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Practice What You Preach: Smart Charging in Practice
A Case Study of Smart Charging Deployment in Distribution System Operations

Baerte de Brey[1], Nanda Kishor Panda[2], Bart Van Der Ree[3]

[1]*(Corresponding author) Chief International Officer, ElaadNL, Arnhem, The Netherlands,* *baerte.de.brey@elaad.nl*

[2] *Doctoral researcher, Department of Electrical Sustainable Energy, EEMCS, Delft University of Technology, Delft, The Netherlands, n.k.panda@tudelft.nl*

[3] *Senior Researcher, Utrecht Sustainability Institute, Bart.vanderRee@usi.nl*

Executive Summary

The rapid transition to renewable energy and the growing adoption of electric vehicles (EVS) are critical to meeting climate neutrality goals, such as the EU's target to reduce greenhouse gas emissions by 55% by 2030. However, this shift has introduced significant grid congestion, particularly in countries like the Netherlands, where electrification has progressed rapidly. Driven by rising electricity demand, renewable generation, and EV charging, congestion threatens the stability of low- and medium-voltage networks. While conventional solutions rely on costly infrastructure upgrades, smart charging offers a more efficient, flexible alternative to manage demand and mitigate congestion. This study investigates how Stedin, a Dutch distribution system operator, leverages smart charging strategies—including Vehicle-to-Grid (V2G) technology—as part of its operational EV fleet management, highlighting practical incentives for fleet electrification through a real-world case study. Simulations of 1,700 light-duty EVS in Stedin's fleet show that cost-optimised unidirectional charging can reduce total charging costs by 24.2% compared to unoptimized, business-as-usual (BAU) charging. In contrast, bidirectional charging achieves savings of up to 87.9%. Participation in the Automatic Frequency Restoration Reserve (aFRR) market can further enhance the economic benefits, with bidirectional strategies yielding net revenues in some cases. The findings demonstrate that leveraging the inherent flexibility of EV fleets not only reduces operational expenses but also opens new revenue streams for fleet operators, while contributing to grid stability and deferring costly infrastructure investments.

Keywords: Electric vehicles, Charging business models, Smart charging, Smart grid integration and grid management, V2H & V2G

1 Introduction

Transitioning from fossil fuel-based energy to renewable energy sources is crucial to meet the climate neutrality goal by 2025 goals[1]. By 2030, the EU plans to cut greenhouse gas emissions by at least 55% of the values measured in 1990. This aggressive cut of greenhouse gas emissions is only possible through the abundant use of renewable energy sources like solar, wind, biomass, etc. One of the global efforts made to reduce greenhouse gases is through the electrification of the transport sector that includes passenger vehicles, public transportation, trucks, ships and air transport [2]. Within transport electrification, the adoption of Electric Vehicles (EVs) that is set to replace the traditional Internal Combustion Engine (ICE) based vehicles are increasing rapidly [3].

Among different classes of EVs, battery EVs (BEVs) constitute the largest proportion, relying entirely on electric power delivered via onboard chargers. Since EVs require regular charging, their increasing adoption necessitates the development of extensive charging infrastructure. Consequently, EVs are closely intertwined with the utility grid, creating both opportunities and challenges in grid planning and operation. As EVs share similar usage patterns based on their location and type, their aggregate charging demand often leads to synchronised peaks that can strain existing power networks [4]. For instance, on-street chargers, which are predominantly used by residential EV users, exhibit similar arrival times, typically after work hours. If all connected vehicles begin charging in an uncontrolled manner immediately upon arrival, it can result in a sharp and simultaneous increase in electricity demand, potentially overloading local distribution infrastructure. Such uncontrolled aggregate charging has led to overloading of power networks—commonly referred to as *congestion*—where certain grid components exceed their rated capacity. This can result in overheating transformers, cables, or substations, as the power limits are violated during sustained periods of excessive usage.

Although the increased adoption of EVs brings us closer to sustainability goals, it can also introduce unintended challenges to the electricity network if left unaddressed. Uncoordinated and unoptimized aggregate EV charging may lead to significant issues, including congestion and voltage instability [5]. Voltage problems are generally confined to the low-voltage distribution grid, while congestion issues affect both low-, medium- and high voltage distribution and transportation networks [6]. These challenges can ultimately strain the grid's capacity, accelerating the need for costly grid reinforcements. Without such reinforcements, the stability and reliability of the grid is at risk.

In this paper, we focus specifically on the issue of congestion in distribution networks and present a case study from the perspective of an EV fleet owner. We demonstrate how a commercially operated fleet of EVs can help alleviate grid congestion while simultaneously creating new business opportunities for the fleet operator. Additionally, we explore how Vehicle-to-grid (V2G) technology can further reduce charging costs, ultimately leading to faster payback periods and an increase in overall revenue for the operator. Lastly, this research is conducted as part of the ROBUST[2] and SCALE[3] projects, which focus on building a smart and resilient grid for the future. These initiatives aim to leverage the flexibility of EVs through smart charging technologies, contributing to a more efficient and sustainable energy infrastructure.

1.1 Grid congestion in the Netherlands

Currently, there are over 900,000 public Charging Points (CPs) in the European Union. This number is projected to grow by more than 250%, reaching the target of 8.8 million CPs by 2030. [4][5]. Out of the total number of CPs, the Netherlands itself contains more than 19% in contrast to its geographical size. As a result, among the countries with high electrification levels and extensive EV adoption, the Netherlands has emerged as a leader in fostering favourable conditions for electric vehicle growth [6]. However, the rapid pace of electrification has placed significant strain on the country's electricity grid, leading to severe congestion. This congestion has imposed substantial restrictions on the transport and in-feed capacity of Dutch power networks, adversely affecting various stakeholders, including network operators, transmission system operators, policymakers, and consumers [7].

In some regions of the Netherlands and Germany, the severity of grid congestion has led to drastic measures, such as the denial of new grid connections. This situation poses a serious challenge to economic development and social welfare, as it hinders the expansion of residential areas, commercial operations, and the electrification of mobility and heating [8]. The primary causes of the grid strain in the Netherlands include the rapid deployment of solar panels, the electrification of industry, increased electric mobility, and the adoption of electric heating in buildings. The situation is critical, with capacity

[2] https://tki-robust.nl/project/

[3] https://scale-horizon.eu/

[4] IEA (2024), Global EV Outlook 2024, IEA, Paris. https://www.iea.org/reports/global-ev-outlook-

[5]

[6] https://mobilityportal.eu/record-europe-surpasses-900000-public-charging-points/

shortages projected to reach 250 megawatts (MW) in the Utrecht province alone by 2029 [9]. As one of the leading provinces in EV adoption, Utrecht exemplifies the urgent need for solutions to address the growing demands on the power grid.

Timely upgrades to the existing grid infrastructure are essential to address both current and anticipated grid congestion. However, while this solution appears straightforward, it is both expensive and fraught with operational challenges [10, 11]. For example, constructing just one additional kilometre of transmission line can require significant financial investment and years of planning, primarily due to permitting procedures, environmental assessments, and land acquisition. Similarly, upgrading or replacing a distribution transformer can be expensive and time-intensive, often involving scheduled downtime that affects local grid reliability and service continuity. Recent estimates suggest that Dutch distribution system operators will need to invest approximately €219 billion in electricity, gas, heat, and hydrogen infrastructure by 2040, with electricity-related investments alone accounting for €195 billion and net management costs expected to more than double during this period [12]. In this context, smart charging of electric vehicles—particularly in operational fleets—emerges as a cost-efficient and flexible alternative to mitigate congestion locally and defer grid reinforcement.

This, in turn, has prompted the search for swift yet effective solutions to manage grid congestion. These measures aim to alleviate grid overload in the affected regions without the high costs and delays associated with infrastructure upgrades. Among the most cost-effective and efficient approaches is the use of *smart charging flexibility* to manage congestion in real time. EV charging inherently offers significant flexibility due to large onboard storage capacities, extended connection durations, and relatively short charging time requirements. Prior research has demonstrated that the aggregated flexibility of EV fleets can effectively alleviate grid congestion, offering a practical and scalable solution to this pressing challenge [11, 12]. However, seven key barriers currently hinder the unlocking of full EV flex potential for the purpose of addressing DSO congestions. Concrete actions should to be taken by regulators, DSOs, policymakers & industry to scale up smart charging [13].

1.2 Smart charging flexibility

Smart charging refers to the process of modulating the charging power of EVs in response to external signals or system conditions. Smart charging flexibility can be activated either in an aggregated [11] or a decentralised manner [3]. Aggregated control enables targeted flexibility in specific congested regions, offering precise interventions, but it tends to be complex and more challenging to implement [13]. Alternatively, flexibility can be activated implicitly through control signals, where each individual EV responds autonomously [14, 15]. These signals may range from day-ahead electricity prices to more abstract signals representing local or global objectives defined by the fleet operator. This decentralised approach is highly scalable and efficient, and it can also unlock additional revenue streams for fleet owners or operators.

In this work, we specifically focus on the implicit activation of flexibility from fleets of EVs, by trading them in two electricity markets:

- Day-ahead market [16]: The day-ahead market is a forward electricity market where energy is traded one day before actual delivery. Prices in this market are determined through a clearing mechanism based on supply and demand forecasts for each hourly (or quarter-hourly) interval. Fleet operators can leverage the flexibility of EVs by shifting charging activities to hours with lower forecasted prices. This temporal shifting helps reduce overall energy procurement costs while also flattening demand peaks, which contributes to grid stability.

- aFRR market [17]: This is one of the key ancillary service markets used to balance short-term deviations in grid frequency. When activated by the Transmission System Operator (TSO), aFRR resources are required to respond within seconds to a few minutes, by either increasing (upregulation) or decreasing (down-regulation) their power consumption or generation. EVs, due to their fast response capability and flexible load profiles, are well suited to participate in this market. Through smart charging infrastructure, fleet operators can modulate charging rates of individual vehicles in real time, effectively offering synthetic inertia to the grid. Participation in the aFRR market not only helps ensure grid stability but also opens up a new revenue stream for EV fleet operators, especially when prices for balancing services are high due to system overloading or high renewable penetration.

We further investigate the above participation in the electricity markets using two charging technologies:

1. Unidirectional charging (V1G): In this setup, EVs can only draw power from the grid to charge their batteries. Flexibility is provided by adjusting the timing and rate of charging, without feeding energy back to the grid. V1G is widely supported by existing infrastructure and vehicle models, making it an accessible option for most fleet operators.
2. Bidirectional charging (V2G): In contrast to V1G, V2G enables two-way energy flow, allowing EVs to both charge from and discharge to the grid. This enhances the flexibility potential significantly, as stored energy in vehicle batteries can be used to support the grid during peak demand or to deliver ancillary services like frequency regulation. Although V2G requires additional hardware and regulatory considerations, it unlocks greater value streams and improves the system's overall ability to balance supply and demand.

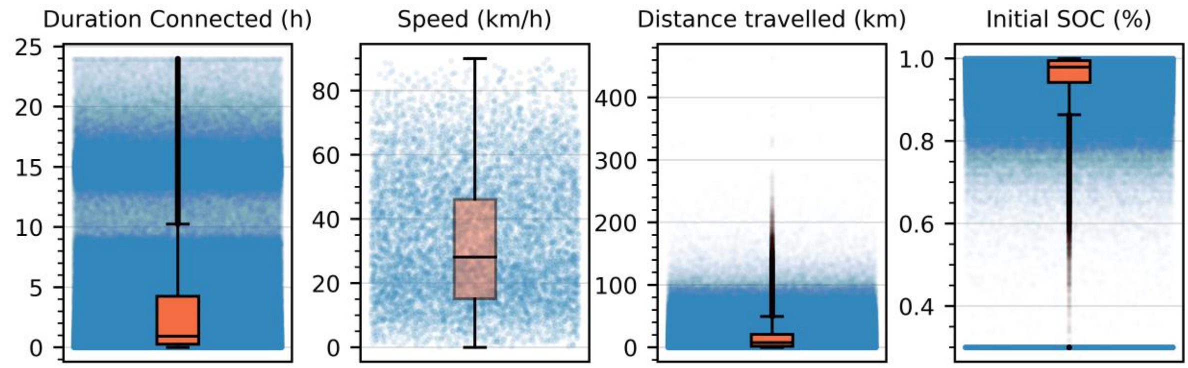


Figure 1: Different statistics related to the electric vans in Stedin's fleet were used to conduct the analysis. Duration connected refers to the total expected time a van remains connected to a CP. Distance travelled and speed pertain to the trip made just before connecting to the CP, while the initial SoC corresponds to the state of charge at the moment of connection.

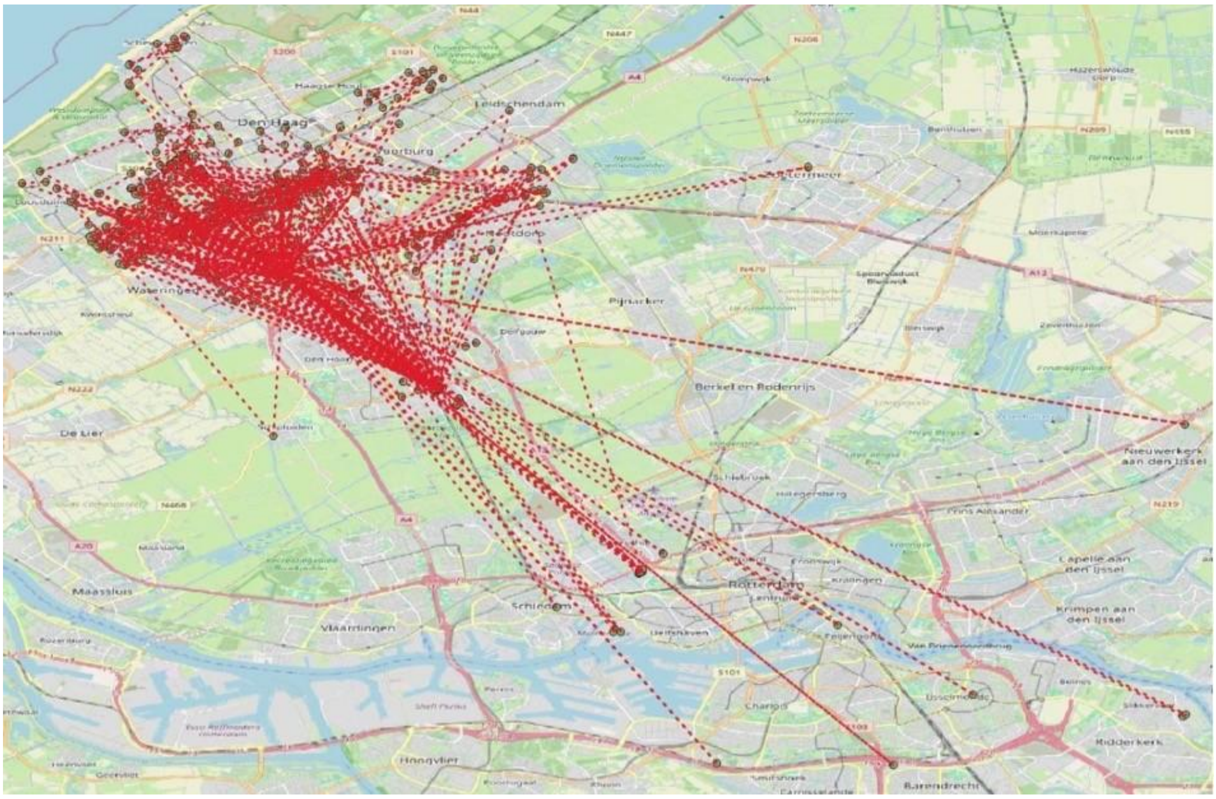
2 Case Study: EV fleet of Stedin

Stedin[7] is one of the major grid operators in the Netherlands, responsible for managing the electricity and gas networks in the densely populated Randstad area, which includes significant urban centres such as Rotterdam, The Hague, and Utrecht. As a grid operator, Stedin is crucial in facilitating the energy transition and supporting the shift towards sustainable energy sources. Stedin as an organisation aims to achieve carbon neutrality in alignment with both national and international climate objectives, including the Paris Agreement. This involves reducing greenhouse gas emissions across all its operations, including its transportation fleet. Since 2017, Stedin has been actively working on electrifying its fleet of service vehicles as part of its broader sustainability goals. This includes transitioning their vehicles to EVs and potentially incorporating other clean energy solutions, such as hydrogen fuel cells, depending on the technological and market developments.

The total Stedin fleet is 2200 vehicles, of which 1700 are light-duty vehicles for our engineers. Electrification of these vehicles occurs in line with the normal depreciation of the vehicles. In this study,

[7] https://www.stedin.net/

a subsection of those electrified fleets is considered to potentially take part in different markets, as stated above. Based on the driving patterns of these vehicles (Fig 0.), appropriate charging schedules were drawn up, which were later used in an optimisation framework.



The charging session data used in the analysis correspond to the year 2023. Fig. 1 shows the variation of statistics within different EVs. The price data used for the year 2023 is shown in Fig. 2. Price surplus and price shortage refer to the imbalance prices that the aggregator pays or receives based on the regulation state during aFRR trading. The regulation state, published by TenneT[8] (the transmission system operator in the Netherlands), determines the imbalance price per Imbalance Settlement Period (ISP) and reflects the activation of balancing energy (aFRR and incident reserves). It takes values of 0, +1, -1, or 2, indicating no activation, upward activation, downward activation, or both directions, respectively.

3 Methods and models

The analysis presented here uses an optimisation framework to schedule individual EVs under different charging technologies—unidirectional and V2G—and charging strategies, including Business-asusual (BAU), cost-optimised charging based on the day-ahead market, and participation in the aFRR market following day-ahead trading. Charging sessions from the selected case study are used as input to the optimisation model after appropriate preprocessing. Logbook data from the vans is utilised to develop charging schedules, considering factors such as arrival and departure locations, vehicle type, and connection duration.

We perform deterministic simulations where each EV is characterized by its arrival time (t_a) at the charging station, departure time (t_d) when the van disconnects, its maximum charging power ($P_{\max}$), the

[8] https://www.tennet.eu/de/node/1940

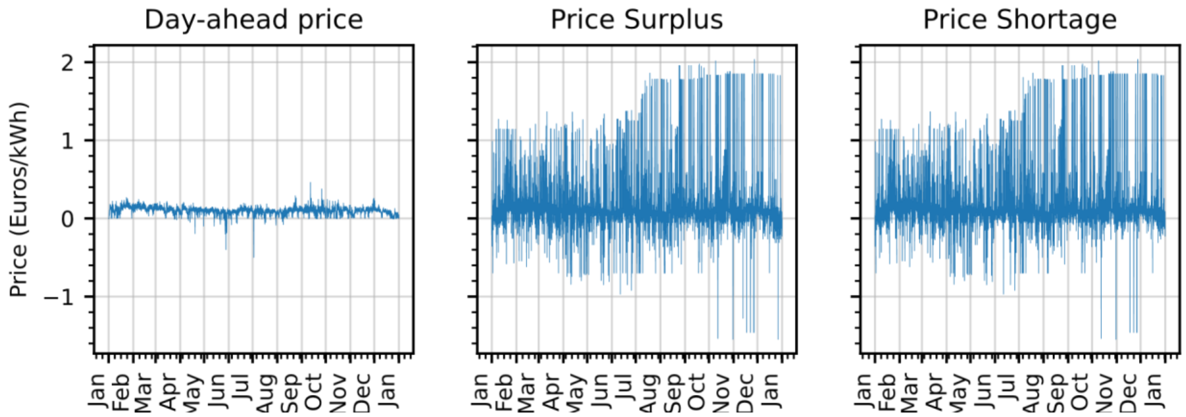


Figure 2: Different prices used to simulate day-ahead market trading and aFRR for the year 2023 [18, 19].

maximum battery capacity (E_{max}) and the initial State of Charge (SoC) (η_i) of the van during connection. Each EV is optimised individually based on certain objectives and a set of constraints depending on the charging technology and strategy. The simulation uses discrete time steps (Δt) of 15 minutes each, where the charging power p_t is assumed to remain constant throughout the time step. The optimization horizon ($\mathcal{T} = \{1, \cdots, \min(t_d - t_a, 24/\Delta t)\}$) corresponds to the connection duration of the EV, or 24 hours—whichever is shorter. For baseline comparison, a BAU strategy is used where the EVs are charged as early as possible.

3.1 Cost optimised charging based on day-ahead prices

In this charging strategy, the charging process of EVs is optimised based on the day-ahead energy prices ($\Pi^{DA}{}_t$). The charging model minimises the total cost of charging (Equation (1)), subject to the constraints

(2)-(10). Different charging efficiencies, ϵ^+ and ϵ^-, are applied to the charging ($p^+{}_t$) and discharging ($p^-{}_t$) powers, respectively. A binary variable u_t is introduced along with a big-M ((8), (9))constraint to ensure that charging and discharging do not occur simultaneously. Solving this optimisation model gives us the optimised power profile: $\mathbf{p}^* = \{p_1^*, \cdots, p_{|\mathcal{T}|}^*\}$.

$$\min_{p_t} \sum_{t \in \mathcal{T}} p_t \Pi_t^{DA} \Delta t \tag{1}$$

$$p_t = u_t \cdot p_t^+ - (1 - u_t) \cdot p_t^-, \quad \forall t \in \mathcal{T} \tag{2}$$

$$-(1 - u_t) P_{\max} \le p_t \le P_{\max}, \quad \forall t \in \mathcal{T} \tag{3}$$

$$0 \le p_t^+ \le P_{\max}, \quad \forall t \in \mathcal{T} \tag{4}$$

$$0 \le p_t^- \le P_{\max}, \quad \forall t \in \mathcal{T} \tag{5}$$

$$0.3 \cdot E_{\max} \le e_t \le E_{\max}, \quad \forall t < \max(\mathcal{T}) \tag{6}$$

$$e_t = E_{\max}, \quad t = \max(\mathcal{T}) \tag{7}$$

$$p_t^+ \le M \cdot u_t, \quad \forall t \in \mathcal{T} \tag{8}$$

$$p_t^- \le M \cdot (1 - u_t), \quad \forall t \in \mathcal{T} \tag{9}$$

$$e_t = \begin{cases} \eta_i \cdot E_{\max}, & t = 0 \\ e_{t-1} + \epsilon^+ p_t^+ u_t \Delta t - \dfrac{p_t^-}{\epsilon^-}(1 - u_t)\Delta t, & \forall t \in \mathcal{T} - \{0\} \end{cases} \tag{10}$$

(11)

3.2 aFRR market modelling

To participate in the aFRR market, the scheduled day-ahead profile $\mathbf{p}^*$ is taken as the reference. The imbalance signal consists of the regulation state ($R_t \in -1,0,1,2$), surplus price (Π^{su}), and shortage price (Π^{sh}). Based on a predefined threshold price ($\Delta\Pi$), the EV aggregator determines whether to participate in the ancillary market and to what extent. The aFRR participation model is implemented as a rule-based method, as illustrated in Algorithm 1, similar to the approach presented by the authors in [20].

Algorithm 1 Rule-Based aFRR Participation Algorithm

Require: Scheduled profile $\mathbf{p}^*$, regulation state R_t, prices $\Pi_t^{DA}, \Pi_t^{su}, \Pi_t^{sh}$, energy requirement $E_{\max}$, initial SoC η_i, price threshold $\Delta\Pi$, time step Δt, max power $P_{\max}$

Ensure: Updated power profile $\mathbf{p}$ for ancillary service

$e \leftarrow \eta_i \cdot E_{\max}$

for each $t \in T$ do

$p^*_t \leftarrow$ scheduled power at time t

if $R_t = -1$ then ⊳ Surplus state

$\Delta\Pi_t \leftarrow \Pi^{DA}_t - \Pi^{su}_t$

if $\Delta\Pi_t \geq \Delta\Pi$ then

Increase p_t:

$$p_t \leftarrow \min\left(p_t^* + \delta_t^{\text{up}}, \frac{E_{\max} - e}{\Delta t}, P_{\max}\right)$$

else

$p_t \leftarrow \min\left(p_t^*, \frac{E_{\max}-e}{\Delta t}\right)$

end if

else if $R_t = 1$ then ⊳ Shortage state

$\Delta\Pi_t \leftarrow \Pi^{sh}_t - \Pi^{DA}_t$

if $\Delta\Pi_t \geq \Delta\Pi$ then

Decrease p_t:

$$p_t \leftarrow \max\left(p_t^* - \delta_t^{\text{down}}, 0\right)$$

else

$p_t \leftarrow \min\left(p_t^*, \frac{E_{\max}-e}{\Delta t}\right)$

end if

else ⊳ Neutral or no regulation

$p_t \leftarrow \min\left(p_t^*, \frac{E_{\max}-e}{\Delta t}\right)$

end if

$e \leftarrow e + p_t \cdot \Delta t$

end for

return $\mathbf{p}$

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4 Results

Based on the presented model, more than 1.1 million individual charging sessions were independently optimised under various charging strategies for both unidirectional and bidirectional charging. The results were later analysed both on a per-EV basis and in aggregate form. The large-scale optimisation was executed in parallel on the Netherlands' national supercomputer, Snellius[9].

Table 1: Yearly costs for different simulated charging strategies and market participation schemes, evaluated for the given fleet of EVs over the year 2023.

Strategy	Tag	Cost (Euros)	% Change from BAU	Error Range (Euros)
Business-as-usual	BAU	470k	0	N/A
Cost optimised (unidirectional)	C-V1G	356k	-24	N/A
Cost optimised + aFRR (unidirectional)	C-V1G-aFRR	313k	-33	72k–87k
Cost optimised (bidirectional)	C-V2G	57k	-88	N/A
Cost optimised + aFRR (bidirectional)	C-V2G-aFRR	-16k	-104	224k–262k

4.1 Aggregate Cost Comparison

Table 1 summarises the total annual cost for each strategy, while Figure 3a provides a visual comparison with error margins for the cases involving aFRR participation. The BAU scenario, where EVs are charged immediately upon plugging in, results in the highest cost—€469.7k—due to uncoordinated charging during expensive peak-price hours.

Cost-optimised unidirectional charging (C-V1G) significantly reduces this cost by 24.2% by shifting charging sessions to cheaper off-peak periods in the day-ahead market. The bidirectional variant without aFRR participation (C-V2G) provides an even larger reduction of 87.9%, primarily by leveraging the flexibility of Vehicle-to-Grid (V2G) technology. This allows the fleet to not only shift charging but also to export energy back to the grid during high-price periods, effectively turning the EVs into decentralised storage assets. Currently in this analysis there is no tax levy on bidirectional charging or accountability for battery charging/ discharging cycles, hence the actual realisation of profits might be lower.

Further reductions are observed when the fleet participates in the aFRR market. C-V1G-aFRR achieves a 33.4% cost reduction compared to BAU, while C-V2G-aFRR results in a net revenue (i.e., negative cost), reducing the total cost by more than 100%. The added benefit in these cases arises from the ability to respond to real-time imbalance prices during regulation states of 1 or -1, exploiting price deviations from the day-ahead forecast.

We simulated various price thresholds, and showed the minimum, maximum and the average costs. However, it is important to note that the cost savings in aFRR-enabled strategies come with increased variability, as shown by the error bars in Figure 3a. This variability is due to uncertainty in price thresholds, which affects how much flexibility the fleet can profitably offer without violating energy balance or SoC constraints.

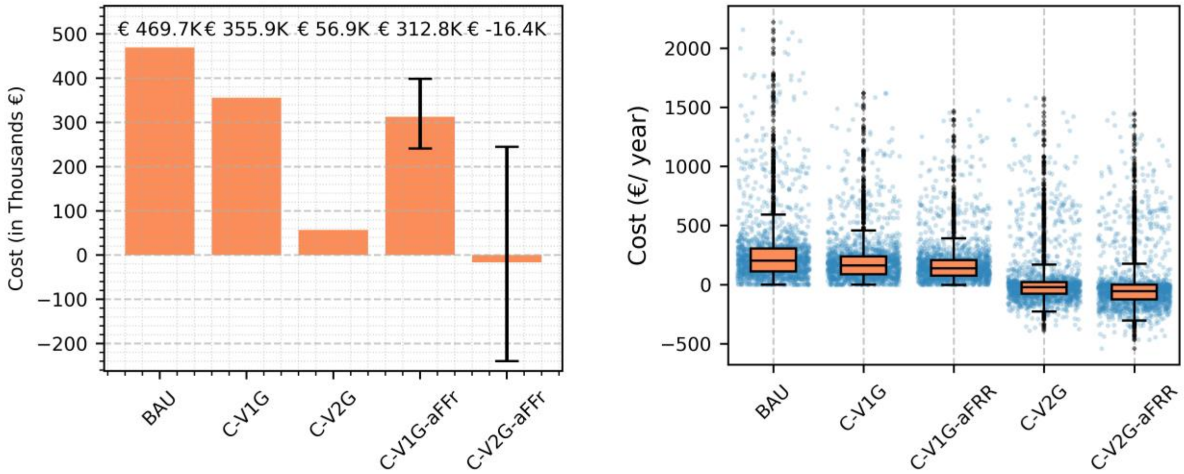
[9] https://www.surf.nl/en/services/compute/snellius-the-national-supercomputer

4.2 Per-EV Cost Distribution

Figure 3b presents the distribution of annual costs per EV across all strategies. The BAU case shows a wide spread, with a high median and many outliers above €1000/year, highlighting the inefficiencies of unoptimized charging.

Optimised strategies not only reduce median costs but also significantly narrow the interquartile range. This suggests more consistent savings across the fleet, making cost-optimised charging a more equitable and predictable approach. C-V2G and C-V2G-aFRR in particular show a shift in the cost distribution toward negative values for a notable fraction of EVs. This reflects successful exploitation of both price arbitrage and ancillary service opportunities, especially for EVs with long connection durations and high flexibility.

Interestingly, some cost outliers remain even under optimised strategies. These typically correspond to EVs with shorter connection durations or those charging during hours of flat price signals, where optimisation has limited leverage. For bidirectional cases, the effectiveness of V2G also depends on technical constraints such as maximum discharge power and battery degradation limits, which were conservatively modelled in this study.



(a) Aggregate annual costs for different charging strategies, with and without aFRR market participation. Error bars represent the variation across thresholds.

(b) Distribution of yearly costs per EV for each charging strategy, highlighting median, interquartile range, and outliers.

Figure 3: Comparison of cost outcomes across different charging strategies. (a) shows the aggregated cost at fleet level, while (b) illustrates the per-EV distribution of yearly costs.

5 Conclusion

The results confirm that smart charging—particularly when integrated with market mechanisms such as the day-ahead and aFRR markets—can unlock significant economic value from EVs. The benefits are especially pronounced in bidirectional configurations, which offer a twofold advantage: reducing electricity purchase costs and generating revenue through grid support services.

These findings highlight the importance of coordination and flexibility in EV fleet operations. Moreover, the analysis demonstrates that even simple rule-based approaches to market participation, as implemented here for the aFRR market, can yield substantial gains. Future work may explore more advanced predictive or learning-based dispatch algorithms to enhance economic performance under uncertainty.

While previous research has laid the groundwork for understanding the potential of V2X and smart charging technologies, there remains a pressing need for comprehensive studies that bridge the gap between technical feasibility, economic viability, and societal impact, especially in the context of large-scale deployment involving fleets of over 800 EVs. Such efforts are essential to fully realise the promise of V2X and accelerate the transition toward a resilient, flexible, and sustainable energy and mobility ecosystem.

This article contributes to that gap by presenting a detailed techno-economic analysis of large-scale smart charging and V2G exploitation in the Stedin use case. We evaluate both the system-level potential and the business case of operating an extensive EV service fleet, focusing on real-world deployment scenarios.

First, the economic impacts of integrating V2X capabilities into large EV fleets require further exploration. Although the potential for revenue generation and cost reduction through demand response programs and ancillary grid services is well acknowledged, a thorough economic assessment—accounting for capital investments, operational costs, market revenues, and long-term profitability—remains scarce in current literature. Additionally, practical implications for employees, such as fair compensation for electricity usage under dynamic pricing or incentives to participate in V2X programs, are rarely addressed. In this work, we aim to advance this discussion by analysing the economic and operational aspects of the V2G service fleet at Stedin.

Second, the dynamic interactions between charging patterns and grid operations under widespread V2X deployment also remain underexplored. While some studies have examined localised effects such as peak shaving, load balancing, or microgrid stability, few have analysed the aggregate impact of hundreds of EVs acting simultaneously on a larger grid segment. The complex interplay between user behaviour, technical constraints, market signals, and external factors such as weather demands a more holistic approach. In this article, we provide such an analysis based on the Stedin use case, offering insights into how large-scale smart charging and V2G can influence grid resilience, efficiency, and reliability.

In the performed analysis, all EVs are assumed to be fully charged before disconnection, which inherently limits the potential revenue that could be achieved. However, in practice, with appropriate adjustments, the actual revenue earned or costs incurred could be higher. Therefore, the presented results may be interpreted as a worst-case scenario. Unlike standard fixed energy price contracts that most Charge Point Operators (CPOs) currently operate under, we assume that the concerned CPO holds a dynamic energy contract, allowing optimisation of the charging schedule based on day-ahead market prices. For the case of bidirectional charging, the analysis does not account for the double energy taxation currently in effect in the Netherlands, which is expected to be phased out in the coming years.

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Presenter Biography

Baerte de Brey works at Stedin, a Dutch DSO on e-mobility, and is the Chief International Officer within ElaadNL. Responsible for analysing the long-term effect of electric mobility on the electricity grids, Baerte helps build a sustainable business case around this transition. This includes vehicle2grids, EV-storage and cyber security. He graduated from Leiden University in 2001 with a law degree and received an MBA from Nyenrode Business University in 2006. On behalf of Stedin, he is one of the executive board members of ElaadNL, the knowledge and innovation centre in the field of (smart) charging infrastructure. As an expert for the European Commission, he sometimes reviews collective European programs concerning EV interoperability and smart charging. In his spare time he is Vice-President of Avere, the European Association for e-mobility.

Bart van der Ree is Senior Researcher and Chairman at the Utrecht Sustainability Institute (www.usi.nl) After obtaining a M.Sc. in Energy Physics at Utrecht University in 1990, he researched and developed solar heating and cooling technologies and test methods at the TNO Institute of Applied Physics, and acted as convenor of a CEN working group developing European standards for solar water heaters. At the consulting company Ecofys, he broadened his work to the energy transition in the built Environment, led large European research and demonstration projects and co-founded a joint venture in China. At USI he acts as project leader of innovation projects and as researcher with a focus on smart and bidirectional charging of EVs.

Nanda Kishor is a doctoral researcher in the Department of Electrical Sustainable Energy, Faculty of Electrical

Engineering, Mathematics and Computer Science at Delft University of Technology, the Netherlands. Originally from a coastal town in Odisha, India, he earned his B.Tech. in Electrical and Electronics Engineering with distinction from Vellore Institute of Technology in 2019. He then moved to the Netherlands to pursue an M.Sc. in Electrical Engineering, specializing in Electrical Energy Systems, graduating cum laude, supported by the Holland Scholarship and the ALSP Scholarship. Nanda's research focuses on enabling aggregate flexibility of electric vehicles (EVs) in distribution power networks. His broader interests include flexibility aggregation in distribution systems, control and optimisation of power systems, and EV integration. He has authored several papers in leading international journals and conferences. Recently, he was awarded the NCCR Automation Fellowship to conduct part of his doctoral research at ETH Zurich.