March 2025

Savings from smart charging electric cars and trucks in Europe: A case study for France in 2040

Part of RAP and ICCT's *Benefits of EVs Through Smart Charging* Global Project

By Julia Hildermeier, Andreas Jahn, Jakob Schmidt, Marie Rajon Bernard, Pierre-Louis Ragon & Hussein Basma

Acknowledgments

We would like to thank the following people for their comments and insights on an earlier draft of this paper. The authors are entirely responsible for the content of this paper.

Jaap Burger, Dave Farnsworth, Louise Sunderland – Regulatory Assistance Project

Marin Dilé, Claire Lucas, Léo Quignon – Artelys

Felipe Rodriguez, Hongyang Cui, Palak Thakur – International Council on Clean Transportation

Authors

Julia Hildermeier – Regulatory Assistance Project

Andreas Jahn – Regulatory Assistance Project

Jakob Schmidt – International Council on Clean Transportation

Marie Rajon Bernard – International Council on Clean Transportation

Pierre-Louis Ragon – International Council on Clean Transportation

Hussein Basma – International Council on Clean Transportation

Regulatory Assistance Project (RAP)

Rue de la Science 23, 1050 Brussels, Belgium

info@raponline.org | www.raponline.org | @RegAssistProj

International Council on Clean Transportation (ICCT)

Fasanenstraße 85, 10623 Berlin, Germany

communications@theicct.org | www.theicct.org | @TheICCT

Table of contents

Benefits of EVs Through Smart Charging: A joint project by RAP and ICCT

This paper is part of a global project by the Regulatory Assistance Project (RAP) and the International Council on Clean Transportation (ICCT) studying the economic and environmental benefits of deploying smart electric vehicle (EV) charging in specific geographies. The project identifies those benefits as avoided system costs and avoided emissions, and shows how system costs can be reduced based on four regional case studies in selected areas within the four largest global EV markets: China,[1] the United States,[2] India[3] and Europe. As the last instalment in the series, this paper investigates the benefits of smart EV charging in Europe, based on a case study of a representative region in France, which is introduced separately below.

The global market for EVs is maturing quickly. In 2023, EVs accounted for 15% of vehicle registrations in Europe (23% if plug-in hybrid vehicles are considered).[4] This is two to three times higher than EV registrations in 2020. National and local policies – such as the European carbon dioxide (CO_2) standards for light-duty vehicles[5] – in several jurisdictions targeting tailpipe emissions of road transport vehicles further contributed to this growth, resulting in an increasing EV fleet globally over the past decade.[6] The global e-heavy duty vehicle (e-HDV) market witnessed significant growth between 2023 and 2024. In Europe, for instance, although e-HDVs only comprised 4.1% of total HDV sales in the EU-27 region, data shows that the e-HDV market grew by 54% between the first half of 2023 and the first half of 2024.

With a continuously growing fleet, challenges and opportunities arise in many regions with regard to the integration of the EV fleet into the power grid. If additional demand from EVs remains unmanaged, this would lead to substantial cost increases to meet their needs both in terms of power production and distribution, as EVs would likely be charged during existing peak periods and exacerbate peak demands. If this transition is not managed carefully, the associated growth in electricity demand will lead to higher costs for consumers, the power

---

[1] Gao, C. (2025, March). *Smoothing the way: Coaxing more flexible charging from China's mammoth EV fleet*. Regulatory Assistance Project. https://www.raponline.org/knowledge-center/smoothing-the-way/

[2] Farnsworth, D., Enterline, S., Basma, H. & Kadoch, C. (2024, June 24). *Unlocking system savings with flexible EV charging: Lessons from Colorado.* Regulatory Assistance Project. https://www.raponline.org/knowledge-center/unlocking-system-savings-with-flexible-ev-charging-lessons-from-colorado/

[3] Hildermeier, J., Scott, D., Reddy, S., Kaur, H. & Thakur, P. (2024, December 16). *Optimising electric heavy-duty truck charging in India.* Regulatory Assistance Project. https://www.raponline.org/knowledge-center/optimising-electric-heavy-duty-truck-charging-in-india/

[4] Monteforte, M., Mock, P., Mulholland, E., Rodrigues Poupinha, C. & Tietge, U. (2024, December). *European vehicle market statistics 2024/25.* International Council on Clean Transportation. https://theicct.org/wp-content/uploads/2024/12/250114_Pocketbook_2024_25_Web_korr.pdf

[5] European Commission. (2024, February 12). *CO_2 emission performance standards for cars and vans*. https://climate.ec.europa.eu/eu-action/transport/road-transport-reducing-co2-emissions-vehicles/co2-emission-performance-standards-cars-and-vans_en

[6] U.S. Environmental Protection Agency. (2023, November 21). *Light-Duty Vehicle Greenhouse Gas Regulations and Standards.* https://www.epa.gov/regulations-emissions-vehicles-and-engines/light-duty-vehicle-greenhouse-gas-regulations-and

system and the environment, and may slow down the transition to a cleaner road transport sector.[7,8]

Smart EV charging (also referred to as ‘optimised’, ‘managed’ or ‘controlled’ charging) can help overcome many of those challenges, enabling EVs to be utilised to provide optimum system flexibility. Smart charging is a key tool to reduce the consumption of fossil-powered electricity and integrate more variable renewables into the grid by charging EVs when there is sufficient renewable energy available. In doing so, smart charging can promote reductions in carbon emissions and reduce or entirely avoid the need for costly upgrades to the power grid.[9] A special category of smart charging is bidirectional or vehicle-to-grid (V2G) charging, which uses vehicle batteries to discharge electricity back to the power system when it is not needed for transport purposes, at times when it is most beneficial to the user and the system.[10] While smart charging of EV fleets has been studied from the user benefits point of view,[11] it is important to better understand the value that EVs can have as flexibility assets[12] for the power system[13] in large EV markets.[14,15]

The analytical framework used in all four regional case studies of this project is designed to demonstrate the economic and environmental value of smart charging of electric light-duty and heavy-duty vehicles. It is composed of five sequential steps, summarised in Figure 1 below.[16] First, the EV stocks are estimated in a given geography for all main vehicle segments (for the segments considered in this EU regional case study, see Annex), highlighting their battery size needs and the expected fleet growth over time. Second, based on the EV stocks, the charging infrastructure needs are assessed, quantifying metrics such as the number of charging stations required and the stations’ power capacity and charging load. The third step entails an estimate of the optimal geospatial deployment of those charging stations, considering constraints related to the local grid power capacity, space limitations, logistical constraints, and drivers’ behaviours. Step four identifies smart charging techniques available or implementable in the region, and opportunities for EV load to

---

[7] Das, H.S., Rahman, M.M., Li, S. & Tan, C.W. (2020, March). Electric vehicles standards, charging infrastructure, and impact on grid integration: A technological review. *Renewable and Sustainable Energy Reviews, 120*(109618). https://doi.org/10.1016/j.rser.2019.109618

[8] Ashfaq, M., Butt, O., Selvaraj, J. & Rahim, N. (2021, May). Assessment of electric vehicle charging infrastructure and its impact on the electric grid: A review. *International Journal of Green Energy, 18*(7): 657–686. https://doi.org/10.1080/15435075.2021.1875471

[9] Hildermeier, J., Kolokathis, C., Rosenow, J., Hogan, M., Wiese, C. & Jahn, A. (2019, December). Smart EV Charging: A Global Review of Promising Practices. *World Electric Vehicle Journal, 10*(4): 80. https://www.mdpi.com/2032-6653/10/4/80

[10] Burger, J. (2023). *Enabling two-way communication: Principles for bidirectional charging of electric vehicles*. RAP. https://www.raponline.org/knowledge-center/enabling-two-way-communication-principles-for-bidirectional-charging-of-electric-vehicles/

[11] Hildermeier, J., Burger, J., Jahn, A. & Rosenow, J. (2023, January). A Review of Tariffs and Services for Smart Charging of Electric Vehicles in Europe. *Energies, 16*(1): 88. https://www.mdpi.com/1996-1073/16/1/88

[12] Flexibility assets are assets to decouple time of supply and consumption, as battery storage, heat storage or EVs.

[13] International Energy Agency. (2022, December). *Grid Integration of Electric Vehicles – A manual for policy makers*. https://iea.blob.core.windows.net/assets/21fe1dcb-c7ca-4e32-91d4-928715c9d14b/GridIntegrationofElectricVehicles.pdf

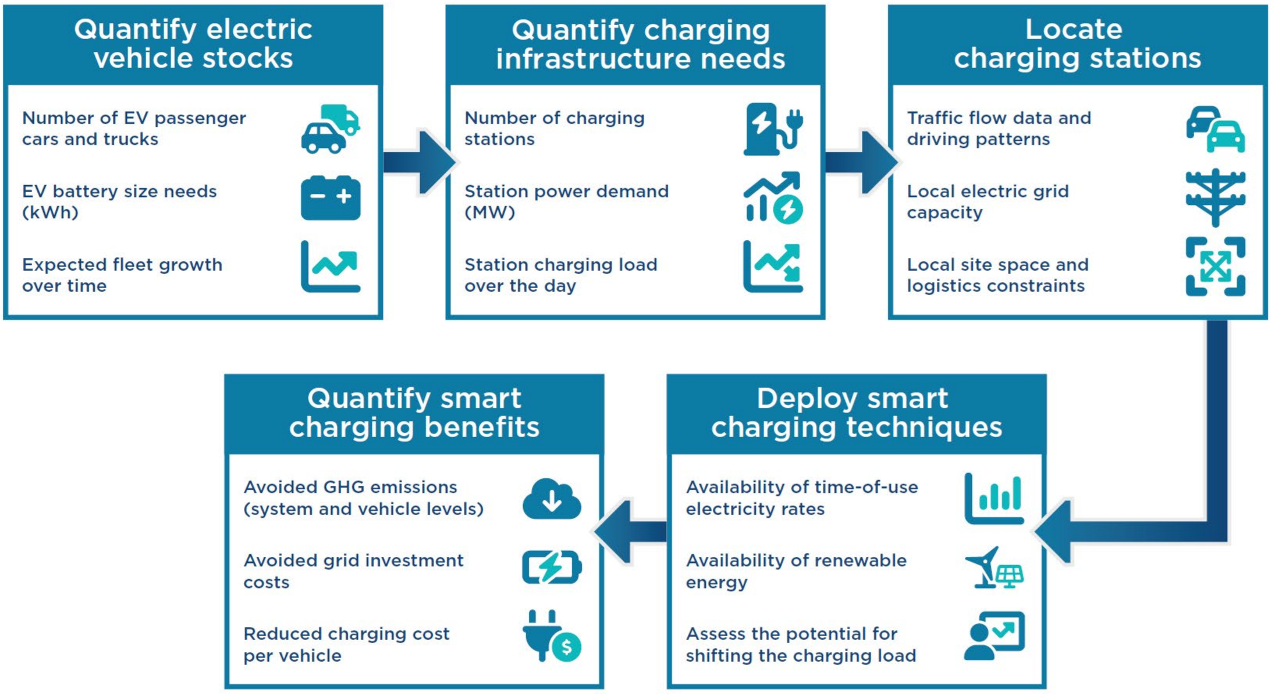
[14] Anwar, M.B., Muratori, M., Jadun, P., Hale, E., Bush, B., Denholm, P., Ma, O. & Podkaminer, K. (2022, January). Assessing the value of electric vehicle managed charging: a review of methodologies and results. *Energy & Environmental Science, 15*(2): 466–498. https://doi.org/10.1039/D1EE02206G

[15] Xue, L., Jian, L., Ying, W., Xiaoshi, L. & Ying, X. (2020, January). *Quantifying the Grid Impacts from Large Adoption of Electric Vehicles in China*. World Resources Institute. https://www.wri.org/research/quantifying-grid-impacts-large-adoption-electric-vehicles-china

[16] Basma, H. (2024, April 26). Assessing the Economic and Environmental Benefits of Electric Vehicles Smart Charging [Presentation]. EVS37.

integrate into, based on which charging can be optimised. To quantify savings from smart EV charging in step 5, we consider optimisation strategies based on flexibility options provided in programmes that utilise time-of-use rates, direct load control, and incentives that can help optimise EV load to support the use of existing grid capacity and renewable energy.

Figure 1. Framework for smart electric transport



Source: Basma, H. (2024, 26 April). *Assessing the Economic and Environmental Benefits of Electric Vehicles Smart Charging*

This interplay between EVs and power systems represents a significant opportunity for demand-side flexibility if policymakers and planners in the power and transport sectors adopt smart charging in decision-making – via, for example, charging infrastructure regulation and build-out. Results of the regional case studies that we consider here illustrate benefits from smart EV charging for both power sector planning and transport.

Findings and recommendations

This paper studies grid benefits of smart EV charging in the French region of Essonne, south of Paris, which comprises a well-developed, urban and rural power network representative of many other European regions. The study finds that using EV flexibility through smart charging has the potential to reduce Essonne's electrical infrastructure costs significantly. We analysed savings from optimally charging the fleet of electric passenger and heavy-duty vehicles forecasted for the region in 2040, taking into account expected transport practices, charging patterns and grid characteristics projected from current traffic behaviour and grid use. We find that:

- Smart charging of the EV fleet can reduce peak load on electricity grids and related system costs. In our case study, smart charging can **reduce peak load on the grid by 6% in 2040,** compared to unmanaged charging.
- **Bidirectional charging can add an even greater reduction** of 9%, compared to unmanaged charging in 2040.
- **Smart charging is a collective task** across all EV fleets: it covers not only smart residential overnight charging, but also optimised daytime charging of EV fleets at workplaces, and fully using electric trucks' flexibility windows while parked at the depot. Even high-capacity truck charging at highways doesn't necessarily contribute to peak load if other fleets present in the grid are charging smartly in parallel and thus free up grid capacity.
- **Smart charging also avoids distribution system costs** by flattening system peaks. In our analysis, smart charging in 2040 could reduce the need for power line reinforcements by 23%, and allow for 37% less transformer reinforcements in Essonne than unmanaged charging. Overall, a broad estimate suggests that smart EV charging avoids about one-quarter of yearly network reinforcement costs in the area studied.

As France's power grids are relatively well developed thanks to electrified heating, it's likely that other average European grids will benefit to an even greater degree from smart charging.

Recommendations:

To make EV grid integration cost-efficient and prepare rapid transport electrification, we recommend that policymakers and energy regulators at EU and national levels:

- Ensure that smart residential and workplace charging for EVs, and smart depot charging for e-trucks, are the default mode of charging and create maximum system benefits.
- Broadly introduce cost-reflective pricing of power networks, e.g. through time-varying network pricing, to incentivise smart EV charging.
- Require transparency on network use from distribution grid operators (DSOs) so that more cost-reflective tariffs can be designed and implemented.
- Allow EVs to participate as flexibility resources in energy markets to generate value for customers through demand-response programmes, e.g. via smart tariffs and services.
- Facilitate joint planning by transport and energy stakeholders to ensure balanced build-out of charging infrastructure; as well as scale distribution system upgrades to the appropriate levels, locally and time-wise, avoiding overinvestment.

Savings from smart charging electric cars and trucks in Europe: A case study for France in 2040

Introduction

The aim of this study is to quantify the savings on a selected distribution grid from optimising charging of a fleet of electric cars and trucks. A lack of investment in distribution grids, paired with the need for more efficient use of existing capacity, are currently one of the key bottlenecks for EV uptake in Europe. Efficient electrification of transport is key to the EU's future competitiveness and to meeting climate targets. This study shows that with optimised charging of EVs, power grids can be used in a more cost-efficient way, that can save grid investment costs and hence accelerate the adoption of transportation electrification. To quantify savings from smart EV charging and illustrate how these savings can be achieved, RAP and ICCT contracted with Artelys (www.artelys.com), a consultancy specialised in distribution grid modelling, to analyse potential studied impacts of light and heavy-duty vehicle electrification.

This paper is structured as follows. First, we set out the policy context for smart EV charging in Europe, providing the broader regulatory background for our case study. The main section of this paper ('Case study') presents projections from EV charging provided by ICCT, and the modelling of grid benefits from smart charging in the selected French region of Essonne. For this analysis, Artelys conducted a physical simulation of Essonne's electrical distribution network,[17] based on projections for electricity demand from EVs in three scenarios with different degrees of EV flexibility used for smart charging (see also Table 2).

The 'Main findings' section discusses results for all scenarios. Granular analysis of a mixed EV fleet composed of electric passenger cars and trucks illustrates how different (smart) EV charging use cases can contribute to reducing peaks on the local electricity system. In addition to positive grid effects from overnight residential EV charging, for example, we also illustrate how midday workplace charging and overnight depot charging of trucks can help to shave peak loads in the grid.

In the last section, 'Conclusions and policy recommendations', we discuss policy options for decision-makers. These are derived from the French case but apply more broadly to enhancing smart EV charging in the European policy context.

Policy context

There is growing understanding among EU policymakers that smart EV charging is an essential tool to ensure that EV uptake is beneficial for users, the power grids and the environment.[18] The EU's first regulation to set up a pan-European public charging network, the so-called Alternative Fuels Infrastructure Regulation (AFIR), entered into force in April 2024 and requires the build-out of essential public charging network starting from 2025. It sets installed capacity and coverage targets for both light and heavy-duty EV charging infrastructure. All new charging infrastructure is capable of smart charging, which means being able to measure and communicate consumption.[19] In addition to this basic smart capability of the charging infrastructure itself, an enabling energy market framework is necessary to ensure that the value of EVs as flexibility assets[20] can be fully captured by

---

[17] A detailed documentation of the simulation and results can be found here: https://www.artelys.com/app/uploads/2025/03/Savings_from_smart_charging_Technical_Report_Artelys.pdf

[18] Energy-efficient electrification of transport, among other sectors, is identified e.g. in the European Commission's report on *The future of European competitiveness* (the 'Draghi report'), https://commission.europa.eu/document/download/97e481fd-2dc3-412d-be4c-f152a8232961_en. The development of an Electrification Action Plan is identified as a policy priority for the Commission, e.g. Energy Commissioner Jorgensen's Mission Letter of 17 September 2024: https://commission.europa.eu/document/download/1c203799-0137-482e-bd18-4f6813535986_en?filename=Mission%20letter%20-%20JORGENSEN.pdf. A new policy focus on improving investments into and smart use of power grids is suggested in the European Commission's Grid Action Plan (2023): https://ec.europa.eu/commission/presscorner/detail/en/ip_23_6044

[19] European Commission. (2021, July). *Proposal for a regulation of the European parliament and of the council on the deployment of alternative fuels infrastructure, and repealing Directive 2014/94/EU of the European Parliament and of the Council.* https://eur-lex.europa.eu/resource.html?uri=cellar:dbb134db-e575-11eb-a1a5-01aa75ed71a1.0001.02/DOC_1&format=PDF

[20] Claeys, B., Hogan, M., Jahn, A., Morawiecka, M., Pató, Z., Scott, D. & Yule-Bennett, S. (2022, July) *Power System Blueprint: Market access for demand-*

market actors – the key condition required to make smart charging beneficial. European energy market reforms from 2019, as well as their recent partial recast in 2023, build toward this goal by adopting some important foundations.[21] For example:

- Transparency is increased by enabling consultation of grid development plans, requiring grid operators to disclose grid information, and providing greater market access for aggregators and charging point operators (CPOs).[22]
- Network operators are encouraged to introduce time-varying network fees.[23]
- Requirements are placed on national energy regulators to introduce standards that apply to DSOs and transmission system operators (TSOs) for using flexible grid agreements.[24]

Smart – and where appropriate bidirectional – EV charging is also encouraged through the amended Renewable Energy Directive,[25] which requires Member States to increase the share of renewable energy used (e.g.) in buildings and transport. To increase the energy efficiency of and renewable energy used in buildings, the Directive requires Member States to develop national support schemes or regulations promoting "substantial increases in renewables self-consumption, renewable energy communities, local energy storage, smart recharging and bidirectional recharging, other flexibility services such as demand response"[26]. To reach the Directive's renewable energy share target set for the transport sector, Member States also have to establish a mechanism to allow fuel suppliers to exchange credits for supplying renewable energy used in transport. This includes renewable energy supply to EVs at public, and in some countries private, charging points, both of which can be helped by smart charging.

Another important regulatory building block enabling smart EV charging is the recently revised European building regulation. The Energy Performance of Buildings Directive[27] requires charging equipment and precabling to be placed in parking areas of new and renovated non-residential buildings, and encourages Member States to support charging equipment for residential buildings. Both requirements present an important opportunity to accelerate smart residential and workplace charging. An important gap in the EPBD's

---

side flexibility. Regulatory Assistance Project. https://blueprint.raponline.org/market-access-for-demand-side-flexibility/

[21] European Commission. (n.d.) *EU electricity market design*. https://energy.ec.europa.eu/topics/markets-and-consumers/electricity-market-design_en That said, previous energy market provisions concluded in 2019 designed to advance demand-side flexibility in national legislation are not yet fully implemented, and the rollout of smart meters has been slow in some European countries such as Germany.

[22] This is not from the recent adjustments (Directive **2019/944** Article 32 – from 2023) but it is not yet implemented into national law everywhere.

[23] Article 2 (7) Amendments to Regulation (EU) 2019/943.

[24] Amendments to Directive (EU) 2019/944 Article 2 (3) – These agreements provide a guaranteed capacity and a non-guaranteed capacity for a grid connection, as an alternative to today's secured grid capacity agreements.

[25] DIRECTIVE (EU) 2023/2413 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 18 October 2023 amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652. ('RED III') https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202302413

[26] RED.III, Art. 15a

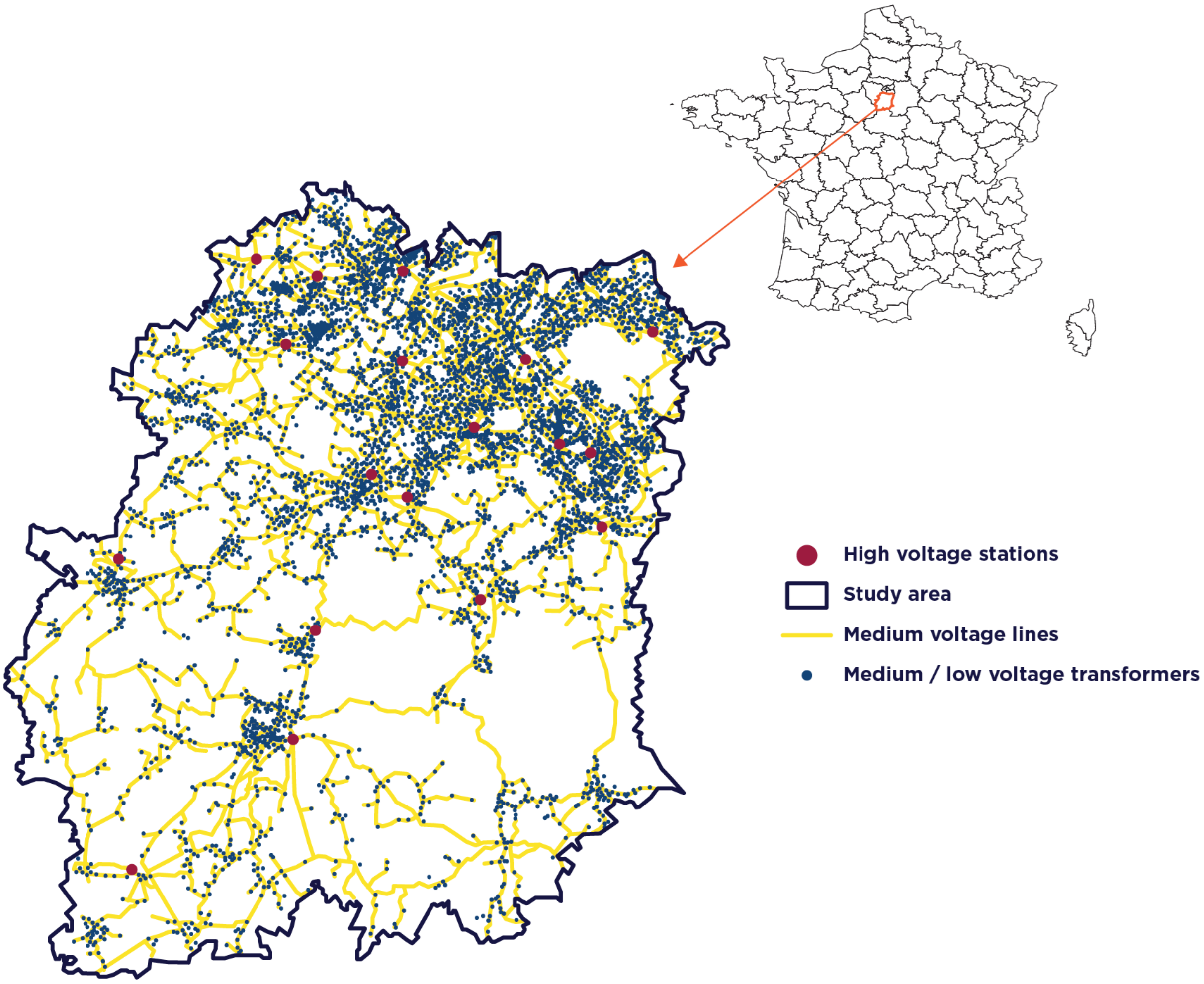
[27] DIRECTIVE (EU) 2024/1275 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 24 April 2024 on the energy performance of buildings (recast) ('EPBD'). https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202401275

definition of non-residential buildings is that it does not include freight vehicle depots, which would further enable smart charging of electric delivery and long-haul trucks, an essential EV use case.[28] This gap could be addressed by Member States through other regulatory means to further support the electrification of truck depots.

Case study: Smart EV charging

We chose the representative French department of Essonne, south of Paris, France (pictured in Figure 2) to study the economic benefits – defined as avoided grid costs – that could be achieved through optimising EV charging.

Figure 2. Case study grid area



By choosing a representative area of electricity consumption, our case study covers the majority of EV charging use cases in the EU and their demands on the electricity network. This region is representative of a European mix of consumption patterns due to its

---

[28] Hildermeier, J., Jahn, A. & Rodriguez, F. (2020). *Electrifying city logistics in the European Union: Optimising charging saves cost.* https://www.raponline.org/wp-content/uploads/2023/09/rap-icct-eu-city-logistics-factsheet-2020-nov-19.pdf

composition. Essonne offers a mixture of urban, semi-urban and rural areas, as well as major highways, each featuring one or several dominant EV charging use cases. For example, public and private electric light duty vehicles (eLDVs) charging in urban areas, heavy-duty vehicles (HDVs) depot charging in semi-urban areas, fast eLDV and eHDV charging along highways, and residential eLDV charging in rural areas.

The degree to which the French grid is representative of other European grids is discussed further down in 'Grid characteristics'. In general, the findings of this case study can be considered as rather conservative, as the French grid is comparatively well developed compared to other EU countries thanks to electrified heating. This implies that our findings would apply to an even greater degree in other average European grids.

EV uptake and charging demand in 2040

We quantified the EV fleet's energy and charging needs using models developed in-house by ICCT, which will be highlighted in this section. The charging needs are directly related to the EV penetration rate across different road transport segments. Those include light-duty vehicles (LDVs) and heavy-duty vehicles (HDVs). Given the different operational and charging patterns for the LDV and HDV segments, and also for sub-segments within them, we further segment LDVs into passenger cars and light commercial vehicles (LCVs), and further segment HDVs into buses, coaches, trucks, regional tractors, and special vehicles, in line with the approach employed by the French Bureau of Statistics.

We estimate there will be 582,510 eLDVs (which include battery and plug-in-hybrid electric vehicles) and 8,355 e-HDVs in Essonne in 2040. As a share of the projected national fleet, this means Essonne will hold 1.9% of all eLDVs and 1.8% of all eHDVs in France in 2040. The EV penetration rate and fleet size are estimated using local vehicle stock and registration data from the Statistical Data and Studies Department,[29] which is then combined with electrification scenarios from the ICCT's Roadmap model,[30] derived from policy scenarios. The policy scenarios considered in this study reflect the policies currently adopted in the EU, namely the 2035 100% CO_2 reduction targets for LDVs and the revised HDV CO_2 standards, which mandate a 45% reduction by 2030, 65% by 2035, and 90% by 2040.[31]

We used ICCT's EV CHARGE model[32] to quantify infrastructure needs for LDVs. This considers several factors when quantifying passenger car and light van charging

---

[29] Statistical Data and Studies Department. (2023, November 16). *Données sur le parc automobile français au 1er janvier 2023*. Ministères Aménagement du territoire Transition écologique. https://www.statistiques.developpement-durable.gouv.fr/donnees-sur-le-parc-automobile-francais-au-1er-janvier-2023?rubrique=&dossier=1348

[30] Braun, C., Jin, L. & Miller, J. (2019). *Roadmap Model Documentation*. The International Council on Clean Transportation. https://theicct.github.io/roadmap-doc/. Forecasts were adjusted with Essonne-specific downscaling factors and data on EV fleet shares.

[31] More details about those projections can be found in the following report under 'Baseline Scenario': Sen, A., Miller, J., Hillman Alvarez, G. & Ferrini Rodrigues, P. (2023, November). *Vision 2050: Strategies to align global road transport with well below 2°C.* https://theicct.org/wp-content/uploads/2023/11/ID-22-%E2%80%93-1.5-C-strategies-report-A4-65005-v8.pdf

[32] Schmidt, J., Rajon Bernard, M., Hillman Alvarez, G., Sen, A., Miller, J. & Jin, L. (2024). EV CHARGE v1.2 documentation (computer software). International Council on Clean Transportation. https://theicct.github.io/EVCHARGE-doc/versions/v1.2/

infrastructure needs. These include charging access at home, work and depot, commuting behaviour, and housing types. The model then distributes the energy needs across home, workplace, public alternating current (AC), public direct current (DC) fast, and LCV depot chargers, taking the aforementioned factors into account, as highlighted in the publicly available model documentation. Highway charging is also included, with the assumption that 5% of the eLDV fleet energy needs are recharged on highways.[33]

For HDVs, ICCT's HDV CHARGE model[34] uses daily vehicle-kilometres travelled (VKT) distributions and charging patterns to allocate energy consumption to overnight, fast and ultra-fast chargers at depots or public locations. Highway charging needs were calculated separately, based on annual average daily traffic data from the French road network.[35] This includes VKT on autoroutes and national roads, using 2019 data.

To isolate the effect of smart charging, no battery storage capacity other than that of EVs was modelled on the distribution network

EV fleet projected for 2040

For our analysis, we identified eight different EV fleets (named EV1-EV8, see below) to reflect the main types of use and charging patterns for both electric passenger cars and trucks. Four fleets are considered manageable, i.e. able to optimise their charging. These fleets represent use cases in which EVs are parked and connected for a longer time window, offering flexibility that can be exploited with smart charging: electric passenger cars charging at home, at work, those charging at normal speed in public, as well as electric trucks charging at the depot. Each fleet is defined by a charging type, a volume of energy, an average charging power level and specific arrival and departure curves (see Table 1). For details on how each fleet was mapped, see Table 5 in the Annex.

---

[33] Based on share of vehicle km driven on highways and drivers' surveys, and the assumption that EVs will predominantly charge at home and on highways only for longer trips. Details outlined in https://theicct.org/publication/charging-infrastructure-to-support-the-electric-mobility-transition-%E2%80%AFin-france%E2%80%AF/

[34] Schmidt, J., Egerstrom, N., Hillman Alvarez, G. & Ragon, P. (2024). *HDV CHARGE v1.0 documentation* (computer software). International Council on Clean Transportation. https://theicct.github.io/HDVCHARGE-doc/versions/v1.0/

[35] Ministère de la Transition écologique. (2021, December). *Trafic moyen journalier annuel sur le réseau routier national*. République française. https://www.data.gouv.fr/en/datasets/trafic-moyen-journalier-annuel-sur-le-reseau-routier-national/

Table 1. EV fleet characteristics in 2040

Name	Type of EV	Charging type	Smart charging	Average charging power (kW)	Annual energy demand (GWh)	Share of total EV demand (%)
EV1	eLDV	Home	Yes	5	1,184	50
EV2		Work	Yes	17	191	8
EV3		Public normal	Yes	13	339	14
EV4		Public fast	No	71	173	7
EV5		Highway fast/ultrafast	No	164	97	4
EV6	eHDV	Depots	Yes	31	290	12
EV7		Warehouses	No	125	5	0.2
EV8		Public fast/ultrafast incl. highways	No	450	96	4
Total					2,375	100

Smart charging scenarios

We define three scenarios: S1 (low flexibility) and S2 (high flexibility) cover the range of the flexibility value that can be captured from smart charging. S1 represents a reference scenario for 2040 assuming 30% of smart charging is already developed, but 70% of charging is not being managed.

Table 2. Smart charging scenarios

Rate of smart charging	S1 — low flexibility	S2 — high flexibility	S3 — vehicle-to-grid
Unmanaged	70%	10%	10%
Smart	30%	90%	80%
Bidirectional			10%

Percentages correspond to the volume of energy needed to meet EVs' mobility demand associated with each charging mode.

The high flexibility scenario S2 assumes that 90% of the energy comes from optimised charging. That means that 90% of the energy used for charging is charged at times when it is optimal for the grid within a flexibility window. A third scenario S3 (vehicle-to-grid, V2G) builds on the high flexibility scenario S2 to explore additional benefits of V2G: it assumes that 10% of the overall energy used is by bidirectionally capable EVs. Optimal times for charging are determined by grid characteristics and smart tariffs, discussed in the two following sections.

Grid characteristics

Most power systems in Europe face winter-driven peak demand due to early sunsets, low temperatures, and higher demand during the week compared to weekends. Since the grids are typically built to serve this peak, a steep or even moderate increase of this peak demand can result in significantly different network extension needs and associated grid costs. In European winter peaking systems, January or February evening peak load drives the annual grid extension costs. Solar energy supply has a limited impact on reducing peak winter consumption: it can only help to reduce the demand at noon or in the evenings via storage to a limited extent, but not at both times, nor significantly. In this study, no battery storage capacity other than that of EVs was modelled on the distribution network.

Compared to power networks in other European countries, the French networks are already built out for the heating demand, and overall need less reinforcement than average EU grids. That is explained by the specifics of the French system: the 2024 peak load was only about 82 GW, but it was above 100 GW a decade ago.[36] This means that most of the time the French system has available grid capacity on the transmission and distribution levels, since the proportion of electrified heating demand is much higher in France than in other EU power networks.[37],[38] Even an increase of peak load on a line or substation does not result in an immediate need for grid extension, as might be the case in grids in other European countries which are prepared for less heating demand and are more congested. As a result, the recommendations in this case study are likely to apply to an even greater degree in other EU countries.

The next section discusses the underlying incentive to drive grid savings from smart charging that we assumed for this study: the availability of time-varying electricity tariffs, which are considered here as the main signal based on which consumers optimise their charging.

---

[36] Veyrenc, T. (2015, September 28). *The French capacity market design.* Réseau de Transport d'Electricité. https://competition-policy.ec.europa.eu/document/download/5ace3816-89e2-419e-a6a8-8ca0656d2a67_en?filename=capacity_mechanisms_conference_2015_slides_veyrenc_en.pdf&prefLang=pl

[37] Artelys considered the electrical distribution network for these analyses by modelling the load changes on every high-voltage/mid-voltage transformer, mid-voltage power line, mid-voltage/low-voltage transformer/substation. For details, https://www.artelys.com/app/uploads/2025/03/Savings_from_smart_charging_Technical_Report_Artelys.pdf.

[38] FfE (2020, June). *Case study on final electricity consumption for space heating in French private households and the danger of data misinterpretation.* https://www.ffe.de/veroeffentlichungen/case-study-on-final-electricity-consumption-for-space-heating-in-french-private-households-and-the-danger-of-data-misinterpretation/

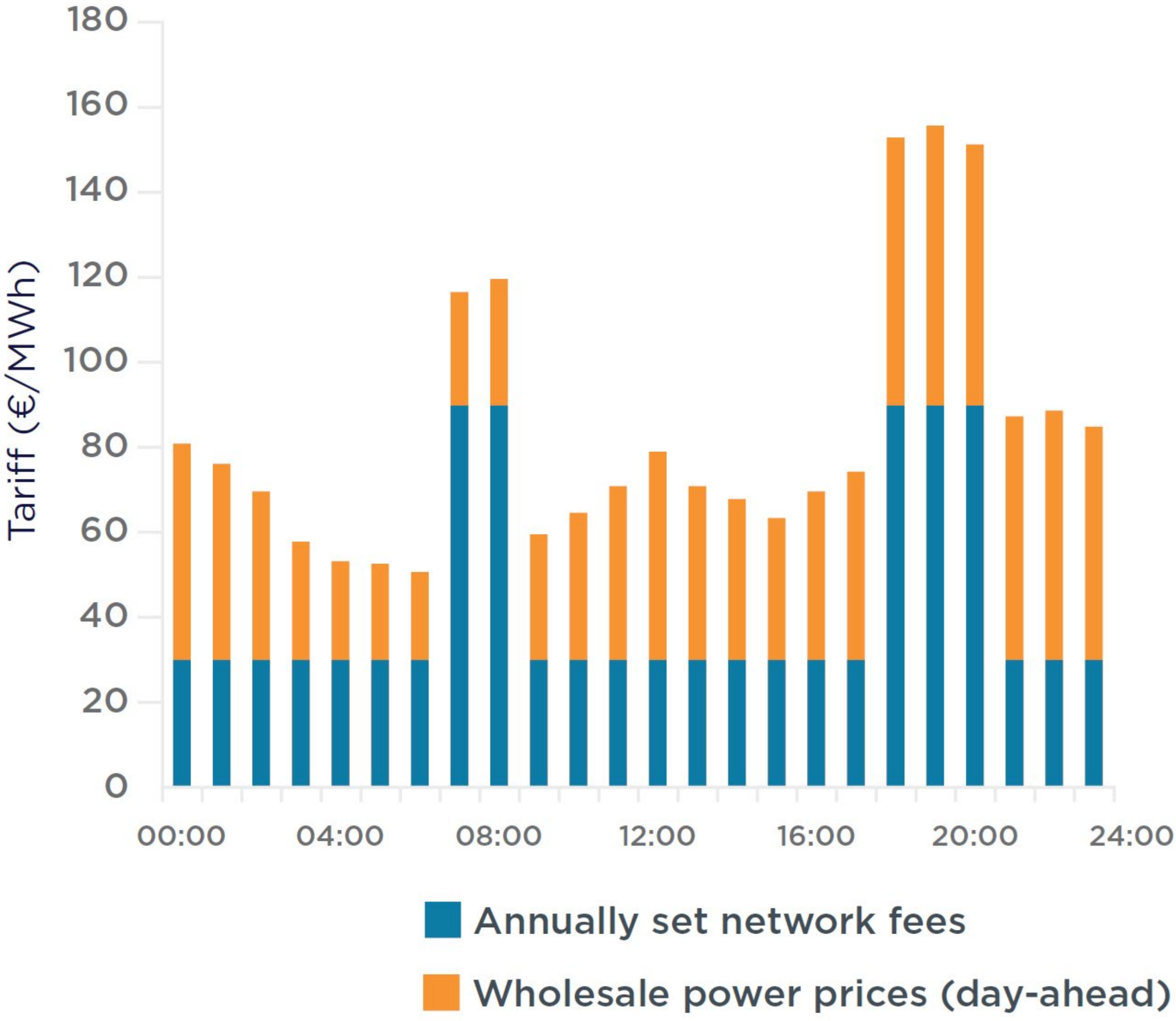
The availability of smart energy tariffs and services has almost tripled in recent years. See Burger, J. (2024). *Imagine all the people: Strong growth in tariffs and services for demand-side flexibility in Europe*. Regulatory Assistance Project. https://www.raponline.org/toolkit/strong-growth-in-tariffs-and-services-for-demand-side-flexibility-in-europe/

Smart charging tariffs

To quantify the potential grid savings from smart EV charging, our model assumes that they are created by EV users aiming to save money by moving charging to cheaper hours. For modelling purposes, we assume that a certain percentage (e.g. in S2, 90%) of energy is charged into EVs based on a time-varying tariff, indicating hours when charging is cheaper. This implies that demand is highly responsive to these price signals. How these tariffs are set (opt-in, mandatory etc.) and the degree of automation and support they offer (e.g., through smart charging apps) is not in scope within this study.

For the purposes of this study, we assumed a time-varying tariff for 2040 as depicted in Figure 3.

Figure 3. Smart charging tariff assumed for 2040



Tariff on a weekday

The tariff design is based on a literature review,[39] and has two components:

- An **energy price-based** component (depicted in orange), built from French pre-energy-crises wholesale power day-ahead prices in 2019.
- A **time-of-use (ToU) network fee** (illustrated in blue). The price spread between low and high prices is modelled on already existing ToU network fee designs e.g. in Denmark, where the standard network tariff applying in low-usage times (i.e. nights) is three times cheaper than the peak tariff (i.e. early evenings). Experience suggests that these ToU network fees are a key tool to incentivise consumers to move consumption away from peaks.[40]
- For both components, we conservatively kept the price differential between highest and lowest tariff rather moderate, making the scenarios more representative for other EU countries. In some markets today there are already wider price spreads, allowing for potentially higher savings.
- Based on Artelys' net demand projections for 2040, two price peaks have been identified: 7:00–9:00 and 18:00–21:00. They only occur on weekdays.

Both the energy and network price components combined form a price signal that incentivises consumers to shift charging to cheaper hours.[41] For simplicity, we assumed that all EV users use this tariff, and that they are fully reactive to these price signals – in other words, that the projected share of smart-charging EVs forecast in Essonne in 2040 will adapt their charging to the pattern of the curve in Figure 3.

Tariff assumptions for bidirectional EV charging (Scenario 3)

Bidirectional (V2G) charging – that is, discharging energy stored in EVs back into the grid at hours of peak demand – can add additional grid savings. To reflect the potential additional benefits from bidirectional charging, analysis for S3 (V2G) sought further optimisation of the observed consumption in S2. Thus, the impact of bidirectional charging discussed in this section is evaluated with regards to the S2 high flexibility scenario. We assumed that EVs discharge back into the grid at the most beneficial times and, as a result, flatten the remaining consumption peaks observed in S2 through bidirectional charging. To determine these times, we assumed the same price spreads as in S2, but moved on-peak prices to times in which EVs can address local grid constraints and act as a grid resource, rather than addressing the national grid situation as assumed for S1 and S2. We assumed that:

---

[39] Eicke, A., Hirth, L. & Mühlenpfordt, J. (2024, March). *Mehrwert dezentraler Flexibilität*. Neon Energy. https://neon.energy/mehrwert-flex

[40] Radius. (n.d.). *Tariffer og netabonnement*. https://radiuselnet.dk/elnetkunder/tariffer-og-netabonnement/

[41] Note that the study considers tariffs as input variables into the model to illustrate potential savings from smart charging of EV fleets in 2040. It does not aim at studying the design or cost-effectiveness of the assumed tariffs, nor whether the assumed design will be cost-neutral, nor how additional system savings will be distributed (see 'Limitations and further research' section below). They do not reflect network investment costs nor wholesale power market scarcity prices. Further, since it can be considered that the tariffs cover the costs, the changes of load from smart charging are network cost savings.

- The share of EVs connected to the grid in a V2G mode is set at 10% in 2040; this means, we assume that 10% of the EVs can charge the system if needed. This is slightly more ambitious than other national projections for V2G uptake in France,[42] but allows us to explore the potential added value of V2G compared to classic 'one-directional' smart charging.
- Network charges are varying more precisely along the regional network utilisation, not as a national year-ahead network tariff.
- The uptake rate of bidirectionally charging EVs is the same for the four manageable fleets.

---

[42] RTE foresees 3% in 2035 and 6% in 2050 in a median scenario; 20% in 2050 in its highest flexibility scenario. Réseau de Transport d'Electricité. (2022, February 16). *Futurs énergétiques 2050: les scénarios de mix de production à l'étude permettant d'atteindre la neutralité carbone à l'horizon 2050*. https://www.rte-france.com/analyses-tendances-et-prospectives/bilan-previsionnel-2050-futurs-energetiques

Main findings

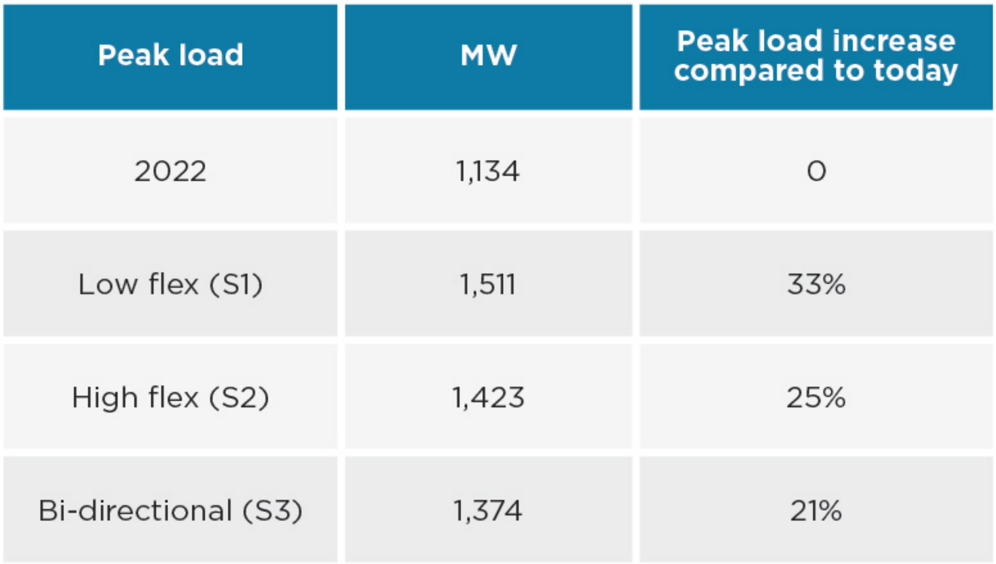
Unmanaged EV charging will increase Essonne’s peak load by 33% in 2040

Without smart EV charging in place (S1), peak load in the Essonne department is about 1,134 MW in 2022. As illustrated in Table 3 below, the peak demand modelled in this low flex scenario increases by one-third to 1,511 MW in 2040.

Smart EV charging can reduce peak in Essonne’s grid by up to 6%

Optimised charging of the EV fleet based on price-based incentives can reduce peak and therefore system costs. In S2 (high flex), system peak only increases by one-quarter (25%) in 2040, compared to 33% in S1 with unmanaged charging. There is a 6% difference in peak load reduction between high flex and low flex scenarios.[43]

Table 3. Scenario results for peak load in 2040



Peak load	MW	Peak load increase compared to today
2022	1,134	0
Low flex (S1)	1,511	33%
High flex (S2)	1,423	25%
Bi-directional (S3)	1,374	21%

Source: Lucas, C. Dilé, M., Quignon, L. (2025, March.) *Savings from smart charging electric cars and trucks in Europe: A case study for France in 2040 - Technical Report.*

---

[43] Lucas, C. Dilé, M., Quignon, L. (2025, March.) *Savings from smart charging electric cars and trucks in Europe: A case study for France in 2040 - Technical Report*. Artelys. https://www.artelys.com/app/uploads/2025/03/Savings_from_smart_charging_Technical_Report_Artelys.pdf

Bidirectional charging can further reduce peak load by up to 9%

Bidirectional EV charging can further reduce system peaks and therefore system costs. S3 modelling indicates that with only 10% of all controllable EVs charging bidirectionally, a further 3% of the expected peak load can be saved, adding to savings from the high flex scenario. The peak load increase in 2040 compared to today is therefore lower than in S1 and S2, at only 21% or 1,374 MW. This illustrates the high potential of bidirectional charging to reduce network peaks and save grid investment costs.

Smart EV charging can save up to 25% on network reinforcement costs in Essonne annually

More efficient grid use from smart EV charging helps to avoid the need for grid investments. In our analysis for Essonne, summarised in Figure 4 below, we quantified the savings from avoided reinforcements of medium-voltage power lines and substations for the studied region. We estimated reinforcement costs against projected 2040 capacity needs;[44] the savings are estimated based on network development plans projected by French DSO Enedis.[45]

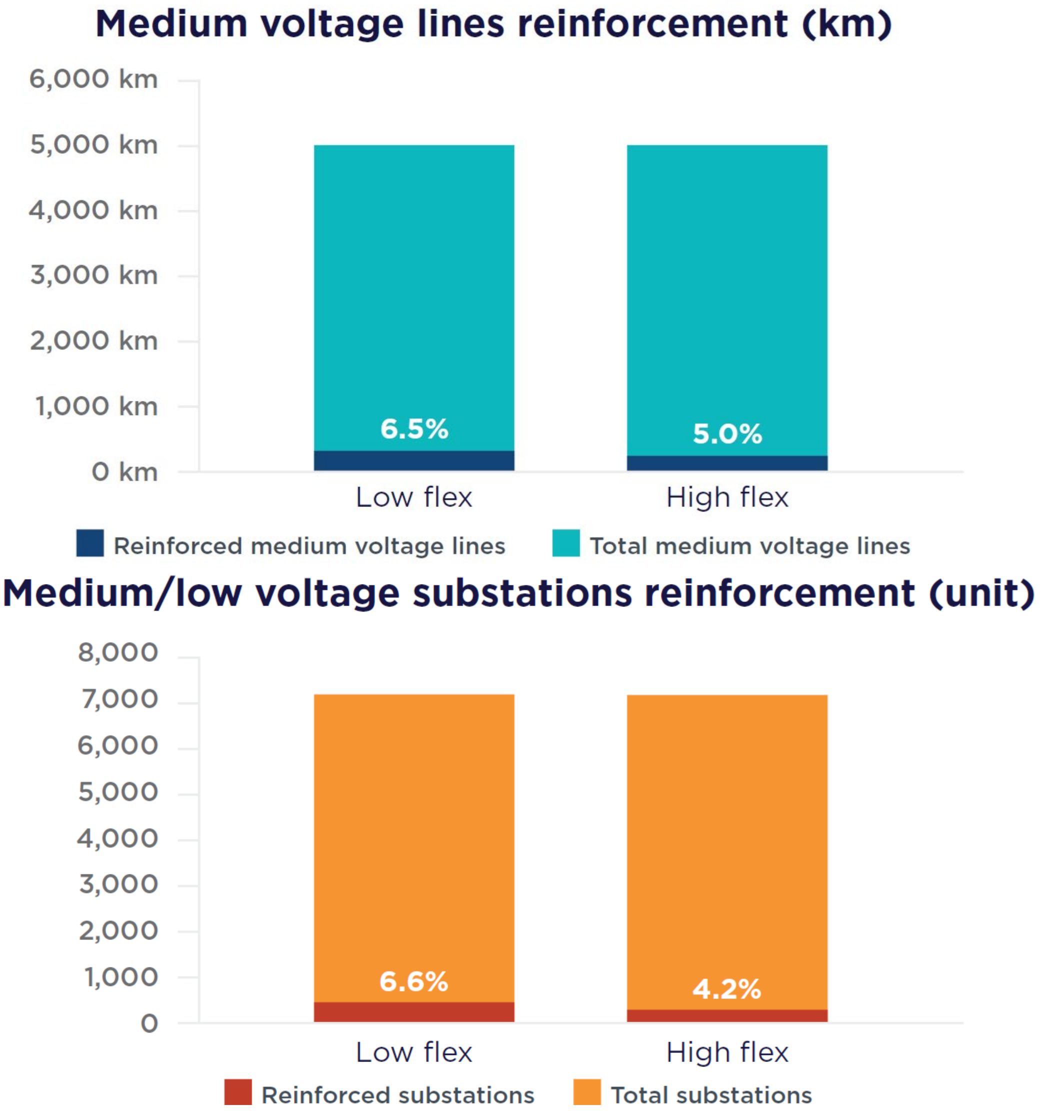
- In the high flexibility scenario (S2), the need for line reinforcements (in kilometres) is 23% lower than in the low flexibility scenario (S1).
- S2 allows for 37% less transformer reinforcements than S1.
- Overall, we estimate that the annual costs of network reinforcements expected through to 2040 can be reduced to about €2.1 million per year in the high flex scenario (S2) compared to €2.8 million in the low flex scenario (S1), a potential saving of 25% per year.

---

[44] Methodology for line and substation reinforcement cost estimated documented in Artelys' technical report: https://www.artelys.com/app/uploads/2025/03/Savings_from_smart_charging_Technical_Report_Artelys.pdf

[45] ENEDIS *Network Development Plan*, according to local requirements, considering its number of MV/LV transformers. ENEDIS. (2023). *Plan de développement de réseau.* https://www.enedis.fr/sites/default/files/documents/pdf/plan-de-developpement-de-reseau-document-preliminaire-2023.pdf

Figure 4. Grid reinforcement needs in low and high flex scenarios



Source: Lucas, C. Dilé, M., Quignon, L. (2025, March.) *Savings from smart charging electric cars and trucks in Europe: A case study for France in 2040 - Technical Report.*

Figure 4 shows that, in both scenarios, the need for reinforcement is generally below 10% as there is ample capacity on the grid. This is a specific characteristic of the French grid, due to its high share of direct electrified heating. Because of this electric heating demand, the demand and peak of the French power system correlate more closely to temperature than is the case in other EU power systems. The average grid utilisation therefore is lower and there will be less need for grid extension if utilisation increases (by smart EV charging) than in other, less temperature-related power systems. It is likely that the potential savings in other European systems would be significantly higher.

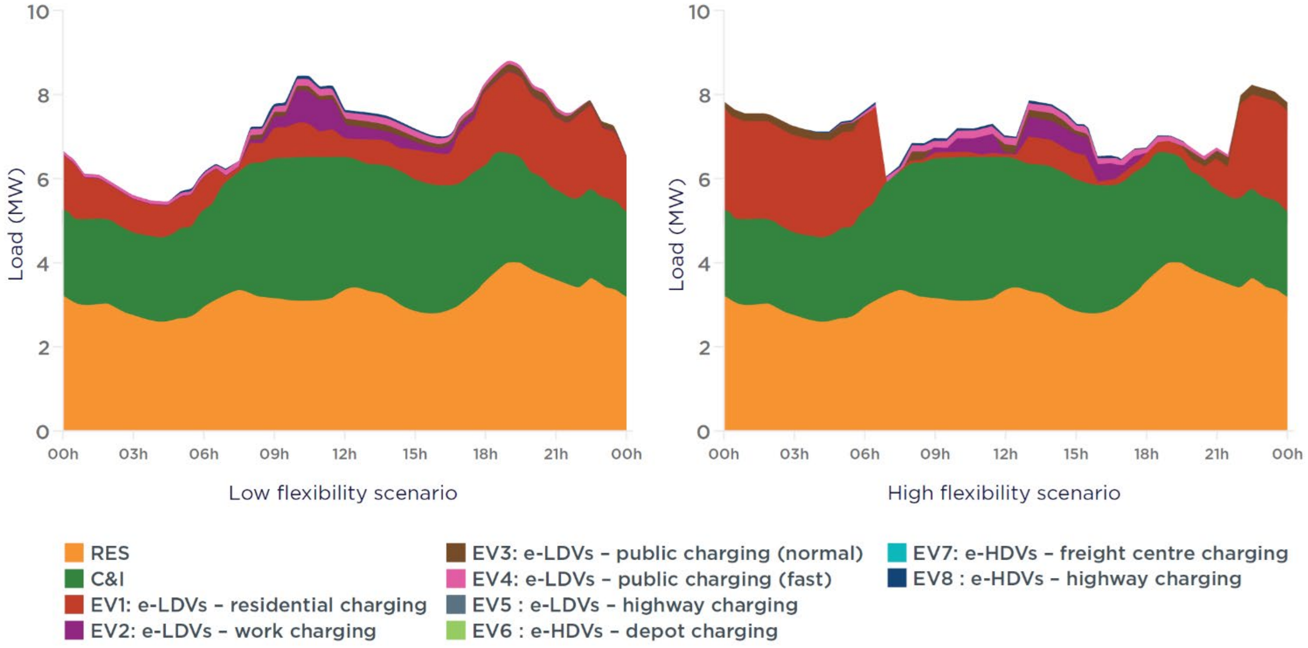
All EV customer groups can contribute with their flexibility to achieve system benefits

Our analysis reveals flexibility gains from smart charging in all studied areas, as the potential to shift charging from different fleets can be combined. The right smart charging mix depends on which fleet is the most dominant by amount of energy and flexibility potential at a given location. In the next section, we discuss selected results from the grid modelling focusing on high-load areas within the studied region. Based on load curves established for these selected areas – close to highways, in commercial zones and residential areas within Essonne[46] – we can illustrate the impact of smart EV charging depending on which form of it is dominant. Results show that smart daytime workplace or depot charging of EVs can contribute to reduce system peaks, in addition to the better-known overnight charging of residential EVs.

Moving residential EV charging to overnight is essential to reduce peak

Findings illustrated in Figure 5 (below) show that smart residential charging is highly effective to reduce system peaks. In the low flex scenario in a residential area, EV charging mostly from privately-used passenger EVs contributes to a peak in the system after 6 p.m. This peak can be fully reduced by shifting the charging of that fleet (EV1) into overnight hours from 10 p.m. to 6 a.m., which are the low-utilisation hours on the grid. These results confirm that ‘classic’ smart residential charging will remain essential to reduce the costs of electrification for consumers and the grid for years to come. Measured by amount of energy and flexibility that can be exploited, truck depot charging is the second-most relevant fleet to look at in the selected area.

Figure 5. Smart residential charging



Load curves in a residential area at the peak consumption in low flex and high flex scenarios.

---

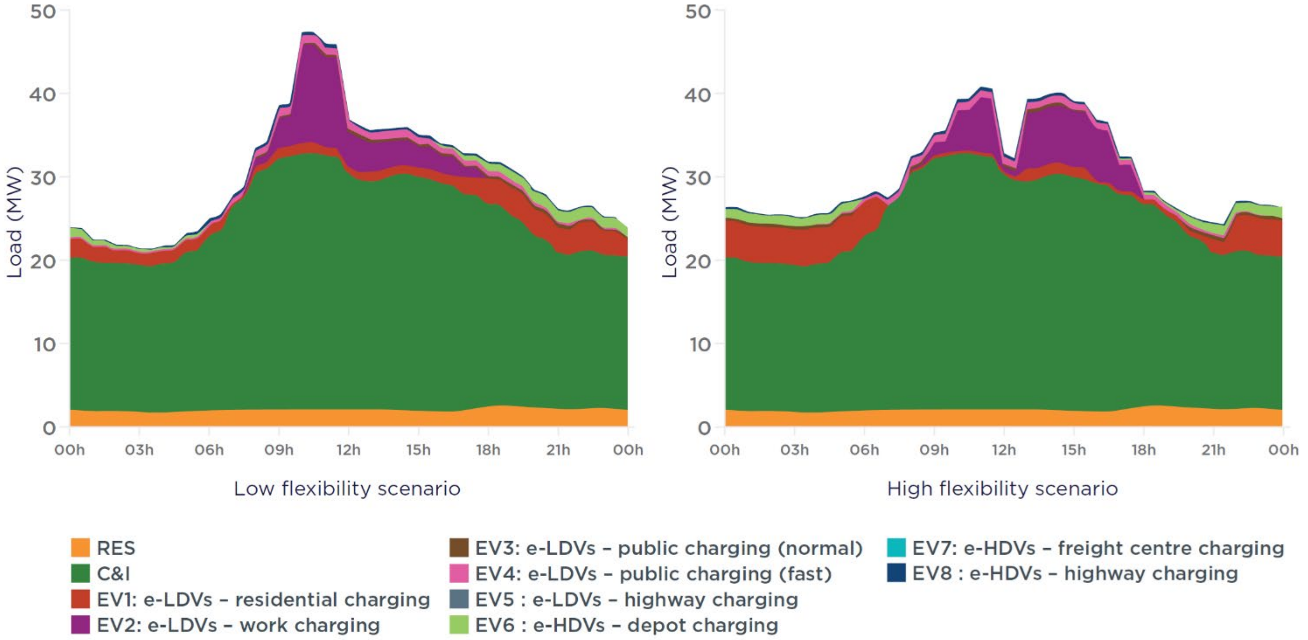
[46] For areas, see Artelys technical background report, slide 42, and 52ff. https://www.artelys.com/app/uploads/2025/03/Savings_from_smart_charging_Technical_Report_Artelys.pdf

Source: Lucas, C. Dilé, M., Quignon, L. (2025, March.) *Savings from smart charging electric cars and trucks in Europe: A case study for France in 2040 - Technical Report.*

Smart workplace charging helps reduce peak load in commercial areas

Results from a business/commercial zone in the grid area illustrated in Figure 6 clearly show how smart workplace charging can reduce the load peak occurring between 9 a.m. and 12 noon. In the high flexibility scenario, this is mainly achieved by shifting the charging of EVs at workplaces (EV2) into the early afternoon, using the time window these EVs have while parked at office buildings. In the business area analysed, peak load reduction was additionally supported by a smaller portion of residential smart charging, moving the charging of privately used EVs (EV1) away from the 9 a.m. to 12 noon time window into night hours, as described above. This highlights the fact that from a system point of view, it is essential to use the flexibility of all EVs, 'stacking' flexibility from different EV fleets, e.g. workplace and residential.

Figure 6. Smart workplace charging



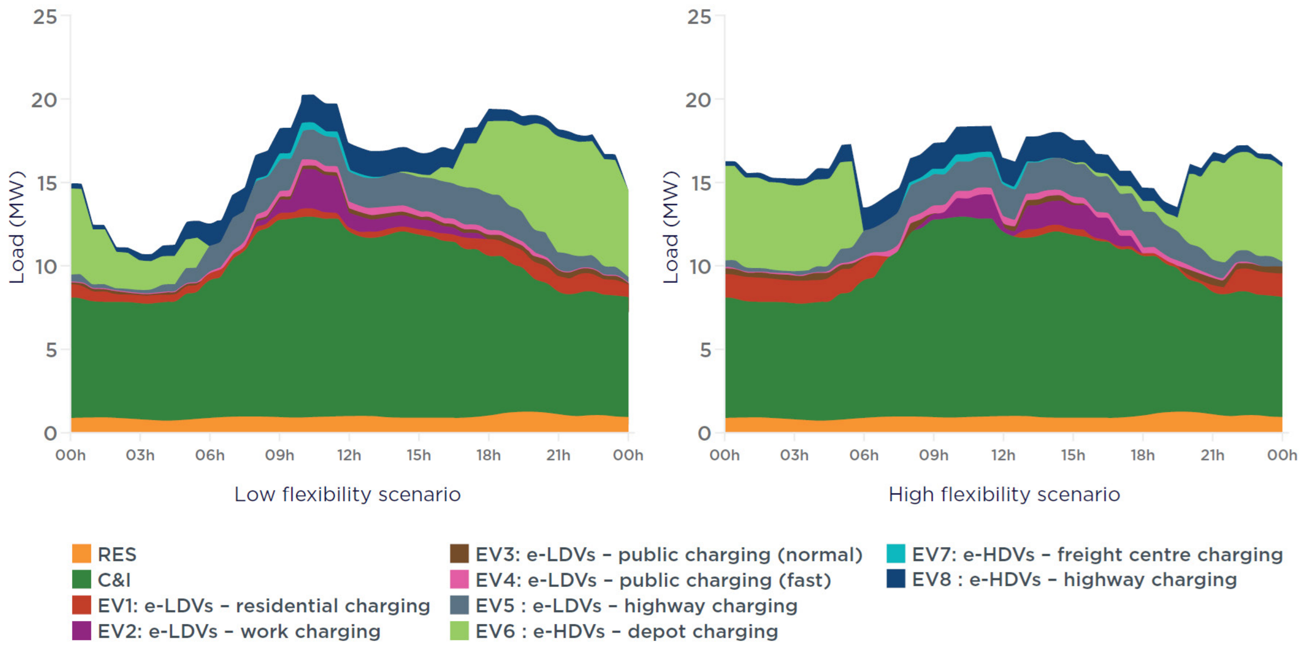
Load curves in a business zone at the peak consumption in low flex and high flex scenarios

Source: Lucas, C. Dilé, M., Quignon, L. (2025, March.) *Savings from smart charging electric cars and trucks in Europe: A case study for France in 2040 - Technical Report.*

Smart depot charging is essential to accommodate charging demand from electric trucks

Optimised depot charging for trucks, similar to residential smart charging of passenger EVs described above, is an essential condition to ensure a maximum of truck charging happens overnight, and that truck charging doesn't cause avoidable costs to the system. Figure 7 below shows a highway station area. The system peak occurring in the low flex scenario around 6 p.m. is shifted by moving depot charging of trucks (EV 6) to overnight hours with lower grid capacity; as a consequence, less charging is added to an already stressed system during the morning through to midday. The system's morning peak (9 a.m. to 12 noon), mainly caused by a higher share of truck highway charging, is also flattened, mostly thanks to the smart workplace charging of passenger EVs in the same area. This case shows that in areas where truck charging is the largest stress on the grid, it's even more important to fully use the optimisation of other fleets to avoid them adding to system peaks during the day.

Figure 7. Depot charging



Load curves in a highway station area at the peak consumption in low flex and high flex scenarios

Source: Lucas, C. Dilé, M., Quignon, L. (2025, March.) *Savings from smart charging electric cars and trucks in Europe: A case study for France in 2040 - Technical Report.*

Taken together, the three examples show that to achieve the full potential of smart EV charging, all EV user groups need incentives to contribute their flexibility to the system: consumers who are flexible need to be incentivised to move charging to grid-optimal hours within their window of flexibility, to allow others who are not flexible to use the grid without adding to peak.

Contrary to frequently voiced doubts, the load curve effects in Figures 5, 6 and 7 above show that ToU network fees do not create new peak loads. To ensure this remains the case, effective coordination of charging processes is needed between vehicles, or the actual charging power needs to be adjusted (as was done during the optimisation process) to avoid creating new peaks (e.g., by starting all charging processes at full power at the beginning of an off-peak hour).

Limitations and further research

The purpose of the study is to illustrate the potential benefits of savings from optimised charging given supportive factors, e.g. the presence of time-varying network pricing, or savings from the grid relative to the expected grid investments needed in 2040. There are several limitations linked to this approach, discussed below:

- The study is explorative and does not attempt to identify the ideal design of such tariffs, nor offer an exact calculation of grid savings. However, the finding that a relatively simple ToU network fee design can already achieve significant load shifts indicates that our assumptions have captured the potential for optimisation well.
- The extent of savings from smart EV charging will depend on conditions in 2040 that are unknown at the time of writing. The modelling does however give an estimate of savings if current projections are correct.
- Our analysis is illustrative of the beneficial effects in one specific grid. To the degree that it is representative, it is likely that smart EV charging will produce similar benefits in similar grids.
- Other costs associated with development of smart/bidirectional charging – such as the cost of chargers, land-use cost etc. – were not in the scope of the study.
- Savings from using EV flexibility can be used in a variety of ways which are beyond the scope of this analysis. Policy options include investments into grid costs, investments in improving the design of ToU network fees to lower electricity bills, and investments into smart and bidirectional charging applications.

Conclusions and policy recommendations

Our study has illustrated how smart EV charging can shave peak loads in the grid and consequently reduce grid costs.

In the Essonne grid, smart charging of a fleet of electric cars and trucks – charging at home, at work, at public charging stations, at depots and on highways – can reduce the load peaks expected for 2040 by up to 6%. This would allow savings in network reinforcement costs in Essonne of up to 25% annually.

Further, we show that bidirectional charging of EVs has additional benefits and can further reduce overall system peak by up to 9%, suggesting that further value from optimisation can be achieved through discharging when it is beneficial for the fleet and tailored to local grid constraints.

Results show that smart EV charging is a collective task, and that flexibility from all types of EVs can be harvested to contribute to a reduction in system peaks. Analysis per EV fleet shows how EV users relying on residential charging, workplace charging and depot truck charging can significantly reduce peak load in areas where the relevant type of charging is dominant. Peak load can be further reduced through a combination of optimised charging regimes from all fleets that represent demand on the local system.

A general conclusion is that in grids where peak demand drives grid build-out, all major types of EV charging that are manageable – in particular residential charging, workplace charging and depot charging of trucks – need to be optimised to help reduce peaks on the system in order to reduce system costs.

A fundamental tool to incentivise all EV user groups to charge smartly is volumetric time-of-use (ToU) network fees – which should be adjusted over time to match the actual grid utilisation, by location and time – to signal to consumers when to shift their charging, and for their flexibility to be rewarded accordingly through cost savings. Also, from a network price perspective there are no savings to be gained when the system is stressed, so ToU volumetric network fees will be high at such times. While not yet widespread across EU Member States, network pricing reforms are underway in some countries: Denmark has introduced ToU network tariffs (see above); France will introduce a seasonal ToU system with an off-peak grid price during daytime hours in summer 2025;[47] and the Netherlands[48] are discussing the introduction of time-varying network fees.

Although this study did not investigate optimal tariff design (which could be a topic for an additional analysis), its results show that peak load could already be shifted substantially with a relatively simple ToU network tariff design with an average price-spread between off-peak and peak prices, assuming flexible demand is price-responsive. This suggests that with a more granular ToU, or with dynamic pricing of network use to be more cost-reflective of network conditions and adjusted over time and also by location, more savings from smart EV charging could be achieved.[49] What's more, these are likely to be much more significant in other countries where networks are more constrained than in France.

Our recommendations for policymakers, energy regulators and planners at EU and national level are as follows:

- Smart residential charging and smart workplace charging for EVs, and depot charging for e-trucks, can make most impact on the system and should be the default mode of charging.

---

[47] Commission de Regulation de l'Energie. (2025). Annexe Communiqué de presse TURPE 7 *Focus sur l'évolution du placement des heures creuses*. https://www.cre.fr/fileadmin/Documents/Communiques_de_presse/2025/250206_Annexe_CP_TURPE_7_HPHC.pdf

[48] Bianchi, R., Meijering, A., Baks, S. & Wolda, J. (2024, October 21). *Verkenning alternatief nettariefstelsel kleinverbruik.* Netbeheer Nederland. https://www.netbeheernederland.nl/publicatie/berenschot-verkenning-alternatief-nettariefstelsel-kleinverbruik

[49] For example, in Germany's new ToU network pricing system various grid operators aggregate to blocks. This diversification will likely help avoid power price-related peaks. FfE (2024, October). *Variable Netzentgelte als Option für steuerbare Verbrauchseinrichtungen nach §14a*. https://www.ffe.de/veroeffentlichungen/variable-netzentgelte-als-option-fuer-steuerbare-verbrauchseinrichtungen-nach-%C2%A714a/

- Time-varying tariffs for energy, and in particular for networks, are the key tool to incentivise consumers to optimise charging. This is helped by a growing number of smart charging tariffs and services available for consumers in the EU.[50] Expanding the availability of time-varying network pricing is a competence of national energy regulators and can be helped by Member States' ambitious implementation of energy market reforms, as the Agency for the Cooperation of Energy Regulators (ACER) recommends.[51]
- To support the design and implementation of more cost-reflective tariffs, energy regulators could require more transparency on network use from distribution grid operators.
- Energy market regulation, e.g. following implementation of recent energy market reforms, should allow EVs to participate fully as flexibility resources in energy markets to generate value for customers through demand-response programmes, e.g. via smart tariffs and services.
- Grid and consumer-beneficial build-out of charging infrastructure requires a balance between normal and fast charging: unless supported by local battery storage, fast charging of cars and trucks offers very little flexibility for smart charging, but charging at normal speed offers plenty. From a grid point of view, it is essential to optimise the types of charging where the EV spends longer connected to the grid, to help reduce system peak and to allow faster, higher-capacity charging to use grid capacity without adding to the peak.
- Smart depot charging is key to help reduce charging costs for fleet owners, and presents an important tool to facilitate the electrification of road freight. Incentives at a national level could include subsidies for depot electrification and targeted information for fleet/depot owners.[52] On the energy market side, time-varying tariffs are key to increase benefits for fleet owners from smart depot charging.
- To allow a more cost-efficient build-out of megawatt charging where needed, time-varying tariffs are equally important to support the business case for high-capacity charging of e-trucks along highways.[53]
- Joint planning of charging infrastructure, in particular granular and systematic forecasting of charging demand from all EVs, is essential to keep grid upgrade costs in check and to ensure cost-efficient EV uptake.

In conclusion, this study has illustrated how smart EV charging can shave peak loads in the grid and consequently reduce grid costs. By ensuring EVs are integrated into power grids cost-optimally, with savings for users, the grid and the environment, smart EV charging is a key tool to accelerate the electrification of road transport and the energy transition.

---

[50] Burger, 2024.

[51] Agency for the Cooperation of Energy Regulators (ACER). (2023, January). *Report on electricity transmission and distribution tariff methodologies in Europe.* https://www.acer.europa.eu/sites/default/files/documents/Publications/ACER_electricity_network_tariff_report.pdf

[52] Hildermeier, J., Jahn, A. & Rodriguez, F. (2020, November). *Electrifying city logistics in the European Union: Optimising charging saves costs.* The International Council on Clean Transportation. https://theicct.org/wp-content/uploads/2021/06/EU-city-logistics-FS-nov2020.pdf

[53] Hildermeier, J. & Jahn, A. (2024, February 1). *The power of moving loads: Cost analysis of megawatt charging in Europe*. Regulatory Assistance Project. https://www.raponline.org/knowledge-center/power-moving-loads-cost-analysis-megawatt-charging-europe/

Annex

Mapping of different heavy-duty vehicle classes used in HDV CHARGE

For the HDV sector, fleet projections using the ICCT's Roadmap model are conducted at the VECTO group level, which is the official classification considered by the European Comission. For charging needs estimates with ICCT's HDV CHARGE model, several VECTO[54] groups are aggregated into broader vehicle segments. Table 4 outlines this mapping.

Table 4. Mapping from HDV CHARGE to Vecto groups

Heavy-duty vehicles CHARGE segments	Vehicle Energy Consumption Calculation Tool (VECTO) groups
Buses	31, 33, 35, 37, 39
Coaches	32, 34, 36, 38, 40
Truck	0, 1s, 1, 2, 3, 4-UD, 4-RD, 6, 7, 9-RD, 51, 52, 53, 54, 55, 56
Tractor (regional only)	5-RD,5v, 8, 10-RD, 10v, 12, 12v, 14, 18
Special	4v, 9v, 11, 11v, 13, 15, 16, 17, 19, bus other, truck other
Long-haul	4-LH, 5-LH, 9-LH, 10-LH

Mapping EV1–EV8 fleets to vehicle segment and charger setting combination in the charging models

Table 5 illustrates the mapping of modeled charging energy needs across various charger settings for different fleets and how these are attributed to the eight distinct fleets (EV1–EV8) introduced in the section 'EV fleet projected for 2040.' For light-duty vehicles (LDVs), charging is modeled separately for passenger cars (PCs) and light commercial vehicles (LCVs). For heavy-duty vehicles (HDVs), charging is modeled for the vehicle segments listed in Table 5.

---

[54] European Commission. (n.d.) Vehicle energy consumption calculation tool – VECTO. https://climate.ec.europa.eu/eu-action/transport/road-transport-reducing-co2-emissions-vehicles/vehicle-energy-consumption-calculation-tool-vecto_en

Table 5. Mapping of modeled charging energy needs to fleets (EV1–EV8) across charger settings

Fleet	Vehicle segment	Charger setting	Data source / Model
EV1	Light-duty vehicles - passenger cars + light commercial vehicles (vans)	Home	*EV CHARGE*
EV2	LDV - PC + LCV	Work	*EV CHARGE*
EV3	LDV - PC + LCV	Public overnight AC	*EV CHARGE*
EV3	LDV - PC + LCV	Public destination AC	*EV CHARGE*
EV4	LDV - PC + LCV	Public overnight DC	*EV CHARGE*
EV5	LDV - PC + LCV	5% of traffic energy needs	Traffic data
EV6	LDV - LCV	Depot	*EV CHARGE*
EV6	Heavy-duty vehicles - Buses	All charging	HDV CHARGE
EV6	HDV - Special	All charging	HDV CHARGE
EV6	HDV - Coaches	Overnight	HDV CHARGE
EV6	HDV - Truck	Overnight	HDV CHARGE
EV6	HDV - Tractor	Overnight	HDV CHARGE
EV7	HDV - Truck	Fast and ultrafast	HDV CHARGE
EV7	HDV - Tractor	Fast and ultrafast	HDV CHARGE
EV8	HDV - Long-haul	All traffic energy needs	Traffic data

Projected eLDV and eHDV fleets

This section provides an overview of the projected EV stock in Essonne, France, modeled with the ICCT's Roadmap model, separated into LDVs (Table 6) and HDVs (Table 7). Each table provides a breakdown of the EV stock across different segments within LDVs and HDVs.

Table 6. Projected eLDV stock in Essonne, France, segmented by vehicle type and year

eLDV segments	2025	2030	2035	2040
Light commercial vehicles	7,358	29,677	61,960	92,883
Passenger cars	47,621	153,099	315,145	489,627
Total	**54,979**	**182,776**	**377,106**	**582,510**

Table 7. Projected eHDV stock in Essonne, France, segmented by vehicle type and year

eHDV segments	2025	2030	2035	2040
Buses	134	504	1,014	1,481
Coaches	23	84	213	424
Long-haul	62	642	1,707	3,266
Special	17	134	348	657
Tractor	1	8	17	27
Truck	138	776	1,659	2,501
Total	**374**	**2,148**	**4,959**	**8,355**

International Council on Clean Transportation

Fasanenstr. 85
10623 Berlin

+49 30233268-411
communications@theicct.org
www.theicct.org

Regulatory Assistance Project (RAP)®
Belgium · China · Germany · India · United States

Rue de la Science 23
B – 1040 Brussels
Belgium

+32 2 789 3012
info@raponline.org
raponline.org