shaving facilitated by the EMS. • Renewable Energy Policies: Favourable policies promoting the self-consumption of solar PV encourage the adoption of solutions like the EMS to optimize PV integration.	• Initial Investment Costs: The high upfront costs for installing V2G-compatible EVSE, upgrading grid infrastructure, and integrating the EMS may deter adoption. • Limited Awareness: Building owners and EV users may not fully understand the financial benefits of reducing electricity costs through optimized energy management. • Regulatory Complexity: Navigating grid codes and policies to enable peak shaving and off-peak charging requires significant effort and compliance expertise.

Optimized Asset Utilization	• Increasing EV Adoption: A growing EV fleet provides more opportunities to use EV batteries as distributed energy resources. • Technological Advancements: Progress in V2G-compatible hardware and EMS software makes the efficient use of EV batteries and renewable energy systems feasible. • Environmental Goals: Rising pressure to meet decarbonization targets encourages the use of assets like EV batteries and PV systems to maximize renewable energy integration.	• Battery Degradation Concerns: Discharging EV batteries for V2G purposes may raise concerns about battery lifespan, discouraging both EV users and providers. • Interoperability Challenges: Compatibility issues between different EVs, chargers, and EMS systems may hinder the seamless deployment of optimized solutions. • Low-Capacity Utilization: In cases where V2G participation is sporadic or poorly scheduled, the EMS may not achieve its potential for asset optimization, reducing its perceived value.
Revenue Generation	• Energy Market Opportunities: Ancillary service markets (e.g., frequency regulation and demand response) present new revenue streams for the EMS provider through V2G integration. • Growing Demand for Flexibility Services: Utilities and grid operators increasingly seek flexible solutions to balance intermittent renewable energy sources and grid demand. • High Value of V2G Services: Aggregating multiple EVs to provide grid services can generate significant revenues, particularly in markets with high electricity price volatility.	• Market Maturity: Limited access to fully developed energy markets in certain regions may restrict revenue generation opportunities for V2G services. • Revenue Sharing Models: Complex revenue-sharing arrangements between stakeholders (e.g., EV drivers, building owners, grid operators) may reduce the profitability for EMS providers. • Uncertain Incentives: Variability or absence of financial incentives for grid services can reduce the attractiveness of participating in energy markets.

Value Proposition Summary

The Chalmers V2G use case in Gothenburg focuses on peak shaving, optimizing PV self-consumption, and integrating bidirectional energy flows into building energy management systems. Through advanced EMS algorithms, interoperability standards, and smart charging, the model aims to lower energy costs, enhance grid stability, and maximize renewable energy use. Addressing key challenges such as battery degradation, market uncertainty, and regulatory complexity, this use case demonstrates a scalable and replicable approach for sustainable EV energy management.

7.5 Business Model Canvas

This V2G solution employs an energy savings sharing approach centred on real-time energy management and integration of bidirectional charging equipment with onsite renewable generation. The key partners consist of Chalmers University, which leads EMS development and research, alongside vehicle manufacturers, hardware suppliers, and grid operators. Activities revolve around creating a robust energy management system able to optimise charging schedules, maintain compliance with ISO 15118-20 standards, and capitalise on dynamic energy pricing. The resulting value propositions include cost savings, improved grid stability, and enhanced energy independence.

Selected Energy Management Service: Optimize PV self-consumption		**Selected Business Model:** Energy Savings Sharing		**Selected Stakeholder Perspective:** Charge point operator
Key Partners Chalmers University (Use Case Leader and EMS Developer) EV manufacturers (providing V2G-enabled vehicles) Energy suppliers (providing electricity for off-peak charging) Grid operators (collaborating for grid stability services) Hardware providers (EVSE and V2G charger suppliers)	**Key Activities** Development of an energy management system (EMS) optimized for V2G and solar PV self-consumption. Implementation of ISO 15118-20 standards for V2G communication. Scheduling EV charging/discharging to reduce electricity costs and peak loads. Monitoring battery degradation to determine economic viability of V2G operations. Integration of EVs with existing building EMS to demonstrate V2G benefits. **Key Resources** V2G chargers and hardware. Onsite solar PV generation systems. EMS software and integration expertise. Skilled personnel for implementation and monitoring.	**Value Propositions** Cost Savings: Reduce electricity bills through off-peak charging and peak-load reduction. Increased Energy Independence: Maximize self-consumption of solar PV. Enhanced Grid Stability: Use V2G to discharge during peak periods, stabilizing the grid. Optimized Asset Utilization: Utilize EV batteries to store and discharge energy efficiently.	**Customer Relationships** Close collaboration with building owners to optimize EMS and ensure cost savings. Continuous engagement with grid operators for grid services. Educational initiatives to inform EV users about V2G benefits and usage. **Channels** Direct installation and integration in buildings. Collaboration with energy suppliers and grid operators for grid services. Workshops or demonstrations showcasing the benefits of V2G for stakeholders.	**Customer Segments** Building owners and managers (residential and office buildings). EV owners utilizing the V2G-enabled chargers. Grid operators benefiting from grid balancing services.
Cost Structure			**Revenue Streams**	

• EVSE Purchase Costs: Moderately higher due to V2G capabilities. • Installation Costs: Moderately higher due to integration requirements. • Metering Equipment Costs: Moderately higher for V2G-compatible equipment. • Additional Hardware/Software Costs: Moderately higher for EMS and communication modules. • Organizational and Administrative Efforts: Moderately higher for coordination and management.	• Cost savings from reduced electricity bills and optimized energy use. • Revenues from providing grid services (e.g., peak shaving, frequency regulation). • Improved asset efficiency, indirectly increasing customer retention and satisfaction.

Close collaboration with building owners, who oversee office and residential infrastructure, ensures that the EMS aligns with each site's operational constraints and energy objectives. Engaging local grid operators offers potential revenue streams through ancillary services and frequency regulation. The principal resources required span bidirectional chargers, solar PV arrays, and software platforms capable of synchronising energy production, consumption, and storage. The cost structure reflects moderately higher expenses for equipment procurement, installation, and administrative oversight, yet these are offset by potential earnings generated from grid services, time-of-use tariff benefits, and improved on-site energy use efficiency. By pursuing this shared-savings model, the project distributes financial risks and rewards among stakeholders, incentivising broader adoption and long-term sustainability.

Business Model Summary

The B4 Chalmers Use Case explores an integrated energy management solution that leverages solar PV generation, Vehicle-to-Grid (V2G) technology, and an Energy Management System (EMS) to optimize energy consumption, reduce operational costs, and enhance grid stability. The system operates within office and residential buildings, where electric vehicles (EVs) function as mobile energy storage units to balance local energy demand and contribute to grid services.

This business model focuses on optimizing PV self-consumption by intelligently managing EV charging and discharging schedules. The EMS ensures that EVs charge during periods of excess solar production and discharge energy back to buildings or the grid during peak demand, thereby reducing dependency on the main electricity grid.

The system uses real-time energy data to maximize financial and operational benefits for building owners, EV users, and grid operators. Revenue is generated through cost savings, grid service participation (e.g., peak shaving, frequency regulation), and improved asset utilization. The business model is designed to be scalable and adaptable, supporting a growing number of EVs, expanding solar PV capacity, and increasing participation in demand-side response programs.

7.6 Key financial indicators

The financial analysis underscores the interplay between capital expenditures, operating costs, and potential earnings derived from time-of-use pricing, solar self-consumption, and flexibility services. Initial investments encompass the purchase of V2G-ready chargers, grid upgrades, and software integration. Although these costs are moderately higher than conventional charging installations, the system's ability to shift consumption away from expensive peak periods and into cheaper off-peak slots fosters meaningful long-term savings.

1. Capital Efficiency Indicators	Example input data
Total Capital Expenditure (CAPEX)	€ 6.200,00
Charger Hardware Cost	€ 2.500,00
Installation & Commissioning	€ 500,00
Software/EMS Setup	€ 200,00
Grid Upgrade Cost	€ 3.000,00
Payback Period (PP)	
2. Operating Efficiency Indicators	
Operating Expenditure (OPEX)	€ 120,00
Maintenance Cost	€ 50,00
Cloud/Software Fees	€ 50,00
Support & Admin	€ 20,00
Utilization Rate of Chargers	33%
Total Hours in Use	8
Total Available Hours	24
Battery Degradation Cost per kWh Discharged	0,14
Estimated Loss in Battery Value	€ 2.000
Total kWh Discharged via V2G	14000
3. Revenue and Savings Indicators	
Demand Charge Savings (Peak Shaving Gains)	€ 40,00
Original Peak Demand Cost	€ 120
Reduced Peak Demand Cost	€ 80
Grid Services Revenue	€ 170,40
Power Provided (t)	568
Price per kWh (t)	€ 0,30
Energy Savings Sharing Ratio	500
α (agreed-upon CPO portion of savings)	50%
Total Energy Cost Savings	1000
Charging Fee Revenues (Income from EV drivers paying per kWh or per session)	85
kWh Delivered (t)	1700
Fee Rate per kWh (t)	0,05

Revenues and cost savings materialise through reduced peak demand charges, as well as additional revenue from providing ancillary grid services. Demand charge savings depend on effectively scheduling charging and discharging to flatten load curves and minimise grid imports during high tariff windows, while real-time energy management optimises the use of solar PV production. Battery degradation rates factor into the overall cost model, but with advanced EMS strategies, the trade-off between revenue generation and battery wear can be balanced. In parallel, the user experience remains central, as maintaining high satisfaction levels ensures wider participation and cultivates a robust customer base. Overall, these metrics demonstrate a financially feasible structure for V2G adoption in office and residential settings, confirming that appropriately managed bidirectional charging can bring measurable economic and environmental benefits.

Revenue Parameters	Cost Parameters
Time-of-Use Pricing Revenue	**Infrastructure and Technology Costs**
• Number of Participating Customers	• Smart Grid Technology Costs
• Time-of-Use Price Differentials	• V2G Integration Costs
• Energy Transacted	• Software and Analytics Tools
• Load Shifted	**Operational Costs**
Grid Service Payments	• Customer Engagement and Support
• Frequency Regulation Payments	• Program Administration Costs
• Incentive Payments from Regulators	• Maintenance Costs
• Ancillary Services Revenue	**Customer Incentive Costs**
• Revenue from Demand Response	• Incentive Payments to Customers
Solar PV Self-Consumption Savings	• Marketing and Recruitment Costs
• Onsite Solar PV Utilization Rate	**Hardware and Installation Costs**
• Electricity Bill Reduction	• EVSE Purchase Costs
• Carbon Emissions Reduction Benefits	• Installation Costs
Customer Retention and Satisfaction	• Metering Equipment Costs
• Customer Retention Rate	**Battery Degradation Costs**
• Customer Referrals	• Battery Replacement Costs
	• Degradation Rate
	Organizational and Administrative Costs
	• Staffing Costs
	• Regulatory Compliance Costs

8 Innovation Cluster C - case study C1: Station-based Serviced Office B2B car-sharing with demand side management (Oslo)

8.1 Use Case Overview

This use case explores station-based car-sharing in a serviced office context, focusing on business-to-business (B2B) demand-side management for electric vehicles at Bertil O. Steen's headquarters in Oslo. The project, led by CURRENT as the charge point operator, aims to optimise economic and operational efficiency by integrating smart EV charging infrastructure with the building's wider energy demand. Through data-driven scheduling, load balancing, and potential V2G interactions, the initiative seeks to demonstrate tangible benefits for fleet operators, building owners, and end users. Emphasis is placed on delivering cost savings, generating new revenue streams, and enhancing overall sustainability. The real-world demonstration is intended to validate the business model, technology readiness, and end-user acceptance required to replicate this solution in other commercial or mixed-use developments.

By employing an energy savings sharing model, the pilot fosters collaborative relationships among stakeholders, including local energy providers, regulatory bodies, and technology manufacturers. The objective is to reduce peak electricity demand while showcasing a financially viable approach for incorporating EVs into existing corporate mobility strategies. Key success factors will include interoperability across multiple hardware and software platforms, as well as regulatory compliance with evolving Norwegian and European policies on energy flexibility and grid services. Ultimately, the project aspires to serve as a catalyst for widespread adoption of smart charging solutions in commercial settings, paving the way for efficient, low-carbon transportation networks.

Use Case Overview	
Use case name	C1 Station-based Serviced Office B2B car-sharing with demand side management (Smart charging EVs + Building energy demand)
Objective	The primary goal of this use case is to optimize the economic and operational efficiency of electric vehicle (EV) charging infrastructure through innovative energy management strategies and business model development. This use case focuses on demonstrating how these strategies can be implemented in real-world scenarios to deliver mutual benefits for energy stakeholders, charging operators, and EV drivers.
Use case leader	CURRENT
Use case leader organization type	Charge point operator

8.2 Case study boundary conditions

General Conditions	
Country	Norway
Time Frame	2-3 years
V2X Type	V2G
Technological Assumptions	
Technology Maturity Level	Emerging (1)
Adoption Rate Outlook	Medium (2)
Interoperability Compatibility Level	Fair (2)
Conditions on Site	
Existing Connection Capacity	Moderate Capacity
Ability to Facilitate Selected V2X	Partial
Connection Capacity Category	Needs Upgrade (2)
Local Infrastructure Condition	Good (3)
Potential to Increase Renewable Capacities	Medium (2)
Selection of Energy Management Services	
EMS Optimization Cluster	Local Behind-the-Meter
Energy Management Service	Peak Shaving
Market Assumptions	
Market Size and Growth	4: Significant Growth
Demand for Electric Vehicles	5: High
Grid Services Demand	4: Above Expectations
Competitive Landscape	2: Dominant
Innovation Rate	3: Expected
Electricity Price Fluctuations	3: Moderately Volatile
Expected Price Changes in the Next 5 Years	Increase
Impact on V2X Profitability	5: Positive

Value Proposition (TOP 5)	
1. Cost Savings 2. Operational Efficiency 3. Enhanced Customer Experience 4. Revenue Generation 5. Optimized Asset Utilization	
Regulatory Assumptions	
Policy Environment Stability	2: Slightly Unstable
Commercial Exploitation Allowance	2: Limited Market
Availability of Incentives	No
Level of Incentives	Poor
Effectiveness	Ineffective
Economic Conditions	
EVSE Purchase Cost	Moderately Higher Price
Installation Costs	Moderately Higher Price
Metering Equipment Costs	Moderately Higher Price
Additional Hardware/Software Costs	Moderately Higher Price
EV Purchase Costs	Moderately Higher Price
EV Operation Costs	Neutral Price
Organizational and Administrative Efforts	Extremely Higher Price Premium
Business model	4. Energy Savings Sharing
Environmental Benefits	
Social Benefits	

The pilot takes place in Norway, where electric vehicle adoption is already considerable, yet the use of V2G technology remains at an emerging level. Over the next two to three years, this use case will examine the technical feasibility of integrating bidirectional charging in a setting with moderately volatile electricity prices and a grid infrastructure that requires upgrades to fully accommodate V2X capabilities. Local infrastructure at the demonstration site provides good baseline conditions, although the ability to facilitate V2G is only partial at present.

Despite a slightly unstable policy environment that offers no significant incentives for V2G activities, market growth for EVs in Norway is expected to remain strong. The high demand for flexible grid services provides favourable prospects for commercial exploitation, although limitations on regulatory allowances and poor incentive structures could slow large-scale deployment. Within the economic framework, moderately higher upfront costs for equipment and software must be balanced against the potential gains from peak shaving and reduced operational expenses. By focusing on energy savings sharing, the initiative aims to prove that appropriately managed V2G solutions can deliver mutual benefits for stakeholders while setting the stage for broader market uptake.

8.3 Stakeholder Analysis

The stakeholder ecosystem for this Oslo-based pilot involves multiple parties with varying degrees of interest, influence, and significance. Electric vehicle drivers, including employees and car-sharing customers, hold moderate interest but lower decision-making authority. By contrast, fleet operators and the site owner, Bertil O. Steen, exercise both higher influence and importance, given their control over fleet management and infrastructure investments. Government and regulatory bodies, such as local municipalities and the Norwegian Water Resources and Energy Directorate, possess substantial policymaking influence, though their direct interest may be tempered by competing priorities.

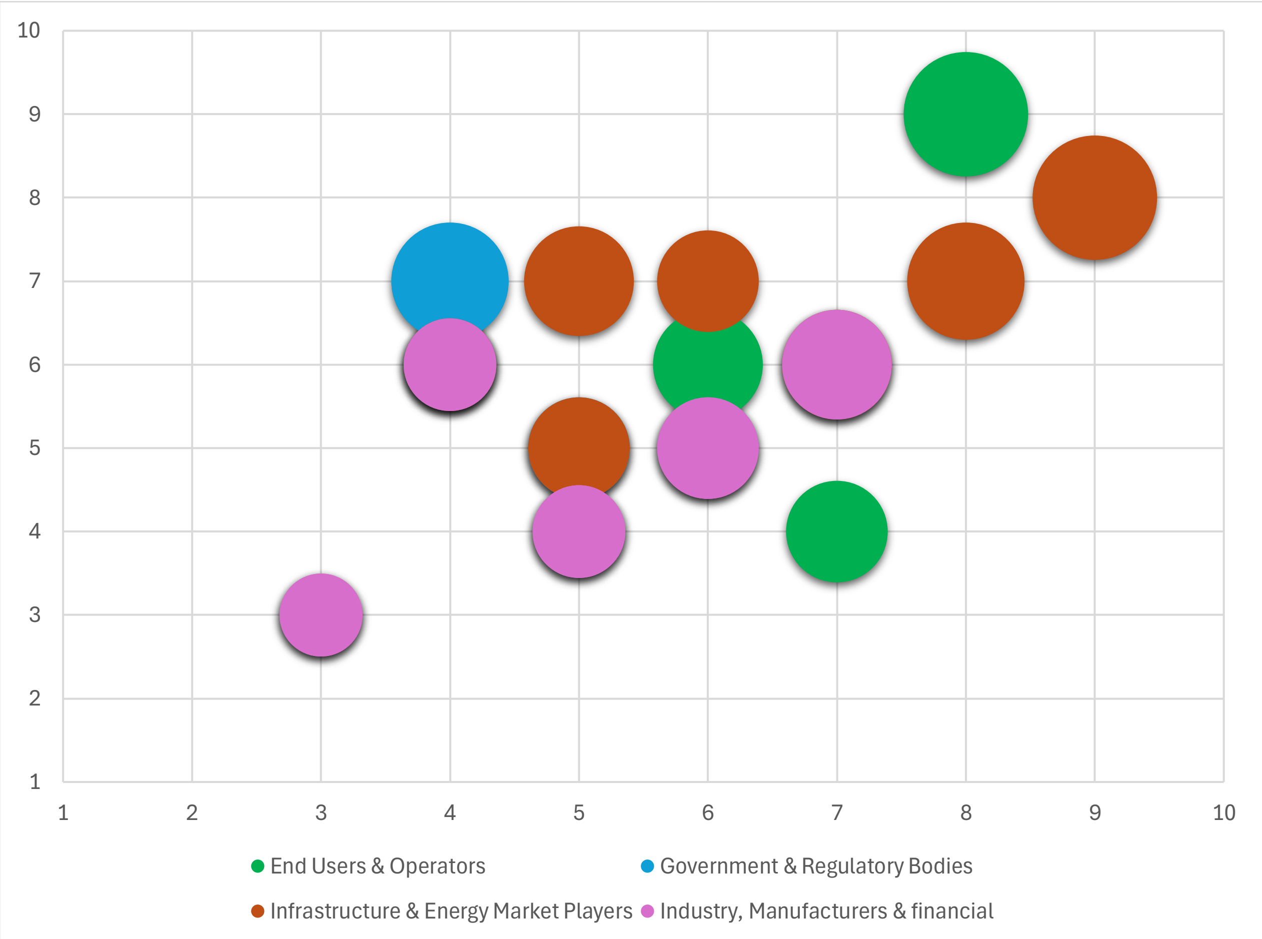


Figure 3: stakeholder matrix about use case C1

In the private sector, aggregators, and flexibility service providers, including CURRENT, operate at the intersection of technology innovation and market engagement, wielding a medium to high level of influence and interest. Equipment manufacturers and battery suppliers play more focused but still pivotal roles by delivering specialised hardware and ensuring the functionality of V2G-capable systems. Financial institutions, research partners, and energy market players contribute capital, technical insights, and operational expertise, shaping both the feasibility and commercial viability of the solution. Balancing the demands of each stakeholder is crucial for achieving consensus on infrastructure upgrades, standardisation protocols, and revenue-sharing models. By aligning these varied interests, the project aims to demonstrate that integrating smart charging and V2G can create new business opportunities and sustainable outcomes for all parties involved.

Type	Stakeholder types	Stakeholder	Interest	Influence	Importance
End Users & Operators	Electric vehicle driver	Employees, fleet users, and car-sharing customers at Bertil O. Steen HQ	7	4	6
End Users & Operators	Fleet operators	Bertil O. Steen's internal fleet management, car-sharing service providers	6	6	7
End Users & Operators	Site owner	Bertil O. Steen (managing car dealership and HQ facilities)	8	9	9
Government & Regulatory Bodies	European and national regulators	Norwegian Water Resources and Energy Directorate (NVE), European Commission	4	7	8
Government & Regulatory Bodies	Local and regional authorities	Lørenskog Municipality, Norwegian Energy Authority	5	5	6
Government & Regulatory Bodies	Standardization organization	ISO 15118 working group, Norwegian EV standards bodies	4	6	5
Industry, Manufacturers & financial	Aggregator and flexibility service provider	CURRENT (potential aggregator for flexibility services)	7	6	7
Industry, Manufacturers & financial	Battery manufacturer	Suppliers of stationary battery storage systems	5	4	5
Industry, Manufacturers & financial	Charge point manufacturer	Suppliers of bidirectional chargers for V2G testing	6	5	6
Industry, Manufacturers & financial	Electric vehicle manufacturer	KIA (testing V2G-compatible vehicles in the project)	6	5	6
Industry, Manufacturers & financial	Financial institution	Investors supporting infrastructure upgrades for smart charging	4	6	5
Industry, Manufacturers & financial	PV manufacturer	Renewable energy technology providers supporting onsite solar integration	5	4	5
Industry, Manufacturers & financial	RTOs and universities	Research institutions involved in smart charging and V2G innovation	3	3	4

Industry, Manufacturers & financial	**Validation data provider**	Research partners validating smart charging/V2G benefits	3	3	4
Infrastructure & Energy Market Players	**Balance responsible party**	Energy trading entities managing energy market participation	5	5	6
Infrastructure & Energy Market Players	**Charge point operator**	CURRENT (operating and managing the smart charging infrastructure)	9	8	9
Infrastructure & Energy Market Players	**Distribution system operator**	Elvia (local DSO managing grid infrastructure in Lørenskog)	5	7	7
Infrastructure & Energy Market Players	**eMobility service provider**	CURRENT (providing smart charging and demand response services)	7	6	7
Infrastructure & Energy Market Players	**Energy Management Service provider**	CURRENT (energy management solutions), potential EMS software providers	8	7	8
Infrastructure & Energy Market Players	**Energy supplier**	Power companies supplying energy to Bertil O. Steen HQ	6	7	6
Infrastructure & Energy Market Players	**Transmission system operator**	Statnett (Norwegian TSO)	4	6	5

8.4 Value Proposition Canvas

This pilot's value proposition relies on intelligent energy management that seamlessly integrates electric vehicles into the building's energy ecosystem. Gains include cost savings from demand charge reduction, additional revenue from flexibility market participation, and more efficient use of onsite renewable energy, where available. These outcomes benefit not just building owners and fleet operators, but also EV drivers who gain convenient, user-friendly access to charging infrastructure. Pain points such as high peak load costs, uncertain regulations, and interoperability challenges are tackled through advanced EMS software, open communication standards, and collaborative engagement with policymakers.

The aim is to deliver both an improved operational profile for the building, by shaving peaks and lowering overall energy expenditure, and a more compelling charging experience for drivers, who benefit from automated billing, flexible pricing, and an easy-to-use interface. The shift to a smarter energy system also has broader environmental advantages, supporting the adoption of cleaner transport options while enhancing grid stability. Overcoming lingering concerns about battery degradation and policy limitations is key to scaling this approach, yet the combined emphasis on tangible cost reductions, technological innovation, and stakeholder cooperation positions the project to provide concrete, data-driven evidence of the long-term value of demand-side management in a commercial setting.

Selected Energy Management Service: Optimize PV self-consumption

Selected Business Model: Real-Time Energy Management

Value Map

Gain Creators (Ways the Smart Charging Ecosystem Creates Value)

Demand Charge Reduction: Smart charging aligns EV charging with off-peak hours and renewable energy availability, reducing electricity costs.

Participation in Flexibility Markets: Charging operators can adjust charging patterns to support grid stability and generate additional revenue.

Renewable Energy Integration: Maximizes self-consumption of on-site energy from the waterfall and PV system, reducing reliance on external power.

Enhanced User Experience: Automation of billing and user authentication through digital platforms and license plate recognition.

Grid-Friendly Energy Management: Dynamic load balancing ensures optimized energy distribution without causing grid strain.

Interoperability & Open Standards: Adoption of OCPP and OCPI enables compatibility with multiple charging networks and fleet management platforms.

Pain Relievers (Solutions That Mitigate Stakeholders' Challenges)

Products & Services (Specific Offerings Provided within the Smart Charging Ecosystem)

Smart Charging Infrastructure: Deployment of unidirectional AC and bidirectional DC charging stations optimized for peak shaving.

Energy Management System (EMS): AI-powered software for real-time load balancing and demand response.

Flexibility Market Participation Tools: Integration with energy markets to enable revenue generation from grid services.

Digital Charging Platform: Real-time monitoring, automated billing, and dynamic pricing for EV drivers.

Regulatory & Compliance Advisory Services: Ensuring adherence to energy policies and charging regulations.

Customer Profile

Gains (Expected Benefits for Stakeholders)

Cost Savings: Reduces electricity costs for building owners by optimizing energy consumption and leveraging demand charge reduction.

Revenue Generation: Enables participation in flexibility markets, creating an additional income stream for charging operators.

Optimized Charging Infrastructure Utilization: Enhances efficiency in energy management, maximizing local renewable energy use and reducing grid dependency.

Seamless Charging Experience: Improved accessibility and usability for EV drivers through smart charging features.

Sustainability Impact: Reduces carbon footprint by integrating EV charging with renewable energy sources such as on-site hydropower and PV.

Regulatory Compliance & Incentives: Aligns with energy regulations and incentives promoting grid-friendly charging and renewable integration.

Customer Jobs (Tasks or Activities Stakeholders Need to Perform)

Pains (Challenges or Problems Faced)

High Peak Load Costs: Grid tariff structures impose high costs during peak demand hours, affecting operational expenses.

Limited Infrastructure Integration: Smart charging solutions need seamless integration with fleet management and building energy management systems (EMS).

Interoperability Issues: Lack of standardization and limitations in existing protocols (ISO 15118-3, ISO 15118-20) restrict the full implementation of Plug & Charge.

Regulatory Uncertainty: Unclear policies around V2G and flexibility services create

Smart Charging Deployment: Reduces peak demand by shifting charging loads to lower-cost periods. Grid Tariff Optimization: Automatically adjusts charging based on real-time energy prices to ensure cost-effective usage. Seamless User Authentication & Billing: Tests license plate recognition as an alternative to Plug & Charge for a frictionless experience. Data-Driven Fleet & Building Energy Management: Integrates with fleet management systems to enable automated scheduling and real-time monitoring. Battery Degradation Mitigation Strategies: Ensures optimal charge/discharge cycles to minimize wear on EV batteries. Regulatory Alignment & Standardization: Supports compliance with ISO 15118-20, OCPP 2.0.1, and OCPI 2.2.1 to future-proof smart charging infrastructure.			Building Owners / Operators: Optimize EV charging costs while ensuring a seamless charging experience for tenants and visitors. Fleet Operators: Efficiently manage EV fleet charging schedules while minimizing operational expenses. EV Drivers: Access reliable and cost-effective charging without dealing with complex billing structures. Energy Suppliers / DSOs: Balance demand loads while optimizing the use of locally generated renewable energy. Regulators & Policy Makers: Develop supportive frameworks for V2G and smart charging while ensuring grid stability.	adoption barriers for stakeholders. EV Battery Degradation Concerns: Frequent charging and discharging cycles raise concerns about battery lifespan and economic viability for fleet owners. Complexity in User Billing & Authorization: Ensuring a smooth payment and authentication process without compromising ease of use.

Drivers and barriers of TOP3 value propositions

Value Proposition	Drivers	Barriers
Cost Savings	• Implementation of smart charging and V2G technologies reduces grid dependency and operational costs. • Avoidance of peak demand charges through demand-side management. • Leveraging local renewable energy (e.g., solar PV) minimizes electricity costs from the grid.	• High initial infrastructure investment for V2G chargers and energy management systems. • Unstable regulatory environment may lead to limited incentives and hinder profitability. • Battery degradation costs from frequent V2G usage might offset potential cost savings.
Operational Efficiency	• Integration with energy management systems ensures optimal scheduling and load balancing. • Real-time data analytics enable adaptive charging to align with grid tariffs and renewable generation. • Optimization of charging based on real-time grid conditions reduces inefficiencies in energy use.	• Lack of interoperability among various systems (e.g., ISO 15118 compliance issues) complicates operations. • Maintenance costs for advanced hardware/software systems (e.g., bidirectional chargers) may increase. • Limited technical readiness of current chargers to fully implement smart and bidirectional charging.

Enhanced Customer Experience	• Seamless user experience with automated processes like Plug & Charge and integrated fleet management systems. • Ability to offer flexible pricing models aligned with customer needs enhances satisfaction. • Advanced digital tools (e.g., mobile apps) provide customers with insights and control over charging.	• Technical limitations in enabling ISO 15118 Plug & Charge functionality hinder customer ease of use. • Lack of customer awareness about the benefits of V2G and smart charging technologies. • Limited trust and adoption by customers due to concerns over battery degradation and data privacy.

CURRENT's Station-Based Serviced Office B2B Car-Sharing model at Mustad Eiendom, Oslo focuses on reducing peak load charges, optimizing energy consumption, and integrating renewable energy sources. By implementing smart charging and V2G, the project enhances the economic and operational efficiency of EV infrastructure, benefiting building owners, fleet operators, EV drivers, and energy stakeholders.

Through demand-side management, automated billing, and flexibility market participation, the solution enables cost-effective and scalable energy optimization. Regulatory compliance, interoperability, and seamless fleet management integration are key enablers of success. By leveraging OCPP, OCPI, and advanced energy analytics, CURRENT creates a future-proof business model that supports grid stability, financial sustainability, and an enhanced charging experience for all stakeholders.

Value Proposition Summary

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8.5 Business Model Canvas

This use case adopts an energy savings sharing approach centred on peak shaving, allowing building owners and fleet operators to share in the cost reductions gained from more efficient energy use. Collaborative partnerships between site owners, local authorities, energy suppliers, and technology providers form the backbone of the model, each contributing complementary resources, expertise, or regulatory support. Key activities include the deployment of both unidirectional and V2G-capable chargers, the integration of software platforms to automate scheduling and billing, and the ongoing alignment of charging patterns with grid capacity and price signals.

Selected Energy Management Service: Peal Shaving

Selected Business Model: Energy Savings Sharing

Selected Stakeholder Perspective: Charge point operator

Key Partners

Local and Regional Authorities: For regulatory support and potential incentives.

Energy Suppliers: Collaboration to optimize energy procurement and usage patterns.

EV Fleet Operators: Partnership to manage EV fleet charging and ensure demand flexibility.

Technology Providers: Suppliers of smart charging infrastructure and software for energy optimization.

Renewable Energy Developers: Integrate locally generated renewable energy (e.g., waterfalls, PV).

Building Owners (Mustad Eiendom): Site hosting for the charging infrastructure.

Key Activities

Smart Charging Deployment: Implementing unidirectional and bidirectional charging stations for demand charge management.

Demand Response Management: Aligning energy consumption with grid capacity and price signals.

Energy Management Optimization: Utilizing local renewable energy production and storage systems.

Interoperability Enhancement: Ensuring seamless communication between chargers, fleet systems, and building energy systems.

System Monitoring and Analytics: Real-time tracking of energy consumption, grid impacts, and cost savings.

Customer Engagement and Support: Simplifying billing, authorization, and usability for EV drivers.

Regulatory Compliance: Adhering to ISO 15118, OCPP 2.0.1, and OCPI standards.

Key Resources

Value Propositions

Cost Savings: Reduced grid fees by minimizing peak loads. Savings from utilizing locally generated renewable energy.

Revenue Generation: Participation in flexibility markets and demand response programs. Monetization of energy optimization services.

Optimized Asset Utilization: Efficient use of charging stations and local renewable energy sources. Enhanced utilization of infrastructure through smart energy management.

Improved User Experience: Seamless plug-and-charge solutions for EV drivers. Transparent billing and efficient charging.

Environmental Benefits: Reduction in carbon emissions by maximizing renewable energy use.

Customer Relationships

Dedicated Support Services: Provide tailored assistance for fleet operators, building owners, and EV drivers through responsive customer support teams.

Partnerships and Collaboration: Build long-term relationships with building owners and energy stakeholders through joint initiatives and shared savings models.

Digital Engagement: Utilize platforms for transparent billing, real-time insights, and personalized energy optimization recommendations.

Channels

Customer Segments

EV Fleet Operators: Manage demand and optimize fleet charging costs.

Building Owners/Operators: Reduce operational costs associated with electricity usage.

EV Drivers: Enhance charging experiences and reduce personal electricity costs.

Energy Suppliers: Leverage local energy production and demand flexibility.

Policy Makers and Regulators: Align with sustainability goals and reduce grid strain.

Flexibility Service Providers: For participating in demand response and flexibility markets.	Charging Infrastructure: AC and DC smart charging stations, including V2G-capable chargers. Renewable Energy Sources: Local power generation from waterfalls and PV systems. Energy Management System: Software for demand optimization and load balancing. Data Analytics Platform: For real-time energy monitoring and decision-making. Partnerships: Stakeholder relationships with energy suppliers, fleet operators, and building owners. Workforce Expertise: Skilled personnel for operations, monitoring, and customer support.		Digital Platform: Online interface for customer engagement, billing, and real-time energy monitoring. Customer Support Services: Direct support for fleet operators and EV drivers. Partnership Networks: Collaboration with building owners and renewable energy developers to reach end-users. Market Participation: Flexibility services and energy trading markets.	

Cost Structure	**Revenue Streams**
• Infrastructure and Installation Costs: AC and DC charging stations, V2G hardware. Upgrading grid connections and local infrastructure. • Technology Costs: Energy management software and analytics tools. Communication protocols (OCPP, OCPI). • Operational Costs: Maintenance and support for charging infrastructure. Customer service and engagement. • Regulatory Compliance Costs: Certification and adherence to ISO 15118 and other standards. • Marketing and Recruitment Costs: Promoting services to EV drivers, fleet operators, and other customers.	• Energy Savings Sharing: Sharing cost savings from reduced demand charges and energy optimization with building owners. • Participation in Flexibility Markets: Revenue from grid services and demand-response programs. • Charging Fees: Payments from EV drivers for charging services. • Increased Renewable Energy Utilization: Revenue from optimized local renewable energy production. • Data Monetization: Insights and analytics sold to stakeholders for energy planning and operations.

By providing transparent insights into consumption data, customer relationships focus on trust-building and service quality, aiming to deliver measurable savings and a smoother EV charging experience. The cost structure arises from the purchase, installation, and operation of the chargers, along with the advanced software tools that enable energy optimisation. Revenues derive from shared savings on demand charges, payments for grid services such as demand response, and typical user or session fees for charging. In this way, the model transforms energy management into a strategic asset, enhancing both financial returns and environmental performance.

Business Model Summary

The business model for CURRENT revolves around leveraging smart charging, local renewable energy sources, and energy optimization strategies to reduce peak demand charges and monetize flexibility services. CURRENT collaborates with local authorities, energy suppliers, and fleet operators to integrate advanced energy management solutions that align EV charging with demand response signals, reducing electricity costs for building owners and EV drivers. By deploying AC and DC smart charging stations, including V2G-capable chargers, CURRENT optimizes energy consumption through load shifting and participation in flexibility markets. The energy management system balances energy flow between EVs, the grid, and locally generated renewable sources such as waterfalls and PV installations, ensuring cost-effective and sustainable energy usage.

Through an energy savings sharing model, CURRENT enables building owners to benefit from reduced demand charges while receiving a share of the cost savings generated from optimized energy use. The company also generates revenue by participating in demand-response programs, earning grid service payments for peak shaving and frequency regulation. Additional income streams come from charging fees, optimized renewable energy utilization, and monetization of energy consumption data for stakeholders involved in energy planning.

CURRENT ensures customer satisfaction through a digital platform that provides real-time energy insights, seamless billing, and automated charging management. Dedicated support services help fleet operators and building owners maximize energy savings, while partnerships with regulators and energy providers ensure compliance with ISO 15118 and other standards. By integrating EV charging with building energy systems, CURRENT creates a scalable business model that enhances grid stability, maximizes renewable energy use, and improves overall energy efficiency for large-scale commercial sites.

8.6 Key financial indicators

The financial success of this pilot rests on balancing moderately higher initial investment costs with the potential for significant, recurring cost savings. Infrastructure expenditures include V2G-ready chargers, metering equipment, and ancillary hardware or software needed for effective load balancing and data analytics. Regulatory compliance and coordination with multiple stakeholders can also elevate administrative costs, albeit with the prospect of earning revenues from flexibility markets and reducing overall electricity bills through peak shaving. Where user uptake is sufficiently high, and local electricity price differentials are pronounced, time-of-use pricing revenue can further enhance the business case.

Ongoing operational expenses typically involve maintenance, support, and ongoing system updates, which must be weighed against the projected savings in demand charges and the potential for future revenues if local regulators move to recognise or incentivise demand-side services. In sum, careful monitoring of cost, revenue, and utilisation metrics is essential to demonstrate that a data-driven, demand-side management strategy can deliver both economic and sustainability benefits in a commercial car-sharing context.

Revenue Parameters	Cost Parameters
Energy Optimization	**Infrastructure Investment**
• Load Shifted (kWh)	• EVSE Purchase Cost
• Time-of-Use Price Differentials	• Installation Costs
• Revenue from Optimized Energy Usage (peak shaving)	• Infrastructure Upgrade Costs
• "Battery Utilization Rate (%)	**Software and Technology**
Grid Service Payments	• Metering Equipment Costs
• Grid Service Payments (peak shaving rewards)	• Additional Hardware/Software Costs
• Ancillary Services Revenue	• Regulatory Compliance Costs
• Incentives from Regulators	**Operational and Maintenance**
• Flexibility Payments	• Operation and Maintenance Costs
Customer Revenue	• Customer Incentive Costs (shared energy savings rewards)
• Customer Participation Fees	• Program Administration Costs
• Number of Participating EVs/V2G Cars	• Battery Degradation Costs
	• Marketing and Recruitment Costs

9 Innovation Cluster C - case study C2 Highway charging with local generation & storage (Eindhoven)

9.1 Use Case Overview

This use case revolves around developing a scalable highway charging infrastructure in Eindhoven that meets the needs of heavy-duty electric vehicles (EVs). VDL, acting as the lead and representing an electric vehicle manufacturer's perspective, aims to integrate local renewables and onsite battery storage to minimise reliance on the grid. Through a combination of V2G technology, frequency regulation services, and well-defined service plans, the objective is to validate a business model capable of cutting operational costs, stabilising the grid, and promoting sustainable transport solutions. Key stakeholders include fleet operators of electric buses and trucks, energy suppliers, and charge point manufacturers who collaborate to integrate on-site solar generation, second-life batteries, and real-time optimisation software.

This pilot also employs pre-booking strategies and simulations to streamline charging logistics for heavy-duty vehicles, which have strict timetables and operational constraints. By charging during off-peak times and using smart discharge protocols, the solution aspires to reduce congestion both on the grid and at highway charging sites. Success indicators include lowering total cost of ownership for fleet operators, demonstrating viable revenue streams from energy market participation, and showcasing the environmental benefits of coupling local generation with high-capacity charging infrastructure. Ultimately, the model aims to serve as a template for efficient, grid-friendly commercial EV operations across Europe's growing network of motorways.

Use Case Overview	
Use case name	Highway charging with local generation & storage (Eindhoven)
Objective	The primary business objective of this use case is to develop a cost-effective and scalable highway charging infrastructure for heavy-duty EVs by integrating local renewable energy and battery storage, minimizing grid dependency, and optimizing operational efficiency through simulations and pre-booking strategies.
Use case leader	VDL
Use case leader organization type	Electric vehicle manufacturer

9.2 Case study boundary conditions

General Conditions	
Country	Netherlands
Time Frame	2-3 years
V2X Type	V2G
Technological Assumptions	
Technology Maturity Level	Developing (2)
Adoption Rate Outlook	Medium (2)
Interoperability Compatibility Level	Good (3)
Conditions on Site	
Existing Connection Capacity	Moderate Capacity
Ability to Facilitate Selected V2X	Partial
Connection Capacity Category	Needs Upgrade (2)
Local Infrastructure Condition	Fair (2)
Potential to Increase Renewable Capacities	Medium (2)
Selection of Energy Management Services	
EMS Optimization Cluster	Balancing Services
Energy Management Service	Frequency Regulation
Market Assumptions	
Market Size and Growth	3: Moderate Growth
Demand for Electric Vehicles	4: Above Expectations
Grid Services Demand	3: Moderate
Competitive Landscape	3: Moderate Competition
Innovation Rate	5: Fast
Electricity Price Fluctuations	4: Volatile
Expected Price Changes in the Next 5 Years	Increase
Impact on V2X Profitability	3: Moderate

Value Proposition (TOP 5)	
1. Enhanced Grid Stability 2. Revenue Generation 3. Cost Savings 4. Environmental Benefits 5. Increased Energy Independence	
Regulatory Assumptions	
Policy Environment Stability	3: Moderately Stable
Commercial Exploitation Allowance	4: Developed Market
Availability of Incentives	Yes
Level of Incentives	Very Good
Effectiveness	Moderately Effective
Economic Conditions	
EVSE Purchase Cost	Moderately Higher Price
Installation Costs	Neutral Price
Metering Equipment Costs	Moderately Higher Price
Additional Hardware/Software Costs	Moderately Higher Price
EV Purchase Costs	Moderately Higher Price
EV Operation Costs	Neutral Price
Organizational and Administrative Efforts	Neutral Price
Business model	10. Retail Sales with Service Plans
Environmental Benefits	This use case reduces grid reliance during peak hours and enables better utilization of on-site solar energy, decreasing carbon emissions.
Social Benefits	The use case improves energy security for local communities and reduces energy costs for low-income households. It eases grid congestion and potentially decreases waiting times of grid connection requests for socially important consumers.

Situated in the Netherlands, the project targets a timeline of two to three years, during which time V2G technology is expected to transition from developing to more widely adopted status. The ability to integrate with the existing grid is partial, necessitating upgrades to accommodate high-capacity charging points suitable for heavy-duty vehicles. Nonetheless, local infrastructure is deemed fair, and there is moderate potential for expanding on-site renewable capacities, particularly through solar PV arrays.

Market assumptions lean towards moderate growth in electric vehicle demand, with a faster innovation rate in hardware and software driving adoption. Electricity prices are volatile, and forecasts point to an overall increase in coming years, suggesting further incentives to optimise onsite energy usage and grid services. Regulatory conditions in the Netherlands are moderately stable, with developed markets for commercial exploitation and particularly good incentives for renewable integration. In economic terms, hardware and software costs remain moderately higher, although installation costs are more neutral, reflecting a maturing ecosystem for EVSE deployment. By focusing on a business model combining retail sales with comprehensive service plans, the project positions itself to balance near-term infrastructure expenditure against longer-term gains in revenue and operational stability.

9.3 Stakeholder Analysis

The Eindhoven project involves a broad spectrum of stakeholders that underpin the design, installation, and operation of high-capacity highway charging infrastructure. Heavy-duty EV drivers and fleet operators hold high interest, motivated by the potential reduction in total cost of ownership and improved reliability for bus and truck operations. VDL, as the site owner and lead innovator, has both high influence and importance, as it manages the charging test centre and shapes the technical requirements for integrating vehicles, battery storage, and local renewable generation. Similarly, charge point manufacturers and energy management service providers wield significant influence through equipment design and the optimisation software they furnish, supporting reliable operations under fluctuating demand.

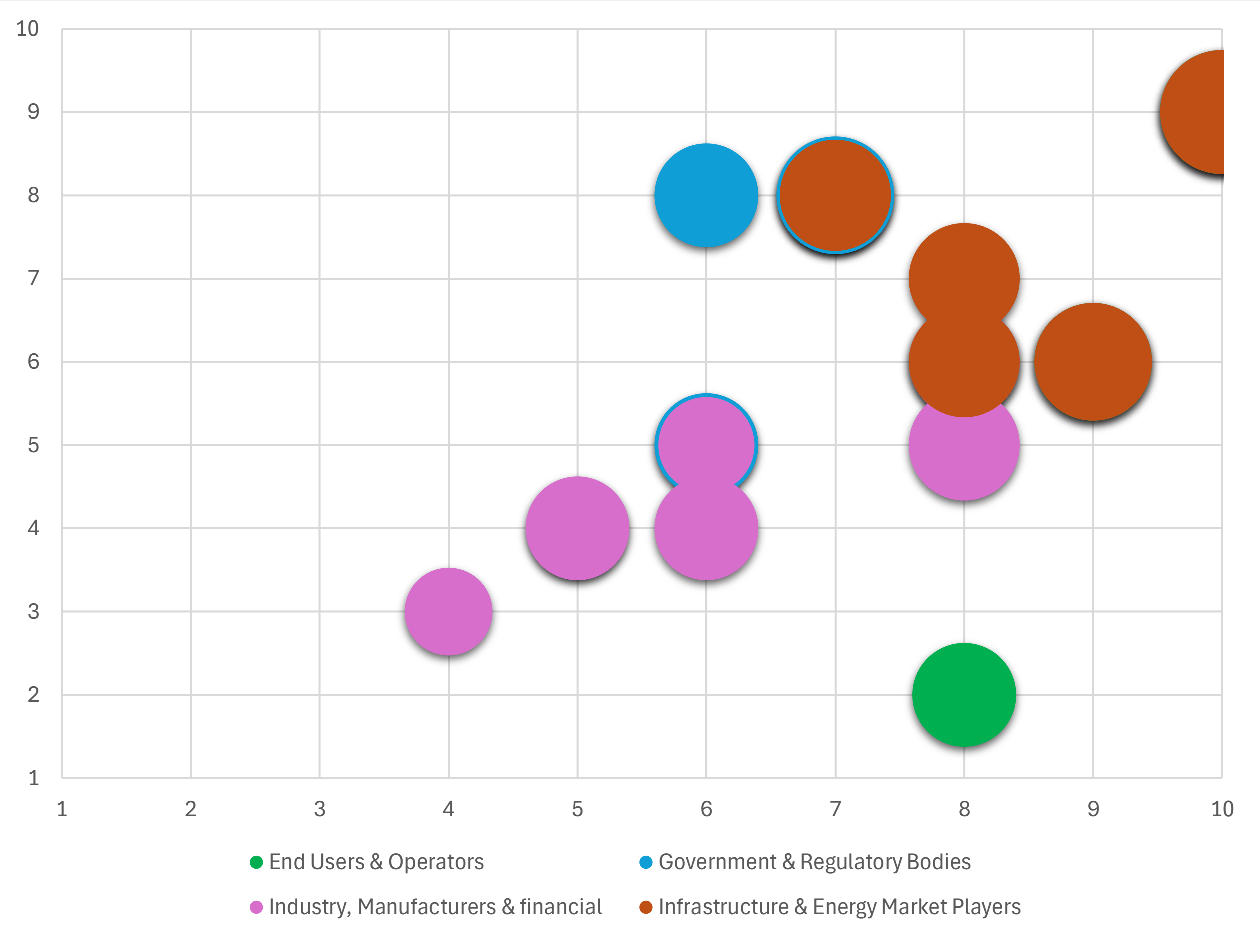

Figure 4: stakeholder matrix for use case C2

Government entities, spanning EU-level policymakers and local/regional authorities, provide essential regulatory oversight and potential incentives, although their ability to act is sometimes tempered by multiple competing priorities. Standardisation bodies such as CharIN and NEN (Dutch Standardization Institute) can accelerate or impede progress by formalising interoperable protocols critical for heavy-duty charging and V2G. In parallel, energy aggregators and grid operators are poised to enable frequency regulation and balancing services, creating new revenue streams for participants. Financial institutions, battery and PV manufacturers, and research organisations round out the ecosystem, each contributing capital, technical expertise, or data-driven insights that collectively shape the project's prospects for technical success and widespread deployment.

Type	Stakeholder types	Stakeholder	Interest	Influence	Importance
End Users & Operators	Electric vehicle driver	Heavy-duty EV drivers (bus and truck drivers) using highway charging infrastructure	8	2	7
End Users & Operators	Fleet operators	Transport companies operating electric buses and trucks	9	6	9
End Users & Operators	Site owner	VDL Charging Test Centre, Valkenswaard site owner	10	9	10

Government & Regulatory Bodies	**European and national regulators**	Netherlands Authority for Consumers & Markets (ACM), European Commission (DG MOVE, DG ENER)	7	8	9
Government & Regulatory Bodies	**Local and regional authorities**	Municipality of Eindhoven, Province of North Brabant	6	5	7
Government & Regulatory Bodies	**Standardization organization**	ISO, IEC, CharIN (Combined Charging System standards), NEN (Dutch Standardization Institute)	6	8	7
Industry, Manufacturers & financial	**Aggregator and flexibility service provider**	Companies managing energy flexibility (e.g., Next Kraftwerke, Sympower)	8	6	8
Industry, Manufacturers & financial	**Battery manufacturer**	VDL, second-life battery providers, Northvolt (potential supplier)	6	4	7
Industry, Manufacturers & financial	**Charge point manufacturer**	Heliox, ABB (suppliers of high-power DC chargers)	10	9	9
Industry, Manufacturers & financial	**Electric vehicle manufacturer**	VDL Bus & Coach (electric buses), DAF Trucks (heavy-duty EVs)	5	4	7
Industry, Manufacturers & financial	**Financial institution**	Banks or leasing companies financing infrastructure (e.g., ING, Rabobank)	4	3	5
Industry, Manufacturers & financial	**PV manufacturer**	Solar panel suppliers (e.g., SunPower, First Solar, or European manufacturers)	5	4	6
Industry, Manufacturers & financial	**RTOs and universities**	Eindhoven University of Technology (TU/e), Research & Technology Organizations collaborating with VDL	8	5	8
Industry, Manufacturers & financial	**Validation data provider**	Eindhoven University of Technology (TU/e), VDL test centre data analytics	6	5	6
Infrastructure & Energy Market Players	**Balance responsible party**	Energy supplier or aggregator managing grid balance (e.g., Eneco, Vattenfall)	7	8	8
Infrastructure & Energy Market Players	**Charge point operator**	VDL, Heliox, ABB	10	9	10
Infrastructure & Energy Market Players	**Distribution system operator**	Enexis (regional DSO managing grid connections for the site)	7	8	8
Infrastructure & Energy Market Players	**eMobility service provider**	eMSPs facilitating access and payment for heavy-duty EV charging (e.g., Allego, Fastned)	9	6	9

Infrastructure & Energy Market Players	**Energy Management Service provider**	VDL's Energy Management System (EMS), potential third-party EMS providers	8	6	8
Infrastructure & Energy Market Players	**Energy supplier**	Local or national electricity suppliers providing power for the charging hub (e.g., Eneco, Vattenfall)	8	7	8

9.4 Value Proposition Canvas

VDL's approach couples advanced energy management services—particularly frequency regulation—with a retail sales model that incorporates optional service plans. Gains stem from monetising grid-stabilisation services via V2G, reducing operational costs through peak avoidance and local renewable energy use, and bolstering environmental credentials. Pain relievers focus on addressing high initial investment costs and complex regulatory pathways by leveraging second-life batteries, automating compliance checks, and coordinating with grid stakeholders to secure incentives and navigate market rules.

In practice, fleet operators and bus companies benefit from stable energy prices, reduced downtime through predictive scheduling, and incremental revenue for providing ancillary grid services. At the same time, VDL strengthens its competitive position, transitioning from a straightforward vehicle manufacturer to a comprehensive solution provider encompassing hardware, software, and system integration. Success depends on the seamless alignment of technology, user experiences, and policy frameworks, ensuring that battery degradation is minimised, revenue streams are predictable, and standardisation efforts converge on practical solutions for heavy-duty V2G applications. By harmonising these elements, the project aspires to demonstrate a replicable template for highway charging stations that cater to commercial-scale electric transport while advancing Europe's decarbonisation agenda.

Selected Energy Management Service: Optimize PV self-consumption		**Selected Business Model:** Real-Time Energy Management	
Value Map		**Customer Profile**	
Gain Creators (Ways the Smart Charging Ecosystem Creates Value)	**Products & Services (Specific Offerings Provided within the Smart Charging Ecosystem)**	**Gains (Expected Benefits for Stakeholders)**	**Pains (Challenges or Problems Faced)**
Monetization of Frequency Regulation: Enables VDL to earn additional revenue by integrating EV charging stations and battery storage into frequency regulation markets. Enhanced Grid Stability: Smart energy management allows EVs and battery storage to contribute to grid balancing, ensuring a stable energy supply. Battery Lifecycle Optimization: Second-life battery applications reduce costs and improve sustainability while supporting frequency regulation. Fleet Efficiency and Predictable Charging: Service plans enable optimized charging schedules, reducing energy costs and improving vehicle uptime. Customer Loyalty Through Service Plans: Offering energy optimization services, predictive maintenance, and frequency regulation participation creates added value for fleet customers. Sustainability and ESG Compliance: VDL strengthens its position as an innovator in green mobility by integrating renewable energy sources with smart charging and storage. Seamless Integration with Existing EV Infrastructure: Ensures minimal disruption to existing charging systems while introducing frequency regulation services.	High-Power DC Charging Infrastructure: VDL provides and manages ultra-fast highway charging stations optimized for heavy-duty EVs. Energy Management System (EMS) for Frequency Regulation: Intelligent software to manage energy flows, charging schedules, and battery storage for grid balancing. Second-Life Battery Storage Solutions: Integration of used EV batteries to provide cost-effective energy storage and frequency regulation. Dynamic Pricing and Energy Trading Services: Optimization tools that allow fleet operators to charge at the lowest possible rates while supporting the grid. Fleet-Oriented Service Plans: Subscription-based maintenance	Revenue Generation: Additional revenue streams from frequency regulation services and energy flexibility. Enhanced Battery Lifecycle Management: Second-life battery utilization for grid services improves sustainability and cost-efficiency. Improved Charging Ecosystem: A more stable and predictable charging infrastructure enhances customer satisfaction. Grid Stability Contribution: EV batteries and charging hubs contribute to grid balancing, aligning with regulatory incentives. Brand Positioning as a Sustainable Leader: Pioneering energy management solutions enhances VDL's reputation in the e-mobility industry. Customer Retention via Service Plans: Offering value-added services like frequency regulation can strengthen customer loyalty and long-term service contracts.	High Initial Investment: Upfront costs for integrating frequency regulation and energy management into VDL's charging infrastructure. Regulatory Complexity: Compliance with energy market regulations and participation in frequency regulation markets is challenging. Technological Integration: Need for seamless integration of energy management systems with existing vehicle and charging infrastructure. Uncertain Market Demand: Unclear adoption rate of frequency regulation by fleet operators and customers. Operational Complexity: Managing the dual function of vehicles for transport and

Pain Relievers (Solutions That Mitigate Stakeholders' Challenges) Reduced Grid Dependency: By using stationary batteries and optimizing charging times, the system minimizes reliance on costly grid reinforcements. Regulatory Compliance Support: Provides VDL with automated systems to comply with European frequency regulation market rules. Lower Operational Costs: Smart energy management reduces peak demand charges and optimizes electricity costs for fleet operators. Advanced Energy Management Systems (EMS): Provides real-time data and analytics to optimize grid interaction and fleet operations. Battery Wear Mitigation Strategies: Implements controlled charge-discharge cycles to minimize battery degradation from frequent energy transactions. Pre-Booking and Predictive Analytics: Enables efficient use of charging stations, avoiding delays and unexpected downtime for fleet operators.	and energy management plans tailored for heavy-duty EV fleet operators. Pre-Booking and Charging Reservation Platform: A digital interface that allows fleet operators to schedule optimal charging slots, ensuring availability and efficiency. Smart Charging Algorithms: AI-driven charge scheduling that aligns with driver rest periods and operational needs while contributing to grid stability.	**Customer Jobs (Tasks or Activities Stakeholders Need to Perform)** Develop and Implement Energy Management Solutions: Adapt EVs and charging hubs for participation in frequency regulation. Ensure Compliance with Energy Market Regulations: Work with regulators and grid operators to meet requirements. Optimize Battery Use for Frequency Regulation: Balance energy storage, charging, and frequency regulation while minimizing degradation. Enhance Customer Engagement & Service Plans: Design retail sales models with service packages for fleet operators and bus companies. Monitor and Optimize Energy Trading: Utilize software and data analytics to maximize financial returns from frequency regulation participation. Maintain High Vehicle and Charging System Availability: Ensure EVs and infrastructure remain operational while supporting energy grid services.	energy services adds operational challenges. Risk of Battery Degradation: Participation in frequency regulation services may accelerate battery wear and impact vehicle performance.

Drivers and barriers of TOP3 value propositions

Value Proposition	Drivers	Barriers
Enhanced Grid Stability	• V2G Provides Frequency Regulation Revenue: Heavy-duty EVs can participate in grid-balancing markets (e.g., FCR, aFRR), offering a new revenue stream while supporting energy stability. • Reduces Need for Costly Grid Reinforcements: By using bidirectional charging, V2G enables charging hubs to provide flexibility to the grid, reducing the need for expensive infrastructure upgrades. • Supports Grid Congestion Management: V2G can offload stored energy during peak periods, making highway charging hubs part of the grid flexibility solution.	• Uncertain Market for Heavy-Duty V2G Services: Unlike passenger EVs, there are no proven heavy-duty V2G business models in real-world applications, making profitability uncertain. • Lack of Standardization for Heavy-Duty V2G: Standards like ISO 15118-20 and CCS for bidirectional charging in buses and trucks are still evolving, delaying large-scale adoption. • Intermittent Charging Behaviour of Long-Haul EVs: Unlike depot-based buses, long-haul trucks and coaches have unpredictable charging patterns, reducing the reliability of V2G as a grid resource.

Revenue Generation	• V2G Unlocks Dual Revenue Streams: Fleet operators can earn money from passenger/freight transport and additional grid services, increasing return on investment (ROI). • Potential for Pre-Booked Charging Contracts: If V2G-compatible trucks and buses pre-book charging slots, operators can sell predictable energy capacity to grid aggregators. • Strong Policy Support for Grid Flexibility: EU and national incentives for demand-side response and grid balancing services could make V2G participation profitable.	• Revenue Uncertainty Due to Energy Price Fluctuations: The profitability of frequency regulation and grid services varies, making financial forecasts challenging for fleet operators. • V2G Business Model Complexity: Fleet operators must manage transport operations while also acting as energy traders, which may not align with their core business. • Higher Infrastructure Costs for V2G Implementation: Upgrading highway charging hubs with bidirectional chargers, metering systems, and grid integration increases CAPEX and OPEX.
Cost Savings	• V2G Reduces Charging Costs via Peak Load Management: Smart charging and discharging allow fleet operators to minimize electricity costs by using off-peak tariffs. • Local Renewable Energy Integration Lowers Energy Costs: Charging hubs with solar and battery storage can use V2G to optimize self-consumption, reducing reliance on grid power. • Long-Term Battery Optimization for Fleets: Controlled bidirectional charging can extend battery lifespan by reducing deep discharge cycles, lowering total cost of ownership (TCO).	• Battery Degradation & Warranty Uncertainty: V2G increases battery cycling, raising concerns about degradation rates and potential impacts on manufacturer warranties. • Higher Maintenance Costs for V2G Chargers: Bidirectional charging infrastructure requires additional hardware, increasing operational expenses. • Fleet Operators May Prioritize Charging Over Discharging: In commercial transport, uptime is critical, and operators may prefer to maximize vehicle availability over participating in V2G services.

VDL creates value by addressing the key challenges faced by fleet operators transitioning to electric mobility. Operators can reduce their electricity costs by charging buses during off-peak hours and selling stored energy back to the grid during peak demand periods. This dual functionality provides an additional revenue stream through participation in frequency regulation and energy arbitrage markets. Smart energy management ensures battery lifecycle optimization, minimizing degradation while maximizing earnings. Additionally, the integration of V2G technology enhances sustainability and ESG compliance, allowing operators to contribute to grid stability while meeting government regulations and unlocking financial incentives. Predictive maintenance can reduce downtime, ensuring higher fleet reliability.

Value Proposition Summary

VDL creates value by addressing the key challenges faced by fleet operators transitioning to electric mobility. Operators can reduce their electricity costs by charging buses during off-peak hours and selling stored energy back to the grid during peak demand periods. This dual functionality provides an additional revenue stream through participation in frequency regulation and energy arbitrage markets. Smart energy management ensures battery lifecycle optimization, minimizing degradation while maximizing earnings. Additionally, the integration of V2G technology enhances sustainability and ESG compliance, allowing operators to contribute to grid stability while meeting government regulations and unlocking financial incentives. Predictive maintenance can reduce downtime, ensuring higher fleet reliability.

9.5 Business Model Canvas

VDL's business model is anchored in offering frequency regulation services through a retail sales framework enriched by subscription-based plans. Its core partners include charge point manufacturers (e.g., Heliox, ABB), energy aggregators (e.g., Next Kraftwerke, Sympower), and battery suppliers supporting both primary and second life uses. By manufacturing V2G-capable electric buses and trucks, VDL extends beyond traditional vehicle sales, integrating advanced software and analytics to align charging schedules with real-time grid requirements. Co-operation with grid operators, in turn, grants access to balancing and ancillary service markets, where heavy-duty EVs and stationary batteries can earn revenue by contributing to frequency regulation.

Selected Energy Management Service: Frequency Regulation		**Selected Business Model:** Retail Sales with Service Plans		**Selected Stakeholder Perspective:** Electric vehicle manufacturer
Key Partners	**Key Activities**	**Value Propositions**	**Customer Relationships**	**Customer Segments**
Energy Aggregators & Flexibility Service Providers: Next Kraftwerke, Sympower – integrating V2G-enabled buses into energy markets. Fleet Operators & Public Transport Agencies: Key customers adopting V2G-capable electric buses for their fleets. Charge Point Operators (CPOs): Allego, Fastned, Heliox – ensuring charging compatibility and access to infrastructure. Battery Manufacturers & Second-Life Battery Providers: Northvolt, CATL – supporting V2G battery technology and lifecycle management. Local & National Grid Operators: Enexis (DSO), TenneT (TSO) – enabling buses to participate in frequency regulation and energy flexibility services. Financial Institutions & Leasing Companies: ING, Rabobank –	Manufacture & Sell V2G-Capable Electric Buses: Produce buses with bidirectional charging to support frequency regulation. Develop & Integrate V2G Technology: Enable buses to discharge energy back to the grid or depot storage when parked. Offer Service Plans for Energy Optimization: Provide fleet operators with tailored V2G participation and energy management support. Ensure Compliance with Energy & Transport Regulations: Collaborate with authorities to align with grid and mobility regulations. Optimize Battery Performance for V2G: Implement smart charging-discharge strategies to extend battery life while maximizing revenue. Collaborate with Energy Markets & Aggregators: Work with energy companies to streamline	Dual Revenue Streams for Fleet Operators: Earn money from passenger transport and frequency regulation via V2G. Extended Battery Life & Lower TCO: Optimized charging-discharge cycles reduce degradation and lower fleet operating costs. Smart Charging & Energy Flexibility: Buses charge during low-demand hours and discharge surplus energy during peak hours. Reliable Public Transport Electrification: A scalable V2G solution enhances grid stability while providing sustainable transit. Turnkey Fleet Management Services: Subscription-based service plans covering vehicle maintenance, charging optimization, and energy trading. Carbon Reduction & Sustainability Compliance: Supports fleet operators in meeting net-zero targets and accessing government incentives.	Long-Term Fleet Service Contracts: Subscription-based maintenance, energy optimization, and V2G participation support. Dedicated Customer Success Teams: Consulting and support for transport operators integrating V2G. Predictive Maintenance & Energy Analytics: Continuous monitoring to optimize charging and fleet efficiency. Regulatory & Compliance Support: Assistance in meeting V2G participation requirements and incentive programs.	Public Transport Operators: Municipal bus fleets transitioning to electric V2G-enabled vehicles. Logistics & Coach Operators: Private fleet owners looking to reduce energy costs and monetize idle vehicle time. Municipalities & Government Agencies: Cities investing in sustainable, grid-integrated public transit solutions. Energy Grid Operators & Aggregators: Entities leveraging V2G-capable buses for grid services. Leasing & Financial Services: Companies offering V2G electric buses as a service with energy monetization plans.

financing vehicle purchases and leasing models for operators. Regulatory Authorities: Netherlands Authority for Consumers & Markets (ACM), European Commission (DG MOVE, DG ENER) – ensuring compliance with V2G regulations and incentives. Universities & R&D Centers: Eindhoven University of Technology (TU/e) – research and development for V2G optimization and market participation.	grid interaction and revenue generation. Fleet Analytics & Optimization: Provide predictive maintenance, energy trading insights, and fleet efficiency recommendations.			
	Key Resources V2G-Enabled Electric Bus Models: Fleet-ready, bidirectional charging-compatible buses. Battery & Energy Storage Technology: High-capacity battery systems optimized for V2G applications. Energy Market Integration Platform: Software enabling seamless participation in frequency regulation markets. Customer Network (Fleet Operators & Transport Authorities): Existing relationships with public transport agencies and logistics operators. Partnerships with Grid Operators & Aggregators: Agreements enabling V2G revenue streams. Technical Expertise & R&D Facilities: Development teams working on V2G, energy management, and optimization.		**Channels** Direct Sales to Public Transport Agencies & Fleet Operators: B2B partnerships for V2G bus adoption. Leasing & Mobility-as-a-Service (MaaS) Models: Subscription-based fleet access with integrated energy management. Online Customer Portal & Energy Optimization Platform: Digital tools for fleet operators to manage V2G participation. Partnerships with Charge Point Operators (CPOs) & Aggregators: Ensuring seamless grid integration and optimized charging. Industry Conferences & Government Partnerships: Advocacy and visibility through transport and energy sector events.	
Cost Structure			**Revenue Streams**	

• Manufacturing & Development of V2G Buses: Costs related to production, battery sourcing, and vehicle R&D. • Software Development & Market Integration: Investments in EMS, AI optimization, and energy market participation platforms. • Regulatory Compliance & Certifications: Ensuring V2G buses meet EU and national energy regulations. • Battery Lifecycle Management & Recycling: Costs associated with second-life battery usage and sustainability compliance. • Partnership & Licensing Fees: Payments to aggregators, grid operators, and energy service providers. • Customer Support & Maintenance Infrastructure: Costs of after-sales service, fleet management tools, and predictive maintenance.	• V2G Bus & Coach Sales: Direct revenue from selling electric V2G-enabled buses. • Subscription-Based Service Plans: Monthly or annual fees covering maintenance, energy management, and fleet optimization. • Revenue from Frequency Regulation & Grid Services: Share of earnings from fleet participation in energy markets. • Fleet Energy Trading Optimization Fees: Commission-based earnings from automated energy trading and demand response participation. • Leasing & Mobility-as-a-Service (MaaS) Plans: Recurring revenue through long-term leasing contracts with built-in V2G monetization.

Key activities focus on designing, deploying, and maintaining high-power DC charging stations equipped with battery storage capacity, enabling dynamic load management and reducing peak demand costs. The resulting value propositions include cost savings via energy arbitrage, improved uptime for fleet operators through predictive maintenance, and sustainability gains through optimised renewable consumption. Customer relationships are maintained primarily via long-term service contracts, with dedicated support to ensure compliance, manage data flows, and manage ongoing integrations. In parallel, revenue streams derive not only from vehicle and charger sales, but also from service fees, energy market participation, and the potential resale or repurposing of used batteries. This integrated approach helps create a scalable, profitable platform for heavy-duty e-mobility solutions.

Business Model Summary

VDL's business model integrates Vehicle-to-Grid (V2G) technology into its electric buses, allowing fleet operators to generate additional revenue from grid services while reducing their Total Cost of Ownership (TCO). Instead of solely selling electric buses, VDL offers a comprehensive package that includes V2G-capable electric buses, smart fleet energy management software, and subscription-based service plans covering maintenance, software updates, and V2G market participation support. This transforms buses from passive transport assets into active energy resources, enabling fleet operators to monetize idle vehicle time while optimizing their fleet's efficiency.

VDL's revenue model combines vehicle sales, subscription-based service plans, and energy trading commissions. The company generates revenue by selling V2G-enabled buses to fleet operators, public transport agencies, and logistics companies, offering service plans that provide AI-driven charging optimization, predictive maintenance, and regulatory compliance support. Fleet operators pay a monthly or annual subscription fee for these services, ensuring recurring revenue for VDL. Additionally, as fleets participate in energy markets, VDL facilitates grid interaction through its partnerships with energy aggregators and earns a commission on each energy transaction. Another revenue stream comes from battery recycling and second-life solutions, where VDL repurposes degraded bus batteries for stationary energy storage, reselling them or offering buyback programs to fleet operators.

In practice, a public transport company purchases a fleet of VDL's V2G-enabled electric buses and subscribes to VDL's Smart Fleet Energy Management service. During the day, buses operate as regular transport vehicles, charging at the lowest-cost times. At night, the parked buses connect to the grid and provide frequency regulation services, discharging stored energy during peak demand and recharging during low-demand hours. By participating in grid services, a fleet operator can save €5,000-€10,000 per year per bus on electricity costs and earn €3,000-€7,000 annually per bus from energy market participation while benefiting from optimized battery performance and longer lifespans.

For VDL, this model moves beyond traditional vehicle sales by integrating energy services into fleet electrification. It creates a continuous revenue stream through service plans and energy trading rather than relying on one-time vehicle sales. The model also enables public transport fleets to actively support energy stability, contributing to grid flexibility. By offering a holistic approach to electrification, VDL positions itself as more than just a bus manufacturer—it becomes a mobility and energy solutions provider, driving the transition to smart, grid-integrated public transport.

9.6 Key financial indicators

Financial viability hinges on balancing up-front investments in V2G and high-power charging hardware against the recurring revenue potential of frequency regulation and other grid services. Capital expenditures typically include EVSE purchase costs, battery packs (potentially second life), and advanced metering or data management systems. Although some installation expenses are considered neutral in the Dutch market, software and integration remain moderately higher in price, reflecting the complexity of real-time energy optimisation.

Over time, operational costs include regular maintenance, licensing fees for any proprietary analytics platforms, and administrative oversight of regulatory compliance and partnership agreements. On the revenue side, profits materialise from the sale of electric vehicles and associated service plans, plus ancillary income through participation in energy markets, especially for frequency regulation. Fleet operators who rely on these highway charging facilities can further offset electricity bills by capitalising on predictable low-price windows or by selling stored energy back to the grid during peak demand. Demonstrating a positive net present value (NPV) and acceptable payback periods will be instrumental in convincing investors, local authorities, and potential customers to replicate the Eindhoven model in other locations.

Revenue Parameters	Cost Parameters
• V2G Service Revenue	**Infrastructure and Technology Costs**
• Bus Sales Revenue	• Smart Grid Technology Costs
• Subscription Revenue (Service Plans)	• V2G Integration Costs
• Energy Market Revenue Sharing	• Battery Management & Optimization Software
• Time-of-Use Pricing Revenue	**Operational Costs**
• Grid Service Payments	• Customer Engagement and Support
• Frequency Regulation Payments	• Program Administration Costs
• Incentive Payments from Regulators	• Maintenance Costs
• Carbon Credit Revenue	• Regulatory Compliance Costs
• Customer Retention and Satisfaction Metrics	• Marketing & Customer Acquisition Costs
• Fleet Expansion Revenue	**Hardware and Installation Costs**
	• EVSE Purchase Costs
	• EVSE Compatibility & Integration Costs
	• Battery Degradation & Replacement Costs
	• Metering Equipment & Data Processing Costs
	• Degradation Rate Impact Assessment
	Organizational and Administrative Costs
	• Staffing & Technical Support Costs
	• Fleet Monitoring & Analytics Platform Costs
	• Metering Equipment & Data Processing Costs

10 Innovation Cluster D - case study D1 EV chargers in at the headquarters of Bertil O. Steen being retrofitted with smart chargers

10.1 Use Case Overview

This use case involves retrofitting existing EV chargers at the Bertil O. Steen headquarters in Norway with smart charging capabilities, aiming to reduce peak demand costs, improve overall energy efficiency, and demonstrate how businesses can capitalise on demand-side flexibility. As the charge point operator (CPO), CURRENT leads the project, coordinating with various stakeholders—including site owners, equipment manufacturers, and local grid operators—to integrate advanced features such as peak shaving, dynamic power allocation, and potentially V2G functionality.

By automating charging schedules and aligning them with periods of lower grid tariffs, the solution aims to offer tangible cost savings to Bertil O. Steen while improving the user experience for employees, fleet drivers, and visitors. This demonstration also tests the feasibility of subscription-based service plans, where the CPO delivers different levels of assistance with predictive maintenance, real-time energy optimisation, and billing services. Ultimately, the project seeks to illustrate how a smart charging retrofit can serve as a cost-effective pathway for businesses to enhance both operational efficiency and grid responsiveness.

Use Case Overview	
Use case name	EV chargers in at the headquarters of Bertil O. Steen being retrofitted with smart chargers
Objective	The primary business objective of this use case is to develop a cost-effective and scalable highway charging infrastructure for heavy-duty EVs by integrating local renewable energy and battery storage, minimizing grid dependency, and optimizing operational efficiency through simulations and pre-booking strategies.
Use case leader	CURRENT
Use case leader organization type	Charge point operator

10.2 Case study boundary conditions

General Conditions	
Country	Norway
Time Frame	2-3 years
V2X Type	V2G
Technological Assumptions	
Technology Maturity Level	Established (3)
Adoption Rate Outlook	Medium (2)
Interoperability Compatibility Level	Good (3)
Conditions on Site	
Existing Connection Capacity	Moderate Capacity
Ability to Facilitate Selected V2X	Partial
Connection Capacity Category	Needs Upgrade (2)
Local Infrastructure Condition	Good (3)
Potential to Increase Renewable Capacities	Medium (2)
Selection of Energy Management Services	
EMS Optimization Cluster	Local Behind-the-Meter
Energy Management Service	Peak Shaving
Market Assumptions	
Market Size and Growth	3: Moderate Growth
Demand for Electric Vehicles	4: Above Expectations
Grid Services Demand	3: Expected
Competitive Landscape	3: Moderate Competition
Innovation Rate	5: Fast
Electricity Price Fluctuations	4: Volatile
Expected Price Changes in the Next 5 Years	Increase
Impact on V2X Profitability	5: Positive

Value Proposition (TOP 5)	
1. Cost Savings 2. Revenue Generation 3. Optimized Asset Utilization 4. Operational Efficiency 5. Enhanced Customer Experience	
Regulatory Assumptions	
Policy Environment Stability	4: Stable
Commercial Exploitation Allowance	3: Emerging Market
Availability of Incentives	Yes
Level of Incentives	Good
Effectiveness	Moderately Effective
Economic Conditions	
EVSE Purchase Cost	Moderately Higher Price
Installation Costs	Moderately Higher Price
Metering Equipment Costs	Extremely Higher Price Premium
Additional Hardware/Software Costs	Moderately Higher Price
EV Purchase Costs	Moderately Higher Price
EV Operation Costs	Neutral Price
Organizational and Administrative Efforts	Moderately Higher Price
Business model	10. Retail Sales with Service Plans
Environmental Benefits	Reduces grid peak loads and optimizes energy consumption, leading to lower carbon emissions and better renewable energy integration.
Social Benefits	Enhances energy security and cost savings for businesses, demonstrating the practicality of smart charging and V2G solutions in urban commercial settings.

The pilot takes place in Norway over a two- to three-year timeline. The existing site has moderate grid capacity and a "good" local infrastructure condition, although an upgrade may be necessary to fully support more advanced V2X scenarios. The technology maturity level is rated as established, reflecting a market well-versed in EV adoption but still evolving in terms of advanced smart charging integrations.

Market assumptions point to moderate growth, with the demand for EVs exceeding initial projections and grid services likely to increase in value. Innovation in charging hardware and software remains fast-paced, supported by a stable policy environment that includes incentives for adopting sustainable energy solutions. The economic outlook indicates moderately higher costs for EVSE purchase, installation, and metering equipment, but these may be offset by the positive impact on V2X profitability due to volatile electricity prices and increasing demand for flexible load resources. By positioning the retrofit project within this favourable market and regulatory context, the use case seeks to demonstrate a replicable model that can scale across commercial and industrial facilities looking to integrate more robust EV charging strategies.

10.3 Stakeholder Analysis

The business case based on the retrofitting of EV chargers at Bertil O. Steen's headquarters engages a wide range of stakeholders whose objectives and influence vary considerably. Employees, fleet drivers, and visitors rank high in terms of interest, since they rely on readily available and user-friendly charging facilities, but they hold relatively modest influence over investment decisions. By contrast, Bertil O. Steen itself wields substantial authority, controlling site infrastructure and long-term strategy, and is thus a pivotal stakeholder capable of driving forward or delaying upgrades.

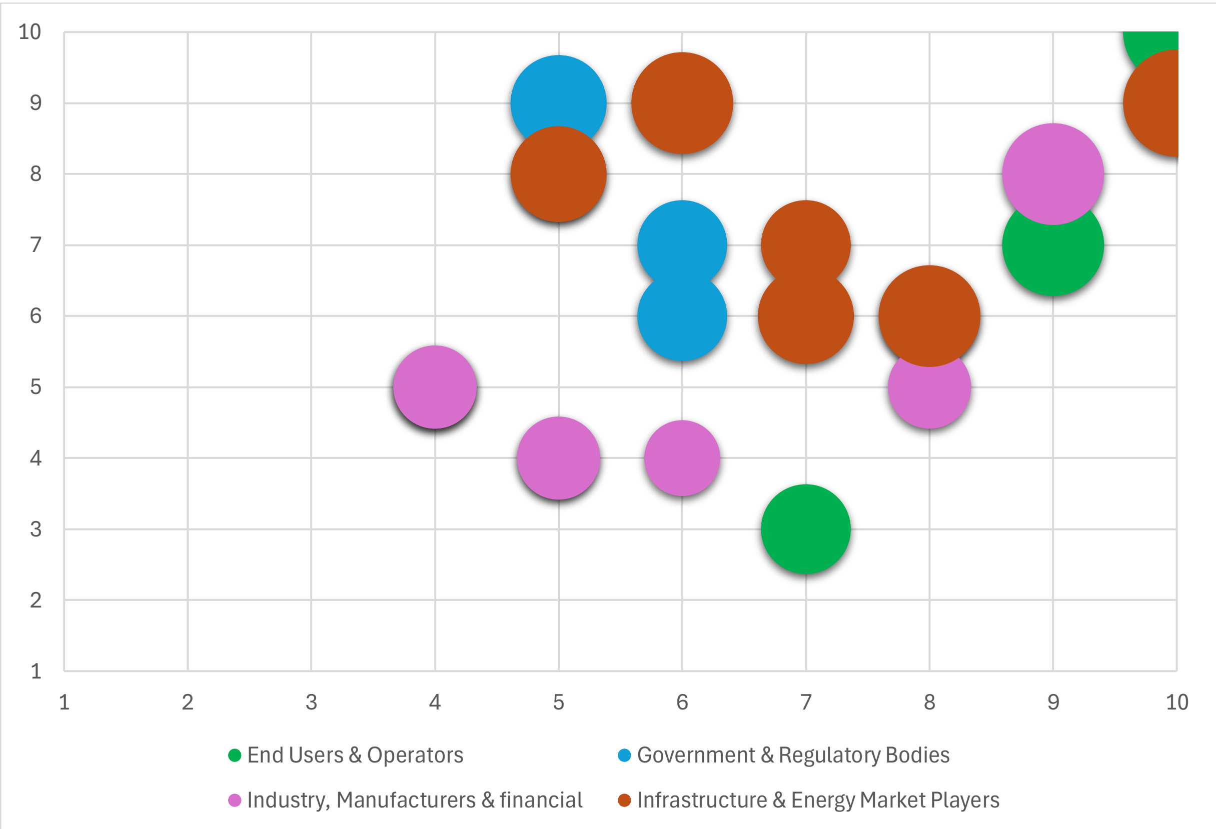

Figure 5: stakeholder matrix for use case D1

Local government entities, including Lillestrøm Municipality, and national regulatory agencies influence the conditions under which smart charging retrofits can flourish, setting policies around load management and energy tariffs. Standardisation bodies like ISO and CharIN shape technical requirements and ensure compatibility between EV charging equipment, software platforms, and vehicle-side systems. In parallel, private-sector players—aggregators, charge point manufacturers, and battery suppliers—provide core technology, commercial motivation, and potential capital for expansion, although their individual bargaining power varies. Financial institutions such as DNB and Nordea remain crucial in funding infrastructure upgrades, while distribution system operators (DSOs) coordinate grid capacity and ensure compliance with local load restrictions.

Type	Stakeholder types	Stakeholder	Interest	Influence	Importance
End Users & Operators	Electric vehicle driver	Employees, fleet drivers, and visitors using smart chargers at Bertil O. Steen headquarters	7	3	7
End Users & Operators	Fleet operators	Bertil O. Steen's company fleet and third-party fleet operators using the site's charging infrastructure	9	7	9
End Users & Operators	Site owner	Bertil O. Steen (as owner and manager of headquarters and facilities)	10	10	10
Government & Regulatory Bodies	European and national regulators	Norwegian Water Resources and Energy Directorate (NVE), European Commission (DG MOVE, DG ENER)	5	9	8
Government & Regulatory Bodies	Local and regional authorities	Municipality of Lillestrøm (local government overseeing transport and energy regulations)	6	6	7
Government & Regulatory Bodies	Standardization organization	ISO, IEC, CharIN (developing smart charging and V2B standards)	6	7	7
Industry, Manufacturers & financial	Aggregator and flexibility service provider	Nodes, Agder Energi, or other flexibility providers managing demand response	8	6	8
Industry, Manufacturers & financial	Battery manufacturer	CATL, Northvolt, LG Energy Solution (battery suppliers)	5	4	5
Industry, Manufacturers & financial	Charge point manufacturer	Zaptec, ABB, EVBox (smart charging station providers)	9	8	9
Industry, Manufacturers & financial	Electric vehicle manufacturer	Mercedes-Benz, Peugeot, Citroën, Opel (brands distributed by Bertil O. Steen)	4	5	6
Industry, Manufacturers & financial	Financial institution	DNB, Nordea (potential funders of infrastructure	4	5	6

		investments and leasing services)			
Industry, Manufacturers & financial	PV manufacturer	REC Solar, First Solar (if on-site solar PV expansion is considered)	5	4	6
Industry, Manufacturers & financial	RTOs and universities	SINTEF (Norwegian research institute), NTNU	8	5	6
Industry, Manufacturers & financial	Validation data provider	Smart charging platform providers collecting usage and grid interaction data	6	4	5
Infrastructure & Energy Market Players	Balance responsible party	Energy supplier or aggregator managing grid balance for charging operations	5	8	7
Infrastructure & Energy Market Players	Charge point operator	Fortum Charge & Drive, Mer, Bertil O. Steen (if operating own charging network)	10	9	10
Infrastructure & Energy Market Players	Distribution system operator	Elvia (DSO managing local grid infrastructure)	6	9	9
Infrastructure & Energy Market Players	eMobility service provider	Fortum, EVBox, Zaptec, or other providers enabling user access and billing	8	6	9
Infrastructure & Energy Market Players	Energy Management Service provider	Enova, smart charging software providers	7	6	8
Infrastructure & Energy Market Players	Energy supplier	Hafslund, Fortum, or other electricity providers supplying energy to the site	7	7	7

10.4 Value Proposition Canvas

The solution delivers value to customers by reducing electricity costs through peak shaving, dynamically allocating charging loads, and offering subscription-based service plans. Users benefit from more consistent charger availability and reduced queue times, while Bertil O. Steen avoids expensive grid upgrades and overage charges by intelligently monitoring energy flows. Adopting real-time analytics, coupled with building- or fleet-level energy management, reinforces the proposition further, as it helps flatten demand peaks and defers the need for increased connection capacity.

One of the core challenges is ensuring seamless integration of retrofitted chargers with existing systems, particularly where multiple brands of hardware or different communication protocols are involved. This complexity is alleviated through strong standardisation (e.g., OCPP, ISO 15118) and advanced software capable of adjusting charging sessions in response to real-time grid signals or spot pricing data. By offering a clear, data-driven business case—highlighting measurable cost reductions, improved reliability, and the potential for new revenue streams via grid flexibility markets—the retrofit model positions itself as an attractive option for businesses seeking to manage growing EV adoption without incurring prohibitively high operational costs or sacrificing user experience.

Selected Energy Management Service: Optimize PV self-consumption

Selected Business Model: Real-Time Energy Management

Value Map

Gain Creators (Ways the Smart Charging Ecosystem Creates Value)

Lower Grid Fees & Operational Costs: By shifting charging loads to off-peak hours, the system reduces peak demand charges and optimizes electricity costs.

Improved Charging Infrastructure Utilization: Smart charging ensures efficient use of existing chargers, preventing power congestion and reducing idle times.

Increased Revenue from Smart Charging Services: Offering subscription-based service plans allows the CPO to create a steady income stream while improving infrastructure management.

Flexibility to Integrate with Dynamic Tariffs: Aligning charging operations with spot market electricity pricing ensures cost-effective energy procurement.

Better Load Distribution & Grid Support: The CPO can balance demand across multiple chargers, avoiding stress on the local grid connection.

Scalability for Future EV Growth: The smart charging setup allows for additional EVSE installations without overloading grid capacity.

Products & Services (Specific Offerings Provided within the Smart Charging Ecosystem)

Smart Charging Infrastructure & Peak Shaving Features

Time-based smart charging schedules to shift loads outside peak hours.

Dynamic power allocation between chargers to prevent grid congestion.

Load prioritization based on charger availability and fleet needs.

Retail Sales with Service Plans

Basic Plan: Remote monitoring, power usage tracking, and manual scheduling.

Advanced Plan: Automated power balancing, tariff-based charging adjustments, and fleet energy optimization tools.

Premium Plan: Full integration with building energy management systems (EMS), priority access to flexibility markets, and tariff-based charging contracts.

Customer Profile

Gains (Expected Benefits for Stakeholders)

Reduction in Grid Fees: By implementing peak shaving, the CPO can significantly lower the site's demand charges, reducing operational costs for charging infrastructure.

Optimized Energy Usage: Smart charging strategies align charging schedules with lower electricity prices, maximizing efficiency while minimizing costs.

Revenue from Service Plans: Offering subscription-based services for energy management, maintenance, and smart charging optimization ensures a recurring revenue stream for the CPO.

Enhanced Charging Infrastructure Utilization: By distributing energy demand more effectively, chargers operate at higher efficiency rates, increasing return on investment (ROI).

Participation in Flexibility Markets: Peak shaving can create opportunities for demand response participation, generating additional revenue.

Customer Satisfaction & Retention: Providing a cost-effective and reliable charging service enhances user experience, leading to greater customer loyalty and higher retention rates.

Pains (Challenges or Problems Faced)

Grid Constraints & Infrastructure Limitations: The existing grid connection may be insufficient to support all charging points at peak hours, requiring load management.

High Initial Investment Costs: Upgrading infrastructure to smart chargers and energy management systems requires upfront capital.

Complex Integration with Existing Systems: Ensuring seamless integration between smart chargers, building energy systems, and fleet operations can be technically challenging.

Regulatory & Compliance Challenges: Adapting to Norwegian grid regulations and ensuring compliance with peak load management policies requires expertise.

Variability in Electricity Prices: While peak shaving optimizes costs, fluctuations in dynamic grid tariffs can impact expected savings.

User Adoption & Behaviour Management: Encouraging fleet operators and EV users to

Pain Relievers (Solutions That Mitigate Stakeholders' Challenges) Prevents Grid Overload & Capacity Issues: Peak shaving techniques dynamically adjust charging loads to stay within site grid capacity limits. Reduces Exposure to Electricity Price Fluctuations: The system prioritizes charging when prices are low, reducing energy cost volatility. Minimizes Unnecessary Infrastructure Upgrades: Instead of costly grid expansions, load management optimizes existing capacity, making V2G expansion more feasible. Ensures Reliable Charging Availability: By balancing load effectively, chargers remain operational and available, reducing queue times for users. Compliance with Norwegian Grid Regulations: The system ensures charging aligns with grid operator (Elvia) requirements, preventing penalties or limitations. Provides Transparent Energy Cost Tracking: Fleet operators and customers can track charging costs and energy savings, improving operational planning.	Energy Cost Optimization & Billing Integration with dynamic electricity pricing models (e.g., day-ahead spot market rates). Transparent billing & reporting for fleet operators and individual EV users. Flexible payment models based on real-time energy use. Customer Support & Operational Services Scheduled maintenance and troubleshooting support for charge point operators. User engagement tools (mobile app, energy usage dashboards) to enhance customer experience.	**Customer Jobs (Tasks or Activities Stakeholders Need to Perform)** Deploy & Manage Smart Charging Infrastructure: Install and operate peak shaving-enabled smart chargers' sites. Optimize Charging Schedules: Implement data-driven algorithms to shift charging to off-peak hours and reduce peak demand charges. Monitor & Maintain Charging Equipment: Ensure service reliability by offering predictive maintenance and technical support as part of service plans. Integrate with Energy Management Systems (EMS): Work with building energy systems and grid operators to balance energy loads dynamically. Ensure Regulatory Compliance: Align with Norwegian grid tariff structures, demand response programs, and V2G regulations. Engage with Customers & Fleet Operators: Provide user-friendly interfaces and training to ensure optimal smart charging adoption. Expand Business Model for Future Growth: Explore additional revenue streams through demand response participation, V2G services, and partnerships with fleet operators.	adopt scheduled charging behaviours to align with peak shaving strategies can be a challenge.

The Charge Point Operator (CPO) provides smart charging solutions with peak shaving, helping businesses and fleet operators reduce electricity costs, optimize EV charging, and improve infrastructure efficiency. By offering subscription-based service plans, the CPO ensures a stable, recurring revenue stream while delivering cost-effective energy management to customers.

Businesses benefit from lower grid fees, better charging infrastructure utilization, and transparent energy cost tracking. Fleet operators gain predictable and optimized charging schedules, reducing operational costs and avoiding grid overload. Additionally, the CPO can participate in energy flexibility markets, earning revenue through demand response programs and load-balancing agreements.

This model is scalable and adaptable, supporting EV market growth while ensuring financial sustainability for both the CPO and its clients.

Value Proposition Summary

The Charge Point Operator (CPO) provides smart charging solutions with peak shaving, helping businesses and fleet operators reduce electricity costs, optimize EV charging, and improve infrastructure efficiency. By offering subscription-based service plans, the CPO ensures a stable, recurring revenue stream while delivering cost-effective energy management to customers.

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10.5 Business Model Canvas

In this use case, the business model builds on retrofitting existing chargers with smart charging features that can reduce peak electricity costs and potentially generate revenue from flexibility services. By offering subscription-based service plans, the charge point operator secures a stable, recurring income and fosters a closer, more strategic relationship with the site owner. The cost structure primarily centres on hardware upgrades and the software platform required to implement load balancing and demand-side management. Over time, these expenditures are offset by energy savings from avoided peak tariffs and greater operational efficiency. Additional revenue may arise through incentive programmes or grid-balancing contracts, adding a layer of financial resilience.

Selected Energy Management Service: Peak Shaving		**Selected Business Model:** Retail Sales with Service Plans		**Selected Stakeholder Perspective:** Charge point operator
Key Partners	**Key Activities**	**Value Propositions**	**Customer Relationships**	**Customer Segments**
Energy Suppliers & Aggregators – Collaborate with electricity providers and flexibility market operators to optimize energy purchasing and potential demand response participation. Fleet Operators & Business Clients – Companies with EV fleets or workplace charging needs that benefit from peak shaving strategies. Smart Charging Technology Providers – Suppliers of smart charging stations, energy management software, and dynamic pricing tools. Building & Facility Managers – Entities responsible for integrating EV charging into site energy management for optimal load balancing. Regulatory Bodies & Grid Operators – Work with distribution system operators (DSOs) and regulators to comply with tariff structures and flexibility programs. Financial Institutions & Investors – Provide leasing, financing, and	Deploy & Manage Smart Charging Infrastructure – Install and maintain peak shaving-enabled chargers at business locations, fleets, and public charging sites. Energy Cost Optimization – Implement dynamic pricing adjustments and time-based charging to reduce peak grid fees. Subscription-Based Service Plans – Offer different tiers of service plans, including maintenance, energy optimization, and grid interaction. Load Balancing & Peak Shaving – Use real-time energy monitoring to ensure charging is spread across low-demand periods, reducing stress on local grid connections. Customer Support & Technical Assistance – Provide ongoing maintenance, troubleshooting, and user training for optimized charging performance. Regulatory Compliance & Market Participation – Ensure compliance with grid regulations and flexibility market requirements, enabling	Reduced Grid Fees & Energy Costs – Smart charging schedules lower peak demand charges, reducing overall operational expenses. Optimized Charging Infrastructure Utilization – Chargers are used more efficiently, preventing grid overload and ensuring availability for users. Flexible, Subscription-Based Service Plans – Businesses can choose from various levels of energy management and maintenance support. Scalable Charging Solutions – The system allows for expansion without major grid upgrades, making it cost-effective for growing EV adoption. Participation in Energy Flexibility Markets – Business clients may earn additional revenue from demand response programs through managed charging. User-Friendly Charging & Cost Transparency – Provides clear billing, cost breakdowns, and usage insights to optimize fleet charging behaviour.	Long-Term Service Contracts – Subscription-based energy management ensures ongoing client engagement and revenue stability. Automated Charging Insights & Energy Reports – Businesses receive monthly reports on cost savings, energy efficiency, and peak shaving benefits. Dedicated Technical Support – Providing businesses with charger maintenance, troubleshooting, and software updates. Customer Training & Optimization Consulting – Helping fleet managers optimize energy consumption and maximize charging efficiency.	Fleet Operators – Companies managing electric delivery vans, buses, or corporate EVs looking to minimize charging costs. Businesses with Workplace Charging – Offices, retail locations, and service hubs offering EV charging for employees and customers. Commercial Property Owners & Facility Managers – Integrating smart EV charging as part of broader energy efficiency strategies. Public & Semi-Public Charging Operators – Entities managing shared or private charging networks that need to optimize grid costs.

investment in charging infrastructure expansion.

participation in demand response programs.

Key Resources

Smart Charging Infrastructure – Network of intelligent charging stations equipped with load balancing and energy optimization capabilities.

Energy Management System (EMS) – Software that enables peak shaving, scheduling, and real-time power allocation.

Customer & Fleet Management Platforms – Online interfaces for users to monitor charging costs, energy usage, and optimize fleet charging schedules.

Partnership Agreements – Contracts with energy suppliers, grid operators, and technology providers to ensure service reliability and cost efficiency.

Technical Expertise & Maintenance Teams – Engineers and support teams responsible for charger upkeep, grid integration, and performance monitoring.

Channels

Direct B2B Sales & Contracts – Selling smart charging services directly to businesses and fleet operators.

Online Platforms & Subscription Sign-Ups – Customers manage their charging services through web portals or mobile apps.

Energy Market & Grid Operator Partnerships – Engaging with aggregators and DSOs for flexibility service integration.

Industry Events & Business Networking – Promoting smart charging solutions at fleet, energy, and mobility trade shows.

Cost Structure

Revenue Streams

• Infrastructure Investment – Capital costs for installing and deploying smart charging stations. • Software Development & EMS Integration – Ongoing costs to maintain energy management platforms. • Operational & Maintenance Costs – Expenses for charger upkeep, customer support, and technical troubleshooting. • Regulatory Compliance & Energy Market Participation Fees – Costs to align with grid operator requirements. • Marketing & Customer Acquisition – Budget for business development, outreach, and promotional efforts. • Administrative & Staffing Costs – Salaries for teams managing charging services, partnerships, and client relationships.	• Hardware Sales – Selling smart chargers with peak shaving capabilities to business clients. • Subscription-Based Service Plans – Monthly or annual fees for energy optimization, maintenance, and priority support. • Energy Cost Optimization Fees – Charging businesses a percentage of electricity cost savings achieved through peak shaving. • Revenue from Demand Response & Grid Services – CPOs may earn income from participation in flexibility markets and load-balancing agreements. • Dynamic Pricing Contracts – Offering businesses customized electricity pricing models for optimized fleet charging costs.

The model depends on seamless coordination among several key players, including hardware manufacturers, software developers, and local grid operators. While upgrading chargers and ensuring interoperability carry upfront costs, the resulting gains in reliability, cost predictability, and improved charger utilisation create a clear value proposition for businesses. Demonstrable savings and simplified administration—achieved via automated billing and usage analytics—strengthen customer relationships and can encourage broader deployment of similar retrofits at other corporate sites. By focusing on these tangible benefits, the business model positions smart charging as both a practical and financially viable approach to meeting future EV demand.

Business Model Summary

CURRENT, a charge point operator, uses peak shaving to make electric vehicle (EV) charging cheaper and smarter for businesses, earning money by selling smart chargers and offering service plans. The company partners with energy suppliers to buy electricity at low rates, smart tech providers for intelligent chargers and software, fleet operators and businesses to install chargers, grid operators to follow rules and join energy-saving programs, and banks to fund expansion. CURRENT installs chargers that charge EVs during off-peak times to avoid high grid fees, uses software to monitor energy and adjust pricing, and offers service plans from basic maintenance to full energy optimization, while providing support, training, and compliance with grid rules.

With smart chargers, energy management software, online platforms for tracking costs, partnership deals, and expert teams, CURRENT helps businesses save on electricity, use chargers efficiently, scale without grid upgrades, earn from grid programs, and get clear cost insights. Serving fleet operators, workplace charging businesses, property owners, and public charging networks, CURRENT reaches customers through direct sales, online tools, energy partnerships, and trade shows, building long-term relationships with service contracts, energy reports, technical support, and training.

CURRENT earns revenue by selling chargers, charging service fees, taking a share of energy savings, earning from grid programs, and offering custom pricing, while spending on chargers, software, maintenance, compliance, marketing, and staff. In this way, CURRENT uses peak shaving to cut costs, help the grid, and grow a sustainable business.

10.6 Key financial indicators

Financial success is anchored in a favourable balance of upfront investment, recurring subscription income, and potential grid-service revenue. Higher EVSE purchase and installation costs may present initial challenges, but they are typically mitigated by real-time energy savings and improved load management. Metrics such as reduced peak demand charges, lower electricity bills, and heightened charger utilisation rates provide a quantifiable foundation for the retrofit's return on investment.

Operational expenses mainly encompass software licensing, user support, and hardware maintenance. Where dynamic tariffs apply, per-session charging revenue and cost-avoidance statistics offer insight into ongoing performance. Monthly or annual subscription fees for service plans deliver a predictable cash flow, enabling the CPO to recoup infrastructure investments and fund incremental site expansions. Overall, well-maintained data records of charging sessions, energy usage, and savings are essential for illustrating the project's financial stability and scaling potential.

Revenue Parameters	Cost Parameters
Charging Services Revenue	**Infrastructure and Technology Costs**
• Time-of-Use Pricing Revenue	• Smart Charger Hardware Purchase Costs
• Energy Cost Optimization Fees	• V2G Integration Costs
• Fleet Charging Revenue	**Software & Platform Costs**
Grid Services Revenue	• Energy Management System (EMS) Development & Maintenance
• Revenue from Demand Response Participation	• Data Storage & Processing Costs
• Grid Service Payments for Load Balancing	**Operational & Maintenance Costs**
Service Plans & Subscription Revenue	• Routine Maintenance & Charger Repairs
• Subscription Revenue (Basic, Advanced, Premium Plans)	• Customer Support & Troubleshooting
• Predictive Maintenance & Energy Insights Revenue	**Customer Engagement & Administration Costs**
• Billing & Usage Analytics Services	• Customer Training & Usage Reports
Additional Revenue Streams	**Regulatory & Compliance Costs**
• Revenue from Dynamic Pricing Contracts	**Marketing & Customer Acquisition Costs**
• Revenue from EVSE Leasing & Financing Options	**Financing & Capital Costs**
	Infrastructure Investment & Financing Costs

11 Innovation Cluster D - case study D2 Installation of public chargers with V2G certification (Budapest)

11.1 Use Case Overview

This use case led by Emobility Solutions (EMS) explores the installation and integration of Vehicle-to-Grid (V2G) certified public charging infrastructure at a market hall in Erzsébetváros (District 7), Budapest. The primary objective is to develop a technically and economically viable model for public smart charging that supports urban sustainability, decentralised energy production, and flexible energy management. The initiative includes the deployment of bidirectional AC chargers, a local battery energy storage system (BESS), and rooftop photovoltaic (PV) generation, all managed through an intelligent Energy Management System (EMS).

Unlike traditional public charging deployments, this case goes beyond infrastructure roll-out by integrating grid-responsive capabilities such as peak shaving, demand-side flexibility, and energy arbitrage through time-of-use optimisation. It also serves as a living laboratory for regulatory testing, technology standardisation, and public-private cooperation in a constrained urban environment with limited grid capacity.

The site serves a dual function: providing charging services for public EV drivers and local fleets, while also operating as a distributed energy resource (DER) that can interact with the local distribution network. With limited grid connection capacity and volatile electricity prices in Hungary, the project aims to demonstrate how energy communities and municipal actors can leverage V2G and smart charging to increase self-consumption of locally generated renewable energy, reduce operational costs, and actively participate in emerging flexibility markets.

The following subsections present the technical, regulatory, and market boundary conditions under which the project is being implemented, along with a detailed stakeholder analysis and a structured evaluation of the use case's value proposition and business model. This use case is representative of bottom-up, decentralised energy innovation and offers high replicability potential in other urban districts across Central and Eastern Europe.

Use Case Overview	
Use case name	D.2 Installation of public chargers with V2G certification
Objective	Emobility Solutions' (EMS) business objective is to install public V2G chargers at a Budapest market hall, creating an energy community with solar PV and storage to maximize renewable energy use, reduce grid dependency, lower electricity bills, and manage peak loads, while demonstrating scalable, cost-effective smart charging solutions for municipalities.
Use case leader	Emobility Solutions
Use case leader organization type	Charge point operator

11.2 Case study boundary conditions

General Conditions	
Country	Hungary
Time Frame	5-10 years
V2X Type	V2G
Technological Assumptions	
Technology Maturity Level	Emerging (1)
Adoption Rate Outlook	Medium (2)
Interoperability Compatibility Level	Poor (1)
Conditions on Site	
Existing Connection Capacity	Low Capacity
Ability to Facilitate Selected V2X	No
Connection Capacity Category	Needs Upgrade (2)
Local Infrastructure Condition	Fair (3)
Potential to Increase Renewable Capacities	High (3)
Selection of Energy Management Services	
EMS Optimization Cluster	Local Behind-the-Meter
Energy Management Service	Peak Shaving
Market Assumptions	
Market Size and Growth	3: Moderate Growth
Demand for Electric Vehicles	4: Above Expectations
Grid Services Demand	4: Above Expectations
Competitive Landscape	3: Moderate Competition
Innovation Rate	4: Above Expectations
Electricity Price Fluctuations	4: Volatile
Expected Price Changes in the Next 5 Years	Increase
Impact on V2X Profitability	4: Somewhat Positive

Value Proposition (TOP 5)	
1. Cost Savings 2. Revenue Generation 3. Optimized Asset Utilization 4. Enhanced Grid Stability 5. Environmental Benefits	
Regulatory Assumptions	
Policy Environment Stability	2: Slightly Unstable
Commercial Exploitation Allowance	2: Limited Market
Availability of Incentives	Yes
Level of Incentives	Very Good
Effectiveness	Moderately Effective
Economic Conditions	
EVSE Purchase Cost	Moderately Higher Price
Installation Costs	Moderately Higher Price
Metering Equipment Costs	Extremely Higher Price Premium
Additional Hardware/Software Costs	Moderately Higher Price
EV Purchase Costs	Moderately Higher Price
EV Operation Costs	Moderately Higher Price
Organizational and Administrative Efforts	Neutral Price
Business model	6. Time-of-Use Optimization
Environmental Benefits	Reduces grid reliance, enhances renewable energy usage
Social Benefits	Enhances energy security and cost savings for businesses, demonstrating the practicality of smart charging and V2G solutions in urban commercial settings.

This use case is being implemented in Hungary, and the assumed boundary conditions of the market are characterised by moderately growing e-mobility uptake, constrained grid capacity in urban areas, and a regulatory framework that is only partially aligned with advanced energy services such as V2G. The time horizon of the project extends over 5 to 10 years, reflecting the long-term nature of infrastructure deployment and regulatory learning cycles.

The selected energy management service is peak shaving, applied within a local behind-the-meter optimisation cluster. This allows the EMS to dynamically balance on-site generation, storage, and EV charging loads, thereby reducing exposure to high grid tariffs and mitigating capacity limitations. Although the site currently has low connection capacity and no ability to facilitate V2G under existing technical conditions, its high potential for renewable energy integration—via rooftop PV and stationary batteries—creates favourable conditions for testing demand-side flexibility strategies.

Technologically, the V2G implementation is in an emerging phase, with limited interoperability and constrained vehicle compatibility, as the Hungarian EV fleet lacks widespread adoption of ISO 15118-20-compliant vehicles. However, the use of certified hardware (e.g. Alfen Twin 5 chargers) and a V2G-capable test vehicle within a controlled environment allows for system validation, standard testing, and operational proof-of-concept under real-world urban constraints.

Market dynamics support the strategic relevance of this case. Electricity price volatility and the expected price increases in the next five years create significant incentives for time-of-use optimisation and grid interaction. The demand for EVs and grid services is above expectations, driven by both policy pressure and macroeconomic trends, although the commercial exploitation of V2G remains limited due to regulatory immaturity and inconsistent incentives. Nonetheless, the availability of strong public funding and moderate policy stability enable experimentation and risk mitigation for early adopters like EMS.

11.3 Stakeholder Analysis

The stakeholder landscape of this use case is notably diverse, comprising municipal actors, private energy and mobility providers, technology suppliers, and emerging market intermediaries such as flexibility aggregators. At the core of the implementation is Emobility Solutions (EMS), acting as both the charge point operator and project coordinator, supported by Enervalis as the energy management system provider. Together, they form the technological and operational centre of the project.

The Municipality of Erzsébetváros, as site owner and public sector partner, plays a pivotal role not only by granting access to public infrastructure but also by aligning the use case with broader urban sustainability goals. Their high interest and influence underscore the strategic relevance of the project within local policy frameworks focused on decentralised energy and smart urban mobility.

Charge points hardware suppliers (notably Alfen) and battery manufacturers support system-level integration through the provision of V2G-compliant infrastructure and stationary storage. Although V2G-certified EVs remain limited in the Hungarian market, the temporary leasing of a compatible vehicle enables technical validation and standard testing. As V2G adoption scales, OEMs will become increasingly central to stakeholder alignment.

On the grid side, E.ON Hungary (DSO) and MAVIR (TSO) are key enablers of regulatory compliance and market access. While their current involvement is limited to technical integration and observation, their future role will be decisive in scaling flexibility services to the wholesale level. Moreover, the emergence of aggregators as intermediaries between energy markets and DER assets introduces a new layer of complexity and potential value creation.

This multi-actor configuration ensures that all critical dimensions—policy, grid, technology, and end-user interaction—are addressed during project implementation. The stakeholder matrix below quantifies each party's interest, influence, and importance, thereby highlighting the alliances, trade-offs, and coordination requirements needed for successful execution and long-term replicability.

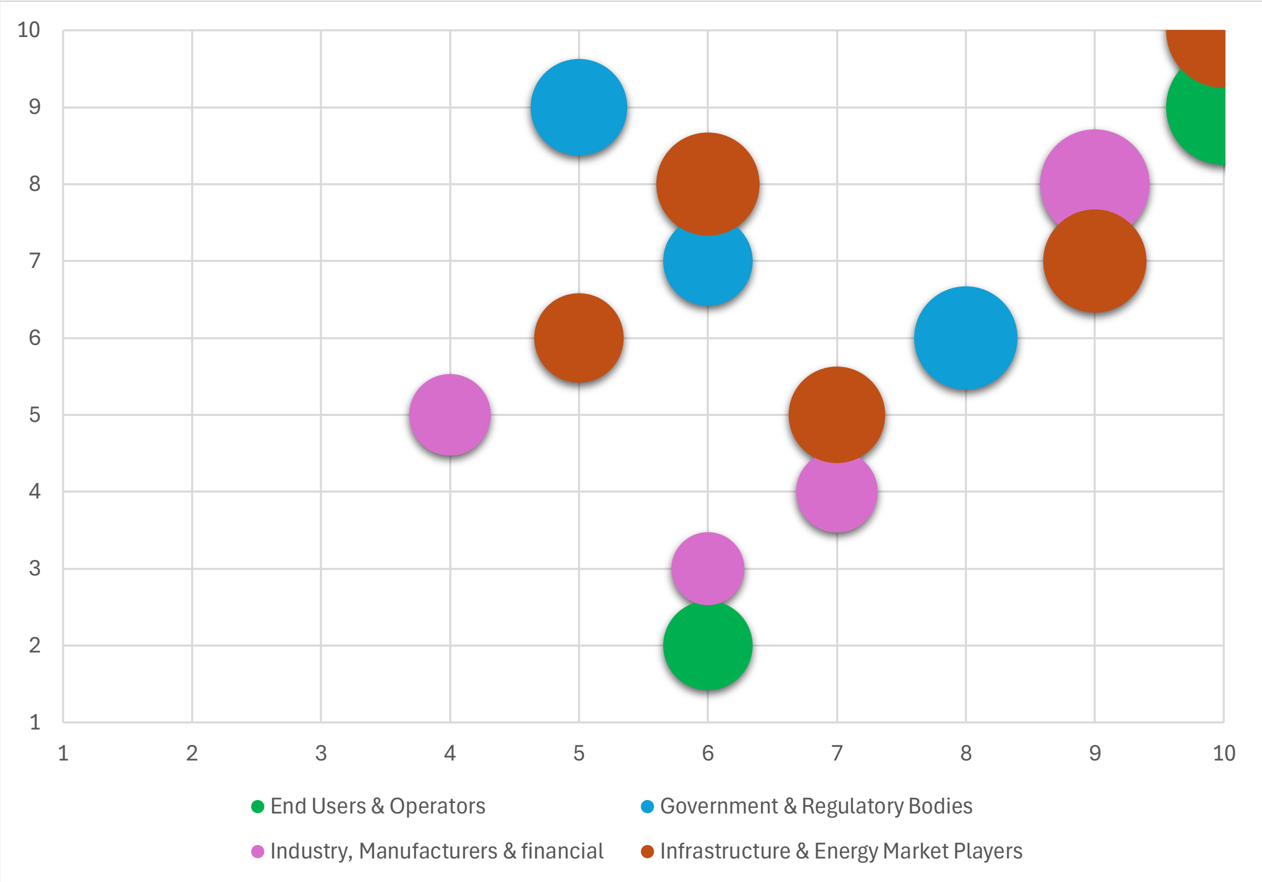

Figure 6: stakeholder matrix for use case D2

Type	Stakeholder types	Identified stakeholder in the use case	Interest	Influence	Importance
End Users & Operators	Electric vehicle driver	Fleet users and public EV drivers using V2G-capable chargers	6	2	6
End Users & Operators	Site owner	Municipality of Erzsébetváros (Market Hall location)	10	9	10
Government & Regulatory Bodies	European and national regulators	Hungarian Energy and Public Utility Regulatory Authority (MEKH), European Commission (DG MOVE, DG ENER)	5	9	7
Government & Regulatory Bodies	Local and regional authorities	Municipality of Erzsébetváros (Budapest District VII)	8	6	8
Government & Regulatory Bodies	Standardization organization	ISO, IEC, CharIN (for V2G and smart charging standards like ISO 15118-20, OCPP)	6	7	6
Industry, Manufacturers & financial	Battery manufacturer	Not specified, but the site includes a 100 kW battery storage system (potential manufacturers: CATL, LG Energy Solution, or Tesla)	6	3	4
Industry, Manufacturers & financial	Charge point manufacturer	Alfen (Twin 5 bidirectional chargers used in the project)	9	8	9

Industry, Manufacturers & financial	**Electric vehicle manufacturer**	Not named, but the project will lease a V2G-compliant EV for testing (potentially Hyundai, Renault, or another automaker supporting ISO 15118-20)	4	5	5
Industry, Manufacturers & financial	**Validation data provider**	Emobility Solutions (EMS) and Enervalis (providing smart charging data and analytics)	7	4	5
Infrastructure & Energy Market Players	**Charge point operator**	Emobility Solutions (EMS)	10	10	10
Infrastructure & Energy Market Players	**Transmission system operator**	MAVIR (Hungarian national TSO)	6	8	8
Infrastructure & Energy Market Players	**Energy Management Service provider**	Enervalis (EMS technology provider)	7	5	7
Infrastructure & Energy Market Players	**Distribution system operator**	E.ON Hungary or another regional DSO managing grid infrastructure	9	7	8
Infrastructure & Energy Market Players	**Energy supplier**	Not specifically named, but likely energy suppliers active in Budapest (e.g., MVM, E.ON)	5	6	6
Infrastructure & Energy Market Players	**Flexibility Aggregator**	Not specifically named, but important future stakeholder	9	6	9

11.4 Value Proposition Canvas

The value proposition of this use case centres on transforming conventional public EV charging infrastructure into an active grid resource through the deployment of V2G-certified chargers, smart energy management software, and local renewable generation. The selected energy management service—peak shaving—enables both cost optimisation and improved load distribution within a constrained urban grid environment. The corresponding business model—time-of-use optimisation—monetises the temporal flexibility of EV charging and discharging by shifting energy transactions to financially favourable periods.

From the perspective of charge point operators, the smart charging ecosystem generates tangible gains through avoided peak demand charges, increased use of on-site PV electricity, and the possibility to participate in local flexibility markets. Intelligent scheduling algorithms ensure that charging occurs when electricity is cheapest, while bidirectional charging allows for energy release during system peaks, turning parked EVs into grid-balancing assets.

For fleet operators and public users, the system ensures a reliable and cost-effective charging experience. Smart interfaces dynamically adapt to user needs while preserving battery health and ensuring compliance with ISO 15118 and OCPP standards. Meanwhile, municipal stakeholders benefit from increased renewable self-consumption, reduced grid congestion, and alignment with decarbonisation goals.

However, the system is not without challenges. Technical integration with diverse EV models, regulatory ambiguities, and the limited penetration of V2G-capable vehicles introduce deployment and adoption barriers. Moreover, ensuring user participation in smart charging schemes requires behavioural engagement strategies and trust in data transparency.

The canvas below maps these interdependencies and illustrates how specific technologies and service features respond to user pains, deliver measurable gains, and support long-term system optimisation. The value architecture presented here is designed for replication across similar urban contexts with constrained grid capacity and growing demand for resilient e-mobility infrastructure.

Selected Energy Management Service: Optimize PV self-consumption		**Selected Business Model:** Real-Time Energy Management	
Value Map		**Customer Profile**	
Gain Creators (Ways the Smart Charging Ecosystem Creates Value) Automated Peak Load Management – Reduces electricity costs by shifting EV charging to off-peak hours and flattening demand curves. Dynamic Energy Optimization – Real-time adjustments based on grid signals, energy prices, and vehicle charging demand. Revenue from Grid Services – Participation in demand response programs and flexibility markets enhances financial sustainability. Improved Energy Utilization – Efficient use of on-site PV generation and battery storage to reduce grid reliance. Enhanced User Experience – Intelligent scheduling ensures that vehicles are charged when needed without excess costs.	**Products & Services (Specific Offerings Provided within the Smart Charging Ecosystem)** Smart Charging Software – Enables automated peak shaving, dynamic pricing adjustments, and real-time grid interaction. V2G-Enabled Chargers – Bidirectional AC charging stations (e.g., Alfen Twin 5) for energy storage and discharge. Energy Management System (EMS) – Cloud-based platform optimizing energy flows between EVs, PV generation, and battery storage. Data Analytics & Reporting – Real-time insights on energy consumption, cost savings, and system performance. Grid Flexibility Services – Participation in demand-side response programs and frequency regulation for additional revenue.	**Gains (Expected Benefits for Stakeholders)** Lower Electricity Costs – Avoids peak demand charges through intelligent load management and optimized charging schedules. New Revenue Streams – Potential participation in flexibility markets and demand response programs. Improved Infrastructure Utilization – Maximizes the efficiency of chargers and on-site energy storage systems. Better Grid Integration – Contributes to grid stability by reducing peak loads and aligning with energy demand. Sustainability & Compliance – Helps meet environmental regulations and corporate sustainability goals by increasing renewable energy consumption.	**Pains (Challenges or Problems Faced)** High Demand Charges – Without optimization, peak loads can result in excessive electricity costs. Grid Capacity Constraints – Risk of overloading the local grid, limiting the number of EVs that can charge simultaneously. Uncertain Revenue Streams – Market regulations and fluctuating energy prices can affect profitability. Technical Integration Issues – Ensuring compatibility with multiple EV models, charging standards, and EMS platforms. User Experience Management – Balancing cost savings with providing reliable and convenient charging services to users.
Pain Relievers (Solutions That Mitigate Stakeholders' Challenges) Demand Charge Reduction – Smart charging algorithms prevent excessive energy costs by smoothing peak loads. Grid Constraint Mitigation – Load balancing prevents overloading of local energy infrastructure, allowing for more EVs to charge simultaneously. Revenue Predictability – Integration with dynamic pricing and demand response markets provides financial stability. Seamless System Integration – Compatible with multiple charging standards (ISO 15118, OCPP 2.0.1) and energy management platforms. Regulatory Compliance Support – Ensures adherence to evolving energy market regulations and sustainability targets.		**Customer Jobs (Tasks or Activities Stakeholders Need to Perform)** Manage Charging Infrastructure – Ensure chargers operate efficiently and comply with grid and regulatory requirements. Optimize Charging Schedules – Implement time-of-use optimization to shift charging loads away from peak periods. Monitor and Respond to Grid Signals – Adjust operations dynamically based on real-time energy pricing and grid conditions. Ensure Customer Satisfaction – Maintain a seamless charging experience for EV drivers while keeping costs low. Integrate Renewable Energy Sources – Utilize on-site PV generation and battery storage to reduce reliance on grid electricity.	

Drivers and barriers of TOP3 value propositions

Value Proposition	Drivers	Barriers
Cost Savings	• Peak Shaving Reduces Demand Charges: By optimizing charging schedules and spreading loads, the system minimizes peak demand costs. • Higher price volatility: Larger time window for charging during low-cost periods and discharging during peak pricing maximizes savings. • Integration with On-Site PV and Battery Storage: Utilizing locally produced renewable energy reduces dependency on expensive grid electricity. • Energy Efficiency Improvements: Smart load balancing prevents wasted energy and ensures optimal infrastructure utilization.	• Unpredictable Energy Price Volatility: Electricity tariffs fluctuate, making ToU savings inconsistent. • Initial Investment Costs: Installing V2G chargers, smart energy management systems, and storage solutions requires significant upfront capital. • Regulatory and Tariff Uncertainty: Grid fees, incentives, and pricing models vary by region and may not always favour demand-side energy management. • System Complexity and Interoperability Issues: Ensuring compatibility with various EV models, charging protocols (OCPP, ISO 15118), and grid interfaces can create technical hurdles.
Revenue Generation	• Participation in Demand Response Markets: The ability to sell flexibility services and grid-balancing support provides additional revenue streams. • V2G Services for Energy Trading: Bidirectional charging enables the CPO to discharge stored energy back to the grid when electricity prices are high. • Dynamic Pricing Models: Offering tiered and time-sensitive pricing to EV drivers based on demand and supply can enhance profitability. • Partnerships with Utilities and Fleet Operators: Collaborations can secure long-term revenue opportunities by providing managed charging services.	• Regulatory and Market Barriers: Many energy markets do not yet fully support or compensate V2G and flexibility services. • Uncertain Adoption of V2G-Capable Vehicles: The limited number of commercially available V2G-ready EVs reduces the short-term market potential. • Integration with Energy Markets: Participation in balancing and wholesale markets requires sophisticated energy management systems and partnerships. • User Willingness to Share Battery Capacity: Some EV drivers may be reluctant to participate in V2G services due to concerns about battery degradation.

Optimized Asset Utilization	• Increased Charger Uptime and Utilization Rates: Smart scheduling and load management ensure that chargers are used efficiently throughout the day. • Balancing Grid Loads with Local Storage: Effective use of on-site batteries allows for better distribution of energy and prevents charger downtime. • Extending Charger Lifespan: Preventing excessive energy surges and optimizing usage cycles reduces wear and maintenance costs. • Scalability for Future Expansion: Smart systems enable the integration of more chargers and EVs without overloading the grid.	• Intermittent Energy Demand: EV driver behaviour can be unpredictable, making it difficult to optimize utilization without real-time data and AI-driven adjustments. • Infrastructure Constraints: Existing grid connections may not support the full potential of asset utilization without additional upgrades. • Compatibility with Different EV Models and Standards: Ensuring that chargers and software are fully compatible with a variety of EVs remains a challenge. • Data Management and System Complexity: Efficient asset utilization requires real-time monitoring, predictive analytics, and robust backend infrastructure, which can be costly to develop and maintain.

The Emobility Solutions (EMS) is transforming public EV charging by integrating V2G-certified chargers with smart energy management, creating a system that benefits both users and the grid. By leveraging peak shaving and time-of-use optimization, EMS helps reduce electricity costs for charge point operators, ensuring that charging happens when energy is cheapest while also preventing expensive demand spikes. This not only cuts operational expenses but also enhances the overall efficiency of the charging network. At the same time, the system enables new revenue streams by allowing participation in demand response markets and offering dynamic …

Value Proposition Summary

Emobility Solutions (EMS) is transforming public EV charging by integrating V2G-certified chargers with smart energy management, creating a system that benefits both users and the grid. By leveraging peak shaving and time-of-use optimization, EMS helps reduce electricity costs for charge point operators, ensuring that charging happens when energy is cheapest while also preventing expensive demand spikes. This not only cuts operational expenses but also enhances the overall efficiency of the charging network.

At the same time, the system enables new revenue streams by allowing participation in demand response markets and offering dynamic pricing models. Instead of just providing a place for EVs to charge, EMS turns chargers into active energy assets that can store and release energy when needed, improving grid stability and making money in the process. By optimizing asset utilization, EMS ensures that chargers are used more efficiently, reducing idle time and making better use of local renewable energy sources like rooftop solar and battery storage.

This means less reliance on the grid, lower carbon emissions, and a more sustainable energy ecosystem. While challenges like regulatory uncertainty and infrastructure upgrades remain, EMS is pioneering a smarter, more flexible, and cost-effective approach to EV charging that benefits operators, drivers, and the entire energy system.

11.5 Business Model Canvas

The business model for this use case is centred on the integration of public V2G-certified chargers within a municipally owned site, leveraging local solar photovoltaic generation and stationary battery storage to support peak shaving and enable participation in energy flexibility markets. The selected business model archetype—Time-of-Use (ToU) Optimisation—aligns well with the fluctuating energy price environment in Hungary and offers a scalable revenue pathway based on energy arbitrage, grid services, and smart charging subscriptions.

The chargepoint operator (CPO), Emobility Solutions, acts as the technical and commercial orchestrator of the system. It provides hardware (Alfen V2G chargers), software (Enervalis), and end-user access (via mobile platforms and charging portals), enabling intelligent management of the charging ecosystem. The CPO monetises the infrastructure through a mix of usage-based pricing, fleet-oriented subscription models, and participation in grid support programmes, such as demand response and flexibility tenders.

The model relies on a network of strategic partnerships. The municipality of Erzsébetváros provides the site and supports local energy transition objectives. DSOs and TSOs enable participation in grid services. EV manufacturers and energy suppliers contribute to system integration and electricity sourcing. The presence of a local 100 kW PV installation and 100 kWh battery storage system allows the CPO to increase self-consumption, reduce grid reliance, and optimise energy flows in real time.

Value creation is delivered to multiple segments. Public EV drivers benefit from lower-cost charging and improved service reliability. Fleet operators gain from predictable energy expenses and enhance operational efficiency. The municipality meets sustainability targets and showcases innovation in urban energy systems. Revenue streams are diversified across charging fees, arbitrage income, grid services remuneration, and potential government subsidies for smart grid and V2G projects.

Cost structure components include high upfront capital expenditure for V2G-compliant infrastructure, EMS deployment, and compliance with interoperability standards (OCPP 2.0.1, ISO 15118-20). Operational costs include charger maintenance, user support, and market participation fees. However, over time, savings from optimised energy procurement and monetised flexibility services can significantly offset initial investments.

This business model positions public EV infrastructure not only as a transport service but also as a multi-functional urban energy node, capable of supporting both the grid and the local economy, while paving the way for broader adoption of distributed energy technologies in Hungary’s capital.

Selected Energy Management Service: Peak Shaving	**Selected Business Model:** Time-of-Use Optimization	**Selected Stakeholder Perspective:** Charge point operator

Key Partners

Municipality of Erzsébetváros (Budapest District VII) – Providing the site and supporting smart energy initiatives.

Energy Suppliers (e.g., MVM, E.ON) – Supplying electricity and offering dynamic pricing models.

Distribution System Operator (E.ON Hungary or another DSO) – Managing local grid connections and ensuring compliance with grid constraints.

Technology Providers (Enervalis, Alfen, OCPP/ISO 15118 standard bodies) – Offering smart charging software, V2G-enabled chargers, and interoperability solutions.

EV Manufacturers (Potentially Hyundai, Renault, or another V2G-ready OEM) – Supplying compliant electric vehicles for testing and future scaling.

Flexibility Service Aggregators (e.g., Next Kraftwerke, energy trading platforms) – Enabling EMS to participate in demand response and grid-balancing markets.

Key Activities

Operating and Managing Smart Charging Infrastructure – Ensuring efficient, demand-responsive operation of public chargers.

Time-of-Use Optimization & Peak Shaving – Shifting EV charging to off-peak hours to reduce costs and balance the load.

Integration with Energy Markets – Selling stored energy or demand-side flexibility to maximize revenue.

Customer and Fleet Charging Management – Providing seamless, cost-effective charging services for public and fleet EV users.

System Interoperability and Compliance – Ensuring chargers work with various EVs and comply with OCPP and ISO 15118 standards.

Renewable Energy Utilization – Coordinating with on-site PV and battery storage to reduce reliance on grid electricity.

Key Resources

Smart Charging Infrastructure – V2G-enabled Alfen Twin 5 chargers installed at the market hall.

Energy Management System (EMS) – Enervalis smart charging software optimizing energy usage.

On-Site Renewable Energy & Storage – 100 kW solar PV system and 100 kWh BESS to support self-consumption.

Dynamic Pricing and Energy Contracts – Agreements with energy suppliers and DSOs for time-of-use optimization and demand-side participation.

Value Propositions

Cost Savings – Smart charging algorithms reduce electricity expenses by shifting charging to off-peak hours and minimizing peak demand charges.

Revenue Generation – EMS can participate in flexibility markets, demand response programs, and energy arbitrage, turning charging infrastructure into a revenue-generating asset.

Optimized Asset Utilization – By ensuring efficient use of chargers, battery storage, and renewable energy, EMS maximizes infrastructure ROI.

Enhanced Grid Stability – Load balancing helps prevent local grid congestion and integrates with DSO flexibility programs.

Sustainability & Compliance – Aligns with municipal sustainability goals, reducing emissions through higher renewable self-consumption and supporting V2G technology adoption.

Customer Relationships

Automated & Self-Service Charging – Users interact with the charging stations and mobile app for access, payment, and charging insights.

Subscription & Membership Options – Potential premium plans for fleets and frequent users that offer optimized charging rates and priority access.

Dynamic Pricing & Smart Charging Support – Providing time-of-use optimization and automated savings recommendations via AI-driven EMS.

Municipal & Business Collaboration – Working with city officials and local businesses to ensure chargers support energy resilience and grid integration.

Customer Support & Education – Offering guidance on V2G benefits, battery health, and cost-saving strategies via digital and in-person resources.

Channels

Physical Charging Infrastructure – Publicly accessible charging points at the market hall, managed by EMS.

Mobile App & Online Platform – Providing real-time pricing, charging availability, and scheduling for users.

Partnerships with EV Service Providers – Collaborating with eMSPs (e.g., Fortum Charge & Drive, PlugSurfing) for seamless access and billing.

Integration with Fleet Management Systems – Offering time-optimized charging solutions for corporate and municipal fleets.

Customer Segments

Public EV Drivers – Individuals using the public V2G-capable chargers for regular and smart charging.

Fleet Operators – Municipal and commercial fleets looking for optimized charging solutions that reduce costs and increase efficiency.

Local Businesses & Market Vendors – Businesses operating within or near the market hall that may benefit from smart charging or V2G services.

Energy Market Participants – DSOs, TSOs, and flexibility aggregators benefiting from grid balancing and demand-side response.

Municipality & Urban Sustainability Projects – Government entities supporting energy-efficient and grid-friendly mobility solutions.

	Data & Analytics Capabilities – Real-time monitoring tools to manage load balancing, charging schedules, and grid interactions. Regulatory & Market Knowledge – Expertise in Hungarian energy policies, demand response markets, and local incentives.		Energy Trading & Demand Response Platforms – Selling stored energy or providing grid-balancing services via aggregator networks.	

Cost Structure	**Revenue Streams**
• Infrastructure & Equipment Costs – Investment in V2G chargers, energy management software, and grid connection upgrades. • Operational Costs – Expenses related to maintenance, software updates, and customer service. • Electricity & Grid Fees – Costs of electricity for reselling in time-of-use optimization and arbitrage models. • IT & Data Analytics – Maintaining the EMS platform, mobile app, and real-time monitoring tools. • Compliance & Regulatory Costs – Ensuring adherence to energy market regulations, OCPP, and ISO 15118 standards. • Marketing & Customer Acquisition – Promoting V2G charging benefits, customer education, and business outreach.	• Pay-Per-Use Charging Fees – Revenue from public and fleet users paying for charging services based on time and kWh consumption. • Time-of-Use Price Optimization – Profit from charging when electricity is cheap and discharging when prices are high (energy arbitrage). • Demand Response Participation – Payments from aggregators, DSOs, or TSOs for reducing grid demand during peak times. • Flexibility Market Compensation – Earnings from providing grid-balancing and load-shifting services. • Subscription Plans for Fleet Operators – Monthly or annual plans offering priority access, discounted rates, and optimized charging schedules. • Municipal & Sustainability Funding – Potential government incentives for supporting urban energy efficiency and V2G adoption.

Business Model Summary

Emobility Solutions (EMS) is redefining the role of public EV charging by turning it into an intelligent energy asset. Instead of just providing electricity to vehicles, EMS uses smart energy management to optimize charging times, reduce costs, and generate new revenue streams.

By leveraging peak shaving and time-of-use optimization, the system ensures that EVs charge when electricity is cheapest and avoids expensive demand charges that come with high grid usage during peak hours. This not only benefits EV drivers by offering lower charging costs but also maximizes the efficiency of the entire charging infrastructure. The business model revolves around earning revenue through pay-per-use charging, fleet subscription plans, and participation in energy flexibility markets.

By integrating bidirectional V2G chargers, EMS enables stored energy in EV batteries to be used to stabilize the grid or power the market hall, creating additional value. The combination of on-site solar power, battery storage, and intelligent load balancing means that energy is used more efficiently, reducing strain on the grid and increasing the use of renewable electricity. Municipal support and partnerships with energy providers ensure smooth operations and regulatory alignment, while the use of open standards like OCPP and ISO 15118 guarantees compatibility with different EVs and charging networks.

The biggest advantage of this model is that it transforms a simple charging station into a smart, revenue-generating energy hub. While the upfront investment in infrastructure and software is significant, the long-term financial benefits of lower operating costs, new income from flexibility services, and improved asset utilization make this approach both sustainable and scalable. EMS is not just providing a place to charge—it is building a future where EV charging actively supports energy efficiency, reduces grid dependence, and creates new business opportunities in urban mobility.

11.6 Key financial indicators

The financial viability of the Budapest V2G-certified public charging use case hinges on balancing the initial infrastructure investment with recurring revenues from smart energy services. The financial model reflects a dual value proposition: lowering electricity costs through intelligent load management and unlocking revenue from grid-support functions.

Revenue generation is segmented into four primary streams: charging fees, energy market participation, self-consumption optimisation, and incentive-based funding. Pay-per-use charging remains the foundational income channel, with time-based and energy-based tariffs aligned with real-time market prices. Time-of-use optimisation enables Emobility Solutions to arbitrage between low-cost electricity procurement and high-price grid sell-back via vehicle-to-grid (V2G) discharge and battery storage. Flexibility services, including demand response and load shifting, offer an emerging but increasingly valuable revenue source in Hungary's evolving electricity markets. In parallel, participation in national and EU-level sustainability schemes may yield grants or subsidies covering part of the infrastructure or operational costs.

Operational efficiency is bolstered by local PV self-consumption, which displaces grid energy during peak pricing hours. Combined with battery storage, the system achieves greater control over when and how energy is consumed, stored, or exported. These savings, when scaled over multiple years, can reduce total energy costs by 20–35%, depending on grid tariffs and solar output.

Cost parameters reveal a capital-intensive structure in the short term. V2G chargers, battery systems, and EMS software together represent the bulk of fixed investment. Ongoing costs include maintenance, data management, and regulatory compliance, particularly with regard to metering, billing, and grid interconnection standards. Grid fees and energy procurement costs will fluctuate based on tariff models, which underscores the importance of the EMS in managing consumption patterns dynamically.

The business case is further strengthened by fleet subscriptions and bulk charging agreements, which offer predictable cash flow and cost recovery opportunities. In the long term, as vehicle compatibility with V2G becomes more widespread and flexibility market mechanisms mature, the site may become a net contributor to grid stability—turning infrastructure into a dispatchable energy asset.

Revenue Parameters	Cost Parameters
Charging Fees & Dynamic Pricing	**Infrastructure & Technology Costs**
• Revenue from pay-per-use charging (per kWh or time-based)	• V2G Charger Purchase Costs
• Subscription plans for fleet operators (monthly/yearly access with discounts)	• Installation & Electrical Work
• Dynamic pricing revenue from adjusting rates based on grid demand and energy costs	• Energy Management System (EMS) software costs
Energy Market Participation & Grid Services	• IT & Data Analytics
• Demand response payments from DSOs/TSOs for peak load reduction	**Operational & Maintenance Costs**
• Time-of-Use Optimization revenue (charging during low-cost hours and discharging when prices are high)	• Charger maintenance and servicing
• Flexibility market compensation (providing load balancing services)	• Customer support & administration

• Ancillary services revenue (participating in frequency regulation or operating reserves)	• Grid fees & electricity procurement
Renewable Energy & Self-Consumption Optimization	**Market & Compliance Costs**
• Onsite PV self-consumption savings (reducing electricity purchase costs)	• Regulatory compliance costs
• Battery storage utilization revenue (selling stored energy during peak pricing)	• Flexibility market participation fees
• Electricity bill reduction from optimized charging schedules	• Marketing & customer acquisition
Incentives & Grants	**Battery & Energy Storage Costs**
• Government subsidies for V2G deployment and smart grid integration	• Battery degradation & replacement costs
•	• Storage system maintenance

11.7 Ecosystem Map

The Emobility Solutions (EMS) in Budapest aims to deploy public V2G chargers to enhance energy efficiency, lower costs, and bolster grid stability. The below methodology is based on the one outlined in Section 6.2.

The network graph, visualizing stakeholder dynamics, translates the scores of the Multi-Criteria Weighted Cost-Benefit Analysis into a visual representation, with **nodes** as stakeholders (e.g., EMS, EV Drivers, National Regulators) and **directed edges** as interactions, weighted by their scores. Key observations from the graph include:

- **EMS as the Hub**: EMS is centrally positioned, connecting to diverse stakeholders like EV Drivers, Site Owners, grid operators, and regulators, reflecting its role in orchestrating the V2G ecosystem.

- **Strong Positive Links**: Interactions with EV Drivers (1.20) and Site Owners (0.65) show thick, positive edges, indicating robust partnerships that drive user engagement and local support.

- **Regulatory Barriers**: Negative scores with National Regulators (-0.95) and Standardization Organizations (-0.05) appear as thinner or dashed edges, signalling obstacles to deployment.

- **Emerging Opportunities**: The high score with Flexibility Service Aggregators (1.35) suggests a critical, yet underdeveloped, connection that could be visualized as a bold, latent edge.

In a visual graph, edge thickness or colour could further emphasize score magnitude, making it easy to spot critical relationships immediately.

Implications for the EMS Use Case

The scores and network graph yield actionable insights for the business case based on the pilot in Budapest:

- **Strengthen Key Partnerships**: The positive scores with EV Drivers and Site Owners suggest EMS should prioritize user incentives and municipal collaboration to ensure adoption and operational success.

- **Mitigate Regulatory Risks**: The negative interaction with National Regulators (-0.95) calls for proactive lobbying and dialogue to reduce compliance burdens and secure supportive policies. This also indicates that the regulatory environment is not ideal for the business case to operate.

- **Tap Market Potential**: The strong score with Flexibility Service Aggregators (1.35) highlights an opportunity to integrate with energy markets, boosting revenue through grid services. This is currently a developing market in the context of the use case.

- **Engage on Standards**: Though slightly negative (-0.05), the link to Standardization Organizations is vital for long-term scalability. V2G standards are important enables for the business case, but it is a double-edged sword,

These insights guide EMS toward a strategy that balances immediate challenges with future growth.

The MCWCBA methodology, coupled with the network graph, offers a comprehensive, data-driven lens into the Innovation Cluster D2 use case in Budapest. By scoring stakeholder interactions across multiple weighted criteria, this approach illuminates both opportunities (e.g., EV Driver engagement, market participation) and hurdles (e.g., regulatory compliance). For the project to thrive, the regulatory environment must change so that it becomes an enabler, instead of a barrier to companies as EMS pursuing flexibility market opportunities.

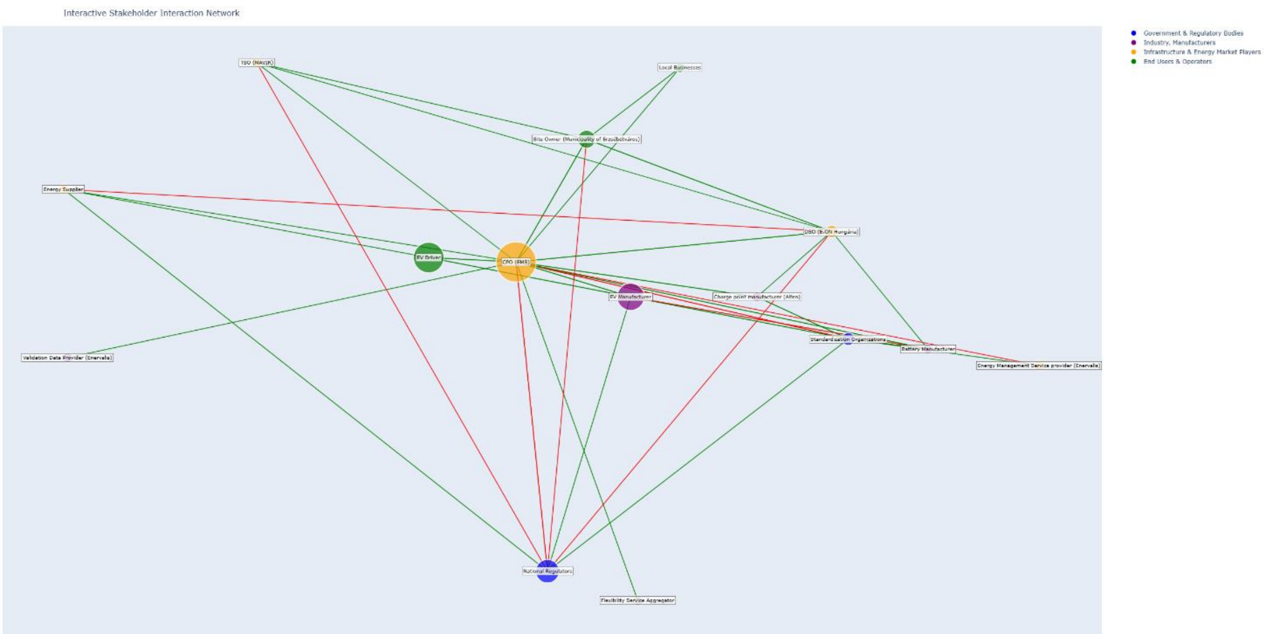

Figure 7: network graph of the stakeholder interaction map of the D2 use case ecosystem

The values of the MCWCBA and the Python script used for visualization is accessible in the Annex to this report.

12 Use Case 00: Bi-directional ecosystem via combined V2G service from large car sharing program under a single owning entity (Utrecht)

12.1 Use Case Overview

This use case explores large-scale station-based car-sharing in an urban context, focusing on a combination of smart charging and bi-directional (vehicle-to-grid, V2G) charging operation. By providing a mix of grid flexibility services (Day Ahead Market driven charging, grid congestion management and balancing market services), charging costs are optimized and grid loads grid are minimized or even reduced. The context is the fleet of V2G chargers currently being rolled out by We Drive Solar in order to charge (and discharge) a fleet of V2G EV's in a car sharing scheme operated by Mywheels as MSP, in and around the city of Utrecht in the Netherlands. The project, led by We Drive Solar as innovator and charge point operator, aims to add extra value to the operation of the shared EV's for Mywheels as service provider, for Utrecht as a city and for the end users of the shared EV's.

Use Case Overview	
Use case name	Use Case 00: Bi-directional ecosystem via combined V2G service from large car sharing program under a single owning entity (Utrecht)
Objective	The primary goal of this use case is to demonstrate and test the economic and operational potential of bidirectional charging of shared E-cars on a large scale, providing multiple services and value models to the MSP, DSO and local authorities.
Use case leader	We Drive Solar
Use case leader organization type	Charge point operator

12.2 Case study boundary conditions

General Conditions	
Country	The Netherlands
Time Frame	2-3 years
V2X Type	V2G
Technological Assumptions	
Technology Maturity Level	Developing
Adoption Rate Outlook	Medium
Interoperability Compatibility Level	Moderate
Conditions on Site	
Existing Connection Capacity	17-22kW per charging station
Ability to Facilitate Selected V2X	Partial
Connection Capacity Category	Needs Upgrade (2)
Local Infrastructure Condition	Fair
Potential to Increase Renewable Capacities	Medium (2)
Selection of Energy Management Services	
EMS Optimization Cluster	Wholesale
Energy Management Service	Day Ahead Market price optimization, congestion management, balancing markets.
Market Assumptions	
Market Size and Growth	4: Significant Growth
Demand for Electric Vehicles	4: Above Expectations
Grid Services Demand	5: High
Competitive Landscape	2: Dominant
Innovation Rate	4 Above Expectations
Electricity Price Fluctuations	4: Volatile
Expected Price Changes in the Next 5 Years	Increase
Impact on V2X Profitability	5: Positive

Value Proposition (TOP 5)	
1. Cost Savings 2. Flexibility and Scalability 3. Balancing services 4. Revenue Generation 5. Optimized Asset Utilization	
Regulatory Assumptions	
Policy Environment Stability	2: Slightly Unstable
Commercial Exploitation Allowance	2: Limited Market
Availability of Incentives	No
Level of Incentives	Poor
Effectiveness	Ineffective
Economic Conditions	
EVSE Purchase Cost	Moderately Higher Price
Installation Costs	Neutral price
Metering Equipment Costs	Slightly Higher Price
Additional Hardware/Software Costs	Moderately Higher Price
EV Purchase Costs	Moderately Higher Price
EV Operation Costs	Neutral Price
Organizational and Administrative Efforts	Higher Price
Business model	6. Time-of-Use Optimization
Environmental Benefits	Lower CO2-emissions
Social Benefits	Less air pollution in cities Less grid congestion, enabling energy transition

The pilot takes place in the Netherlands, where electric vehicle adoption is considerable, yet the use of V2G technology remains at an emerging level. At the moment of writing (spring 2025), WDS is installing the first 50 AC-V2G chargers that are compatible with ISO15118-20, and the first 50 Renault 5 V2G EV's that are also compatible with ISO15118-20 are arriving in the Netherlands to be exploited as shared EV's by

Mywheels, location-based on the WDS chargers. By the end of 2025, the fleet of bidirectional shared EV's is expected to have grown to 500 V2G Renault 5's with their WDS chargers. The goal is to have several thousands of shared bidirectional EV's operational within the next two or three years.

Despite a slightly unstable policy environment that offers no significant incentives for V2G activities and even provides a penalty in the form of double energy taxation, market growth for bidirectional shared EVs in the Netherlands is expected to remain strong. The high demand for congestion management and other flexibility services to the power grid services provides favourable prospects for commercial exploitation, although regulatory allowances and poor incentive structures could slow large-scale deployment. Notwithstanding the unfavourable incentives, the slightly higher capital costs for bidirectional functionality of EV's, roadside chargers and their ICT backoffice, the price advantages associated with V2G on Day Ahead Market prices and the additional grid flexibility and congestion management services that can be provided are expected to lead to a positive business case.

12.3 Stakeholder Analysis

The V2G charging services, applied to shared V2G EV's, serve the interests of several stakeholders:

- The MSP exploiting the V2G shared EV's (in this case Mywheels) can expect lower charging costs and thus a more competitive price level for their shared EV scheme;
- The local DSO can expect a fleet of EV's that can not only eliminate grid load for charging at moments of peak demand on the grid, but even contribute to lowering the grid load at such moments, thus reducing grid congestion problems and decreasing the need for fast grid reinforcements;
- The TSO can expect the fleet of EV's to contribute to grid balancing markets;
- The local authority can expect alleviation of the grid congestion, which is a severe problem in most parts of the Netherlands and limits new housing construction, the establishment and growth of companies and the energy transition.
- Also, local authorities can expect more rapid roll-out of EV sharing schemes to lead to less need for parking space, less need for urban public space for power grid reinforcement infrastructure, lower air pollution levels and greener and healthier urban mobility.

On the supply side, V2G operation on this scale involves investors, manufacturers, aggregators, ICT supporters and flexibility service providers. The complex cooperation between these partners is complex and the profitability needs to be balanced between them, but the overall value case is positive. By aligning these varied interests, the use case aims to demonstrate that integrating smart charging and V2G with EV sharing can sustainable business for all parties.

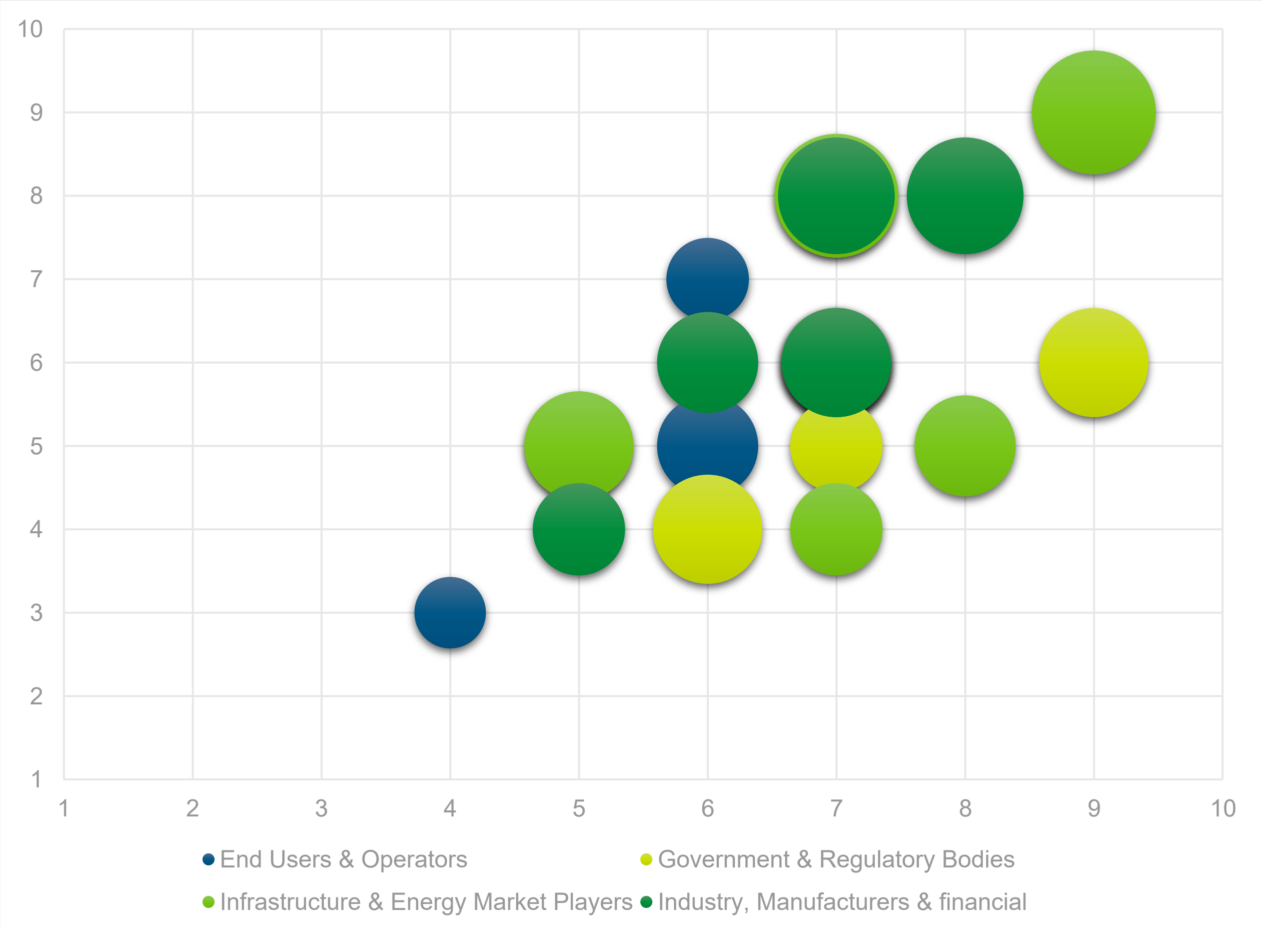

Figure 8: Stakeholder Analysis for Use Case 00

The table below outlines these considerations in detail, assigning numerical values to interest, influence, and importance. The associated graph visually represents each stakeholder's position in the influence-interest matrix, highlighting where collaboration, negotiation, or compliance efforts are most needed to ensure successful implementation and long-term viability of the V2G pilot.

Type	Stakeholder types	Identified stakeholder in the use case	Interest	Influence	Importance
End Users & Operators	Shared EV Driver	Customers of Mywheels driving V2G cars	4	3	3
End Users & Operators	Fleet operators	Mywheels as fleet operator exploiting V2G cars	6	7	4
End Users & Operators	Housing developer	Developer of new housing projects	6	5	6
Government & Regulatory Bodies	Local and regional authorities	City of Utrecht	9	6	7
Government & Regulatory Bodies	Regional authority	Province of Utrecht	7	5	5

Government & Regulatory Bodies	**Standardization organization**	ISO15118 working group, Hungarian standards bodies	6	4	7
Infrastructure & Energy Market Players	**Charge point operator**	We Drive Solar as CPO	9	9	9
Industry, Manufacturers & financial	**eMobility service provider**	Backoffice for chargers	5	5	7
Industry, Manufacturers & financial	**Energy Management Service provider**	Central control of chargers	7	8	9
Industry, Manufacturers & financial	**Distribution system operator**	i.e., Stedin	8	5	6
Industry, Manufacturers & financial	**Transmission system operator**	TenneT	7	4	5
Industry, Manufacturers & financial	**Energy supplier**	Partner energy providers for Duna Auto’s grid connection	7	6	7
Industry, Manufacturers & financial	**Balance responsible party**	BRP of WDS	5	5	6
Industry, Manufacturers & financial	**Aggregator and flexibility service provider**	Aggregator of WDS	7	6	7
Infrastructure & Energy Market Players	**Validation data provider**	Aggregator or BRP	6	6	6
Infrastructure & Energy Market Players	**Electric vehicle manufacturer**	Renault (later also others?)	7	8	8
Infrastructure & Energy Market Players	**RTOs and universities**	i.e., Utrecht University	5	4	5
Infrastructure & Energy Market Players	**Charge point manufacturer**	WDS	8	8	8
Infrastructure & Energy Market Players	**Financial institution**	Investor	7	6	7

12.4 Value Proposition Canvas

The V2G charging proposition for shared EVs developed by WDS enables fast roll-out of V2G charging, reduces charging costs, helps EV sharing as a green, healthy mode of urban transport, while reducing CO_2 emissions, air pollution and enabling further progress of the energy transition.

Customer Profile	Value Map
Gains (Expected Benefits for Stakeholders)	**Gain Creators (Ways the Smart Charging Ecosystem Creates Value)**
Cost savings: Lower charging bills for MSP through arbitrage, balancing services, and congestion management benefits. Optimized Asset Utilization: Shared EV serve as temporary energy storage to reduce grid congestion and imbalance. Operational Efficiency: Smart and V2G charging aligns with EV sharing operations (coupling to reservation schedule), ensuring vehicles are ready for customer use. Sustainability Gains: Strong reduction in CO_2 emissions because of load shifting; contribution to grid congestion. Transparent Customer Experience: EV sharing customers don't need to know what's under the bonnet but may enjoy lower prices and sustainability.	Smart scheduling shifts charging and discharging to minimize high grid tariffs and creates benefits through congestion management and balancing markets. Grid Optimization: Reduce grid load, contribute to grid congestion management. Energy Monitoring & Analytics: Real-time insights help MSP and CPO track savings, vehicle readiness, and charging efficiency. Interoperability & Standardization: Ensures compatibility with multiple EV brands and charging networks using protocols like OCPP and ISO 15118.
Pains (Challenges or Problems Faced)	**Pain Relievers (Solutions That Mitigate Stakeholders' Challenges)**
Regulatory Barriers: Uncertainty around V2G policies, incentives, and double energy taxation issues hinder upscaling. Interoperability Issues: Lack of standardization across different EV brands and energy management systems complicates implementation. Limited Vehicle Availability: EV's may be in operation (as shared cars) or in maintenance. Battery Degradation Concerns: OEMs may be hesitant to open V2G interoperability to fear of battery lifespan reduction.	Fully automated central control of EVSE and AI-driven optimization to ensure charging and discharging are cost-optimized across the revenue models. Regulatory Alignment: Advocates for supportive policies and compliance frameworks to enable V2G and demand-side participation.

Customer Jobs (Tasks or Activities Stakeholders Need to Perform)	Products & Services (Specific Offerings Provided within the Smart and V2G Charging Ecosystem)
Fleet Operators (shared EV MSP): Introduce V2G cars and charging and integrate into operation Energy Suppliers & Grid Operators: provide access to balancing markets and congestion management platforms Policy Makers & Regulators: Ensure incentives and regulations align with V2G to gain benefits: reduction of grid congestion, increased grid balance and flexibility.	Smart Charging & V2G Infrastructure: AC bidirectional chargers designed for large-scale on-street charging, arbitrage, congestion management and grid balancing. Management Software (EMS): Central AI-based optimization platform for load balancing, arbitrage and congestion management. Grid Services Integration: Participation in ancillary services such as frequency regulation and demand flexibility. Digital Charging & Billing Platform: Real-time monitoring, automated billing, and customer-facing insights. Regulatory & Market Advisory Services: Ensuring compliance with evolving V2G policies and energy-sharing frameworks.

Drivers and barriers of TOP3 value propositions

Value Proposition	Drivers	Barriers
Cost Savings	Ability to react on spot market price fluctuations reduces charging costs. These costs can be further reduced by (or rather balanced with benefits from) aFRR services and congestion management services (voluntary redispatch).	Organisational and ICT investments for controlling V2G chargers. Lack of regulatory frameworks (e.g., double energy taxation) and market infrastructure (balancing market and congestion management platforms are still developing access from distributed flexibility sources on a large number of small connections. OEMs are still releasing the very first EV supporting ISO15118-20 AC V2G functionality.

Flexibility and Scalability	The grid flexibility will create new price points for EV charging while providing additional social benefits. Application in EV sharing market provides fast scalability and high utilization rates for V2G (because the reservation schedule is known, V2G can be deployed much more often than with private EV without bothering the end user).	Regulations are hindering market flexibility e.g. application in energy communities. Only first EV models on the market.
Optimized Asset Utilization	Even shared EVs are idle most of the time and use as battery optimizes their utilization.	Vehicles may not always be available due to operational needs (e.g., reserved for driving, maintenance). Poor interoperability between chargers, vehicles, and EMS systems creates operational inefficiencies. Limited V2G-compatible EVs in inventory may restrict.

Value Proposition Summary

The V2G charging proposition for shared EVs developed by WDS enables fast roll-out of V2G charging, reduces charging costs, helps EV sharing as a green, healthy mode of urban transport, while reducing CO2 emissions, air pollution and enabling further progress of the energy transition.

12.5 Business Model Canvas

Selected Energy Management Service: Dynamic Grid Tariffs

Selected Business Model: Time-of-use optimization

Selected Stakeholder Perspective: Charge point operator

Key Partners

Car sharing providers (MSP): Partner with Mywheels to roll out V2G in their fleet

Car Manufacturers: Partner with Renault to ensure V2G compatibility and roll-out. Later, also OEM providing AC-V2G EVs possible .

Technology Providers: Suppliers of back-office software, aggregators

Local Grid Operators: Coordination for utilizing flexibility in grid congestion management and for balancing services.

Regulators and Policymakers: Advocate regulatory frameworks that better enable V2G services for on-street charging (double energy taxation, inclusion in energy communities).

Energy Suppliers: Collaborate for off-peak electricity procurement and monetization of stored energy. Flexibility Service Providers: For participating in demand response and flexibility markets.

Key Activities

Optimize charging and (with V2G) discharging on Day Ahead spot market prices.

When congestion management and aFRR platforms support distributed resources: develop control algorithms to optimize charging and discharging seeking maximal value across dynamic prices and these services.

Calculate benefits and share these with MSP (by adapting charging fees).

Key Resources

Shared EVs, when not being used and connected to their charger, act as dynamic storage resources.

Control system to optimize charging and discharging based on reservation schedule, dynamic energy pricing, congestion management benefits, balancing market benefits, based on the fluctuating availability of vehicles on their chargers.

V2G Chargers: Bidirectional chargers capable of integrating with central control system

Workforce: Skilled personnel for charger installation and maintenance, system operation, and customer engagement.

Value Propositions

Cost Savings: The MSP benefits from reduced charging fees.

Revenue Generation: CPO generates revenues by reducing charging costs and maintaining a margin in charging fees.

Optimized Asset Utilization: Shared EVs can incidentally be kept on their chargers (made unavailable for reservation) to increase flexibility at moments when severe price fluctuations and/or congestion conditions are expected.

Operational Alignment: The EMS is tailored to ensure EV sharing operations (e.g., vehicle readiness, maintenance schedules) are not unnecessarily disrupted.

Environmental Benefits: Increased renewable electricity consumption and reduced CO2-emissions because electricity is used at moments with higher fraction of RES production..

Customer Relationships

Revenue Sharing: Lower charging costs and benefits from V2G operation can lead to lower charging fees to the MSP.

Customer Outreach: Engage end customers to highlight the sustainability and operational benefits of V2G and smart charging.

Channels

Dealership Energy Management: Integration of energy-saving services directly into the dealership's operational processes.

EMS User Interface: Provide dealership management with easy-to-use interfaces to monitor savings, vehicle availability, and energy flows.

Customer Communication: Offer transparent updates to customers on how their vehicles contribute to sustainability and cost savings during their time at the dealership.

Marketing Campaigns: Use success stories from the dealership to promote the business model to other potential clients (e.g., other dealerships, fleets)..

Customer Segments

Primary customers: MSP providing shared EV services to citizens, benefiting from lower charging costs and environmental and social benefits. The end users are the final customers and benefit from lower costs the environmental and social benefits, but the smart and V2G charging are transparent to them.

Car Manufacturers: Secondary beneficiaries showcasing V2G capabilities in vehicles.

Power Grid Operators: Indirect customers benefiting from grid services (congestion management, balancing services).

Local authorities: indirect customers benefiting from congestion management benefits, which may decrease the present problems grid posed by congestion to realisation of new housing and construction projects, industry expansion and energy transition.

Cost Structure

Revenue Streams

• Hardware Costs: Production and installation of V2G chargers and integration with EV sharing ICT infrastructure. • Software Development: Development and maintenance of central control algorithms customized for fluctuating vehicle availability. • Operational Costs: Maintenance of V2G chargers and ICT systems. • Administrative Costs: Managing revenue-sharing agreements and compliance with operational requirements. • Regulatory Advocacy Costs: Engagement with policymakers to address challenges related to V2G.	• Charging fee: fee received from MSP for charging services for their shared EV. • Power costs: lower kWh costs as a result of arbitrage. • Grid Services Revenues: Payments from grid operators for providing congestion management and grid balancing services. • Alternative Fuel Units benefits: as a result of the charging electricity being generated by RES. • Customer Retention Revenue: Improved sustainability may attract more EV sharing customers, indirectly increasing revenue.

Business Model Summary

The business model for WDS focuses on leveraging distributed grid flexibility by exploiting vehicle-to-grid (V2G) technology in combination with smart charging and grid services, thus creating several revenue models. In close cooperation with Renault (currently rolling out the first ISO15118-20 AC V2G EV) and Mywheels (large EV sharing provider), V2G technology is rolled out at high speed, using parked vehicles as temporary energy storage assets. The system dynamically manages charging and discharging, scheduling EV charging when electricity prices are low and discharging stored energy during peak periods to reduce dealership electricity costs. Furthermore, congestion management services and grid balancing services will create additional revenues.

12.6 Key financial indicators

The financial success of this pilot rests on balancing moderately higher initial investment costs with the potential for significant, recurring cost savings. Infrastructure expenditures include V2G-ready chargers, metering equipment, and ancillary hardware or software needed for effective load balancing and data analytics. Regulatory compliance and coordination with multiple stakeholders can also elevate administrative costs, albeit with the prospect of earning revenues from flexibility markets and reducing overall electricity bills through peak shaving. Where user uptake is sufficiently high, and local electricity price differentials are pronounced, time-of-use pricing revenue can further enhance the business case.

Ongoing operational expenses typically involve maintenance, support, and ongoing system updates, which must be weighed against the projected savings in demand charges and the potential for future revenues if local regulators move to recognise or incentivise demand-side services. In sum, careful monitoring of cost, revenue, and utilisation metrics is essential to demonstrate that a data-driven, demand-side management strategy can deliver both economic and sustainability benefits in a commercial car-sharing context.

Revenue Parameters	Cost Parameters
Energy Optimization	**Infrastructure Investment**
• Load Shifted (kWh)	• EVSE Purchase Cost
• Time-of-Use Price Differentials	• Installation Costs
• Revenue from Optimized Energy Usage (peak shaving)	• Infrastructure Upgrade Costs
• "Battery Utilization Rate (%)	**Software and Technology**
Grid Service Payments	• Metering Equipment Costs
• Grid Service Payments	• Additional Hardware/Software Costs
• Ancillary Services Revenue	• Regulatory Compliance Costs
• Congestion Management Revenue	**Operational and Maintenance**
	• Operation and Maintenance Costs
Customer Revenue	• Customer Incentive Costs
• Customer Participation Fees	• Program Administration Costs
• Number of V2G Cars	• Electricity Procurement Costs
	• Marketing and Recruitment Costs

13 Innovation Cluster C – Case Study C4 Stedin Use Case - Quantitative Assessment of V2G in E-vans

13.1 Use Case Overview

To quantitatively assess the economic potential of smart charging and V2G strategies, a dedicated simulation was conducted using real-world operational data from 1,731 electric vans in the Stedin fleet operating in the Den Haag area throughout 2023, by FfE, in form of a cooperation with the SCALE project. The detailed presentation is available as an annex to this report, yet this chapter aims to summarize the key findings. The dataset comprises over 6700 trips per vehicle in some cases, which were cleaned and validated to correct errors and remove anomalies such as unrealistic trip durations or locations.

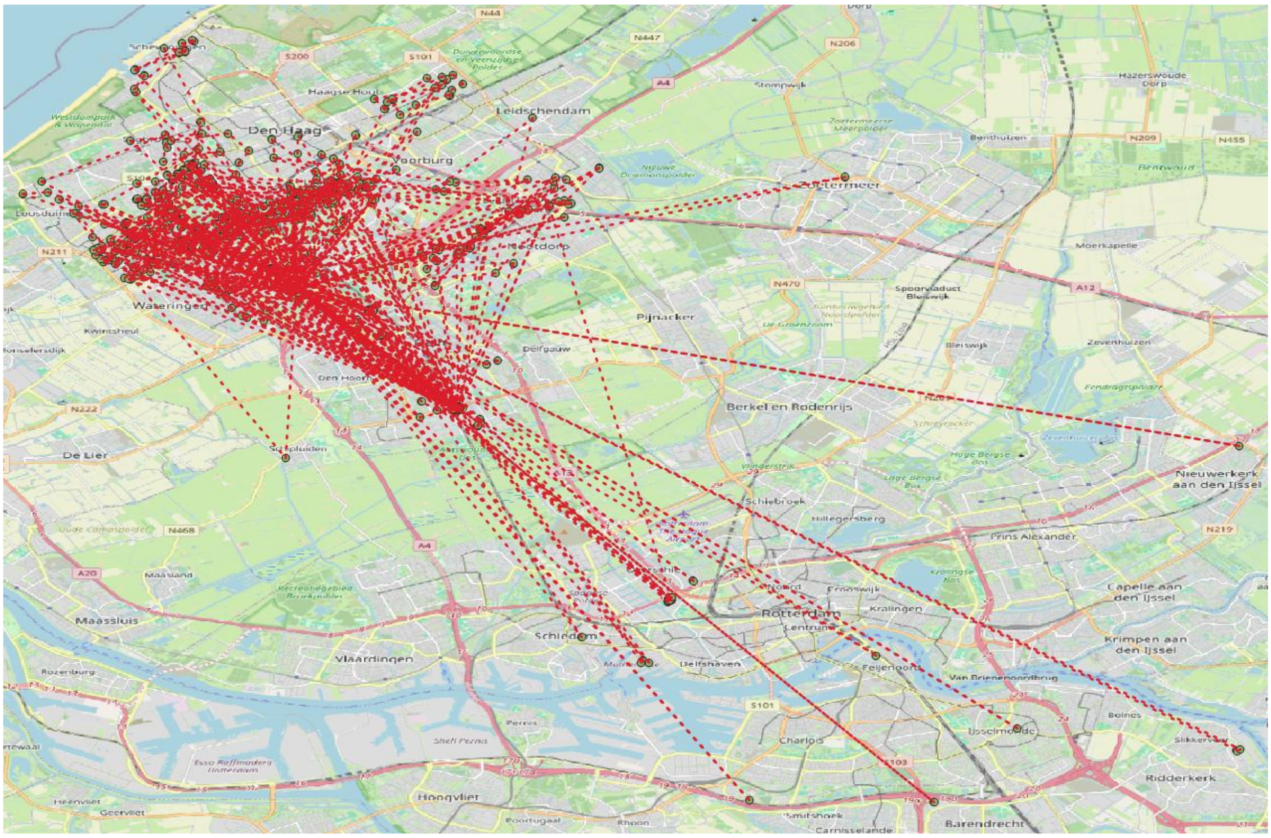

Figure 9: raw data analysed in the Stedin use case

13.2 Case study boundary conditions

For the cost optimisation modelling, the eFlame simulation framework developed by FfE was applied. eFlame is a mixed-integer linear programming (MILP) optimisation model, capable of capturing real-world boundary conditions in quarter-hourly time resolution across a full year. The model simulates three charging strategies for each of the 20 representative driving profiles derived from the dataset:

1) REF – Unmanaged, direct charging;
2) UNI – Managed, unidirectional smart charging (V1G);
3) BIDI – Managed, bidirectional charging (V2G).

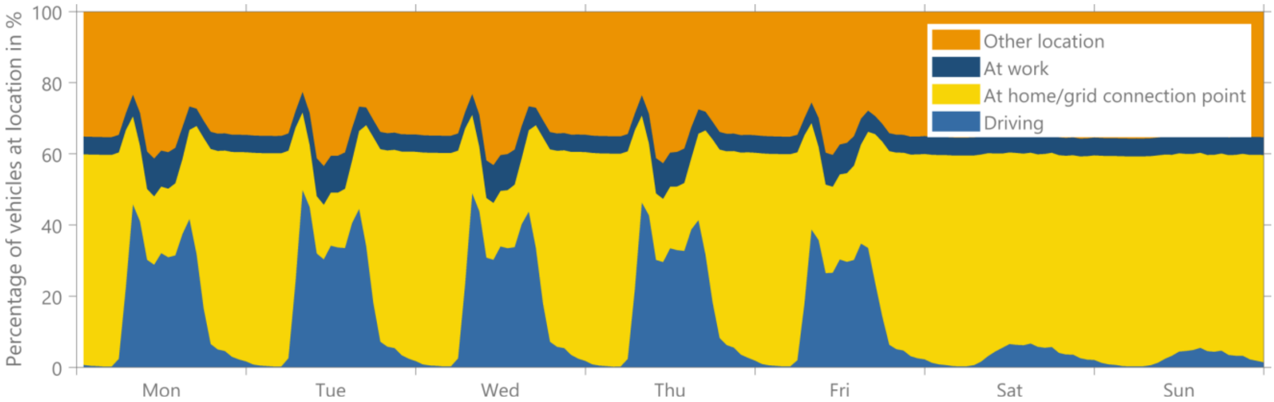

Figure 10: driving profiles in the Stedin use case

The objective function minimises the net electricity cost (charging costs minus discharging revenues) at the household or depot connection point, considering Dutch day-ahead electricity prices and applicable levies (incl. VAT and grid fees) for 2021, 2022, and 2023. Charging and discharging were only permitted when the vehicle was connected at its base location, and the state-of-charge (SoC) was constrained to maintain operational flexibility, with a 30% minimum SoC and a mandatory 70% SoC before the next trip.

13.3 Business Case Analysis

Results across the three years show that V2G can provide cost savings in the range of €220–€1,080 per vehicle per year, depending on energy price volatility and vehicle configuration. In 2022—characterised by high price volatility—V2G yielded the greatest benefits, especially for vans with larger battery capacities (100 kWh) and 22 kW charging power. In contrast, for the base case of 54 kWh battery and 11 kW charger, V1G achieved nearly the same savings as V2G in most scenarios, indicating that intelligent unidirectional charging is already highly effective under current market conditions.

Year	Charging Strategy	Battery Size	Charging Power	Average Net Savings (€)
2021	Unmanaged (REF)	54 kWh	11 kW	—
2021	Smart Charging (V1G)	54 kWh	11 kW	~ €180
2021	Bidirectional (V2G)	54 kWh	11 kW	~ €220
2022	Smart Charging (V1G)	54 kWh	11 kW	~ €500
2022	Bidirectional (V2G)	54 kWh	11 kW	~ €600
2022	Bidirectional (V2G)	100 kWh	22 kW	~ €1,080
2023	Smart Charging (V1G)	54 kWh	11 kW	~ €340
2023	Bidirectional (V2G)	54 kWh	11 kW	~ €400

Figure 11: Annual Net Cost Savings per Vehicle from Smart Charging Strategies (2021–2023). Note: Cost savings shown are relative to the unmanaged charging baseline. Exact values vary across vehicle profiles and are influenced by energy price volatility.

The simulations also show that battery degradation, expressed through equivalent full cycles (EFCs), increases moderately under V2G usage (20–80 EFCs/year), though battery wear costs were not explicitly considered in the cost analysis. This underlines the importance of considering both revenue and technical implications when deploying V2G at scale.

Overall, the Stedin case study confirms that while V2G can unlock substantial economic value, the magnitude of these benefits is highly sensitive to electricity market conditions and hardware configuration. The results also suggest that smart unidirectional charging is a cost-efficient and lower-risk entry point into flexibility services, with V2G offering incremental but situation-dependent advantages.

For further details on the model structure, assumptions, and boundary conditions, see: ffe.de/tools/eflame-electric-flexibility-assessment-modeling-environment and the related publication ScienceDirect.

14 Policy Recommendations

1. European Union Level

1.1. Harmonize Grid Service Markets and Aggregator Access Across Member States

The EU should promote the alignment of rules for flexibility and ancillary services markets, ensuring that V2G aggregators can participate on equal footing in all Member States. A directive or regulation should mandate clear rights for small-scale flexibility providers to access markets like frequency regulation (FCR, aFRR).

1.2. Support Standardization and Interoperability for V2X Technologies

The EU should expand mandates for implementing OCPP and ISO 15118-20 to ensure backward compatibility across charging standards. Funding should be allocated for conformance testing and open protocol integration (e.g., OCPP 2.0.1 & 2.1) across all V2X equipment deployed. This is in line with the Draghi recommendations.

1.3. Create a Dedicated EU Fund for Smart Charging and V2X Pilots

Establish a Horizon-style program to support the deployment of V2X business models in diverse urban and rural contexts, especially in regions with underdeveloped energy infrastructure. The fund should cover hardware costs, EMS development, and market participation testing.

1.4. Recognize V2X in EU Taxonomy and ESG Criteria

Include V2G services as a recognized green activity in the EU taxonomy, allowing private and public investors to classify V2X investments as sustainable. This should be tied to CO_2 reduction benchmarks and local renewable energy integration.

2. National Governments

2.1. Introduce National Frameworks for Aggregator Licensing and Participation

Create or update national legislation to define the role of V2G aggregators, remove barriers to market entry, and facilitate their participation in wholesale and ancillary markets. This should include simplified procedures for small aggregators and clear contractual rules for revenue sharing.

2.2. Mandate Dynamic Pricing and Time-of-Use Tariffs

Require electricity retailers and DSOs to offer dynamic or time-of-use tariffs to all EV users. These pricing mechanisms are essential to unlock the cost savings and grid benefits of V2X services, especially for fleet operators. Don't let profits be spoiled by old regulation which doubles energy tax.

2.3. Align Grid Connection Fees with Flexibility Contributions

Revise grid connection rules to reward sites that deploy V2G or stationary storage by lowering grid upgrade requirements or fees. Smart charging and V2X infrastructure should be treated as peak-reducing technologies in grid sizing calculations.

2.4. Expand Incentives for V2G-Ready EVs and Chargers

Incentive schemes for EVs and charging stations should favour V2G-capable vehicles and bidirectional chargers. This includes purchase subsidies, tax deductions, or direct installation grants for fleet operators and building owners. Explore the idea of a bonus-malus incentive forbidding-directional vs ICE vehicles.

3. Regional Governments

3.1. Coordinate Regional Flexibility Procurement Programs

Regional energy authorities should develop programs to procure flexibility services from local fleets, buildings, and charging hubs. These can complement national balancing markets and address regional grid bottlenecks.

3.2. Support Fleet Electrification with V2G in Regional Public Transport

Provide co-funding and technical assistance for integrating V2G into public transport depots, waste collection fleets, or school buses. Regional procurement frameworks should include V2G criteria in tenders and operational planning.

3.3. Launch Regional V2X Innovation Zones

Designate specific districts or industrial zones as testbeds for V2X deployment. These zones would receive regulatory waivers, investment support, and performance-based rewards to accelerate learning and private sector involvement.

4. City Level

4.1. Integrate V2X in Urban Grid Planning and Permitting

Cities should account for smart charging and V2G infrastructure in their urban energy and mobility plans. Grid permitting processes for new buildings or developments should include a requirement or incentive for V2G readiness.

4.2. Enable Public Charging Networks to Participate in Flexibility Services

Municipal CPOs or contracted operators should be allowed and encouraged to offer grid services through V2X-capable infrastructure. Cities should ensure their concessions and public tenders include provisions for V2G participation.

4.3. Use V2X to Support Critical Infrastructure Grid Connections

Leverage V2G as a tool to manage grid congestion and prioritize grid connections for socially important buildings (e.g., hospitals, schools, emergency shelters). This can help cities optimize their grid usage while avoiding expensive reinforcements.

4.4. Promote Citizen Engagement and Awareness of V2X Benefits

Cities should invest in awareness campaigns and pilot programs that showcase the societal and environmental benefits of V2X, such as reduced emissions, improved air quality, and energy resilience. Involvement of citizens in energy communities can help build local acceptance and participation.

15 Conclusions

The business cases of V2X technologies are influenced by a complex interplay of country-specific conditions, market regulations, electricity pricing, and stakeholder cost-benefit distribution. This section distils key findings from the SCALE V2X use cases, emphasizing business model scalability, financial viability, and critical enablers for V2G adoption.

Business Case viability is highly country-dependent

The financial attractiveness of V2X business models is heavily influenced by country-specific conditions, as electricity market structures, grid fees, regulatory environments, and available incentives differ significantly across Europe. In markets with high electricity price volatility, such as the Netherlands and Sweden, the feasibility of V2G participation becomes unpredictable due to fluctuating revenues from grid services. The presence of clear and supportive grid codes, along with well-defined aggregator regulations, plays a crucial role in shaping the market potential of V2G business models. Without proper policy alignment, opportunities for vehicle-grid integration can be limited or financially unviable. Additionally, national policies on dynamic pricing, congestion management, and grid access for flexibility service providers are essential in ensuring that V2G services remain a financially attractive and scalable solution. The varying levels of regulatory support across different countries highlight the need for tailored business models that adapt to the specific market conditions of each region, which might not be suitable for smaller business actors.

Electricity price volatility directly affects V2G business case feasibility

The viability of V2G as a cost-saving and revenue-generating solution is closely tied to the volatility of electricity prices. Findings from Stedin’s 2022 pilot in the Netherlands revealed a significant variation in V2G savings per electric light commercial vehicle, ranging from €1,080 per year in 2022 to a maximum of only €410 in 2021. This variation was driven entirely by fluctuating electricity market conditions. Dynamic pricing, while essential for maximizing potential revenues from grid services such as frequency regulation and peak shaving, also introduces financial uncertainty for fleet operators and energy aggregators. The unpredictability of energy prices complicates long-term financial planning, making it challenging for businesses to commit to V2G investments with confidence. To ensure a stable business case, market structures must evolve to offer more predictable compensation mechanisms for flexibility services, reducing exposure to extreme price fluctuations.

Vehicle battery size and charging power are key cost-saving enablers

The potential for V2G cost savings and revenue generation is linked to the size of vehicle batteries (and therefore the types of vehicles) and the power capacity of charging infrastructure. Larger battery capacities enable vehicles to store and discharge greater amounts of energy, allowing for increased participation in energy markets and greater cost savings from optimized charging schedules. High charging power is equally important, as it allows for faster energy transactions, making bidirectional charging more responsive to grid needs and enabling higher revenues from frequency regulation services. The VDL Eindhoven use case demonstrated that heavy-duty electric vehicles have an inherently stronger business case for V2G due to their large battery sizes and higher per-session revenue potential, making investment in bidirectional chargers financially more viable. Additionally, fleet-scale V2G participation presents a more stable and attractive business model than individual consumer participation, as aggregated vehicle capacity can provide a more predictable and valuable service to the grid, improving financial returns for both fleet operators and flexibility providers.

Benefits and costs are distributed unevenly among stakeholders

The financial implications of V2X technologies do not impact all stakeholders equally. Some entities bear a disproportionate share of the costs, while others benefit significantly without direct investment. The Chalmers V2G use case highlighted these disparities. Among the major cost bearers, electric vehicle drivers face higher upfront vehicle costs and uncertainties regarding battery degradation, while battery manufacturers are impacted by increased battery cycling, requiring them to adapt warranty frameworks to address potential wear and tear. EV manufacturers also face financial challenges, as integrating bidirectional charging capabilities into their vehicles requires additional investment in both hardware and software development. Mixed impact stakeholders, such as charge point operators, may see potential service revenues from managing V2G infrastructure but also face increased costs due to the need for specialized charging hardware. Site owners benefit from optimized energy costs but must bear the upfront installation expenses. On the other hand, major beneficiaries such as transmission system operators, energy suppliers, and distribution system operators profit significantly from V2G-enabled grid balancing and peak load reduction without being responsible for substantial capital investments. If the DSO and TSO are investor owned, then there is an argument to leverage the disparities. If the TSO and DSO are (indirect) in the hands of the public, then the need for equitable cost-sharing models to ensure fair distribution of financial benefits and risks among all involved stakeholders is less, since this is already socialized by the governmental shareholder structure.

Table 1: Insights from D3.3 Business Case Analysis in the SCALE project indicate (Case study B4 – Gothenburg)

Major Cost Bearers	Mixed Impact Stakeholders	Major Beneficiaries
• Electric Vehicle Driver • Battery Manufacturer • EV Manufacturer	• Charge Point Operator • Charge Point Manufacturer • Site Owner	• Transmission System Operator • Distribution System Operator • Energy Supplier

Non-monetary gains play a role in business case justification

Beyond direct financial returns, V2X technologies offer several societal benefits that contribute to the overall justification for investment in vehicle-grid integration. In urban areas with grid congestion, V2G can play a critical role in reducing waiting lists for grid connections, helping to free up capacity for important public institutions such as schools, hospitals, and emergency services. This impact goes beyond financial metrics and contributes to overall energy security and resilience. Additionally, sustainability benefits such as reduced CO_2 emissions and increased self-consumption of renewable energy create further incentives for adopting V2G technologies. These environmental and social advantages can support the case for regulatory incentives and corporate ESG-driven investments, reinforcing the long-term viability of V2X solutions. As policymakers and market actors consider the future of smart charging, these broader benefits should be integrated into decision-making frameworks to ensure a comprehensive evaluation of the true value of V2G beyond immediate financial returns.

The business case for V2X is highly dependent on regulatory frameworks, market conditions, and stakeholder alignment. While the technology holds significant promise for cost savings, revenue generation, and grid stability, its success relies on favourable policy conditions, well-designed pricing mechanisms, and equitable benefit distribution. Electricity price volatility remains a key challenge, highlighting the need for stable compensation mechanisms for grid services. Larger vehicle batteries and higher charging power enhance V2G profitability, making fleet-scale participation more attractive than individual ownership models. Finally, beyond financial considerations, the societal and environmental benefits of V2X play an essential role in justifying its adoption, reinforcing the need for policy support and regulatory alignment. The lessons from SCALE's business case analysis highlight the importance of a structured, country-specific approach to

V2X implementation, ensuring that the technology delivers both financial and societal value in the transition toward a more flexible and sustainable energy system.

15.1 Conclusive recommendations

Harmonization of Regulatory Frameworks Across Member States

The current regulatory landscape for V2G in the EU exhibits significant variability, with each member state maintaining distinct rules for grid access, energy trading, and safety standards. This fragmentation elevates compliance costs and introduces operational inefficiencies, impeding the scalability of V2G systems. Research already highlights differences in V2G integration strategies among France, the UK, and Germany, with commercial offers in France and the UK, but only pilot projects in Germany, underscoring regulatory disparities.

A harmonized regulatory framework would mitigate these issues by establishing uniform standards, reducing legal and administrative burdens. This approach would enhance market predictability, facilitate cross-border operations, and stimulate innovation by creating a cohesive market for V2G technologies. The economic rationale is clear: standardized regulations lower barriers to entry, enabling businesses to allocate resources more efficiently toward technological development rather than regulatory navigation. For instance, the establishment of a centralized EU body, such as the Agency for the Cooperation of Energy Regulators (ACER), could streamline processes and reduce associated costs, providing a scalable model for implementation (European Union Agency for the Cooperation of Energy Regulators).

Calibration of Financial Incentives to Regional Energy Dynamics

The economic feasibility of V2G deployment varies widely across the EU, influenced by regional differences in energy market structures, renewable energy penetration, and electricity price volatility. Data from Eurostat shows significant price variations, with Italy having the highest and Sweden the lowest, reflecting diverse market conditions. A uniform or one size fits all incentive scheme fails to account for these disparities, rendering V2G less viable in regions where its benefits are less immediately apparent.

A more effective strategy involves tailoring financial incentives to local conditions, prioritizing regions with high renewable energy contributions or pronounced price fluctuations. For example, implementing tax incentives in Denmark, with significant wind energy integration, could enhance the financial attractiveness of V2G systems, optimizing return on investment by aligning subsidies with potential revenue generation through grid services and energy arbitrage. This targeted approach reflects an adaptive policy design that leverages empirical data on regional energy profiles to maximize economic and environmental outcomes.

Alignment of National Grid Codes with EU Standards

Technical interoperability remains a critical challenge for V2G adoption, as divergent national grid codes across member states complicate integration into existing infrastructure. Issues like taxation and grid code fulfilment as barriers, with no country fully ready yet. Aligning these codes with EU-wide standards, such as the ISO 15118 protocol for V2G communication, would enable seamless energy flows across borders and reduce technical and legal obstacles.

This harmonization enhances system compatibility, lowers integration costs, and expands market potential for V2G services, benefiting both grid operators and technology providers. Alignment is essential for ensuring grid reliability and resilience, minimizing operational risks associated with inconsistent requirements. A practical application might involve an EU directive mandating the adoption of a unified V2G grid code, facilitating efficient energy trading and system integration, as seen in efforts to standardize under the Alternative Fuels Infrastructure Regulation (AFIR).

Acceleration of Standardization Processes

The protracted development of standards in the V2G sector, such as the ongoing updates to ISO 15118, increases research and development costs and delays commercialization. ISO 15118-20:2022 was published in 2022, but after a lengthy process. Expediting the adoption of key technical standards—such as those governing charger protocols and communication interfaces—would reduce these barriers, enabling faster market entry and enhancing interoperability across diverse systems.

This acceleration is critical for lowering the financial threshold for technology providers and fostering a competitive market environment. Scientifically, standardized protocols underpin the reproducibility and scalability of V2G solutions, ensuring consistency in performance and safety. An example initiative could involve an EU-led effort to finalize V2G communication standards, shortening the development timeline for manufacturers and accelerating deployment.

Monetization of Long-Term Grid and Environmental Benefits

V2G technology offers significant long-term advantages, including deferring expensive grid upgrades and reducing greenhouse gas emissions. However, these benefits are challenging to translate into immediate financial returns, deterring private investment. To address this, mechanisms must be developed to monetize these future gains upfront, providing stakeholders with tangible economic incentives.

Financial instruments such as green bonds or contractual agreements between public and private entities could bridge the temporal gap between costs and benefits, enhancing the bankability of V2G projects. For example, issuing V2G-specific green bonds could mobilize capital based on projected grid and environmental savings, supporting infrastructure development, as seen in general green bond applications.

Structuring Financing to Match Revenue Timelines

The substantial initial investment required for V2G infrastructure, including bidirectional chargers and grid integration systems, poses a significant barrier to adoption, despite the promise of long-term profits from energy trading and grid services.

Financing models that distribute the premium costs of V2G capable infrastructure and vehicles over time—such as loans repaid through future revenues—can alleviate this burden, aligning expenditures with the gradual realization of economic benefits. This strategy enhances cash flow management and improves financial viability, particularly for smaller enterprises. Deferred payment loans tied to energy trading revenues are good examples of this.

Enhancement of Public-Private Partnerships

Public-Private Partnerships (PPPs) offer a strategic solution to manage the uneven distribution of costs and benefits in Vehicle-to-Grid (V2G) deployment, as highlighted by the SCALE project. V2G technology involves significant short-term investments—such as installing chargers and upgrading grid infrastructure—typically shouldered by private stakeholders, while its benefits, like enhanced grid stability and reduced emissions, unfold over the long term and primarily serve societal interests. This misalignment often discourages private investment. PPPs address this challenge by combining public resources with private expertise and capital to create a balanced framework. For example, a PPP could see a public entity, such as a municipality, subsidizing a portion of the upfront costs—say, 40% of V2G charger installations—while a private partner manages operations and maintenance. In return, revenues from energy trading or grid services could be shared, providing immediate financial incentives to private entities. Additionally, PPPs can mitigate risks through mechanisms like guarantees against regulatory changes or market fluctuations, making projects more appealing. By aligning the interests of public and private stakeholders, PPPs transform long-term societal gains into viable, short-term opportunities, accelerating V2G adoption effectively.

The EU's EPEC and funding programs like CEF provide frameworks for PPPs, enhancing V2G deployment by de-risking private investments (Public-private partnerships - European Commission).

Development of Secondary Markets for V2G Services

Creating secondary markets for trading V2G services, such as capacity or flexibility, can provide additional revenue streams, making V2G more attractive. Flexibility markets, like GOPACS in the Netherlands, or Piclo Flex in the UK, allow DSOs to procure flexibility from V2G aggregators, potentially enabling secondary trading.EU support through regulatory frameworks and pilot funding could enhance market liquidity, increasing economic incentives for V2G operators.

More experiments and pilot activities, especially internationally are needed

Due to the complex nature of the V2G ecosystem, especially in Europe, where each country represents a totally different environment, and each stakeholder has their own specific perspective, it would be desirable to support more pilot activities for better understanding the various needs of stakeholders, business needs, technology and regulation.

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17 Annex

Table 2: Energy Management Services considered and their definitions

Energy Management Service	Definition
Optimize PV self-consumption	Direct usage of self-generated PV electricity for immediate consumption; cost optimization
Peak Shaving	Reduce peak loads by managing energy consumption during peak hours; cost optimization; resolution to grid constraint
Dynamic Grid Tariffs	Load shifting based on variable pricing; cost optimization
Emergency Power Supply	Security of electricity supply through backup power solutions
Long-term Flexibility Agreement	Prevention/resolution of grid congestion through strategic load management agreements
Grid-serving Power Range	Adjust energy output to serve grid needs during congestion
Market-based Redispatch	Redistribute power resources to address grid imbalances
Power Quality Control	Maintain voltage and frequency within desired levels
Spot Market Trading	Utilize price spreads in electricity markets for financial gains
Market-oriented Price Signal	Respond to market signals for optimal portfolio management
Operating Reserve	Provide grid reserves to restore frequency and balance
Resource Adequacy	Provide capacity to meet future peak demands, enhancing grid reliability
Frequency Regulation	Maintain grid frequency stability through active power adjustments
Demand Response-Wholesale	Alter energy demand in response to market signals to support grid conditions
Energy Arbitrage	Buy low and sell high: purchase electricity during off-peak and sell during peak
Spinning Reserves	Maintain energy reserves ready to balance supply and demand
Load Following	Adjust energy output to match demand variations due to renewable fluctuations
Excess RES Generation	Absorb excess renewable energy generation to prevent curtailment

Generation Pairing	Pair energy output with renewable generation to improve grid reliability
Reactive Power Support	Provide reactive power to support voltage levels and power factor
Network Deferral	Delay or avoid infrastructure upgrades by managing load growth
Demand Response-Utility	Modulate energy demand in response to utility signals to improve grid efficiency
Site-located RES Firming	Use V2G for firming solar or wind generation on-site to improve reliability
Bill Management	Manage energy use to minimize electricity bills
Emergency Back-up	Provide backup power to critical sites in emergencies
Non-Emergency	Provide portable energy for various applications

Table 3: Business Models considered and their definitions, examples related to energy management services

Business Model	Definition	Example
Subscription	Customers pay a recurring fee for continuous access to a service or product.	An energy management service provider offers a monthly subscription for EV owners to access their smart charging and optimization platform, providing real-time data and usage analytics.
Pay-Per-Use	Customers are charged based on their actual usage or consumption of a service.	A charge point operator charges EV users each time they use a charging station, with fees based on the amount of energy consumed during the session.
Performance-Based Contracts	Compensation is tied to the achievement of specific performance metrics or outcomes.	An aggregator earns money by achieving specified load reduction targets during peak periods, receiving payments from grid operators for contributing to frequency regulation.
Energy Savings Sharing	Savings achieved through efficiency measures are shared between the service provider and the customer.	An energy management service provider installs V2X systems for a commercial building and shares the savings from reduced energy bills with the building owner.
Leasing	Customers pay to use equipment or vehicles for a specified period without owning them.	An EV manufacturer leases V2G-enabled vehicles to fleet operators, charging a monthly fee and providing maintenance services.

Time-of-Use Optimization	Prices are adjusted based on time-of-use rates, encouraging users to shift consumption to off-peak periods.	A DSO offers time-of-use tariffs, incentivizing EV owners to charge their vehicles during off-peak hours, thus maintaining grid balance and reducing operational costs.
Real-Time Energy Management	Provides services that optimize energy consumption in real-time using data analytics and smart technologies.	A smart grid company offers real-time optimization services for residential solar panels with integrated V2G technology, ensuring maximum efficiency and cost savings for homeowners.
Energy Aggregation	Combines energy resources from multiple sources to offer larger-scale services, like demand response or energy trading, to the grid.	An aggregator combines multiple V2G-enabled EVs to participate in ancillary services markets, providing frequency regulation and earning revenue from grid operators.
Consultancy Services	Provides expert advice and strategic planning to organizations looking to improve their energy efficiency or implement new technologies.	A consultancy firm advises a city government on integrating V2X technology into public transportation systems to enhance energy efficiency and reduce emissions.
Retail Sales with Service Plans	Products are sold with optional service plans for ongoing maintenance and support, offering a bundled value proposition.	A charge point manufacturer sells charging stations to businesses with a service plan that includes regular maintenance, software updates, and customer support.
Freemium	Basic services are offered for free, with additional features or services available at a premium cost.	An eMobility service provider offers a free app for finding charging stations, but charges a subscription fee for premium features like reservation and peak time alerts.
Contractual Flexibility Agreements	Long-term agreements that provide compensation for the ability to adjust energy consumption or production in response to grid needs.	A utility enters into a flexibility agreement with a large industrial site, compensating them for reducing power usage during peak demand times as part of a demand response program.
Advertising	Generates revenue by displaying ads through platforms or physical spaces associated with the business.	An eMobility platform includes advertising space in their app, earning revenue from ads targeted at EV owners looking for related products or services.
Data Monetization	Revenue is generated from the collection, analysis, and sale of data insights gathered from operations or users.	A V2X technology provider sells aggregated data on EV charging patterns to city planners and energy companies for use in infrastructure planning and demand forecasting.

Razor and Blades	The core product is sold at a low margin or loss, with profits generated from high-margin complementary products or services.	An EV manufacturer sells V2G-capable vehicles at competitive prices but charges for premium connectivity services, maintenance packages, and software upgrades.
Shared Ownership and Economy Models	Assets are co-owned or shared among multiple users, spreading costs and maximizing utilization.	A community co-owns a fleet of V2G-enabled EVs, allowing members to book vehicles as needed, sharing operational costs and maintenance responsibilities.
Insurance and Risk Management	Provides insurance products and risk management services to protect against potential losses or operational risks.	A financial institution offers specialized insurance products for EV fleets, covering risks associated with V2G operations and potential disruptions.
Franchise Model	Allows third-party operators to use the company's brand and business model in exchange for a fee, expanding reach and standardizing services.	A charge point operator franchises its brand and operational model to local entrepreneurs, providing them with equipment, training, and marketing support.
Pay-as-You-Save (PAYS)	Customers pay for new technology installations through savings on their utility bills, effectively offsetting upfront costs.	A V2X service provider installs V2G chargers at no upfront cost to consumers, with payments recouped through savings realized from lower energy bills.
Virtual Power Plant (VPP) Participation	Aggregates distributed energy resources (like EVs) to operate as a single entity in energy markets, providing services such as frequency regulation.	An aggregator coordinates a fleet of V2G-enabled EVs to participate in a VPP, selling grid services such as load balancing and earning revenue from energy markets.
Dynamic and Tiered Pricing Models	Prices are adjusted in real time or based on tiers according to demand or usage levels, optimizing revenue and consumption patterns.	An energy supplier uses dynamic pricing to adjust electricity costs based on real-time demand, encouraging customers to use energy during low-demand periods to reduce costs.
Public-Private Partnerships	Collaborations between public entities and private companies to develop infrastructure or services, sharing risks and benefits.	A city partners with a private company to build and operate EV charging infrastructure, sharing investment costs and operational responsibilities while enhancing public services.

Further excel sheets of the use case analysis are attached as excel sheets.