Future principle layout and organisation of motorway service areas in Luxembourg

Final report

PREPARED FOR
Grand-Duchy of Luxembourg,
Ministry of the Economy

DATE
11th April 2025

REFERENCE
0753408

DOCUMENT DETAILS

DOCUMENT TITLE	Future principle layout and organisation of motorway service areas in Luxembourg
DOCUMENT SUBTITLE	Final report
PROJECT NUMBER	0753408
DATE	11th April 2025
VERSION	04
AUTHORS	Richard RILEY, Paul LORANG, Timothy HOWGEGO, Will DRAKE, Gaspard DEBAINS, Annie HARGROVE, Thomas BOSTSARRON
CLIENT NAME	Grand-Duchy of Luxembourg, Ministry of the Economy

DOCUMENT HISTORY

				ERM APPROVAL TO ISSUE		
VERSION	REVISION	AUTHORS	REVIEWED BY	NAME	DATE	COMMENTS
V1.0	01	Paul LORANG, Timothy HOWGEGO, Will DRAKE, Gaspard DEBAINS, Annie HARGROVE, Thomas BOSTSARRON	Celine CLUZEL, Richard RILEY	Celine CLUZEL	23rd December 2024	
V2.0	02	Paul LORANG, Timothy HOWGEGO, Will DRAKE, Gaspard DEBAINS, Annie HARGROVE, Thomas BOSTSARRON	Celine CLUZEL, Oliver ROBINSON	Celine CLUZEL	5th February 2025	Addressing comments received on V01 Addition of Executive Summary
V3.0	03	Paul LORANG, Timothy HOWGEGO, Will DRAKE, Gaspard DEBAINS, Annie HARGROVE, Thomas BOSTSARRON	Celine CLUZEL	Celine CLUZEL	24th February 2025	Addressing comments received on V02
V4.0	04	Paul LORANG, Timothy HOWGEGO, Will DRAKE, Gaspard DEBAINS, Annie HARGROVE, Thomas BOSTSARRON	Celine CLUZEL	Celine CLUZEL	11th April 2025	Addressing comments received on V03

CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

Acronym	Description
AFIR	Alternative Fuels Infrastructure Regulation
ART	Transport Regulation Authority
ATEX	ATmosphère EXplosive
BE	Belgium
BEV	Battery Electric Vehicle
CPO	Charging Point Operator
DE	Germany
DSO	Distribution System Operator

Acronym	Description
EV	Electric Vehicle
EVCP	Electric Vehicle Charge Point
FCEV	Fuel-cell electric vehicle
FR	France
HDV	Heavy Duty Vehicle (lorry, truck, or coach)
HGV	Heavy Goods Vehicle
HPC	High-power charging
IEA	International Energy Agency
IFRS	International Financial Reporting Standards IFRS
LDV	Light Duty Vehicle (car or van)
LU	Luxembourg
MCS	Megawatt Charging System
MSA	Motorway Service Area
RED	Renewable Energy Directive
SAF	Sustainable Aviation Fuels
SCA	*Sociétés Concessionaires d'Autoroute*
STEPS	Stated Policies Scenario
TEN-T	Trans-European Transport Network

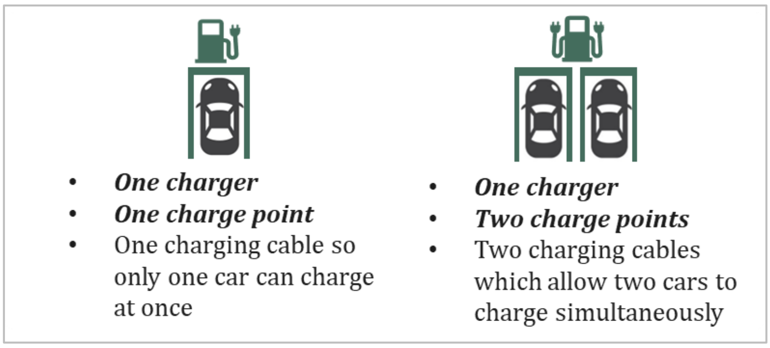
DEFINITIONS OF TERMS:

LDV, HGV and HDV:

- A light-duty vehicle (LDV) is defined as a car or van.
- A heavy-good vehicle (HGV) is legally defined in the EU as a vehicle with a total weight of 3.5 t or more for the carriage of goods.
- In this report, a heavy-duty vehicle (HDV) is defined as an HGV (e.g., articulated, rigid) or a coach.

Charger and charge point:

- A charger is the device/hardware box that a charging cable is attached to.
- The number of **charge points** at a site is the number of vehicles that can charge at one time.
- Some **chargers** have more than one charging cable, in some cases this allows more than one vehicle to charge simultaneously meaning there would be more than one charge point per charger, as presented below:



- It should be noted that in some cases, a charger may have multiple cables, but they cannot be used simultaneously (e.g. many 50kW chargers have 3 cables which offer different plug types but only one vehicle can charge representing one charge point).
- In some cases, the main electrical hardware will be located in power cabinets located near the parking bays, which are then supplying several charge points at a given site.
- **The numbers in this report refer to the number of charge points, and the power of the individual charge points, unless specified otherwise.**

Pump:

- A fuel pump is the cabinet housing a number of nozzles.

ACKNOWLEDGMENTS

The authors would like to thank the many stakeholders who shared their insights and data, including the Gouvernement du Grand-Duché du Luxembourg and the Ministère de l'Economie du Luxembourg, motorway service area operators, charging point operators and experts from public authorities in other European countries.

EXECUTIVE SUMMARY

CONTEXT

The Grand Duchy of Luxembourg owns the land of the country's eight Motorway Service Areas (MSAs) located along its motorway network. These MSAs are run by private companies under concession contracts. The fees from these concessions represent an important source of revenue for the Luxembourg Government. Most of the revenue from these sites currently comes from fossil fuel sales. Therefore, the upcoming transition to zero-emission vehicles will have a range of impacts on MSAs in the future and it is critical that a plan is put in place early to manage the transition. The objective of this study is to outline the building blocks for that plan by developing a concept for the MSAs of the future in Luxembourg, and to answer the following questions:

- How will demand for fossil fuels – and their low/zero-emission replacements – evolve over time at the MSAs?
- How can the MSAs evolve over time in order to adapt their offer to changing demand and to replace reducing fossil fuel revenues with new revenue sources such as electric vehicle (EV) charging?
- What are the practical considerations and actions that the Luxembourg Government may wish to consider (for example, around structuring of MSA concessions) to enable this transition of the MSAs?

KEY FINDINGS ON FOSSIL FUEL DEMAND

- **Demand for fossil fuels, in particular diesel, has recently rapidly declined and is not expected to return to 2018 levels.** Between 2018 and 2023, demand for fossil fuels at Luxembourg's MSAs dropped by ca. 50%. This is primarily driven by a reduction in demand from heavy duty vehicles (HDVs, i.e. trucks and coaches): the reasons for this are likely diverse, potentially including changes to excise duties and VAT (see section 3.1). Demand for petrol and diesel is expected to continue to reduce commensurately with the rollout of electric HDVs and light duty vehicles (LDVs, cars and vans) (see sections 3.3 and 3.4).
- **Fossil fuel replacements such as HVO and e-fuels are not predicted to replace significant quantities of conventional petrol and diesel**: the total availability of HVO makes up only 2.3% of final energy demand for transport in the EU and e-fuels are prohibitively expensive and low in supply (see section 3.2.1).
- **Hydrogen vehicles are unlikely to make up a large portion of either the LDV or HDV fleets** and are significantly more expensive on a total cost of ownership basis than an electric equivalents, including for long-haul transport (see section 3.2.2). As a result, **electric vehicles and their associated charging demand are taken to be the priority of MSAs in the future.**

KEY FINDINGS MSA EVOLUTION OVER TIME

- **Large scale EV charging deployment for both cars / vans (LDVs) and HDVs should be considered for all 8 MSAs.** For example, at Berchem Luxembourg site, by the time the next concession is released (ca. 2029), in addition to the existing Chargy installation, demand modelling indicates a clear need for further charging points.

Almost every parking space, as well as the fuel pump infrastructure, would require conversion to charging space (ultra-rapid, 150/300kW) before 2050 in order to meet projected charging demand for LDVs and HDVs (subject to technical feasibility and safety assessments). For HDVs, chargers are limited to the "drive-through" type due to manoeuvrability considerations, whereas both "bay" and "lane" chargers are considered for LDVs (see section 5.2). Meeting peak demand will likely be achievable for the MSAs (see section 3.4.2).

- **Limited site size for the MSAs means that parking is likely to become constrained as charging infrastructure is rolled out.** Due to loss of space from the installation of charging infrastructure (20% for LDVs, and 33% for HDVs), as well as the limited area of the sites, parking and charging space is likely to become highly constrained in the 2040s (see section 4). Alternatives such as charging hubs along the TEN-T road network but not on MSAs, or safe and secure HDV parking especially for overnight charging, may supplement the charging offer on MSAs.
- **Significant grid infrastructure enhancement may be considered at MSA sites to accommodate the growing electrical power demands**. Taking Berchem Luxembourg as an example, while the existing 16 MW existing grid capacity will suffice until ca. 2031, substantial upgrades will be necessary thereafter. This is evidenced by projections indicating that the site's power requirements will reach ca. 75 MW by 2050, nearly five times the current capacity (see section 5.1).
- **Luxembourg has frequent, high-power charging available on and near (within 3km) its stretch of TEN-T**, at a rate of approximately double its closest competitor's (Germany's) charge point provision. Within Luxembourg, there is considerable competition from non-MSA sites for high-power charging for LDVs. The rollout of AFIR is unlikely to cause a significant change in the area's competition (see section 3.5).
- The provision of facilities (including restaurant, shops, toilets) is expected to remain similar through time, as they are currently assumed to serve the site well. A brief scenario analysis demonstrates that **increasing the fee on shop and restaurant revenue can help to maintain total revenue for the MSA** as fossil fuel sales decrease and charging revenues increase (see section 6.6).

KEY PRACTICAL AREAS AND ACTIONS TO BE CONSIDERED

- **Number of concessions per site**. Currently, there is typically only one concession per site for the fuel pumps and the shop and restaurant. In addition, there is one common concession for LDV HPCs ("SuperChargy") on 7 of the 8 MSA sites. However, the number of HPC is limited to 6 charge points on 5 sites and to 12 charge points on 2 sites. The concessionee runs the whole site, including the fossil fuel pumps. Having one concessionee per site brings administrative efficiencies and economies of scale but excludes many of the leading charge point operators (CPOs) from running the site under a future concession. This is because these players are pure-play CPOs and do not operate fossil fuel infrastructure. Excluding these players greatly reduces competition for the tenders. Therefore, it is suggested that the option of a multi-concession model (with separate concessions for charge points and petrol pumps) is considered alongside the single-concession model as an option for future concessions.

- **Concession duration.** Shorter concessions give greater flexibility to the government, whilst longer concessions can present a more attractive business case to operators, particularly when making large upfront investments in EV charge points.
- **Linking concessions to charger deployment rather than land.** The challenge with concessions linked to land is that while they can give a good business case for EV charger deployment at the start of the concession, they may not give a good business case for EV charger deployment later in the concession as demand ramps up. For example, if more chargers were needed to respond to demand in year 10 of a 15-year concession, the concessionee would only have 5 years left in the concession, which may not be long enough to achieve a good return on investment in new charge points. There are three possible approaches here. Firstly, an even longer concession (e.g., 30 years), and secondly, introducing a framework agreement such that concessions apply to individual banks of chargers rather than a whole area of the site. In this way, each time a new bank of chargers is installed, a new concession of defined length is triggered specifically for that bank of chargers. This enables the CPO to respond in an agile manner to increasing demand, but also avoids locking in a single CPO on the site for more than the length of the concessions. Finally, the option to reimburse the net book value of the chargers to the concessionee at the end of the concession may be explored (this is the current approach).
- **Financing and ownership of the site grid connection**. A much larger grid connection on the sites will be needed compared to the current grid connections. The new, larger grid connection will last longer than the individual concessions and may serve multiple players on the same site. For these reasons, and while the CPOs on the site could finance the grid connection, other options could be considered as well, including the Luxembourg Government or the distribution system operator financing the grid connection and recouping the investment through a fee per kWh of electricity sold charged to the CPOs.
- **Additional qualitative award criteria could be considered in order to enhance the concessionaire's offer for the MSA**. This might include product offer in the shops (for ex. local products), quality of the architecture of the shop building, global design of the MSA (in the case of a single concession), the installation of solar panels, other low-carbon initiatives, etc.. This may also include the customer offer of the CPO. The inclusion of these type of criteria can help ensure the service/offer at the MSA is of a high quality and will ensure customers return to the site. Also, other attractiveness criteria could also be considered like playgrounds for children or others.
- **The fee structure of the concession contracts may require updating to include EV charging**. As fossil fuel fee revenues reduce, a concession fee on electricity used for charging at the MSA could make up part of the difference. Total concession fee revenues are then very likely to decrease because the new revenues from the electricity fee cannot compensate the decrease in revenues from the fossil fuel fee (not considering any other excise duty or taxes). Higher fees on shop and restaurant revenues, on fuel volumes and higher monthly fees could also make up part of the difference, but this would need to be considered carefully in order to ensure that provision of facilities is still high quality and that the opportunity from this revenue stream is not excessively degraded.
- **Fuel pump replacement with EV chargers is probably required to meet the modelled charging demand and could be carried out in a single project per MSA or gradually.** Given the space limitations on MSA sites, the fuel pump infrastructure

should start being converted to charge points before 2050 in order to meet the projected charging demand (see section 3 and section 6.10). This is complex given the colocation of charging infrastructure with fuel tanks. As a result, completing the transition of the current fuel area to charging infrastructure in one project could be the quicker and less expensive option, but a staged approach could also be explored: cost and operational considerations should be considered in order to choose the best approach. The business case for fuel infrastructure is predicted to be poor by the time chargers are required in this area.

- **Safety assessments would be required for all sites to choose the final charging infrastructure layout.** There is no consolidated guidance on minimum safety distances between EV charging infrastructure and refuelling stations across Europe and domestically in Luxembourg (see section 4.1). The distances depend on the specific fuel in question. This is relevant to substations, cabling, and charge points themselves. A full technical safety assessment would be required to confirm appropriate charger and substation layout options.
- **Additional data collection could improve infrastructure planning capabilities as well as revenues from site amenities.** Current data collection and sharing practices mean that relatively little is known about the rate of passing traffic which stops at MSAs, their driving cycles (i.e., are they long or short distance drivers), and customer behaviour at MSAs (i.e., stop times, shopping habits). This impedes the planning process, and as such the government might consider adding data collection aspects to the concession contracts. Alternatively, if a multiple concession approach is chosen, a central government organisation such as the Administration des Ponts et Chaussées could take on the task of data collection. This can help improve demand forecasting and thus maximise the utilisation of infrastructure and revenues from facilities.
- **A combination of signage and monitoring solutions may be required at MSAs to aid the flow of traffic as parking provision reduces.** The advent of EV charging infrastructure means that parking space is likely to be limited at MSAs in Luxembourg by the 2040s. This is due to the additional space required for charging infrastructure. The issue of space loss is compounded by the likely increase in customer stop times (for cars and vans, but not HDVs[1]) as a result of the switch from fast refuelling to longer charging times. In order to ensure traffic flow through the site, monitoring solutions to enforce maximum stay times, overstay fees at charge points, and clear signage to direct customers to the correct parking type could be employed by the Luxembourg government or the concessionaire.

KEY AREAS OF UNCERTAINTY

The demand modelling in this report is inherently uncertain. This is due to a number of reasons, such as the availability of high-quality data, the accuracy of EV charging behaviour projections, and uncertainty in technology progress. As a result, MSAs and concessions must be able to accommodate uncertainty by instantiating flexibility in contracts (i.e. by not defining a certain number of charge points that must be installed, and not defining exact years for their

[1] HDV drivers are likely to charge their vehicles on their mandated break, and therefore their stop times are unlikely to change as a result of the switch to charging.

installation). The fuel and electricity demand projections should be updated ahead of the next MSA tender (the next new concession contract will start in 2029).

NEXT STEPS

- **Planning grid upgrades at each MSA**: current grid capacity available at the MSAs is insufficient, and careful advance planning is needed to prevent this from curtailing EV charger deployment. The long lead times associated with grid reinforcements make this a high-priority action.
- **Consult with stakeholders ahead of the call of tender for the next MSA concessions.** Given the potential complexity of the future concession arrangements and relatively new nature of the EV charging aspects, it will be valuable to consult stakeholders. This will be an opportunity to refine the contract and tender features while also making the market aware of the upcoming call for tenders. Stakeholders here should include existing concessionaires, pure-play CPOs who may operate on the sites in future, related industry bodies, and parties relevant to the development of safety guidance.
- **Choosing and defining the concession contract features**
- **Additional next steps** for the Luxembourgish government to take may include:
  - Consider parking provision holistically, and perhaps look at fast-tracking building of new vehicle parks along Luxembourg’s main roads, due to the space constraints on MSAs
  - Reevaluate future recharging and refuelling demand (electricity, hydrogen and fossil fuels) before the next concession so any changes in the market is taken into consideration in the new concession contract features
  - Identifying European funded projects that may impact the charging landscape in Luxembourg

1. INTRODUCTION

1.1 CONTEXT

The Grand Duchy of Luxembourg owns the land of the country’s eight Motorway Service Areas (MSAs) located along its motorway network. Each of these sites are leased to a concession holder, generally a major Oil and Gas company through a concession agreement, which mandates the provision of refuelling services, amenities, and maintenance by the concession holder.

Luxembourg is located on key road freight routes and passenger routes for international travel and commuting between neighbouring countries, and historically, Luxembourg has also had relatively lower prices of petrol and diesel compared to neighbouring countries: these strategic advantages have made Luxembourg's MSAs among the busiest and largest in Europe. It makes this associated network a strategic piece of infrastructure in Luxembourg which requires careful planning to ensure future success.

Figure 1-1 displays the MSAs’ locations and their associated concession holders as of November 2024, and highlights which roads are on the Trans-European Transport Network (TEN-T), including the core and comprehensive networks (TENTEC on the map).

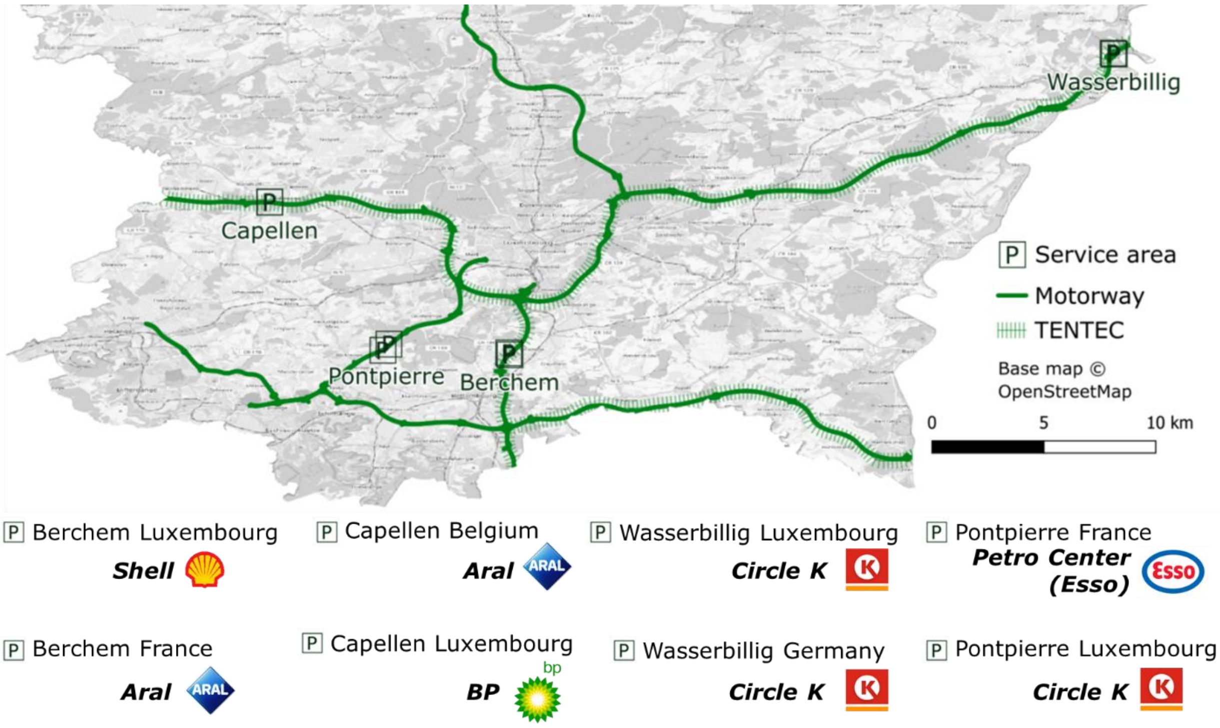


FIGURE 1-1 – LOCATION AND CONCESSION HOLDERS OF MSAS IN LUXEMBOURG[2]

These sites are managed by five different MSA operators (as of end 2024). While Luxembourg’s eight MSAs serve significant demand, are in the heart of Europe and along major freight routes, fuel sales have significantly decreased over the past five years. This highlights the potential for rapid changes in demand and the need to plan for the impact of the transition to zero-emission vehicles on the sites.

[2] Aral is owned by BP. Capellen Belgium and Berchem France are operated under the Aral brand, while Capellen Luxembourg is operated under the BP brand.

1.2 OBJECTIVES

The upcoming transition to zero-emission vehicles will have a wide range of impacts on MSAs including changes in:

- The economics and profits from the sale of fuel
- Patterns of when and where people need to refuel publicly (given the 'refuelling' can be done in many other locations in the case of electric vehicles, including in private settings)
- Land area required to support a set number of vehicles
- Time spent refuelling at the MSAs and therefore what amenities people want to see onsite

With all these complex and interlinking changes impacting MSAs in the future, it is critical that a plan is put in place early to manage the transition. The objective of this study is to outline the building blocks for that plan by developing a concept for the MSAs of the future in Luxembourg. The concept is based on an understanding of the key changes that will occur and what they could mean for MSAs.

1.3 SCOPE AND APPROACH

The study considers the transition of HDVs, cars, and vans to zero tailpipe emission vehicles, namely battery-electric vehicles and hydrogen vehicles. Coach is considered only as a marginal user of future HDV infrastructure, because coach represents a far smaller market segment. CNG (compressed natural gas) and LNG (liquefied natural gas) powertrains are not part of the scope. The timeframe considered in the study is from 2025 to 2050. The approach taken to develop a concept for the MSA of the future in Luxembourg is presented in the different work packages (WP) below:

FIGURE 1-2 – OVERVIEW OF THE APPROACH TAKEN FOR THIS PROJECT

More specifically:

- **WP1 identified key trends in MSA planning, management and business models**. This was done through a literature review and stakeholder engagement. 8 MSA operators, charge point operators (CPO) and public bodies in charge of MSA concessions were consulted (5 with phone interviews, 3 through email exchange only).
- **WP2 quantified the future energy demand at Luxembourg MSAs per fuel (fossil fuel, electricity).** This was based on detailed modelling of uptake of electric vehicles, assumption on charging behaviour, vehicle mileage/energy consumption and a scaling of regional demand down to each MSA. A second modelling approach was also deployed (starting from current fuel demand at each MSA), to sense-check the results.

- **WP3 gathered the findings of WP1 & WP2 to develop a concept for MSAs of the future**: refuelling and recharging infrastructure requirements, practical steps to support this transition, possible approaches for the future concession model.
- **WP4 developed a case study of the transition required** at the two Berchem MSAs.

Unless specified, all the conclusions of this report have been drawn and evaluated on a technical basis, and not on an economic basis. They are based on the future energy demand from the vehicles on the Luxembourg motorways and on technical constraints at the MSAs, and the report does not include any detailed cash flow modelling or similar analysis.

1.4 STRUCTURE OF THE REPORT

The rest of the report is structured as follows:

- **Chapter 2 examines key trends in MSAs in neighbouring countries**, focusing on the different MSA concession systems and their different strategies to adapt to the transition to zero-emission vehicles.
- **Chapter 3 focuses on the quantification of the future energy needs of vehicles at the Luxembourg MSAs**. The current energy demand at MSAs is analysed, and then the future petrol, diesel and electricity demand for HDVs, and for cars & vans are presented, along with the theoretical provision of pumps and charging infrastructure needed to meet this demand. Other alternative fuels, such as hydrogen, are discussed. A comparison with the requirements of the Alternative Fuels Infrastructure Regulation (AFIR) is also provided.
- **Chapter 4 brings together the findings of the previous chapter to** explain how the MSAs will need to transition to meet the future energy demand of vehicles, in terms of alternative fuels infrastructure (chargers, grid connection, etc.) and how space can be a constraint.
- **Chapter 5 is the detailed analysis of the two Berchem MSAs**, considering their current design and space constraints.
- **Chapter 6 explores what actions are needed** to enable this transition to the MSA of the future (considering both changes to the concessions needed and the short-term actions needed to prepare for the new concessions). **An Appendix provides further details** on current fossil fuel price differences between Luxembourg and neighbouring countries, on comparisons between MSAs in Luxembourg and MSAs in neighbouring countries, on battery-electric HDV and car / van uptake calculation method, on current revenues from shops and restaurants, on other site layouts for the Berchem MSAs, and a summary of the forecasted transition of each Luxembourg MSA.

2. COMPARISON WITH MSA IN LUXEMBOURG'S NEIGHBOURING COUNTRIES

To better understand how MSA infrastructure needs to evolve in the coming years to support the decarbonisation transition, a comparative analysis has been conducted between Luxembourg and its neighbouring European countries. This study has examined the key differences in infrastructure management approaches and explored how different nations are incorporating decarbonisation into their strategic planning.

In Luxembourg, the government is responsible for issuing the tenders and awarding the MSA concessions. During past tenders, the winning bidders, after an initial verification of their technical and administrative ability to operate such sites, have been selected based on financial criteria, and the concession terms typically range from 4 to 10 years in duration. The scope of the concession contract varies depending on the specific service area, but generally encompasses the fuel stations as well as any shops and restaurants. However, the selected concessionaire is afforded the flexibility to sub-concession some of these activities to other operators.

While some similarities may exist, the management of MSAs demonstrates notable differences between Luxembourg and the various European countries presented. Table 2-1 presents MSA concession systems across different European countries. It shows differences in areas such as the awarding authorities, the scope of the concessions, the contract durations, and the flexibility in deploying alternative fuel infrastructure, among other factors. The following sections will explore these country-specific nuances in greater detail.

TABLE 2-1 – MAIN CHARACTERISTICS OF MSA CONCESSION CONTRACTS IN SELECTED EUROPEAN COUNTRIES

Countries / Information type		Luxembourg	France	Germany	Belgium	Switzer-land	Nether-lands
Part of highway concession contract?		No	Yes	No			
Contract	Award	Competitive bidding					
	Awarding authority	Grand Duchy of Luxembourg	Highways concession holders	Autobahn (Public body)	Regional authorities	Cantons & Federal State	Rijkswaterstaat (Public body)
	Duration	4 – 10 years	20 to 30 years	At least 20 years	20 – 25 years	Up to 30 years	15 years
Motorway Service Areas scope		Managed **as a whole** (restaurants, refuelling, shops)	Managed **as a whole** (restaurants, refuelling, shops), **or sub-concession contracts**	Managed **as a whole** (restaurants, refuelling, shops) *Tank & Rast manages 90% of MSAs*	**Flandres:** Split contracts **Wallonia:** One operator	Often managed **as a whole** (restaurants, refuelling, shops)	Managed **as a whole** (restaurants, refuelling, shops), **or sub-concessio**

						n contracts
Additional alternative fuel infrastructu-re	**Not included** in concession contracts **as of 2024**[3]	Either included in current contract; or new concession awarded by the authority it must be **validated with public sector** in either case	**Part of initial** concession scope	**New concession** awarded by the public authority	**New concession** awarded by the public authority	

2.1 MSA CONCESSION SYSTEMS AND DECARBONISATION TRANSITION

2.1.1 FRANCE

MSA concession system

MSAs in France are managed within the framework of the broader motorway concession system. This system involves the French State (the grantor) entrusting private companies (the concessionaires) with the construction and operation of motorways through long-term contracts. The Motorway Concession Companies (*Sociétés Concessionaires d'Autoroutes*, or *SCAs*), of which there were 19 as of 2020, are responsible for the comprehensive management of the motorway network, including its design, construction, development, maintenance, and operation.

Regarding MSAs specifically, the SCAs are required to delegate their operation to third-party businesses. A competitive call for tenders is therefore conducted by the SCA, under the supervision of the Transport Regulation Authority (ART), that acts as a regulatory overseer. Similarly to Luxembourg, call for tenders' criteria involve financial aspects, but also sustainability and design aspects regarding how the MSAs will be handled.

In France, the MSA tender process specifically requires the operators to be fuel companies. The winning concessionaire is typically mandated to manage both the fuel operations, and any shops/restaurant activities associated with the MSA, though they are granted the flexibility to sub-contract some of these activities to other parties. The concession contract's duration depends on the initial investment size of the operator, but it usually runs between 20 and 30 years.

Decarbonisation transition

In France, the deployment of alternative fuel infrastructure within MSAs can be carried out in one of two ways. Firstly, the existing MSA operator may incorporate such infrastructure into their current concession contract, upon validation from the SCA. Alternatively, a new tendering process may be initiated for a separate portion of the concession area not awarded to the initial

[3] Electric vehicle charging points development was only possible through a conglomerate of network operators named **Chargy.** However, the November 2024 tender for the Berchem site concession **mandates bidders to finance photovoltaic installations across all viable roof and canopy surfaces within the service area.**

MSA operator. This is because MSA sites do not always encompass the entire parking and roadway areas, allowing for the presence of different charging point operators in some locations.

The French government plays a central role in driving the rollout of this alternative fuel infrastructure. A €100 million support from the government's Recovery Plan[4] has facilitated the furnishing of service areas along major road networks in 2021-2023. The objective consisted of the deployment of electric charging infrastructure across all 440 MSAs within the French network. The initiative mandated the installation of a minimum of four charging points per facility, with 50% of these units required to deliver a minimum power output of 150 kW. As of October 2023, 99% of the MSAs on the motorway network under concession (366 MSAs) had charge points of 150 kW or more[5].

In addition to the deployment of charging hubs on MSAs, a few multifuel sites are being developed in France, including the example below – note it is not located on an MSA but presents some similarities.

Zero – emission site case study: Multifuel station of Les Sables-d'Olonne[6]

Description:

Near the city of Les Sables-d'Olonne, a multifuel site started operation in 2023, and offers a single location providing three locally sourced, alternative energy options for road transport:

- Renewable hydrogen produced by an electrolyser supplied by wind turbines, in Bouin.
- Biomethane (BioCNG) produced at digesters of farms across the department.
- Renewable electricity generated by ground-mounted solar plants (on former waste landfill sites), rooftop solar, and parking lot canopies.

Location	Station d'énergies vertes, 85340 Les Sables-d'Olonne (46.5169, -1.7534), on the highly frequented departmental road 160, supplied by adjacent hydrogen and biogas production facilities
Fuel type	• Renewable hydrogen (one hydrogen refuelling station with 350 and 700 bar dispensers) • Electric vehicle charging (2 x 150 kW chargers) • Bio – GNV (2 refuelling dispensers)
Operators	SYDEV (public sector) – Land owned by the city, one of the project partners

[4] Aide de l'État pour l'installation de bornes de recharges pour véhicules électriques
[5] Gouvernement, Déploiement des bornes de recharge, October 2023
[6] Inauguration de la station multi-énergies vertes et locales aux Sables d'Olonne | SyDEV

Vehicle type	Light-duty vehicles (for electric charging) and heavy-duty vehicles (2 hydrogen buses and 2 Bio-GNV refuse trucks were bought by the Les Sables-d'Olonne city to come refuel onsite)
Amenities	Alternative refuelling, charging points

2.1.2 GERMANY

MSA concession system

Historically, Germany's federal structure meant that each of the 16 Länder (states) was responsible for operating and maintaining their respective sections of national highways and the associated MSAs. However, a major restructuring began in 2018, culminating in the creation of Die Autobahn des Bundes, commonly known as Autobahn. This public organization, fully owned by the federal state, now plays a central role in motorway management across the country.

In contrast to France, MSAs are not part of a highway concession contract, instead being subject to dedicated operating contracts, while the highways operation and management are handled by the public authority. The contract awarding process for MSAs follows a competitive bidding system. The authority responsible for awarding these contracts is Autobahn, aligning with its overall role in motorway management. Notably, despite the competitive bidding process, the MSA landscape in Germany is dominated by a single private company. Tank und Rast operates about 90 percent of the MSAs, following a privatization process that took place around 20 years ago. The long-term nature of MSA concession contracts, which typically run for at least 20 years, explains why a single operator manages most of these facilities.

Similarly to France, the winning concessionaire is typically mandated to manage both the fuel operations, and any shops/restaurant activities associated with the MSA.

Decarbonisation transition

Germany has set ambitious goals for the development of alternative fuel infrastructure, and more specifically on electric vehicle (EV) charging infrastructure, which significantly impacts MSA operations. The government aims to have one million public charging stations by 2030, with specific targets for MSAs. By the end of 2024, at least 50% of all service areas should be equipped with high power charging stations dedicated to heavy-duty vehicles (HDVs), increasing to 75% by the end of 2026[7].

In Germany, Tank & Rast operates the vast majority of MSAs. The government has recently authorized this operator to develop electric charging infrastructure on these sites without conducting a formal tendering process. This move has raised concerns within the charging point operator (CPO) industry, with companies such as Tesla and the Dutch firm Fastned taking legal action against Autobahn Tank & Rast in 2023[8], as they were granted this exclusive right without a competitive bidding procedure.

The process for issuing MSA concession contracts in Germany has therefore recently evolved. This evolution aims to help the country fulfil its ambitious goals for infrastructure development, while simultaneously ensuring a fair, competitive selection process that allows CPOs to

[7] Germany Builds Nationwide Fast-Charging Network for EVs | EV Magazine
[8] Tesla's Fight Against Charging Station Monopoly in Germany Moves to European Court

participate equitably. As a result, the government started the *Deutschlandnetz*[9] initiative. Under this process, the Federal Ministry of Digital and Transport (BMDV) and Autobahn have awarded 900 regional locations and 200 motorway locations for the construction and operation of high-power charging infrastructure (dedicated to both light-duty vehicles (LDVs) and HDVs) in tenders to 10 different CPOs.

When awarding the contracts, the selection decisions were not based solely on the most favourable financial offer. The evaluation of the bids also considered other key criteria, such as:

- The operators' ability to expedite site construction, leveraging existing suitable spaces
- The user-friendliness of the bidders' proposed site designs
- The overall credibility and quality of the bidders' plans for the new service area location

As an example, Milence (a joint venture founded by Daimler Truck, Traton Group and Volvo Group) secured two locations to accelerate its network expansion in Germany. The company is developing two new charging hubs along key TEN-T corridors, scheduled to become operational by the end of 2024[10].

2.1.3 BELGIUM

MSA concession system

In Belgium, the management and operation of motorways falls under public control, specifically handled by three regional road agencies. This reflects the country's decentralized governance structure, allowing each region to tailor its approach to local needs and priorities.

In Wallonia, MSAs are jointly managed by two key entities:

1. SPW Mobility Infrastructure (*Service Public de Wallonie Mobilité et Infrastructures*): This is the regional road agency responsible for overall mobility and infrastructure in Wallonia.
2. SOFICO (*Société Wallonne de Financement Complémentaire des Infrastructures*): This organization plays a crucial role in the management and financing of road infrastructure in Wallonia.

In other regions of Belgium, different agencies handle similar responsibilities:

- In Flanders: Agentschap Wegen en Verkeer (AWV);
- In Brussels-Capital: Bruxelles Mobilité.

Similarly to the German approach, in Belgium MSAs are not incorporated into a primary motorway concession contract (as highways management and operations are handled by regional authorities), but rather subject to distinct operating agreements between the regional authority and the MSA operator.

The scope of the MSA contracts varies by region within Belgium. In Wallonia, the typical model involves a single operator responsible for the comprehensive management of the service area. Conversely, the Flanders region demonstrates a distinctive feature, utilising a split contract structure where the fuel stations are often operated separately from the other service amenities

[9] Deutschlandnetz | National Centre for Charging Infrastructure
[10] Milence accelerates network expansion into Germany with two new charging hubs on key TEN-T corridor - Milence

within the MSA. This decentralised approach, as opposed to the integrated management of the MSA as a whole, enables specialised operators to handle the distinct facets of the service area.

Decarbonisation transition

Belgium has demonstrated remarkable progress in expanding its EV charging infrastructure. The country has experienced significant growth, with the number of CPOs doubling to 60 companies within just one year (from 2022 to 2023), contributing to an 89%[11] increase in total number of charging points.

The infrastructure deployment is coordinated at the federal level, with each region implementing distinct yet complementary strategies. The Brussels-Capital Region has introduced the 'Electrify.brussels' mobility transition plan[12], which aims to install 22,000 public charging points by 2035, ensuring charging accessibility within 150 meters of every resident's location.

In the Flanders Region, authorities announced comprehensive infrastructure plans in May 2024, targeting the installation of charging infrastructure every 25 kilometres along or near motorways by the end of 2025[13]. This commitment was exemplified by an initiative on the E17 near Ghent, where the Flemish Road Authority (AWV) organized and awarded Europe's first tender for electric-only service areas to Fastned. These coordinated regional efforts underscore Belgium's nationwide commitment to advancing electric mobility infrastructure.

Zero – emission site case study: Fastned motorway service station of the future[14]

Description:

The Charging Point Operator Fastned inaugurated in May 2024 its first motorway service station in Belgium. This service area site includes a shop, a restaurant, and restroom facilities, providing essential amenities for drivers. The company has branded this concept the "motorway service station of the future".

Location	E19 motorway, close to Brecht, in Belgium (51.32218, 4.58621). Highway connecting Antwerpen and Breda, located on the North Sea–Baltic and the North Sea–Rhine–Mediterranean TEN–T corridor.
Fuel type	• 2 x 50 kW CHADEMO chargers • 8 x 300 kW CCS (Combined Charging System) chargers

[11] Belgium solidifies its position as a fast-charging hub: How did it double its CPOs in just one year? - Mobility Portal
[12] Electrify.brussels : un plan de déploiement et de nouvelles mesures pour la mobilité électrique en Région de Bruxelles-Capitale | Région de Bruxelles-Capitale
[13] Fast charging points every 25 km on Flemish motorways by end of 2025
[14] Fastned opens first motorway service station in Belgium: A glimpse into the future of electric vehicle charging. - Altavia Watch

Operators	Fastned only (Charging Point Operator) – Land lease won through public tender conducted by the Flanders region
Vehicle type	Only LDVs
Amenities	Shop, restaurant, toilets, charging points - All amenities are operated by Fastned

2.1.4 SWITZERLAND

MSA concession system

Switzerland's approach to managing motorways and MSAs reflects its federal structure and a strong emphasis on public oversight. The responsibility for road infrastructure in Switzerland is shared between the Confederation (federal government), cantons (administrative divisions), and municipalities. For national motorways, which are designated by the Federal Assembly as the most important transport routes, the Confederation takes the lead in construction, maintenance, and operation, and handle the motorway services areas. Cantonal and communal roads and their associated services areas, on the other hand, fall under the jurisdiction of their respective cantons and communes.

Switzerland has a total of 49 rest areas along its motorways, with the highest concentration along the A1 and A2 motorways. The management of these MSAs, while overseen by public authorities, operates differently from the broader motorway infrastructure:

1. MSAs in Switzerland are not part of a highway concession contract (highways are managed and maintained, depending on their locations, by the Cantons and the Federal State). Instead, they are generally managed by third parties based on separate concession agreements.
2. The contract awarding process for MSAs follows a competitive bidding system. The authority responsible for awarding these contracts is shared between the cantons and the federal state, reflecting Switzerland's federal structure and the collaborative approach to infrastructure management.

MSA contracts are typically long-term in nature. For example, Tamoil SA secured in 2022 a 30-year concession contract for operating an MSA in the canton of Zurich[15].

Decarbonisation transition

The Swiss government has taken significant steps in modernising its MSAs, particularly regarding EV charging infrastructure. In 2019, the Federal Roads Office (OFROU) conducted a public tender for EV charging stations at highway rest areas, awarding five concession lots each covering 20 rest areas, to different operators for a 30-year duration. This initiative, enabled by a recent legislative revision, aimed to rapidly expand the country's highway charging infrastructure between 2019 and 2023, supporting Switzerland's transition to electric mobility. A subsequent tender was carried out in 2024, this time with five lots each containing eleven plots.

[15] Tamoil SA acquiert une nouvelle concession de 30 ans en Suisse en étroite collaboration avec Autogrill | TAMOIL

These efforts are justified by the deployment of the Roadmap for Electric Mobility 2025[16] in Switzerland, which brings together approximately 70 relevant stakeholders from the business, public, association, and scientific sectors. Initiated by the Federal Department of the Environment, Transport, Energy and Communications (DETEC), the roadmap outlines three goals to be achieved by the end of 2025: increasing the share of plug-in vehicles to 50% of new registrations, expanding the public charging network to 20,000 stations, and promoting user-friendly and grid-friendly charging.

2.1.5 NETHERLANDS

MSA concession system

The Netherlands employs a distinctive two-tier system for managing MSAs, keeping it separate from motorway infrastructure governance. The first tier involves the *Rijksvastgoedbedrijf* (Dutch Real Estate Agency), which manages competitive auctions where participants bid exclusively for ground lease rights of MSA locations, with price being the sole selection criterion, similar to the Luxembourg's model. Upon winning, bidders gain the authority to lease these grounds from the Dutch government.

The second tier involves the *Rijkswaterstaat* (Directorate General for Public Works and Water Management), which issues operational permits to auction winners, authorising MSA activities. While the concession encompasses both fuel infrastructure and commercial facilities, physical infrastructure elements such as fuel stations, shops, and charging points are excluded from the auction scope. Operators typically engage subcontractors for MSA-related activities, with concessions usually spanning 15-year periods. This system effectively separates ground rights from operational management, creating a clear governance structure for MSA operations.

Decarbonisation transition

The Netherlands' decarbonisation strategy, anchored in the Dutch Climate Agreement, mandates all new passenger vehicles to be zero-emission by 2030, necessitating significant expansion of the country's charging infrastructure network. The initial phase of charging infrastructure deployment began in 2012, when the Dutch government distributed building permits for light-duty vehicle charging stations without competitive bidding, resulting in Fastned becoming the dominant operator across MSAs.

Currently, the Ministry of Infrastructure and Water Management is revising the existing MSA policy framework to enhance zero-emission mobility transition, strengthen the permit system to provide operators greater investment security in zero-emission infrastructure, and facilitate renewable energy integration at MSA locations. This comprehensive policy revision aims to create a more effective framework for managing MSA resources while supporting the Netherlands' broader decarbonisation objectives.

[16] Accueil / Roadmap Elektromobilität 2025

Zero – emission site case study:
Shell Eindhoven Acht truck stop[17]

Description:

Shell has inaugurated its first "hybrid" truck service station in the Netherlands, located in the southern city of Eindhoven. Opened in 2023, the objective of this station is to provide logistics and transportation companies access to a range of energy solutions. The station includes conventional and renewable diesel fuels, bio-LNG, as well as electric vehicle fast chargers. The "Eindhoven Acht" truck stop marks the initial deployment in a larger network of Shell's hybrid service stations planned along major European freight corridors.

Location	Southern city of Eindhoven, in the Netherlands – 2 kilometres away from the A58 highway, part of the TEN-T comprehensive network (51.46610, 5.41808)
Fuel type	• Electric high power chargers for electric trucks (6 charging points with power of 300 kW maximum) • Traditional and renewable diesel • Bio - LNG
Operators	Shell only
Vehicle type	Heavy duty vehicles
Amenities	Shop, restaurant, toilets, classic refuelling, alternative refuelling, charging points, truck wash – Operated by Shell

2.1.6 ADDITIONAL CASE-STUDIES OF ZERO-EMISSION SITES

Two additional case studies of "zero-emission" sites are presented below.

In Finland, the government offers incentives to promote EV charging infrastructure deployment. It provides a 30% subsidy for public EV chargers over 11 kW, increasing to 35% for chargers over 22 kW. The 2022 State budget allocated €13.2 million for the development of charging infrastructure[18]. These incentives aim to make charging stations more affordable and drive the development of extensive fast-charging networks across the country and along the motorway service areas.

[17] Shell establishes first energy hub for trucks in the Netherlands
[18] Finland | Accelerating to Zero Coalition

Zero – emission site case study:

Neste low-emission service station[19]

Description:

Neste has inaugurated in 2020 Finland's first "low emission" service station, situated within the Tuusula Housing Fair 2020 area (*Tuusula Housing Fair is a yearly event hosted in Finland to showcase the ongoing and future trends in building*). Through the implementation of construction and maintenance strategies, the lifecycle emissions associated with this service station facility are claimed by Neste to be 70% lower compared to a conventional station. The energy powering the station is generated by solar panels installed on the rooftop, completed with hydroelectric power, and sustainable materials have been utilised throughout the construction process. Additionally, the station features a self-service retail store.

Location	Tuusula Housing Fair area in Finland – One kilometre away from the E75 highway, part of the TEN-T North Sea - Baltic corridor (60.39906, 25.04930).
Fuel type	• Electric vehicle charging (4 chargers for light-duty vehicles, unspecified power) • Renewable diesel • Bio - CNG
Operators	Neste only – Land lease won through tender
Vehicle type	Light-duty vehicles (cars & vans). Suitability for heavy-duty vehicles unknown.
Amenities	E-Shop, classic refuelling, alternative refuelling, charging points

In Sweden, the country has the second highest rate of EV sales per capita, trailing only Norway in this metric[20]. To bolster the development of EV charging infrastructure, the Swedish government provides significant financial support through various initiatives. Specifically, organisations interested in constructing public charging stations can submit a bid to receive investment assistance from the program known as *Klimatklivet*[21], which can cover up to 70% of the total investment cost. This favourable policy environment has attracted CPOs, including for HDV charging providers such as Milence to establish a strong presence within the Swedish market. With 10 charging hubs currently under development and an additional 3 slated to open by the end of 2024, Sweden has emerged as one of Milence's key target markets for infrastructure expansion.

[19] Neste opens Finland's first low-emission service station in Tuusula Housing Fair area – a service station of the future with over 30% smaller carbon footprint
[20] New registrations of electric vehicles in Europe | European Environment Agency's home page
[21] Promoting "all types" of charging: how is the Swedish government's commitment progressing? - Mobility Portal

Zero – emission site case study:

Milence Sweden charging Hub[22]

Description:

Milence opened on the 10th of October 2024 a Charging Hub in Varberg, Sweden, dedicated to heavy duty trucks. This charging hub represents the first of 10 such Milence facilities currently in development across Sweden. Strategically situated along the Scandinavian-Mediterranean TEN-T corridor, it aims to enable electric road transportation between the cities of Gothenburg and Malmö. A second phase of development, slated for launch in 2025, will expand the charging infrastructure by adding more charging bays and Megawatt Charging System (MCS) chargers. This enhancement will significantly increase the overall charging capacity and provide faster charging solutions for a greater number of heavy-duty vehicles.

Location	Varberg, in Sweden, located on the TEN-T Scandinavia-Mediterranean corridor between Gothenburg and Malmö near exit 55 on the E6 motorway (57.16752, 12.27444)
Fuel type	Electric vehicle charging – 8 charging bays with 400 kW chargers
Operators	Milence only - Land lease probably won through tender conducted by the Swedish government
Vehicle type	Heavy duty vehicles
Amenities	Shops, toilets and showers, charging points

2.2 INITIAL CONCLUSIONS

The comparison of MSA operations in Luxembourg versus other countries has revealed several key structural and practical challenges that can be examples of good practices to ensure an appropriate fuel and service offer during the energy transition.

A primary difference is the relatively short MSA concession durations in Luxembourg, typically ranging from 4 to 10 years for the current concessions. The standard duration is 10 years but shorter durations have been introduced in recent concession renewal to maintain flexibility during the energy transition. At the end of the concession, concessionaires are refunded the investments that are not amortised. In contrast, regulatory frameworks in some other countries allow for MSA concession duration between 20 and 30 years, which could give to the operator enough room to actually incorporate into the MSA operation a suitable decarbonisation strategy but can also lock the MSA with a company for a very long duration. The pros and cons of various concessions duration are discussed in more detail in section 4.

[22] Milence Expands Operations to the Nordics with the Opening of the New Charging Hub in Varberg, Sweden - Milence

Neighbouring countries have also seen their government set out ambitious targets for the development of alternative fuel sites, especially around charging infrastructure, from which the government of Luxembourg could take additional inspiration:

- Germany's *Deutschlandnetz* initiative (where 900 regional locations and 200 motorway locations were tendered for the construction and operation of HPC (high-power charging) fast-charging infrastructure) offers a robust model of selecting charging infrastructure operators through comprehensive criteria beyond financial metrics, considering site construction speed, design user-friendliness, and overall plan quality.
- France's government-supported strategy includes mandating minimum charging points per motorway service area with specific power output requirements through its €100 million support from its National Recovery Plan.
- Finally, Switzerland's approach of dividing charging infrastructure into multiple concession lots and setting clear national goals provides another valuable blueprint.

This initial comparison supports a first series of options for future tender processes, in order to address the multifaceted challenges associated with the future operation of MSA sites – all of these options are detailed in chapter 6, with pros and cons:

- Adopt a multi-criteria approach that considers factors beyond financial considerations and the usual checks of the financial, technical and operational suitability of the candidate, particularly when evaluating electric charging infrastructure proposals.
- Explore a lot-based tendering system, with carefully designed lot divisions (i.e. specific lots for fossil fuel and electric charging activities), to help avoid the exclusion of certain stakeholders and promote a more diverse and competitive landscape.
- Extend concession durations to allow for the amortisation of investments in new technologies.

These different options are discussed in detail in chapter 6 of this report, with potential approaches for the future MSA concession system and tender process in Luxembourg. These options are based on the present chapter analysing other MSA concessions in neighbouring countries, and the following chapter about the future energy needs at the Luxembourg MSAs.

3. QUANTIFYING FUTURE NEEDS

This chapter aims to assess the charging provision required at each MSA in Luxembourg, in terms of the number of charge points and their power rating for both heavy- and light-duty vehicles (HDVs and LDVs). It presents the quantifications of the future energy needs of HDVs (primarily trucks or lorries, with an adjustment for enroute coach, as a marginal user) and LDVs (cars and vans) at the Luxembourg MSAs, between 2025 and 2050. The chapter covers first an analysis of the past and current demand in fossil fuels and electricity at the Luxembourgish MSAs, and of the infrastructure provision compared to other similar MSAs in neighbouring countries. The second sub-section reflects on which fuels (/energy vectors) are relevant to future MSAs. Then, the method and results of the energy need modelling for HDVs and LDVs are detailed – this modelling determines the number and type (power rating) that are required to meet the projected demand. Finally, the AFIR requirements in terms of alternative fuel infrastructure deployment on Luxembourg's motorways are described.

3.1 CURRENT DEMAND

This section investigates the following data for each Luxembourg MSA site:

1. Fossil fuel sales by volume
2. Fuel pump provision relative to MSAs in neighbouring countries
3. EV charging sales

These data points help to provide a picture of current demand at MSA sites in Luxembourg, with particular focus on key trends and differences from MSAs in surrounding countries. This picture is subsequently used to calibrate and validate the future demand modelling.

3.1.1 FUEL SALES

In the past five years, there has been a considerable decrease in diesel sales across all eight MSA sites in Luxembourg. The observed drop between 2018 and 2023 ranges between 40% and 60% (by fuel volume) depending on the MSA, representing a significant proportion of total revenue for these locations. This drop is illustrated by Figure 3-1, which shows that the decrease in fuel sales is exclusively driven by a reduction in diesel sales to HDVs, whereas petrol and diesel sales to car and van drivers has remained steady across the same period[23].

[23] The breakdown of fuel sales into LDVs (cars and vans) and HDVs is based on estimations provided by Luxembourg's Ministry of the Economy and interviews with stakeholders. Assumption: 80% and 50% of fuel sales are attributable to HDVs in 2018 and 2023, respectively.

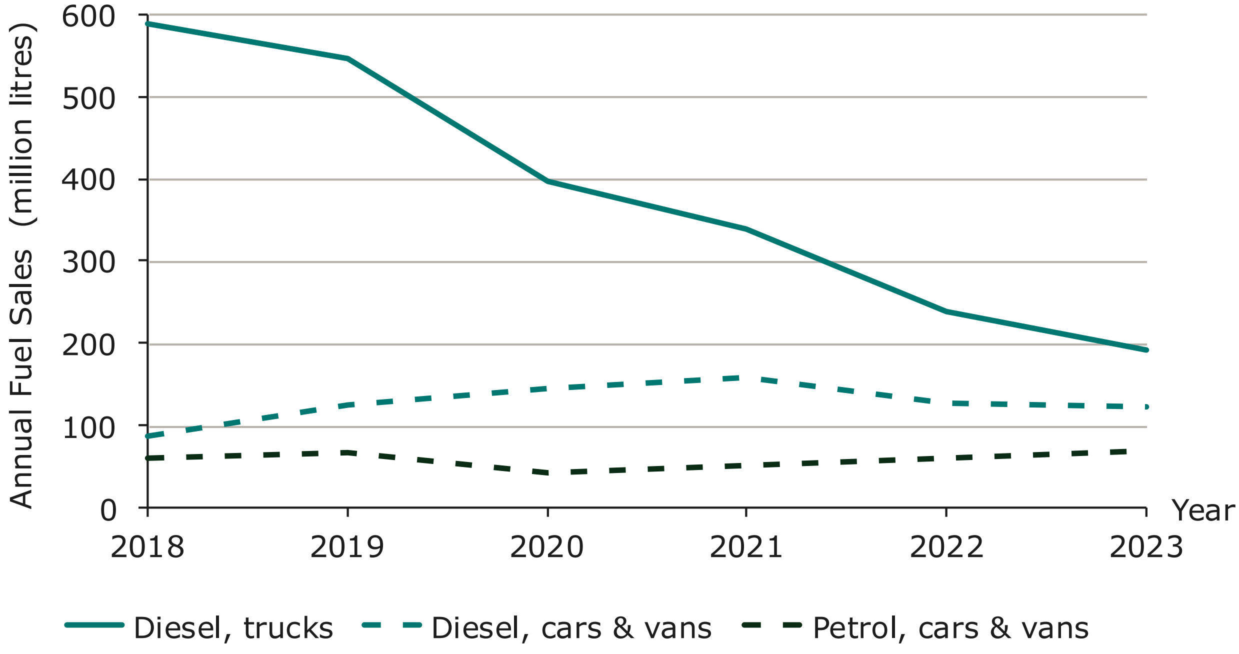


FIGURE 3-1 – HISTORIC TOTAL FUEL SALES AT MSAS IN LUXEMBOURG FOR DIESEL HDVS, AND PETROL AND DIESEL CARS AND VANS[24]

There are several reasons for this marked drop in fuel sales:

- **Changes in excise duty for trucking companies in France and Belgium**: historically, Luxembourg offered a fuel price advantage for truckers[25] compared to its neighbours when excise duty rebates are accounted for. Luxembourg's fuel price advantage has reduced because of the introduction of the CO_2 tax in Luxembourg, and because of the rebate available for road freight transport in Belgium[26] and France[27] but not in Luxembourg[28]. This change represents the removal of a reason to stop for fuel in Luxembourg rather than another en route country, although other factors such as VAT may also play a part in this.
- **Changes in HDV traffic flows**: HDVs were historically responsible for most of the diesel consumption at MSAs in Luxembourg. HDV traffic on motorways in the vicinity of the MSAs reduced between 2018 and 2023 by between 7% and 24% (based on traffic counters near Wasserbillig and Berchem)[29].
- **Impact of COVID**: part of the drop in fuel sales between 2019 and 2020 can be explained by the decreased traffic flow during the lockdown periods in 2020.

[24] Total fuel sales and split between petrol and diesel given by Ministry of Economy for Luxembourg. Estimation of split between car / van and HDV fuel sales based on MSA concession holder interviews.
[25] ca. 15¢/litre, which is about €4.5/100km for a 40t articulated HDV with a fuel consumption of 30 litre/100km
[26] In Belgium, fuel is subject to an energy tax of €60/hl. Transport operators receive a €24.8/hl refund, effectively reducing their pump price.
[27] In France, fuel is subject to the TICPE energy tax of €60/hl. Transport operators receive a €15/hl refund, effectively reducing their pump price. This refund is scheduled for removal by the government by 2030.
[28] Appendix A details analysis of the fuel price difference from 2018 to 2023
[29] Based on traffic camera data from https://travaux.public.lu/fr/infos-trafic/comptage.html. No well-placed camera is available for sites at Capellen and Pontpierre, therefore flows at Wasserbillig and Berchem are used to represent all sites.

3.1.2 FUEL PUMP PROVISION

As described in section 3.1.1, HDV fuel sales reduced by approximately half across all eight MSA sites in Luxembourg between 2018 and 2023. Evaluation of Luxembourg's MSAs compared to similar sites across France and Germany[30] has revealed that refuelling infrastructure is geared much more towards HDVs in Luxembourg (see Appendix B). Metrics such as number of LDV and HDV fuel pumps, number of parking spaces (LDV and HDV), and area of fuelling station/shop/restaurant were used to assess a sample of MSAs in these countries[31].

Figure 3-2 illustrates this focus on HDV refuelling infrastructure, with Luxembourgish MSAs having an average of 9 HDV fuel pumps, whereas outside of Luxembourg the average is less than 3. In France and Germany, the number of HDV pumps remains consistently between 2 and 4 regardless of passing HDV traffic. The provision in Luxembourg appears similarly decoupled from passing traffic volumes.

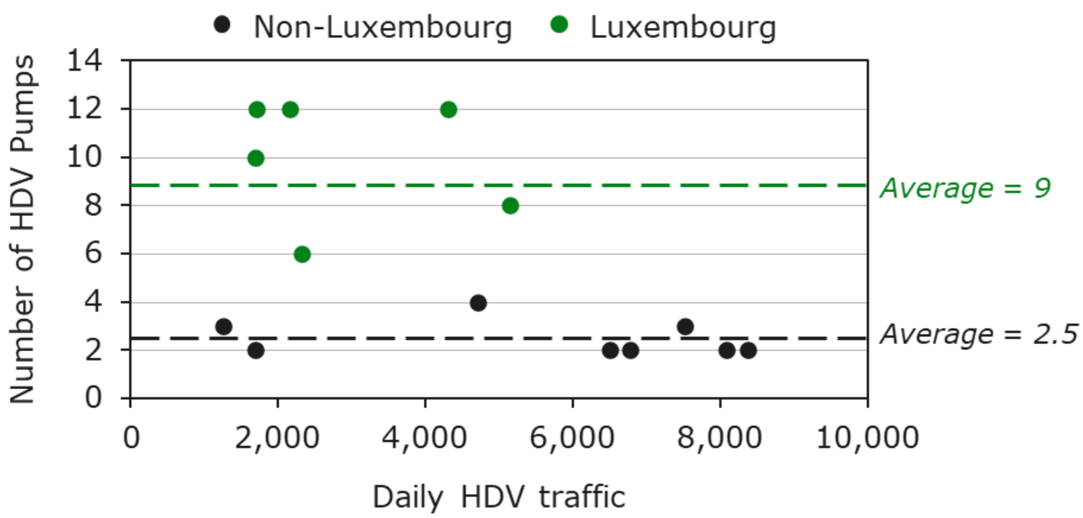


FIGURE 3-2 – NUMBER OF HDV FUEL PUMPS AGAINST DAILY HDV TRAFFIC

Figure 3-3 shows that, while Luxembourg's MSAs do have more LDV pumps on average (16) than those in France and Germany (9), the difference is less stark than for HDVs. This pattern further highlights Luxembourg MSAs' historic skew of fuel provision to specifically commercial HDV customers.

30 Sites on Europe's TEN-T network were chosen at a variety of locations.
31 Metrics calculated using Google Maps.

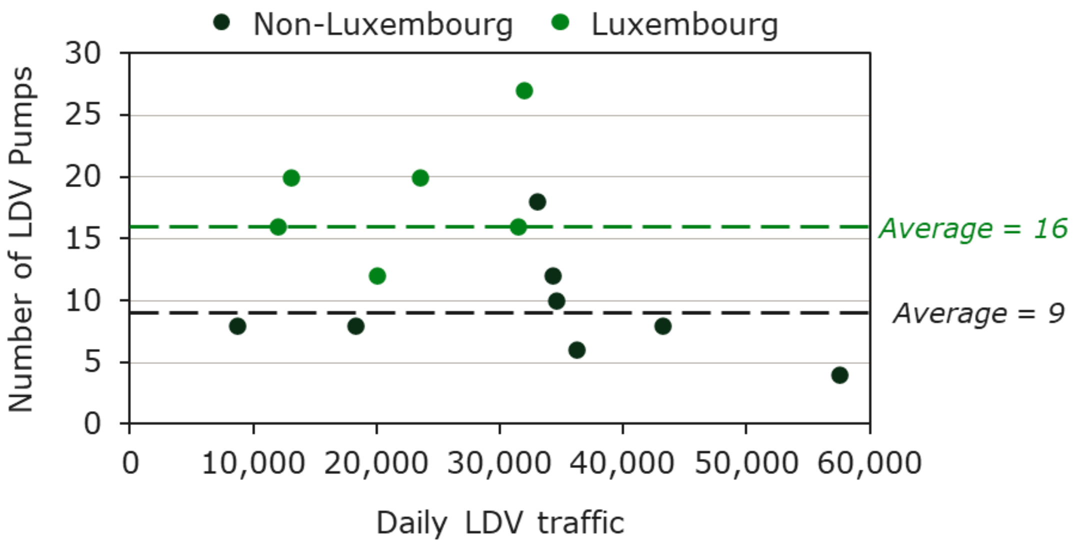


FIGURE 3-3 – NUMBER OF LDV FUEL PUMPS AGAINST DAILY LDV TRAFFIC

Analysis of parking space provision compared to pump provision (see Appendix B) illustrates that Luxembourg's MSAs have a similar number of HDV parking spaces compared to MSAs outside of Luxembourg but have a disproportionately large number of HDV fuel pumps. This compounds the findings observed in Figure 3-2 which show that Luxembourgish MSAs prioritise providing fuel to HDVs and suggests that HDV drivers are not currently commonly expected to park up and spend time at the MSAs beyond refuelling.

3.1.3 CHARGING DEMAND

As of December 2024, in Luxembourg, all EV charging demand derives from LDVs as there are no HDV-specific charge points at any Luxembourgish MSAs, despite BEV HDVs being on the road in Europe: over 1,600 electric HDVs are registered in France, 6,500 in Germany, 230 in Belgium and 30 in Luxembourg, as of December 2024 based on the European Alternative Fuels Observatory (EAFO) statistics[32]. HDV charge points are differentiated from electric LDV charge points by their bay size and location. Today, all charge points at Luxembourgish MSAs are LDV chargers because they are in the area of the car park designated for cars and cannot be accessed by HDVs. LDV HPC chargers are available at six of the eight MSA sites as of October 2024, with an additional site set to install LDV chargers by the end of 2024. The Pontpierre Luxembourg site is unlikely to install any charge points (LDV or HDV) imminently due to space constraints[33].

Figure 3-4 below shows that the charging demand aggregated across all sites has a peak which generally lies between 10:00 and 16:00, which demonstrates that charging behaviour is the opposite of that associated with commuter travel (which generally peaks around 8:00 and 18:00). The pattern is a typical longer-distance, leisure journey profile and, compared with commuter traffic profiles, suggests that MSAs are serving very few commuters.

32 Homepage | European Alternative Fuels Observatory
33 Information provided during meetings with Luxembourg Ministry of the Economy

FIGURE 3-4 – ELECTRICITY CONSUMPTION BY HOUR AT ALL MSAS WITH CHARGE POINTS INSTALLED (TOTAL OVER 6 MONTHS OF USE IN 2024)

The average charging event consumed 33.6 kWh with no significant monthly variation, with the majority of charging in the 30-50 kWh range. These events constitute typical customers charging at least 50% of their battery's capacity, with the most popular BEV models having battery capacities of 51-75 kWh[34]. This typically corresponds to increasing the battery's state of charge from 20% to around 80%, as the fast-charging process slows significantly beyond this point to safeguard the battery's health. These charging events take an average of half an hour. This compounds the finding that those stopping to charge at MSAs are not commuters and are likely on long-distance journeys.

Peak Demand

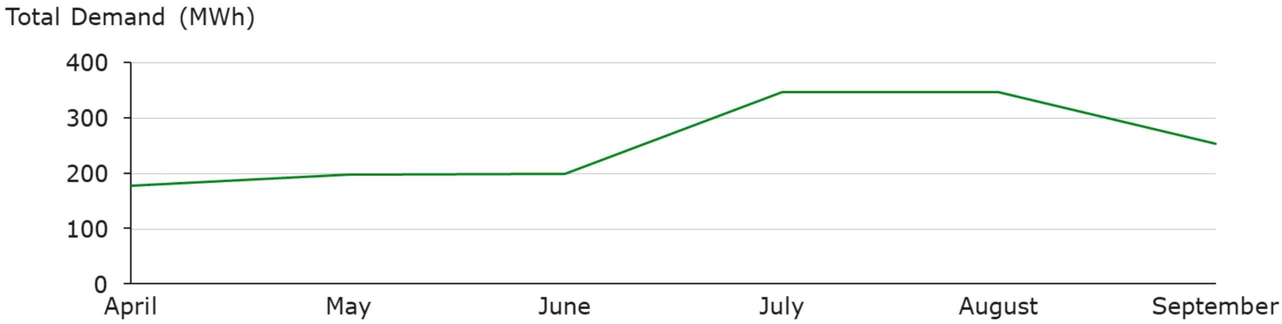


FIGURE 3-5 – MONTHLY ELECTRICITY CONSUMPTION ACROSS ALL CHARGE POINTS BETWEEN APRIL AND SEPTEMBER 2024

Figure 3-5 shows that electricity demand at LDV chargers at MSAs in Luxembourg almost doubles (+95%) between June and July/August, despite minimal increases in traffic flows during this time. This demonstrates that charging demand at Luxembourgish MSAs is currently heavily influenced by season, further showing that demand there is driven by leisure journeys.

[34] https://alternative-fuels-observatory.ec.europa.eu/general-information/news/europes-ev-market-update-may-2024

In order to quantify the impact of high-demand days, the number of days in the 6-month period of data available for analysis (April to September 2024) during which daily demand exceeds twice the average daily demand is tabulated below in Table 3-1. The proportion of the year for which demand is double the average demand is also given in the table, demonstrating that these events represent a small proportion of the year. Finally, the number of hours that each charge point is in use on the highest-demand day is given.

TABLE 3-1 – NUMBER OF DAYS BETWEEN APRIL AND SEPTEMBER 2024 DURING WHICH DAILY DEMAND EXCEEDED DOUBLE AVERAGE DAILY DEMAND

MSA	Number of days when demand is more than double average demand	Proportion of the year during which demand is more than double average demand (%)[35]	Hours per day that each charger is in use on the highest demand day
Berchem Luxembourg	11	3.0%	10.1
Berchem France	11	3.0%	7.1
Capellen Luxembourg	5	1.4%	10.6
Capellen Belgium	4	1.1%	9.5
Wasserbillig Luxembourg[36]	6	1.6%	2.2
Pontpierre France[36]	3	0.8%	0.7

As shown in Table 3-1, at sites such as Berchem Luxembourg and Capellen Luxembourg, chargers are expected to be in use for more than 10 hours per day on the highest demand day. Current demand profiles (see Appendix C) demonstrate that charging demand is often spread across ca. 12 hours per day on high-demand days.

Days with the greatest demand (such as days around the bank holidays in North-West Europe) can reach up to ca. three times average daily demand, depending on the MSA. Analysis of current charging demand shows that on the three highest demand days for each site, all chargers are occupied for periods up to 9 times per day at the Capellen Luxembourg MSA, up to 5 times per day at both Berchem MSAs, and up to once per day at the remaining 3 sites[37]. The hours during which this occurs vary from 6am to 11pm. This demonstrates that MSAs occasionally cannot meet charging demand on peak days, which means queuing may occur in these situations.

[35] Given peak demand is most likely to occur in the months for which data is available, potentially with the exception of Christmas travel in late December, the values in Table 3 1 can be considered to represent the number of days of high demand across a whole year.
[36] Note: the demand at these MSAs is so small on average that although peak days have much higher demand than the average day, the number of hours each charge point is active for each day is less than 3. This means that there is unlikely to be congestion at these sites even on peak days.
[37] Based on hourly charging data.

However, the temporal distribution of the demand (see Appendix C) demonstrates that frequent queues at one particular time of day are unlikely even on peak days.

For the Berchem and Capellen MSAs, all busiest days in 2024 were in July and August (with 20/07, 21/07, 27/07 and 04/08 being in the top 10 busiest days for charging of 3 out 4 MSAs). For Wasserbillig Luxembourg, 7 of the busiest days were in July-August, the rest in April, May and September. Interestingly, 8 of the 10 busiest days for charging at Pontpierre France were in April and September.

3.1.4 CONCLUSIONS FROM CURRENT DEMAND

- **HDV fuel sales have declined: HDV refuelling has dropped between 40% and 60%**, depending on the specific site, at MSAs in Luxembourg since 2018. This decrease can be attributed to CO2 tax and rebates for trucking fuel purchased within France or Belgium, amongst other factors (as described above).
- **Luxembourg's MSAs have disproportionately high numbers of fuel pumps, especially for HDVs** compared to similar sites in France and Germany. Luxembourg has historically provided an excess of fuel pumps relative to what factors such as parking would predict.
- **Charging demand appears to come mainly from long-distance car drivers** who recharge in general from 20% to 80% of their battery's capacity during the charging session, despite considerable passing commuter traffic. Charging demand nearly doubles over the summer months.
- **Peak charging demand can be up to three times average daily charging demand on the highest-demand days.** At the Luxembourgish MSAs in April to September 2024, there were up to 11 days when charging demand exceeded double the average daily demand, generally during July and August.

3.2 FUELS OF RELEVANCE TO FUTURE MSAS

This study is about the MSA of the future so focuses on zero (tailpipe) emission vehicles, in line with the EU CO_2 regulations applying to the sales of light and heavy duty vehicles[38], which requires vehicle Original Equipment Manufacturers (OEMs) to eventually sell only battery electric or hydrogen powered vehicles. Natural gas/biomethane (compressed or liquefied) is therefore not relevant for future MSAs, and rarely used in trans-European fleets. The case of existing and future drop-in fuels is different but still result in them not being in scope for this study, for reasons outlined in 3.2.1. Given demand for diesel and petrol will decline but continue during the transition to zero (tailpipe) emission vehicles, these fuels are considered in this study.

Among zero (tailpipe) emission vehicles, the demand for hydrogen powered vehicles (and thus the case for hydrogen fuel at MSA) significantly lags behind the demand for battery electric vehicles and is projected to stay very small over the next decade – this is discussed in 3.2.2. Therefore, the potential hydrogen demand at MSAs and corresponding pumps numbers have not been modelled for this study. The compliance with AFIR requirements is however discussed for both hydrogen stations and charging points in 3.5.

---

[38] For LDV: Regulation 2019/631 https://eur-lex.europa.eu/eli/reg/2019/631/oj/eng and for HDV: regulation 2019/1242 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02019R1242-20240701

3.2.1 DROP-IN FUELS

Drop-in fuels are attractive in theory to operators, as they promise a way to reduce emissions without having to change vehicles or how they currently operate. However, their demand at MSA is not predicted to be significant:

- **HVO**, an existing diesel drop-in fuel, is used by some commercial fleets already despite its cost premium over diesel, as a way to lower their reported emissions. However, limited availability of waste-based feedstocks that are needed to make low-carbon HVO means that EU policy (Renewable Energy Directive) places a cap of 1.7% on the share of such feedstocks in final transport energy demand. This is roughly 2.3%[39] of road transport final energy demand. In practice this is unlikely to be achieved due to existing use of the feedstock within biodiesel blends (such as Fatty Acid Methyl Esters blends), and in future due to competition from sustainable aviation fuels if these are included within the cap, which is not clear as of January 2025.
- **E-fuels** are not yet sold for road transport applications and their use in road transport is likely to be a niche for three main reasons:
  - **No regulatory drivers:** Their use is not incentivised in the current EU CO_2 standards meaning manufacturers will still need to make low/zero emission vehicles which cannot use e-fuel. If the CO_2 regulations are altered to incentivise manufacturers to produce vehicles which can only use e-fuels, this would require on-board technology which currently does not exist to verify the vehicle is using e-fuels and not fossil fuels. If a technology is invented to achieve this, it will almost certainly increase the cost of the vehicle, further reducing the commercial viability.
  - **Low supply:** Supply of e-fuels is unlikely to be sufficient to significantly impact road transport, as production will likely be focused on achieving sustainable aviation fuel (SAF) targets from ReFuelEU. Even if the supply of e-fuels for road transport was equal to that for ReFuelEU, this would only be able to replace less than 0.5% of diesel in 2030 and less than 4% of diesel use in 2040 compared to current usage (0.6 Mt/year SAF in 2030 and 5 Mt/year SAF in 2040[40] compared to approximately 170 MT/year road diesel currently in the EU[41]).

    Cost: E-fuels are expensive (200-400% higher than fossil diesel in 2030, 50-150% higher at least up to 2040)[42] meaning e-fuels are uneconomical for commercial use.

---

[39] ERM calculation based on the share of final transport energy demand from road transport in the EU: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Final_energy_consumption_in_transport_-_detailed_statistics#:~:text=In%202022%2C%20transport%20activities%20accounted,rail%20transport%20(1.4%20%25).
[40] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202302405
[41] https://ec.europa.eu/eurostat/databrowser/view/ten00126/default/table?lang=en&category=t_nrg.t_nrg_indic
[42] 2030 estimate based on power-to-liquid diesel and fossil diesel costs from: https://www.concawe.eu/wp-content/uploads/Rpt_22-17.pdf , and 2040 from https://theicct.org/wp-content/uploads/2022/02/fuels-us-europe-current-future-cost-ekerosene-us-europe-mar22.pdf, Costs of e-fuels only include production, this does not include the cost of distribution or supply to vehicles.

It is recommended that Luxembourg reassess these conclusions at a future update of the study, in case market conditions and regulatory conditions have changed.

3.2.2 THE CASE OF HYDROGEN

Hydrogen is seen as a fuel that could help decarbonising the road transport sector, especially some specific applications for HDVs and buses. For the purpose of this study, hydrogen was not considered in the detailed calculation of the future energy demand at the MSAs and its impact on the future of the MSAs in Luxembourg, for several reasons detailed below:

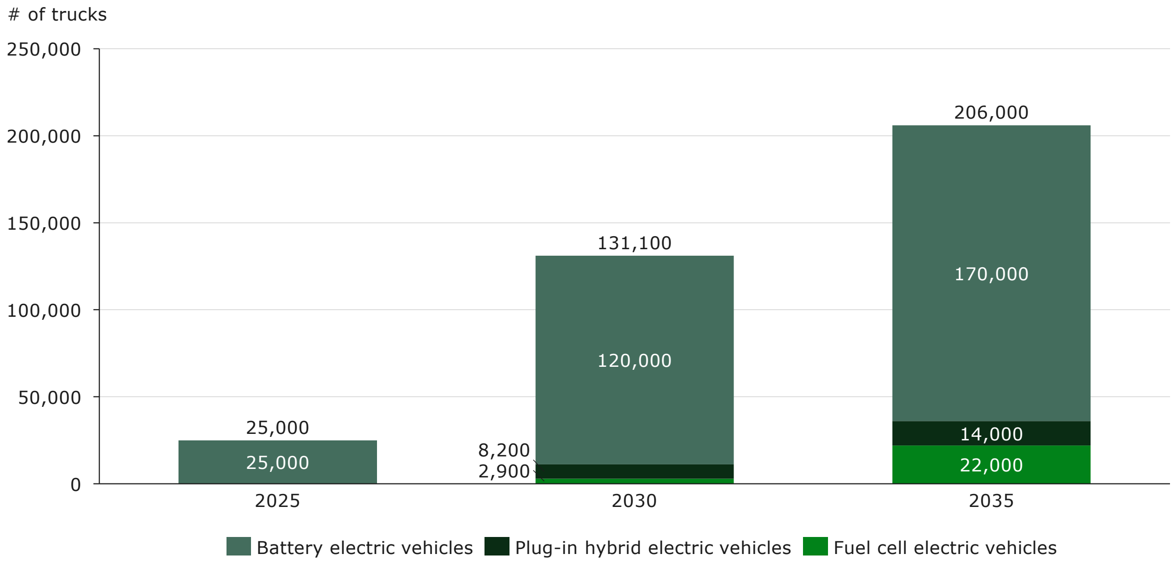
- Sales of hydrogen road vehicles are projected to stay limited in the next decade - see below projections of hydrogen road vehicle stock from the IEA. Several interlinked factors are behind this:
  - Upfront costs of fuel-cell electric vehicles (FCEVs) are much higher than upfront costs for BEVs, with the gap unlikely to close in the coming decade. BEV are benefitting for the learning curve of over 28 million sales globally versus ca. 82 thousands FCEVs sales in the period 2016-2023 (cars, vans, buses and trucks)[43].
  - Running costs of FCEVs are bound to stay higher than for BEVs as hydrogen is more expensive than electricity. The higher efficiency of BEVs (lower kWh/km needed) means hydrogen would need to be ca. 50% cheaper than electricity on a EUR/kWh basis[44]. For example, for a charging price of 0.40 EUR/kWh[45], a hydrogen price of ca. 6.5 EUR / kgH_2[46] would be needed to reach parity in EUR/km terms between both powertrains. This is about 70% lower than current hydrogen pump price[47] and thus unlikely to be realised even with import of hydrogen from outside Europe, and would likely require pipeline distribution as opposed to truck delivery.
  - The hydrogen refuelling infrastructure is not widespread (and largely designed for LDVs only): 194 stations in operation, with the highest density in Germany and the Netherlands[48]. While installing stations at MSAs would help improve this point, it will not overcome the other barriers. Hydrogen infrastructure deployment targets set out by the AFIR regulation are discussed in more details in section 3.5.
  - The product offer is limited. Several vehicle OEMs have announced models of hydrogen HDVs (including internal combustion engine hydrogen HDVs) and vans, that are however less readily available compared to battery-electric vehicles. For the reasons above, the BEV technology lock-in increases.
- The opportunity cost associated with putting a hydrogen fuelling station on site is unlikely to be afforded, as it takes space away from other uses of the site (which is already space-constrained).

[43] Source: IEA, Global EV Data Explorer
[44] Battery electric powertrains for tractor-trailers are 50% more efficient (tank-to-wheel, on a kWh/km basis) than fuel-cell powertrains in long-haul operation. Source: 2022, ICCT, Fuel cell electric tractor-trailers: Technology overview and fuel economy
[45] Price excluding VAT from Milence, one of the leading European charging operators for HDVs. Source: Charging & Payment - Milence, accessed on 29/01/2025
[46] Assume energy content of 33.33 kWh/kgH_2
[47] Average at the pump as of January 2025 is ca. 20 EUR/kgH_2, with variations between countries. Current prices across Europe, per station, can be found on H2.LIVE: Hydrogen Stations in Germany & Europe.
[48] Source: h2-map.eu, accessed on 29/01/2025

In the estimations, a highly compact design of the hydrogen refuelling station (HRS) was considered to address space constraints. For a station with a capacity of 2 tH_2/d (which could refill approximately up to 50 articulated HGVs per day[49]), this results in an area required of approximately 600-1000 m^2, based on ERM experience with highly compact HRS designs. If a blast wall could be used around the storage area of the HRS, the need for a safety clearance area would be removed. With this, around ca. 9-15 HDV parking bays would be lost[50]. However, if this was not possible or practical, the area occupied by the HRS would rise to c. 20-25 HDV parking bays when including safety distances (8 metres between the HRS and a parking spot or other gathering location and 5 metres between the HRS and electrical installations).

To conclude, considering the low expected demand for hydrogen, the option to deploy an HRS on either MSA site seemed less strategic as of now as it would have a material impact on the space available in what is already a highly space-constrained site.

The conclusions presented in this section are in line with the IEA projection for the hydrogen market in Europe (as shown on the diagram below). Battery-electric vehicles will represent the majority of the vehicles stopping in Luxembourg MSAs. Considering space constraints and redundancies with hydrogen hubs deployed in the neighbouring countries and at Bettembourg in Luxembourg (notably to respect the AFIR regulation, which is discussed in detail in 3.5), as well as the need for high offtake for all of the distribution station to be economically viable, it was deemed better to focus on battery electric vehicles for the upcoming concession renewal.



Source: IEA, EV sales, trucks, Europe, STEPS scenario 2020-2035

FIGURE 3-6 – PROJECTED SALES OF ELECTRIC HGVS IN EUROPE[51]

In future, it is recommended that the Luxembourg government updates this analysis in line with future market trends, to reassess the possibility to install a hydrogen station in the relevant

[49] Assumptions: 40kgH_2 per refill based on typical tank sizes (source: Fuel cell electric tractor-trailers: Technology overview and fuel economy), assume HDV refuelling events are well spread throughout the day so downtime needed for compression is limited.
[50] The basis for these estimations is provided in section 4.
[51] Based on the Global EV Data Explorer of the IEA: https://www.iea.org/data-and-statistics/data-tools/global-ev-data-explorer - Stated Policies Scenario (STEPS)

MSAs. In particular, this scenario could be envisaged from 2035 onwards, when the share of fuel cell electric vehicles could start to increase to around 10% of the total European electric HDV stock (includes battery electric vehicles, plug-in hybrid vehicles and fuel cell electric vehicles), and the price of renewable / low-carbon hydrogen may become more affordable thanks to increased European production and imports. This possibility should be explored in a further analysis closer to the renewal of the concessions and taking into account the evolution of the hydrogen sector. Afterwards the commercial viability of hydrogen in road transport should be further verified by market trends. The government may choose the location of one or more hydrogen stations, if proven necessary, based on space constraints and proven demand: securing offtakers will likely be necessary for concession bidders to invest in an HRS, so a consultation with industry (hauliers) will likely be beneficial before setting off the terms of the concession contract related to the HRS. This consultation would aim to identify hauliers which are or will be driving hydrogen HDVs on the Luxembourg motorways and will be using the future HRS.

3.3 FUTURE HDV DEMAND

It is strategically optimal to plan the infrastructure for the transition to zero-emission Heavy Duty Vehicles (HDV) based on a clear understanding of the end state to avoid investment in assets during the transition which are unsuited to the final site design. Our method focuses on the future end state of Heavy Goods Vehicle (HGV) decarbonisation, which is the overwhelmingly dominant segment of the HDV market. Coach – here meaning private group hire or tours – is anticipated to be a marginal user of future MSA HDV infrastructure, with the caveat that MSAs are well suited to handling groups of passengers, while traditional HDV-specific facilities are not. Other categories of bus are excluded, as these rarely operate on motorways or outside the locality of their home depots.

3.3.1 HOW DECARBONISATION CHANGES TRUCKING

We expect BEV to be the overwhelmingly dominant, and potentially the only, powertrain used in European mainstream commercial trucking by the 2050s due primarily to cost. While niche uses for other fuels may emerge, the Grand-Duchy's relatively small geographic footprint within Europe means it is unlikely that such users will depend on refuelling when passing through Luxembourg. The consequent implications of the EU Alternative Fuels Infrastructure Regulation, which only estimates an uptake from hydrogen (at a smaller scale than BEV, after 2030), are discussed in 3.5.

Two thirds of the European HGV parc are rigid chassis vehicles. These tend to perform local distribution or service roles. Their operations tend to be focused on a home depot or industrial location (such as a warehouse) where future charging facilities can be assumed. Rigid HGVs are unlikely to make use of MSAs, both now and in their battery electric future.

Currently sold BEV tractors for articulated HGVs are capable of 300-400 kilometres on a single charge. This is also the maximum distance that a single driver is likely to drive before taking their mandatory rest break. Consequently, by providing high power charging at the place drivers take their rest breaks, BEV artic HGVs can continue to operate most existing vehicle duties without additional vehicle downtime. The location of high-powered charges thus becomes far more important than conventional MSA market differentiators, such as diesel price and driver facilities.

Artic HGV operations will logically seek to minimise public en route charging as this will tend to be the most expensive form of charging, as already demonstrated in car markets. So, while any charge that needs to take place away from a home depot might theoretically occur at an MSA, many such charging events are more likely to occur at or near journey destinations, such as warehouses. The acquisition of land for overnight parking with charging represents a significant additional investment, so MSA provision *might* disincentivise long-duration "overnight" en route stops as a natural consequence of commercial optimisation of finite facilities. The wider practical and policy implications of not accommodating overnight stops at existing MSAs is discussed in section 4.1.

These considerations initially serve to frame our three demand scenarios:

- High demand – all artic HGV charging not at depots or major destinations.
- Mid demand – all stops likely to be made en route, excluding those at destination.
- Low demand – only "daytime" (mid-duty) en route stops, excluding overnight en route.

3.3.2 FUTURE EUROPEAN HGV CHARGING DEMAND

Luxembourg's MSAs serve an inherently European market, not one limited to or even primarily focused upon, the Grand-Duchy of Luxembourg. Our modelling of future HGV charging activity therefore starts from a European perspective, which we then apply to Luxembourg. Figure 3-7 summarises how different source datasets (tubular boxes) feed into our calculations of future HGV charging demand. These sources and calculation steps are described in more detail below.

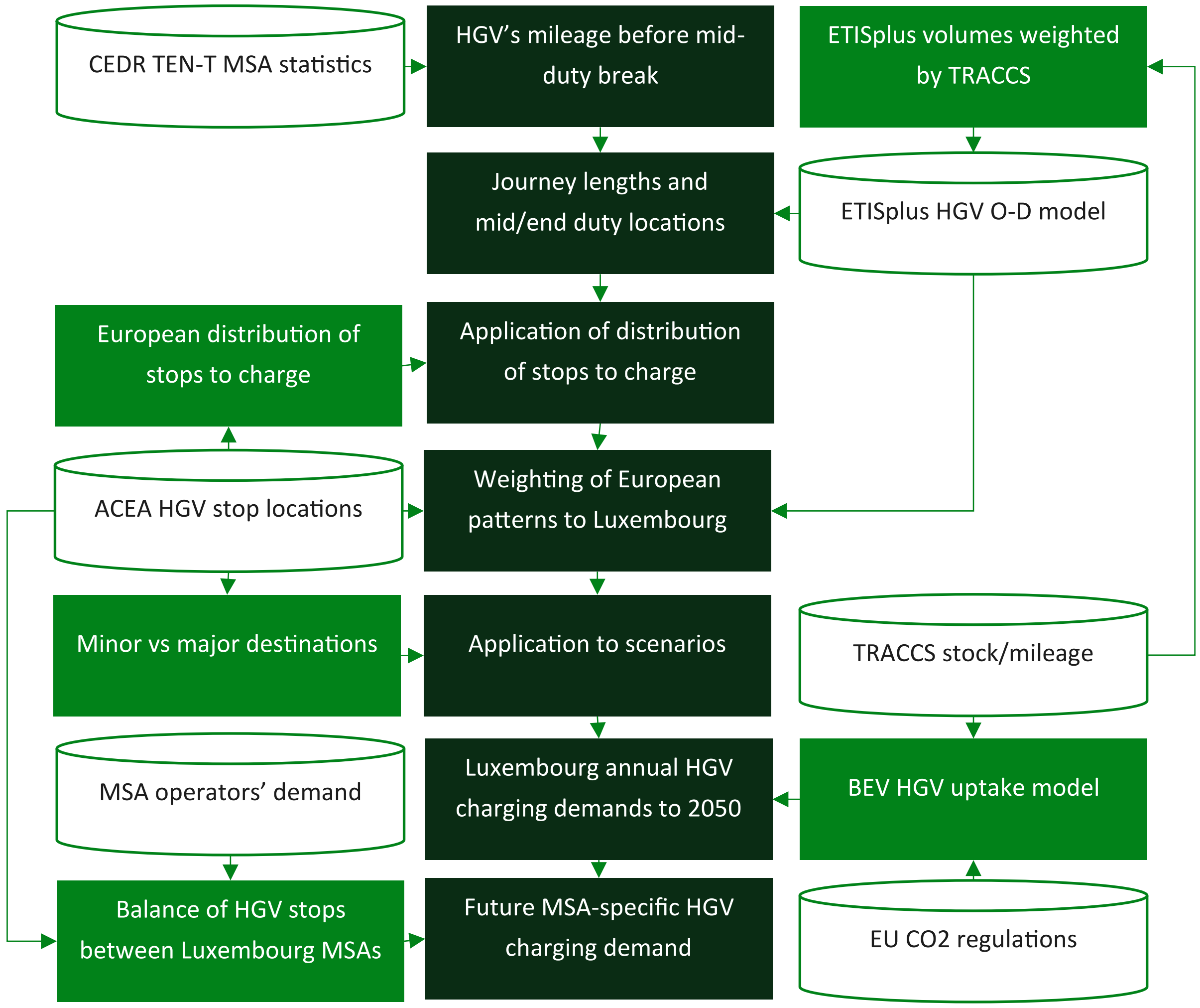


FIGURE 3-7 – OVERVIEW OF HGV MODELLING INPUTS AND PROCESSING (TUBULAR BOXES INDICATE SOURCE DATASETS, LIGHT GREEN BOXES SHOW PRE-PROCESSING, DARK GREEN BOXES ARE THE CORE CALCULATION STREAM)

A European inter-regional HGV is assumed to average 70 km/h. Analysis suggests[52] HGVs typically average about 10 km/h less than the speed limit, which is 90 km/h on motorways in Luxembourg and France, but typically lower elsewhere, notably 80 km/h on German autobahns. Further, a portion of most journeys will be on local roads, where speeds are significantly lower than motorways.

For the purposes of modelling, European driving hours regulations are assumed to require one 45 minutes break in the middle of two 4.5-hour drives. HGVs averaging 70 km/h can therefore travel 315 km before a rest stop or arriving at their destination. HGV stop locations with fuelling are assumed to occur every 50 km[53], and thus on average an HGV driver will need to stop 25 km before. This gives an effective range of 290 km per half driver duty.

[52] https://assets.publishing.service.gov.uk/media/6005a93ae90e0763a5d760e1/evaluation-of-the-national-hgv-speed-limit-increase-in-england-and-wales-year-2-interim-report-document.pdf
[53] https://www.cedr.eu/download/Publications/2020/CEDR-Technical-Report-2020-01-TEN-T-2019-Performance-Report.pdf CEDR data suggests the average density of MSAs with truck facilities alone TEN-T is approximately one every 40 driven kilometers, after adjusting for single-direction sites on multi-carriageway routes. However, there is significant variation between countries in the data, with sites particularly sparse in neighboring Germany, so a slightly higher 50 km value is adopted in our modelling.

The standard European ETISplus[54] economic model estimates inter-regional HGV flows across TEN-T. ETISplus estimates about 750 million vehicle kilometres in 2019, which is 20% above that estimated by TRACCS[55] for all artic HGVs in Europe during 2018. TRACCS is based primarily on actual vehicle data sources, so absolute traffic volumes from ETISplus have been factored down to match TRACCS.

ETISplus origin-destination pairs allow the modelling of both overall journey length and likely rest break stopping locations. We assume all journeys are out-and-back with a home depot at the start of one end of that round-trip sequence. In practice depots tend to cluster close to logistics hubs, which means the distinction between the start location of the vehicle and the start location of its haul represents a small error for long-haul trucking. Certain styles of operation, notably "tramping", may not return directly home, for which a small uplift has been applied within the "remote overnight" calculations. We can then sum the type and number of future stops to charge from journey length. For example, a single outbound journey of under 290 km can return to its home depot "overnight" (start/end of duty). As modelled, if over 145 km is assumed to need to remote charge during the "daytime" (mid-duty), mostly likely at or near the destination of the journey.

Artic HGV destinations tend to cluster geographically, so we can expect high-powered chargers, suitable for daytime rapid charging, to be available at or near the destination of most hauls. Analysis of the least frequented category of local HGV stop clusters in the ACEA/Fraunhofer[56] HGV stop data, suggests an average of about 10 HGV stops per day at such clusters. That is potentially too little local activity to justify investment in high-power rapid charging equipment, and such hauls may need to seek charging elsewhere. Stops to charge that would naturally occur at these "minor" destinations therefore have the potential to divert to MSA charging.

The graph below shows the resulting distribution of artic HGV stops by charging circumstance long term. These findings closely mirror estimates by Scania[57] of 55-60% of charging at depot, 15-20% at destination, and 20-30% en route.

[54] https://data.mendeley.com/datasets/py2zkrb65h/1 - routes over 3000 km were excluded
[55] https://traccs.emisia.com/
[56] https://isi.pages.fraunhofer.de/acea_truck_stops/
[57] https://www.scania.com/group/en/home/electrification/e-mobility-hub/truck-charging-3-crucial-elements-you-need-to-know.html for regional and long haul

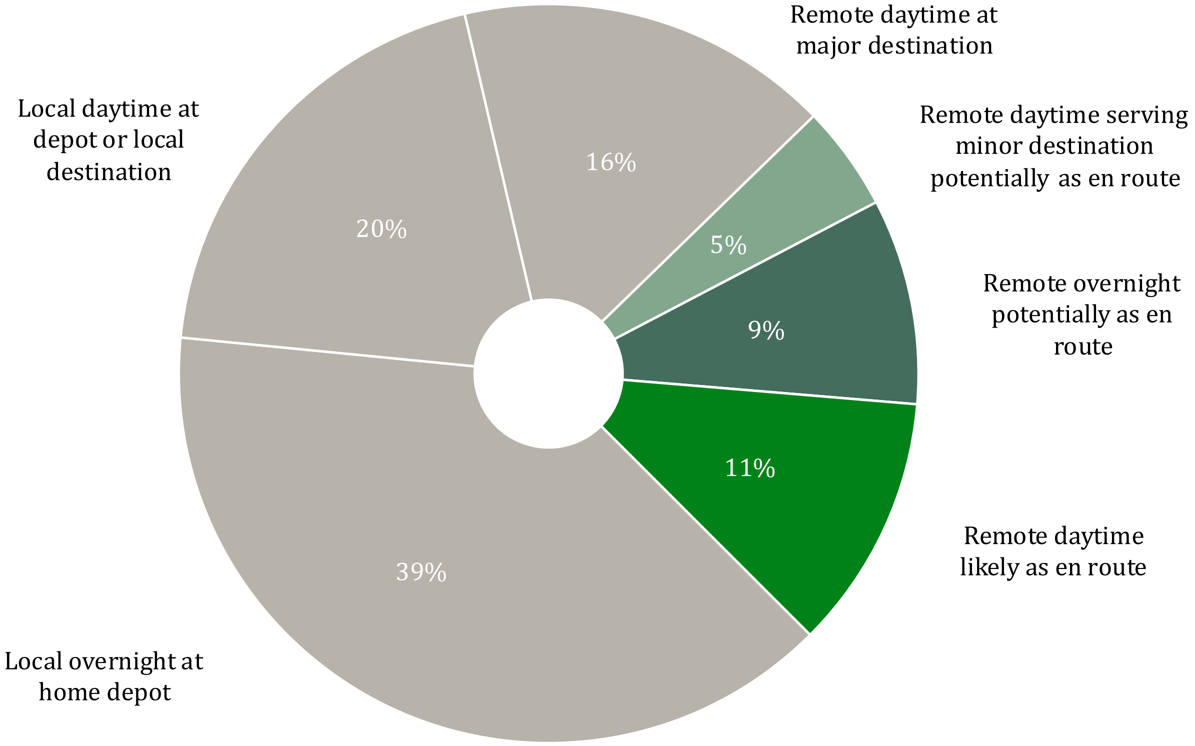


FIGURE 3-8 – EUROPEAN DISTRIBUTION OF FUTURE ARTIC HGV STOPS TO CHARGE MODELLED BY ERM (GREY SEGMENTS ARE NOT FUTURE MSA DEMANDS, GREEN SEGMENTS ARE POTENTIAL MSA DEMANDS DEPENDING ON SCENARIO)

The addition of coach charging demand in this distribution and in the overall HDV charging demand is discussed in the next section.

3.3.3 FUTURE LUXEMBOURG MSA HDV CHARGING DEMAND

The ACEA/Fraunhofer study[58] reported 0.4% of all European[59] (non-local/depot) HGV stopping activity to be in Luxembourg. ERM's ETISplus-based modelling located 0.41% of all comparable en route stops to be in Luxembourg. Both proportions are the same, so it is reasonable to apply European patterns direct to Luxembourg as 0.4% of totals. This 0.4% compares to about 0.1% of all TEN-T route distance within Luxembourg, however CEDR analysis[60] confirms HGV traffic volumes on Luxembourg's TEN-T routes to be far higher than most European countries.

The uptake of BEV HDVs over time has been modelled from EU CO_2 performance standard regulations[61], which will have the effect of forcing OEMs to sell artic BEVs into the regional and long-haul markets, with half of new sales expected to be BEV by 2033. Longer-haul HDVs operating in the countries surrounding Luxembourg have more rapid replacement cycle than HDVs in general. This means that we expect most such HDVs to adopt battery electric traction between 2030 and 2040. Sales and fleet projections are shown in Appendix D. The total volume

58 https://www.isi.fraunhofer.de/content/dam/isi/dokumente/cce/2021/ACEA_truckstop_report_update.pdf
59 European Union, plus United Kingdom, Switzerland and Norway
60 https://www.cedr.eu/download/Publications/2020/CEDR-Technical-Report-2020-01-TEN-T-2019-Performance-Report.pdf
61 https://climate.ec.europa.eu/eu-action/transport/road-transport-reducing-co2-emissions-vehicles/reducing-co2-emissions-heavy-duty-vehicles_en

of longer-haul artic HGVs is assumed consistent into the future, reflecting trends in the 2010s for HGV traffic on TEN-T routes[62]. Our HGV modelling reflects patterns across Europe, but logically the deployment of BEV artic HGVs will tend to skew to those routes and areas where supporting charging infrastructure is established sooner. Luxembourg's infrastructure strategy can therefore have some influence on the rate at which demand emerges at Luxembourg MSAs, especially in conjunction with, or relation to, near neighbours.

TRACCS data for northwest Europe[63] suggests the coach-bodied vehicle fleet is equivalent to 14% of the same region's total artic HGV fleet. Modern coach markets tend to be less long-haul than artic HGVs because aviation is more competitive for passengers, hence we reference a more local geographic area. Like artic HGVs, vehicle type only approximates to use, with coach vehicles performing a mix of longer distance and more local roles. 14% has been added to the modelled "HGV remote daytime enroute" charging demand to account for future coach charging demand. Luxembourg's MSAs are assumed to serve only enroute coach stops, as the sites do not provide hotel accommodation for overnight passengers, and coach destinations tend to be urban or tourist-orientated, both of which can be expected to provide coach charging long-term. Coach flows may vary substantially from HGVs in parts of Europe with strong tourist activity, however the area around Luxembourg is not strongly influenced by tourism, and instead echoes the underlying patterns of geospatial economic activity that influences trucking. BEV coach technology currently lags slightly behind HGVs.[64] However, the same EU CO_2 regulations and tendency to deploy young vehicles apply to both vehicle types, so there is no basis for assuming different vehicle uptake projections.

The resulting pattern of future HDV stops to charge, across all Luxembourg MSAs, is shown in the graph below for each of the three demand scenarios. The low scenario eventually attains a similar magnitude to current demand for HDV fuelling. This suggests there is potential to grow current MSA HDV traffic volumes over the transition, with no natural tendency for the current market volume to decline further in the long term.

---

[62] https://www.cedr.eu/download/Publications/2020/CEDR-Technical-Report-2020-01-TEN-T-2019-Performance-Report.pdf
[63] Defined as Belgium, France, Germany, Luxembourg and the Netherlands
[64] For example, Yutong's GTe14, one of the first models designed for touring duties, only entered European markets in 2024, while even in China diesel still dominates new coach sales (Figure 3.1, https://theicct.org/wp-content/uploads/2024/11/ID-247-%E2%80%93-China-ZEMHDVs_spotlight_final-1.pdf)

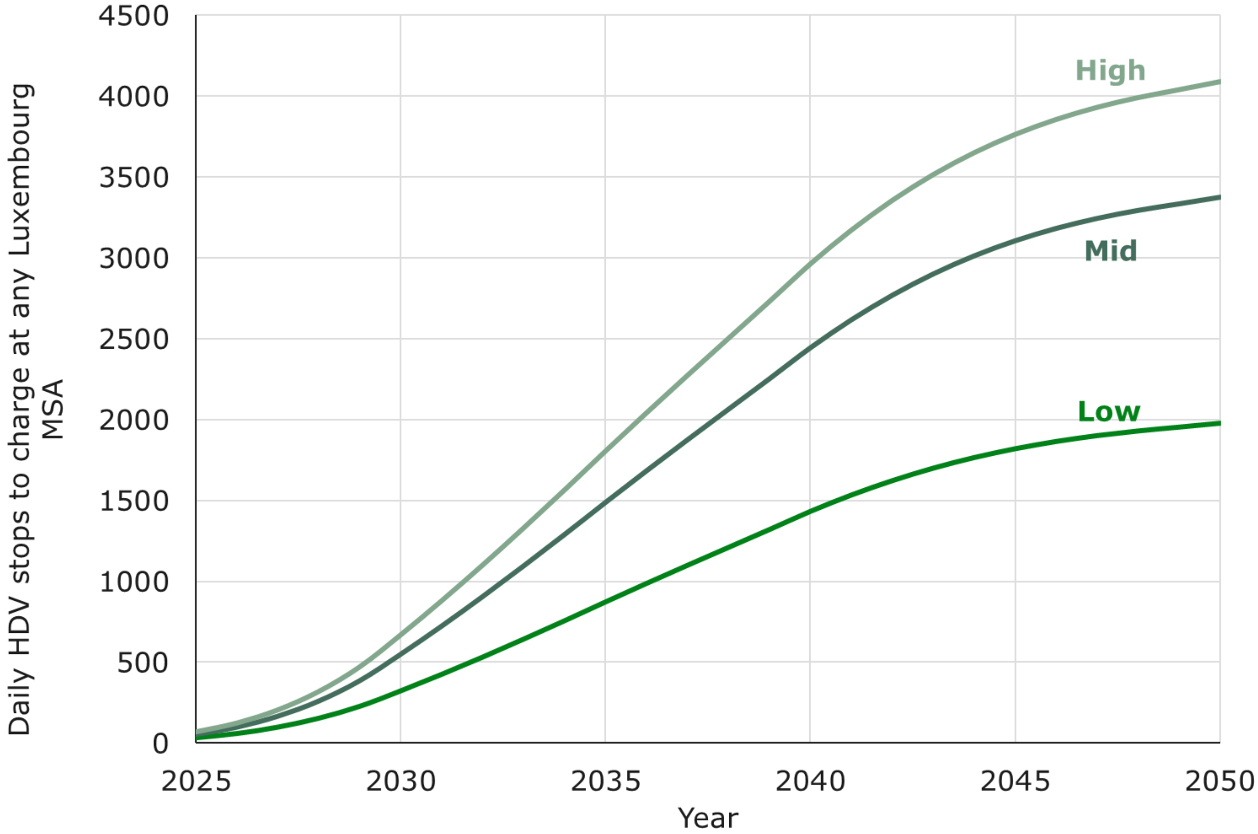


FIGURE 3-9 – MODELLED DAILY HDV STOPS TO CHARGE AT ANY LUXEMBOURG MSA FOR EACH SCENARIO OVER TIME

The demand shown above may be assumed to be distributed across the 8 current MSA sites. However:

- TEN-T based traffic flows cannot be strictly applied to the non-TEN-T Pontpierre pair.
- In practice some MSA sites may be electrified earlier than others.
- Land constraints may mean additional sites are required, especially to exploit overnight charging opportunities.

The ultimate distribution, per one-direct single site shown in the table below, should thus be read as only indicative of the demand a typical site might be designed to serve. The table additionally shows approximate corresponding energy demand (assuming HDVs average 1.1 kWh/km) and MegaWatt chargers (assuming 10 daily uses per charger, where overnight stops are assumed not to occupy the charger overnight, but park nearby after rapidly charging). Even in the low scenario, the grid implications of connecting so many high-powered chargers are significant and may force the development of alternative sites in practice to distribute the demand geographically. Coach represents between 12% (low scenario) and 6% (high scenario) of all modelled HDV MWh charging demand.

TABLE 3-2 – LONG TERM LUXEMBOURG MSA HDV CHARGING DEMANDS BY SCENARIO (2050, FIGURES AS MODELLED)

Metric by scenario	Low	Mid	High
Daily stops to HDV charge			
Total of Luxembourg MSAs	1995	3405	4126
Single site on TEN-T	296	505	612
Single Pontpierre site	110	187	227
Daily MWh to charge HDVs[65]			
Total of Luxembourg MSAs	636	1086	1316
Single site on TEN-T	94	161	195
Single Pontpierre site	35	60	72
Number of MegaWatt chargers			
Total of Luxembourg MSAs	199	340	413
Single site on TEN-T	30	51	61
Single Pontpierre site	11	19	23

3.4 FUTURE LDV DEMAND

3.4.1 METHOD FOR LDV CHARGING DEMAND PROJECTION

Per-site electricity demand for LDV charging has been used to assess the required charging infrastructure at MSAs in the future. A combination of top-down and bottom-up approaches is used to determine and project total and per-site demand. The top-down approach takes traffic in Luxembourg as a whole and apportions this into EV traffic and the associated charging demand at all Luxembourgish MSAs. The bottom-up approach takes current fuel sales and converts this into equivalent charging demand per MSA, and how this evolves from today to 2050. Using the bottom-up approach alone to calculate and project future charging demand would likely produce inflated forecasts, as Luxembourg's historic fuel price advantage over its neighbours mean that fuel sales have previously been comparatively high – this trend is unlikely to be replicated in the EV charging market. Provision of facilities (shops, restaurants, etc.) which might attract additional customers and increase charging sales is addressed in section 6.8. The combined approach takes current fuel demand to attribute a portion of total charging demand (calculated from the top-down approach) to each site. This method accounts for the demand differences at each site, while preserving the whole-country approach. Figure 3-10 illustrates the constituent data points[66] of these approaches. Competition for charging demand is addressed in section 3.5.3.

[65] As only energy used by trucks, excluding charger or distribution inefficiencies. Charger and distribution inefficiencies accounted for in the sizing done in Chapter 4, when relevant.
[66] See Appendix E for full list of sources.

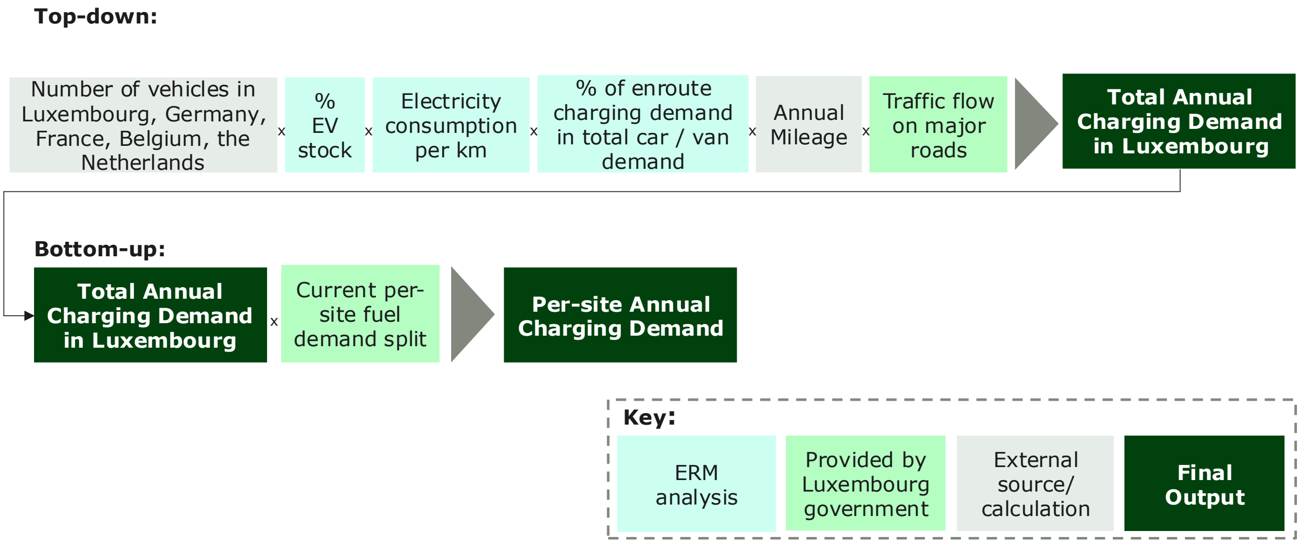


FIGURE 3-10 – ILLUSTRATION OF FUTURE DEMAND MODELLING APPROACH

3.4.1.1 CHARGING DEMAND GROWTH

Future demand for charging in Luxembourg is a function of the uptake of electric vehicles, of the growth in the number of vehicles in North-West Europe (i.e. Luxembourg, Germany, Belgium, France, Netherlands), amongst other factors. The main assumptions and steps are:

- Electricity consumption is predicted to decrease for cars, from 0.17 kWh/km in 2020 to 0.16 kWh/km from 2040 onwards. Electricity consumption for electric vans is assumed to be 0.30 kWh/km. These consumptions factors are applied to the whole annual mileage of the vehicles, so considering their different driving types (urban, motorways, etc.).
- The annual growth rate of the number of cars and vans driving in North-West European countries is taken to be 0.2%[67] and 1%[68], respectively. Figure 3-11 illustrates how the proportion of total cars that are electric is predicted to change over time, based on modelling by ERM of the impact of EU CO_2 performance standards on BEV sales share over time in North-West European countries. Significant growth in the EV market is projected between 2025 and 2045, with nearly 100% of cars on the road being electric by 2050. A similar analysis is done for vans, with 13% of the total stock of vans predicted to be electric in 2030, and 61% in 2040.
- Combined with the electricity consumption of vehicles, the annual mileage[69] enables to estimate the total charging demand of the stock of these vehicles in North-West European countries.
- The proportion of en route charging demand in total car and van charging demand is detailed next (in section 3.4.1.2).
- The total en route charging demand from the North-West Europe vehicle stock captured by Luxembourg is then calculated based on the traffic flow and length of the Luxembourg road Trans-European Transport Network (TEN-T - roads). Luxembourg has 90 km of TEN-T road network, compared to ca. 24,000 km in Luxembourg, Germany, France, Belgium

[67] https://www.statista.com/statistics/452449/european-countries-number-of-registered-passenger-cars/
[68] https://alternative-fuels-observatory.ec.europa.eu/transport-mode/road/
[69] Data from European Commission, New Mobility Patterns Study: insights into passenger mobility and urban logistics

and the Netherlands combined[70], so it is assumed that the Luxembourg MSAs captures ca. 0.5% of the total en route charging demand of cars and vans in North-West European countries

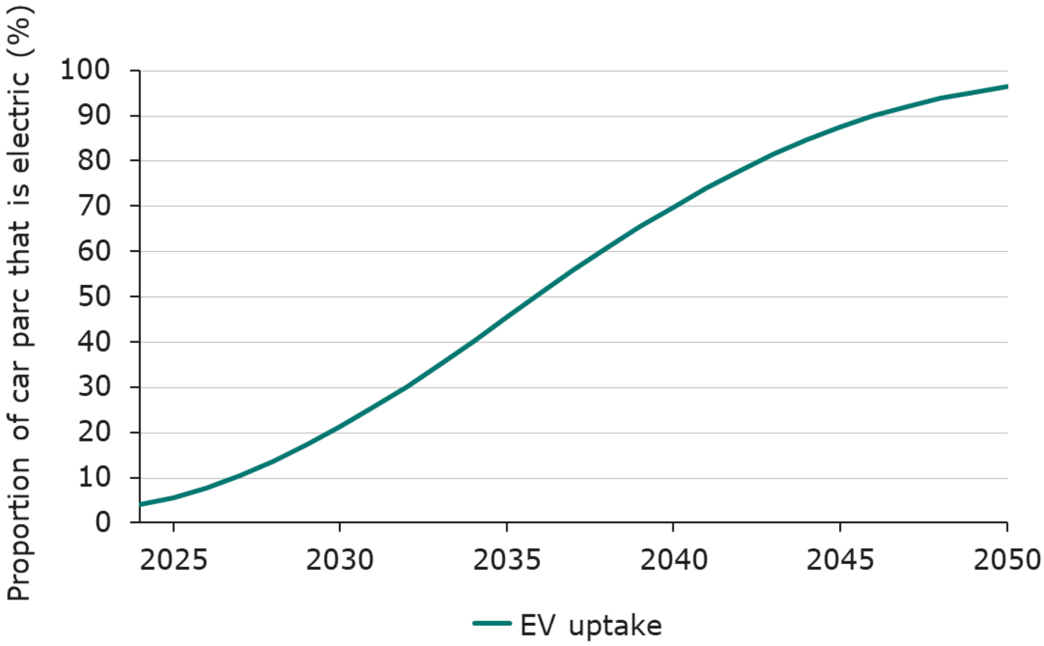


FIGURE 3-11 – MODELLED UPTAKE OF ELECTRIC CARS IN LUXEMBOURG, GERMANY, BELGIUM, FRANCE, NETHERLANDS BASED ON ERM ANALYSIS

3.4.1.2 SCENARIO ANALYSIS OF CHARGING DEMAND

As a result of uncertainty in the magnitude of future charging demand at MSAs, ERM have run three scenarios which vary the amount of en route charging as a proportion of total LDV charging for drivers in Luxembourg and neighbouring countries. The need for en route charging for LDVs depends on various factors, including:

- Access to off-street parking. LDV drivers with access to off-street parking are much more likely than others to use home charging, which reduce their needs for public charging, including en route charging on MSAs.
- Operation of the vehicles. Drivers with high daily mileage, for example long-distance travellers or commercial vehicles (e.g. freight transport in vans), will usually require a top-up charge during the day at an en route charging station, for example at an MSA.

High quality data concerning the rate of traffic stopping at MSAs is not freely available and data collection in this respect is suggested as an addition to concession contracts later in this report. As a result, demand for charging at MSAs has been estimated based on a number of assumptions, and a range of possibilities for demand outcomes is presented. Passing car traffic has been partitioned into short-medium distance and long distance drivers, and drivers with or without home charging (see Table 3-3). The population of vehicles has been apportioned into these categories and assigned a rate of en route charging based on these characteristics.

[70] Conference of European Directors of Roads, TEN-T (Roads): 2019 Performance Report

TABLE 3-3 – ASSUMPTION ON PROPORTION OF CHARGING SATISFIED EN ROUTE FOR DIFFERENT CAR DRIVER TYPES, BASED ON THE KWH CHARGED ANNUALLY

	Proportion of annual car charging demand that is satisfied en route	
Driver types	With home charging	Without home charging
Short-medium distance drivers	5%	10%
Long distance drivers	10%	

As shown in Table 3-3, 5% of the total yearly charging demand of short-medium distance car drivers with off street parking is assumed to be en-route, while 10% of the total yearly charging demand for short-medium distance drivers without off street parking and long distance drivers is assumed to be en route: this is based on the analysis of typical charging behaviours[71]. The proportion of en route charging demand for all the cars is then estimated using the scenario assumptions, described next.

The scenarios are created based on the minimum, central, and maximum reasonable expectations of en route charging needs for LDVs using motorways in Luxembourg. The variable in the scenario analysis is based on the proportion of each type of traffic passing the MSA (see Table 3-4). They are based on an analysis of different sources for various European countries[71]. The scenarios are described below:

> ***Low:*** only drivers with access to home charging (and also depot charging for vans) and driving short to medium distances during the day which rarely require en route charging are driving past the MSAs. This includes commuters based in Luxembourg or in neighbouring countries driving to Luxembourg for work. Previous research shows that only ca. 5% of the total charging demand from these cars will be en route, and 10% for vans. This scenario is the lower boundary in terms of total charging demand at the MSAs.
>
> ***Mid:*** drivers with access to home charging (and also depot charging for vans) and driving short to medium distances during the day represent half of the passing traffic: they will need only a small proportion of en route charging, as described in the Low scenario. The rest of the drivers are either driving short to medium distance but do not have access to home charging so will need public charging, which can be en route or at destination (including workplace), or are driving long-distance (e.g. business cars) so are more likely to require a top-up charge during their journey or at destination / workplace.
>
> ***High****:* this scenario represents an upper boundary in terms of total charging demand at the MSAs. It assumes that only a quarter of passing traffic are short to medium distance travellers with off-street parking. Similarly to the Mid scenario, the remaining drivers are either driving short to medium distances but without off-street parking, or are driving

[71] ERM analysis of car charging behaviour based on data from ICCT reports and internal modelling: Regional charging infrastructure requirements in Germany through 2030, Charging infrastructure to support the electric mobility transition in France, and ERM analysis of van charging behaviour adapted from Analysis to identify the EV charging requirement for vans (Element Energy) - Climate Change Committee

long distance and are more likely to need access to charging en route to their destination than short distance travellers with access to home charging.

TABLE 3-4 – PROPORTION OF TOTAL CAR DRIVERS IN EACH CATEGORY

Driver types	Low scenario	Mid scenario	High scenario
Short-medium distance drivers – with home charging	100%	50%	25%
Short-medium distance drivers – without home charging	0%	17%	25%
Long distance drivers	0%	33%	50%

Table 3-5 lists the values used in each scenario for the en route charging parameter, based on the analysis described above. It shows that vans usually have 2-4 times more demand coming from en route charging, due to their specific characteristics, which include: longer daily mileage (commercial activities) than most cars, higher kWh/km, need for rapid charging during the day during shifts to avoid long stops. The weighted average is based on the fact that vans constitute ca. 7 - 16% of the total LDV stock in the analysed countries[72].

TABLE 3-5 – SCENARIOS USED TO ADDRESS DEMAND UNCERTAINTY FOR CAR AND VAN CHARGING DEMAND[72]

Scenario	Proportion of en route charging in total charging demand of the vehicles driving by the MSAs		
	Cars	**Vans**	**Weighted Average**
Mid	7.5%	25%	9.1%
High	8.8%	40%	11.7%
Low	5.0%	10%	5.5%

These scenarios are then applied to the increase in EV presence on the road as outlined in Figure 3-11 to generate the charging demand over time from 2024 to 2050, for the whole of Luxembourg and then for each MSA based on current per-site fuel demand.

The results of the demand analysis have been compared with real-world charging demand data from 2024 at each of the sites with SuperChargy charge points installed. The data for 2024 lies between the Low and Mid scenario results, demonstrating that the projections are within an appropriate margin of error based on the data available.

[72] Weighted average based on an analysis of total stock of cars & vans in Luxembourg, Germany, France, Belgium, Netherlands, data from Vehicles and fleet | European Alternative Fuels Observatory

For diesel and petrol demand in Luxembourg and at each of the MSAs, the same approach is used: while the share of electric cars and vans passing by the MSAs in Luxembourg is expected to grow, the share of petrol and diesel vehicles will decrease. This change in vehicle typology is then converted into diesel and petrol demand at the Luxembourg MSA, using the demand of 2023 as a starting point. For example, in 2035, it is projected that the stock of petrol / diesel[73] LDVs in North-West European countries will be 45% lower than in 2023. The total demand of petrol and diesel in 2035 for LDVs is then forecasted to be 45% lower than the demand observed in 2023 at the MSAs.

3.4.2 RESULTS OF CHARGING DEMAND ANALYSIS

The results of the charging demand analysis, projected to 2050, are illustrated in Figure 3-12, which shows the total GWh of electricity per year required across all eight Luxembourgish MSAs to meet LDV charging demand.

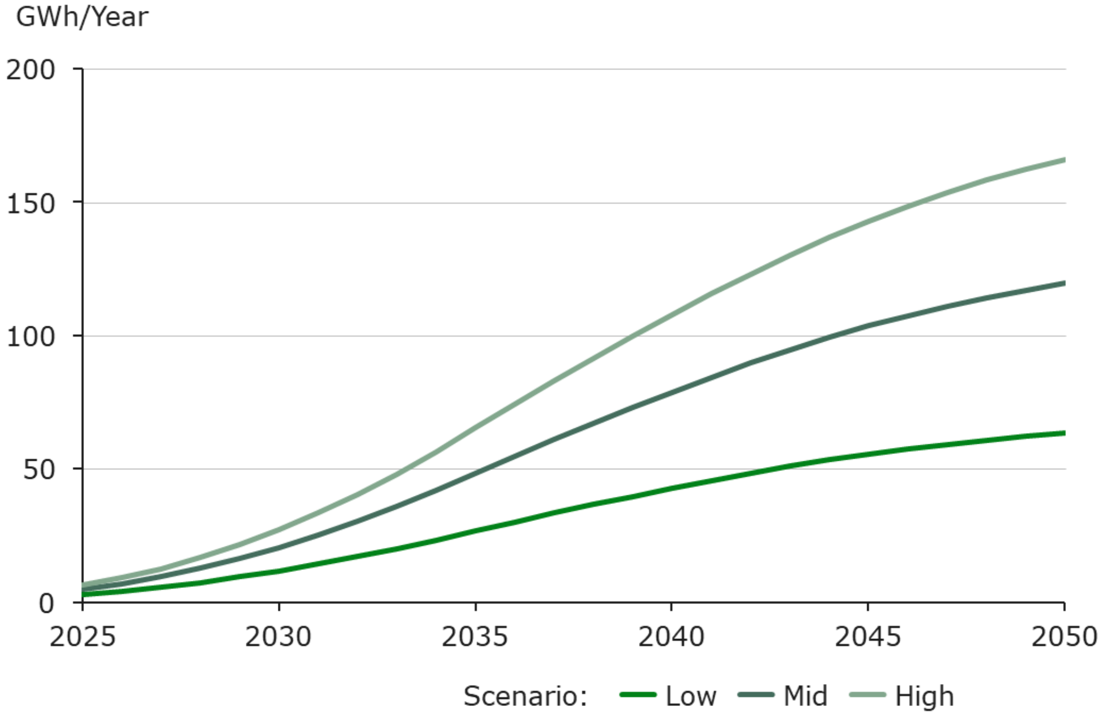


FIGURE 3-12 – RESULTS OF THE THREE SCENARIOS FOR TOTAL CHARGING DEMAND FOR CARS AND VANS ACROSS ALL MSAS IN LUXEMBOURG

The results of this analysis, summarised for 2050 in Table , demonstrate that considerable growth in charging demand is predicted between 2030 and 2045. 2050 is used at the reference year as this is when the vast majority of the transition to EVs is predicted to be completed (>96%, see Figure 3-11) and therefore most growth beyond this year will come from vehicle population growth, which is generally a shallower and more predictable change. This translates to between 325 and 855 total LDV charge points to be installed across the eight MSA sites, with between 50 and 135 required at an MSA along the TEN-T network. Similarly, at either of the Pontpierre sites, between 10 and 25 LDV charge points are expected to be required to satisfy car and vans charging demand by 2050.

[73] This includes hybrid vehicles and plug-in hybrid vehicles, which will typically not use rapid charging at MSAs.

TABLE 3-6 – LONG TERM LUXEMBOURG MSA CAR AND VAN CHARGING DEMANDS BY SCENARIO (2050)

Metric by Scenario	Low	Mid	High
Daily MWh to charge LDVs[74]			
Total of Luxembourg MSAs	173	327	455
Single site on TEN-T (per site)	27	52	72
Single Pontpierre site (per site)	5	9	13
Number of LDV charge points			
Total of Luxembourg MSAs	327	618	857
Single site on TEN-T (per site)	52	97	135
Single Pontpierre site (per site)	9	17	24

Based on the daily demand at each MSA as shown in Table 3-6, on an average day in 2030 charge points will be plugged into an EV for 4.2 hours per day. This is predicted to drop to 3.8 hours per day by 2035 due to the increase in the average real power draw that LDVs will be able to take from charge points (from ca. 138kW in 2030 to 150kW in 2035)[75]. These assumptions were based on typical utilisation forecast for high power charging on motorways.

On high demand days during the summer, this number of hours a charge point is in use is expected to double based on historic demand profiles (see Figure 3-5). The analysis in section 3.1.3 shows that on the highest demand day charging demand could reach ca. 3 times average daily charging demand – this is assumed to remain constant with time. From 2035, this would represent ca. 12 hours per day that a charge point is plugged into an EV on the highest-demand day: today, charging is seen to be spread across approximately 12 hours of the day (see Appendix C). This suggests that, under the projected MWh and number of charge points, MSAs would be able to meet charging demand for more than 97% of the year (see Table 3-1) from 2035.

This presents an important aspect of assessing charging demand projection for the MSAs of the future: in order to cater for both seasonal and intra-day demand peaks, infrastructure will not be fully utilised most of the year. The impact of peak demand is further discussed later in the report (sections 4.1, 5.2, and 6.8).

3.5 IMPACT OF AFIR

To increase the number of alternative refuelling stations for LDVs and HDVs in key locations such as highways, logistics centres, depots, and urban areas, the Alternative Fuel Infrastructure Regulation (AFIR) has put in place a set of infrastructure requirements deployment rules at the European level[76], with the legal obligation being placed on Member States. These rules put minimum requirements for the deployment of electric and hydrogen refuelling infrastructure

[74] As only energy used by LDVs, excluding charger or distribution inefficiencies
[75] ERM modelling of existing and future EV charging power capabilities
[76] Regulation (EU) 2023/… of the European Parliament and of the Council of 13 September 2023 on the deployment of alternative fuels infrastructure, and repealing Directive 2014/94/EU

along the TEN-T core and comprehensive network[77]. As part of the Luxembourg highway network belongs to the core and comprehensive TEN–T network[78], these minimum deployments rules have an impact on the required infrastructure deployments at existing MSA sites.

3.5.1 REGULATED REQUIREMENTS FOR THE COVERAGE OF THE TEN-T NETWORK

The rules in place and that might impact Luxembourg are summarised in the paragraphs below:

Electric infrastructure

For light-duty vehicles:

By 31 December 2027, along the TEN-T core road network, publicly accessible recharging pools dedicated to light-duty electric vehicles are deployed "*in each direction of travel with **a maximum distance of 60 km between them**, with each recharging pool offering a power output of at least **600 kW** and including at least **two recharging points with an individual power output of at least 150 kW**."*

For heavy-duty vehicles:

By 31 December 2025, along at least **15% of the length of the TEN-T road network**, publicly accessible recharging pools dedicated to heavy-duty electric vehicles are deployed "*in each direction of travel and that each recharging pool offers a power output of at least **1 400 kW** and includes at least **one recharging point with an individual power output of at least 350 kW**"***.**

By 31 December 2027, along at least **50% of the length of the TEN-T road network**, publicly accessible recharging pools dedicated to heavy-duty electric vehicles are deployed "*in each direction of travel and that each recharging pool offers a power output of at least **2 800 kW** and includes at least **two recharging points with an individual power output of at least 350 kW***".

By 31 December 2030, **along the TEN-T core road network**, publicly accessible recharging pools dedicated to heavy-duty electric vehicles are deployed "*in each direction of travel with a maximum distance of 60 km between them, with each recharging pool offering a power output of at least **3 600 kW** and including at least **two recharging points with an individual power output of at least 350 kW**."*

Hydrogen infrastructure

For hydrogen, publicly accessible hydrogen refuelling stations (HRS) capable of delivering one tonne per day at 700 bar must be deployed with a maximum distance of 200 km in between them along the TEN-T core and the TEN-T comprehensive network and **at least one must be available in every urban node**[79]. AFIR allows HRS at such nodes to be used to satisfy the TEN-T "per 200 km" requirement.

---

[77] Along the TEN – T core/comprehensive network means the infrastructure should located on the TEN-T road network or within 3 km driving distance from the nearest exit of a TEN-T road

[78] Motorways A1, A3 and A6 are part of the core network. Parts of the A13 are part of the comprehensive network. Source: TENtec Map Viewers - Explore the TEN-T Network | European Transport Infrastructure

[79] Defined by https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32013R1315 but broadly a city that functions as a logistics hub.

3.5.2 MEETING THE REGULATION COVERAGE TARGETS

Electric infrastructure

The table below highlights the selected infrastructure deployment locations for Luxembourg's Motorway Service Areas. These specific locations were chosen to meet the AFIR requirements, which mandate infrastructure deployment every 60 km in each direction of travel.

The selected MSAs below (Capellen, Berchem, Wasserbillig, all in both directions) ensure comprehensive coverage of Luxembourg's core TEN-T network in both directions of travel.

While this configuration serves as an illustrative example, alternative infrastructure deployments are feasible, featuring installations along the TEN-T network independent of MSA locations, provided they comply with AFIR's 60-kilometer spacing requirements.

By 2030, Member States will also have to ensure this maximum distance of 60 km in the AFIR regulation is not exceeded for cross-border sections of the TEN-T network. Looking at Luxembourg specific geographic position, the following areas, given as an illustrative example (other configurations are possible), could develop charging pools meeting the criteria's listed in the paragraph above to meet this regulation:

- **Thionville, France,** for the cross–border section between the Berchem MSAs and France, on the A3 motorway
- **Arlon, Belgium**, for the cross–border section between the Capellen MSAs and Belgium on the A6 motorway
- **Wittlich, Germany**, for the cross–border section between the Wasserbillig MSAs and Germany on the A1 motorway

TABLE 3-7 – INFRASTRUCTURE DEPLOYMENT REQUIRED IN 2027 (LDVS) AND 2030 (HDVS) BY AFIR AT MSA LOCATIONS ON THE TEN-T NETWORK

MSA site	Current infrastructure	Deployment for electric LDVs	Deployment for electric HDVs[80]
Capellen Belgium	12 x 475 kW CCS connectors (dedicated to LDVs[81])	2027 AFIR targets respected	• Power capacity respected • Need for HDV dedicated infrastructure
Capellen Luxembourg	6 x 475 kW CCS connectors (dedicated to LDVs)	2027 AFIR targets respected	• Minimum 1,350 kW of additional power required • Need for HDV dedicated infrastructure

[80] Meeting AFIR requirements is not conditional on these specific sites necessarily deploying heavy-duty vehicles dedicated chargers. The text in red corresponds to a possible AFIR-compliant scenario.
[81] Available bay size is not suitable for HDV charging

Berchem France	6 x 475 kW CCS connectors (dedicated to LDVs)	2027 AFIR targets respected	• Minimum 1,350 kW of additional power required • Need for HDV dedicated infrastructure
Berchem Luxembourg	6 x 475 kW CCS connectors (dedicated to LDVs)	2027 AFIR targets respected	• Minimum 1,350 kW of additional power required • Need for HDV dedicated infrastructure
Wasserbillig Luxembourg	6 x 475 kW connectors (dedicated to LDVs)	2027 AFIR targets respected	• *Power capacity respected* • *Need for HDV dedicated infrastructure**
Wasserbillig Germany	No charging points	*2027 AFIR targets respected**	• *Power capacity respected* • *Need for HDV dedicated infrastructure**

** AFIR targets are fulfilled thanks to the COPAL Belle Boutique S.A. charging site close to Wasserbillig, featuring 8 x 400 kW and 8 x 300 kW connectors*

The selected MSA sites comply with AFIR's 60-kilometer spacing requirements along the TEN-T network in both directions for light-duty vehicle charging infrastructure. While current electrical charging facilities on the TEN-T network exclusively serve light-duty vehicles, these locations must be upgraded by 2030 to accommodate heavy-duty vehicles through enhanced charging capacity and specialised infrastructure. First deployments to meet the AFIR HDV objectives in 2025 and 2027 could take place at the busiest MSAs for HDV refuelling at the moment, such as the Berchem MSAs.

Hydrogen infrastructure

Based on an analysis of Luxembourg's TEN-T length and AFIR spatial requirements for hydrogen infrastructure (which mandate deployment every 200 km), ERM's interpretation is that no hydrogen refuelling stations are strictly required at the identified MSA sites in Luxembourg[82].

Luxembourg as a capital is however understood to be an urban node, with Arlon, Metz and Trier the nearest surrounding nodes[83]. Luxembourg is thus obligated to provide an HRS for the city, most rationally sited to serve logistics hubs in the south-east and thus potentially sited sufficiently close to the TEN-T network to serve it. The HRS at Bettembourg, opened in January

[82] This is an interpretation and not a legal review.
[83] As indicated by EU Transport Corridor mapping: https://transport.ec.europa.eu/document/download/ff77d210-e40a-4765-805f-ac88e3aba460_en?filename=TEN-T-revision-2023-annex-3.pdf

2025, fits this role. That might avoid any legal dispute with the European Commission or request to contribute to 95% of an HRS in a neighbouring country in lieu, regardless of the minimal demand for hydrogen anticipated in our modelling.

However, Luxembourg's current regulation preventing HDVs transiting Luxembourg from leaving strategic roads may prevent such an "urban node HRS" from being accessed by any TEN-T hydrogen HDV traffic. Hydrogen, as a road fuel, scales poorly down to low daily volumes[84]: refuelling equipment is relatively expensive in comparison to chargers, hydrogen safety concerns have to be managed at each location, and overall fuel supply becomes less efficient, especially when using on-site electrolysers. It is therefore sensible to maximise what is expected to be a niche demand around the fewest number of HRS sites. A regulatory solution that allows HDV in transit access to the Bettembourg HRS from the motorway might be considered a more pragmatic approach. More generally, exemptions to allow hydrogen and battery-electric HDVs in transit to leave the motorway to recharge or refuel (so they could benefit from infrastructure outside of the TEN-T) should be considered.

3.5.3 CHARGING INFRASTRUCTURE IN OTHER COUNTRIES NEAR LUXEMBOURG

In order to assess the potential impact of AFIR legislation on Luxembourgish MSA's competitiveness in the charging market, a 75-km area (i.e., roughly an hour's drive, to account for the range of time in which drivers may be willing to stop to use another recharging station) around Luxembourg's border is investigated. This frame of study is illustrated in Figure 3-13 and covers car and van charging, as high-power HDV charging is not a mature market today. The charge points shown below are those within 3km of the TEN-T network.

[84] Typically, under a tonne of hydrogen each day – in the order of less than 25 HGVs refuelling daily, assuming 40 kgH_2 per refill.

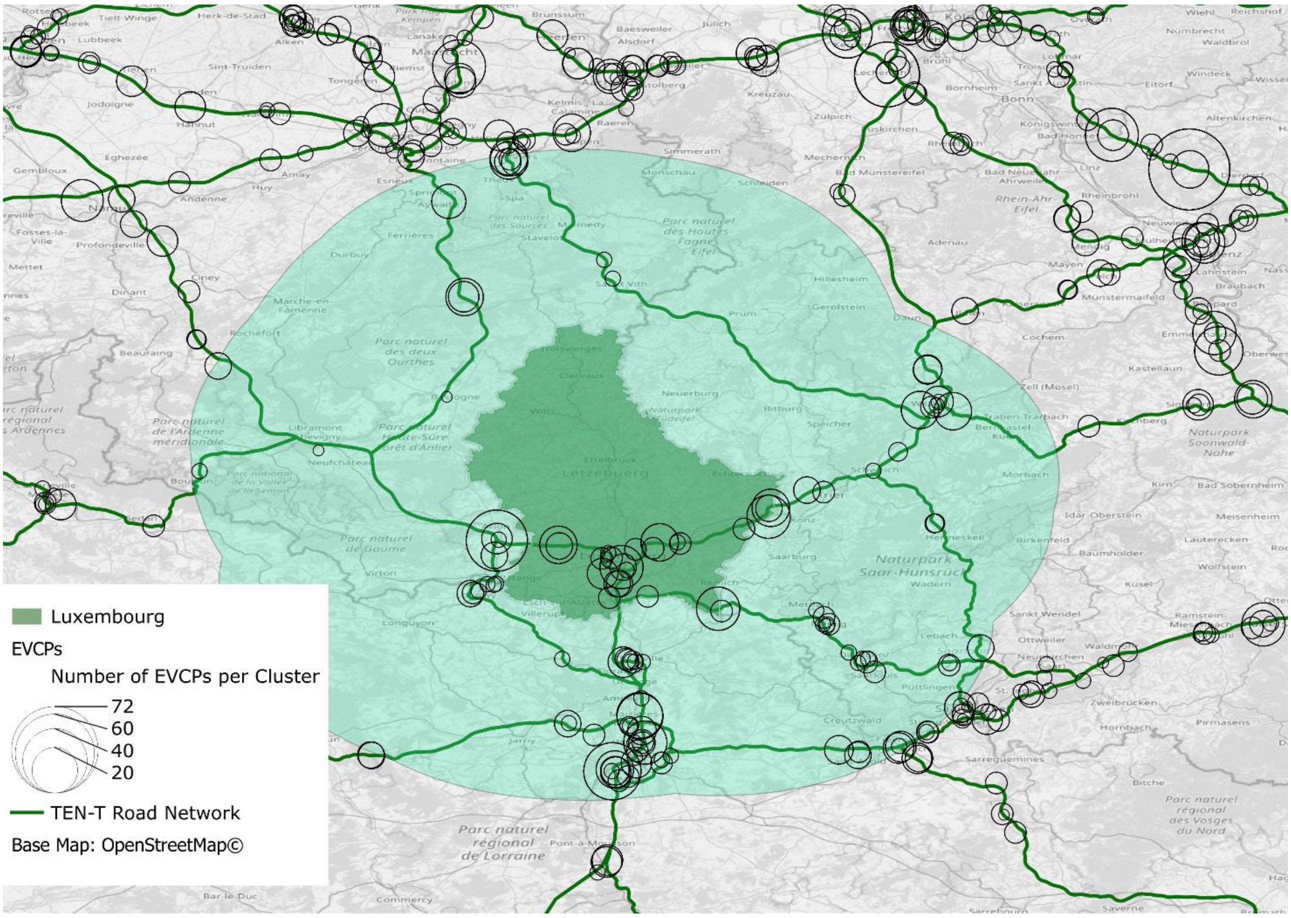


FIGURE 3-13 – MAP SHOWING ALL CHARGE POINTS ABOVE 150 KW WITHIN 3KM OF THE TEN-T NETWORK IN THE VICINITY OF LUXEMBOURG[85]

Figure 3-14 details the number of charge points in Luxembourg and each of its neighbouring countries. Aside from Luxembourg, France has the greatest number of charge points, which can be attributed to the inclusion of Metz, which is located close to the TEN-T network and has significant charging infrastructure. Notably, Northern France besides Metz appears to have sparse provision of charge points. More generally, South and East of Luxembourg (France and Germany) appears to be more developed from an EV charging perspective than the North and West (Belgium).

[85] Extracted from TEN-Tec interactive map viewer. Please note that EVCP rollout is occurring rapidly, and this extract was accessed in January 2025. Therefore, additional EVCPs may have been added since this analysis was performed.

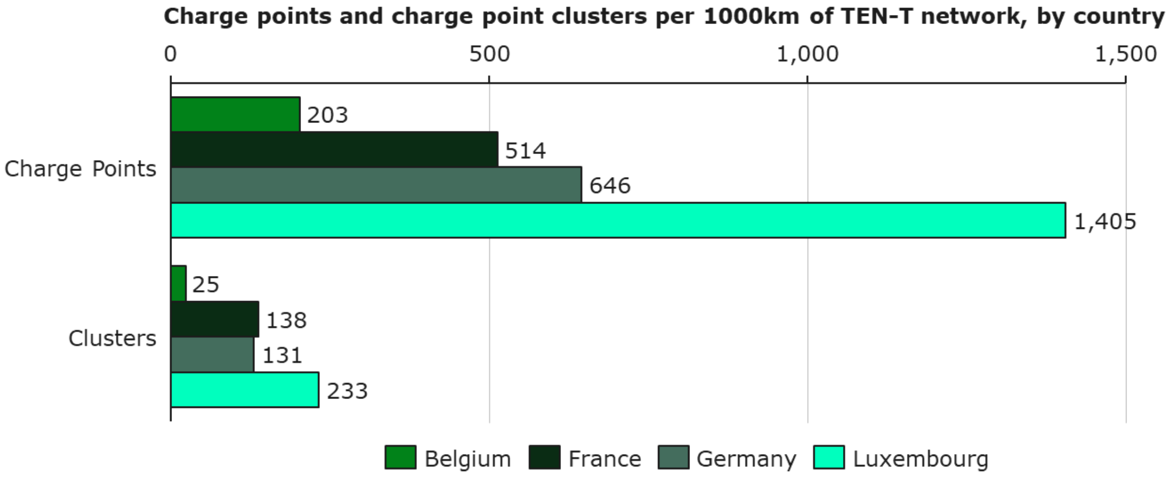


FIGURE 3-14 – NUMBER OF CHARGE POINTS AND CLUSTERS PER 1,000 KM OF ONE-DIRECTION TEN-T NETWORK WITHIN 75 KM OF LUXEMBOURG'S BORDER, BY COUNTRY[85]

Luxembourg has more than twice as many charge points per 1000km of TEN-T network than its nearest competitor, France, as shown in Figure 3-14. The graph also demonstrates that Germany and France have between two and three times more charge points than Belgium (in their respective areas within 75 km of Luxembourg). France has the most charge points "clusters" (i.e., sites with more than one charge point within 200 m), with approximately twice as many as Germany and more than seven times as many as Belgium. This highlights the low frequency of charging clusters in Belgium meaning drivers would have to travel further to get to the next cluster in Belgium than they would in France. As a result, Luxembourg faces relatively less competition for charging from Belgium as the main clusters are close to the border with Luxembourg and customers can be driven by cost and the quality of the facilities to a greater extent.

In total, Luxembourg has over 160 charge points[85] installed in 27 clusters, with 51 of these being within the 8 MSAs. The high frequency of charging clusters in Luxembourg means that charge points at Luxembourg's MSAs face significant competition from non-MSA charging sites. Customers have a number of options to choose from to meet their charging needs within 3km of the TEN-T network. MSAs have an advantage in their convenience to the customer: EV drivers are willing to pay around 10% more for charging at MSAs due to added convenience[86]. Although MSAs are convenient, they will likely need to provide similar charging prices to non-MSA charging sites or other attractions (e.g. shops and restaurants) if their charging prices are more than 10% higher than non-MSA charging in order to ensure the utilisation of charge points on their sites.

[86] A new EV survey: What consumers want in charging | McKinsey

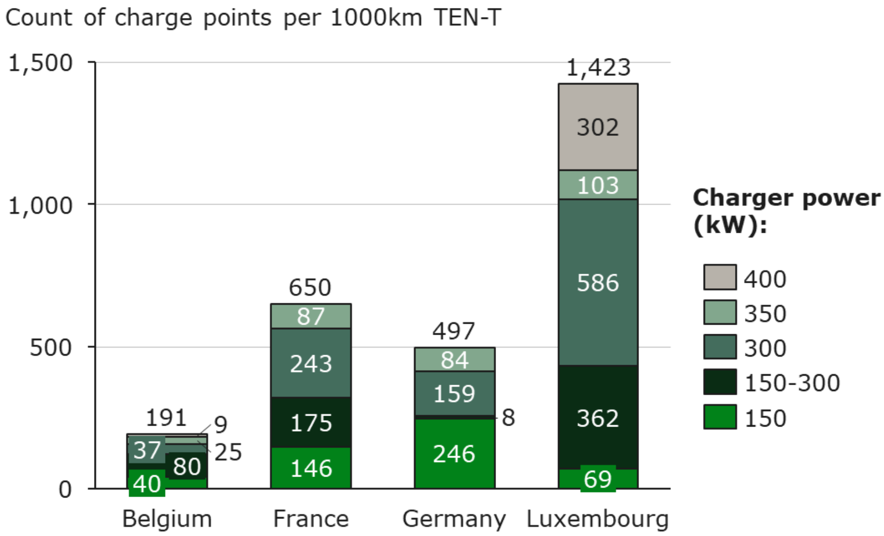


FIGURE 3-15 – DISTRIBUTION OF CHARGER POWER BY COUNTRY WITHIN STUDY AREA (WITHIN 75KM OF LUXEMBOURG'S BORDER, AND WITHIN 3KM OF THE TEN-T NETWORK)[85]

Figure 3-15 shows the power of the charge points (**per 1,000 km TEN-T network**) in Luxembourg and its neighbouring countries within the study area. Germany and France skew towards 300 kW and above, whereas the largest proportion of Belgium's charge points are 150-300 kW. Luxembourg's charge point power distribution skews very high, with a high frequency of 300-400kW chargers compared to its neighbours. This may give Luxembourg an advantage, especially over Belgium in terms of fast charging: customers with limited time may drive slightly further to access a 300-400kW charger in Luxembourg over a closer 150 kW charger in Belgium, France, or Germany.

Despite the relative sparsity of charging clusters in Belgium, there are adequate charging stations to satisfy AFIR. France and Germany already have significant EV infrastructure for LDVs installed. Therefore, increased competition because of chargers installed to meet AFIR is unlikely, although the growth of the charging network Belgium due to its current sparsity is possible.

There are very few installed HDV charging stations as of December 2024. For example, there are none at any of the investigated Luxembourgish MSAs, nor at the MSAs in France and Germany investigated as case studies (see Appendix B), nor in close proximity to Luxembourg in general according to an analysis from June 2024[87]. As shown in section 3.5.2, significant build-out of high-powered HDV charging will be required to meet AFIR. This presents an opportunity for Luxembourg to capitalise on the lack of existing infrastructure and establish itself as a provider of charging for HDVs. The current regulation preventing HDVs in transit to leave the motorway in Luxembourg may have to be further analysed to decide if exemptions should be introduced, to allow battery-electric vehicles to recharge at future recharging infrastructure along the TEN-T and fuel-cell electric vehicles to refuel at HRS along the TEN-T.

[87] Beyond EV Charging #8 - HDV - GIREVE

4. WHAT THE MSAS MAY LOOK LIKE IN FUTURE, AND HOW TO GET THERE

The following section presents the infrastructure changes that would be required within MSAs to meet the demand modelled in section 3, which predicts that over time, fossil fuel demand from Luxembourg MSAs will decrease and EV charging demand will increase. A transformation of the MSAs would be required to ensure they are prepared to deliver this modelled demand[88]. Due to space constraints, detailed below, installing adequate numbers of LDV and HDV charge points in line with demand modelling may require decommissioning of most of the fossil fuel pumps by 2050 at MSA sites, which has associated practical challenges. Grid connection capacities will also likely be highly constrained and would need thorough planning for each MSA to ensure a smooth infrastructure deployment. The impact of these changes on parking provision is also addressed as part of this section.

This section covers the following subjects:

- **The implications of space constraints and grid connection requirements in each MSA for the actions needed at the MSAs**. This does not account for the specific shape of each of the MSAs.
- **The allocation of MSA concession through time in regards with the number of charging points to be installed** and the corresponding contracts specifications, with the example of Berchem Luxembourg.

4.1 THE IMPACT OF SPACE CONSTRAINTS AND CURRENT LEVELS OF GRID CAPACITY AT THE SITES

Space availability at the sites

Because of the overall fleet electrification at the European level, all Luxembourgish MSA sites see a similar and proportional need to develop more electrical infrastructure over time. However, current site specificities lead to different levels of space constraint issues, depending on the actual number of parking bays and forecasted required number of charging points[89].

There are two distinct considerations on the MSAs related to space availability:

- **Firstly, loss of parking spaces due to space taken up by EV charging infrastructure.** Installation of EV chargers on the site requires placement of substations and power cabinets on site. If the MSA size is fixed, the space taken up by this infrastructure therefore reduces the number of parking bays available. Installation of one charger (and the associated power cabinet and portion of substation) results in loss of

[88] This study has focused on the conversion of existing MSAs. It has found that the change in space requirements and complexity of contractual arrangements of having both fossil fuel pumps and chargers creates high constraints. Putting in place new MSAs could be a way to overcome these constraints but is not within the scope of this work.
[89] Note that the analysis in this section does not account for the shape of each MSA – this is looked at in detail for the case studies of the Berchem MSAs Chapter 5.

around 20-33% of a parking bay[90]. This means that **expansion of the MSAs or provision of additional MSAs would be necessary to compensate for loss of HDV and LDV from EV charger installation.**

- **Secondly, availability of space to install sufficient numbers of EV chargers to meet demand at the sites.** Over time, the number of chargers required on the MSAs to meet demand will increase. It is therefore necessary to assess whether there is likely to be sufficient space on the MSA to install all the chargers that will be needed.
  - For light-duty vehicles, **when incorporating the additional space that could become available from the removal of traditional fuel pumps, most MSA sites can adequately accommodate the projected charging infrastructure requirements through 2050**. The notable exception is Pontpierre Luxembourg, which faces space constraints even with this additional area. However, **if considering only existing parking areas without the repurposed fuel pump space, most sites would encounter spatial limitations around 2040**.
  - For heavy-duty vehicles, the spatial outlook is similar: six out of eight MSAs will face space constraints in the 2030s and 2040s. As for LDVs, Pontpierre Luxembourg is the most space constrained site. This suggests that HDV fuel pump space will require transition to HDV chargers if demand at the site is to be met.
  - As addressed in sections 3.1.3 and 3.4.1.2, based on analysis of current charging behaviour, modelling suggests that there may be up to ca. 11 (3% of the year) peak days (days on which charging demand exceeds double average daily charging demand), depending on MSA and on future charging behaviour. This is based on no space constraints: any significant restriction on the number of charge points could increase queuing. Addressing the risk of queuing during peak days is further discussed in sections 5.2 and 6.8.

Figure 4-1 gives the predicted years for which space requirements for **light-duty vehicle charging points will exceed available parking bays space at the MSA sites:**

[90] There are several sources here. Firstly, the loss of parking bays per charger for the existing LDV EV charging points at the Luxembourg MSAs is around 20%. Secondly, Vinci Autoroutes (https://public-content.vinci-autoroutes.com/PDF/TTE-ENEDIS-VA_RECHARGE%20ITINERANCE%20%20POIDS%20LOURDS_mD_240308.pdf) estimate that for the case of HDV charging, the loss of parking space is around 20% - 33% of a bay per charger. ERM has verified that the figure of 33% is appropriate for HDV MCS infrastructure by inspection of site layout diagrams provided publicly by Milence.

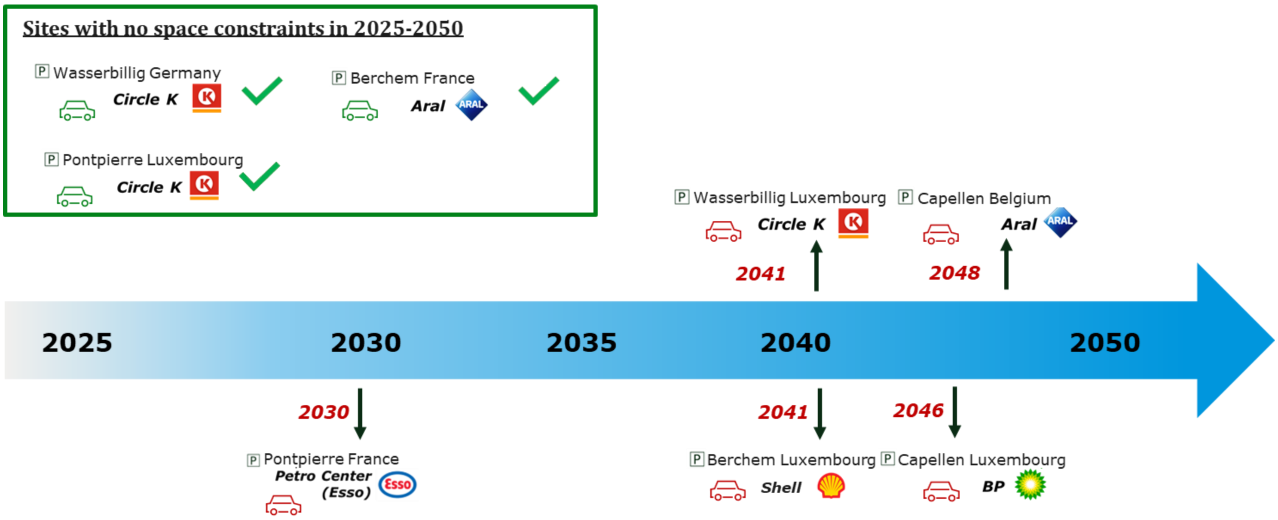


FIGURE 4-1 – EXPECTED DATES[91] FOR CHARGING INFRASTRUCTURE SPACE CONSTRAINTS AT MSA SITES - **LIGHT DUTY VEHICLES**, UNDER THE CENTRAL DEMAND SCENARIO

An analysis of space constraints for charging infrastructure across the eight MSA sites reveals the following hierarchy of limitations[92]:

1. Pontpierre Luxembourg (most constrained);
2. Berchem Luxembourg and Wasserbillig Luxembourg;
3. Capellen Luxembourg;
4. Capellen France.

The remaining three MSA sites have adequate space to accommodate future charging infrastructure.

The picture below gives the predicted years for which space requirements for **heavy-duty vehicles required number of charging points will exceed available parking bays space at the MSA sites:**

[91] Under Mid scenario for light-duty vehicles electric demand
[92] Sites not on the list are those that are not space-constrained as shown in the green box in figure Figure 4-1.

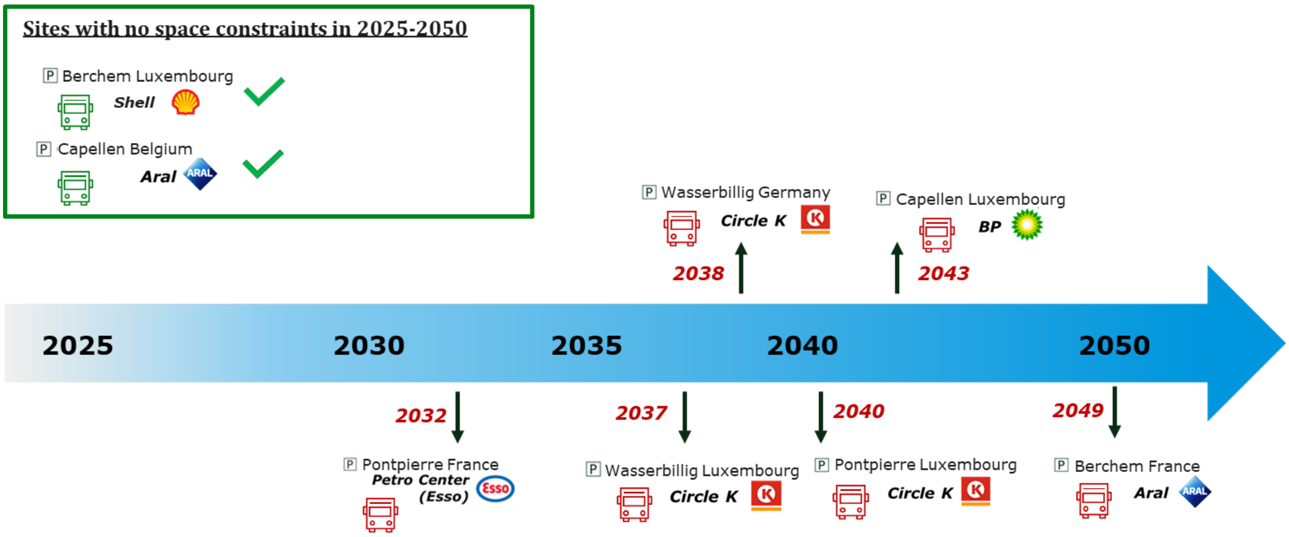


FIGURE 4-2 – EXPECTED DATES[93] FOR CHARGING INFRASTRUCTURE SPACE CONSTRAINTS AT MSA SITES - **HEAVY DUTY VEHICLES**, UNDER THE CENTRAL DEMAND SCENARIO

Spatial limitations for heavy-duty charging infrastructure present similarly challenging future compared to light-duty vehicle facilities. By 2050, six of eight sites will encounter space constraints for heavy-duty charging infrastructure, as opposed to five sites for light-duty vehicles. In order to meet the level of demand predicted, the fuel pump infrastructure would need to transition to charging infrastructure.

Safety Considerations

When considering the installation of EV charge points on the same sites as fossil fuel pumps, it is important to assess the safety of the site. CENELEC, the European Committee for Electrotechnical Standardization, states there is no specific standard to determine separation distances for high power charging stations within fuel stations and that it depends on the specific ATEX regulation for the particular fuel in the vicinity.[94] Similarly, there is no minimum safety distance prescribed within Luxembourgish guidelines.[95] While the exact safety distances required in Luxembourg are not clear, minimum safety distances between charge points and fuel pumps could mean that a number of the pumps would need to be removed before any charge points are added. This should be included in detailed site assessments.

Parking considerations

In the case of the MSAs whose car parks should fully transition to electric charging bays to meet predicted charging demand, listed above, this should be weighed with the practicalities of not having alternative parking spaces for customers who do not need to charge. A lack of parking space for non-charging customers could have knock-on effects on revenues at the shops or restaurants. Further, if there are penalties for overstaying at charge points but no alternative parking, this may reduce customer confidence in the site and cause charging, fuel, shop and restaurant sales to decrease. This underscores the balance to be struck or chosen between providing enough charging to satisfy future demand and avoid queuing and maintaining

93 Under Mid scenario for heavy-duty vehicles electric demand
94 https://www.cencenelec.eu/media/cen-cenelec_guide38.pdf
95 https://itm.public.lu/dam-assets/fr/securite-sante/conditions-types/itm-cl-1100-2000/ITM-SST-1800-1.pdf

customer satisfaction with the site by avoiding excessive overstay fines and providing adequate non-charging parking. This issue has also been identified by a 2024 report by Vinci Autoroutes[96] regarding French MSAs: Luxembourgish (and likely many European) MSAs may be fundamentally too small to provide the full range of parking and charging space required for the energy transition. The government and concession holders can look to understand the trade-offs of this matter and may consider site expansion to alleviate the parking availability issue, despite its practical difficulties. Alternatively, the Luxembourg government may wish to invest in non-MSA secure parking sites.

Similarly, if there is insufficient space to accommodate overnight stays for HDVs, this may cause issues for the transition to electric HDVs as a whole. Given the space constraints of MSAs, the government may consider investing in larger sites with secure parking with lower-power charging (i.e. CCS (Combined Charging System, generally with a maximum power of 350kW) rather than MCS (MegaWatt Charging System, generally with a charging power of 1MW) for use when charging times are not based only on a driver's short break.

Peak demand considerations

The practical considerations associated with dealing with peak demand are discussed in section 6.8. They include:

- Potential charging infrastructure sharing between LDVs and HDVs
- Provision of appropriate signage to let customers know how busy the car park/charge points are
- Enforcement of "idle fees" or limiting charging to 80% of battery capacity on busy days

Grid connection requirements

As the charging demand from LDVs and HDVs increases at the sites, the required grid capacity at the sites increases dramatically. If sufficient grid capacity is not available at the sites in a timely manner, this will delay the deployment of EV chargers at the sites and cause the Luxembourg Government to lose revenue as a result.

The current grid connection available at the MSAs ranges from 0 to 16 MW[97]. For all the MSAs, the future maximum available grid capacity for each is around 16 MW in total, based on a connection to medium voltage, with additional work needed on the network if the connection is requested. However, for both of the Berchem locations (discussed in more details as case studies later), the total required power is projected to exceed the future maximum available grid capacity of 16 MW in the early 2030s, as presented later. Grid infrastructure upgrades are likely to be necessary to meet future charging demands at this location.

While the timing differs between locations, this pattern highlights that grid capacity issues will be a widespread challenge across multiple MSA sites. **Planning for these must start now, as wider upstream reinforcements will be needed to provide power beyond the current 16 MW available.**

---

[96] https://public-content.vinci-autoroutes.com/PDF/TTE-ENEDIS-VA_RECHARGE%20ITINERANCE%20%20POIDS%20LOURDS_mD_240308.pdf

[97] 0 MW for 1 MSA (Pontpierre Luxembourg, due to space constraints), 2 MW for 3 MSAs, 4 MW for 1 MSA, 8 MW for 2 MSA and 16 MW for 1 MSAs. Data provided by the Luxembourg government.

4.2 TIME EVOLUTION OF THE MSAS

EV charge points could either be deployed as part of a single concession for the whole site, or as part of a specific concessions for part of the site – for example, as discussed later, the MSA sites could be divided into an LDV charging concession area, an HDV charging concession area, a fossil fuel pump concession area and a shop/restaurant concession area.

The number of charge points required in the site will increase over the course of the concession contract. Therefore, if multiple concessions are considered, the EV charging concession areas must be large enough to allow CPOs to invest and deploy charging points increasingly as demand grow.

Berchem Luxembourg timeline – example case study with a 15-year CPO concession contract

Illustrative example for the case of LDV charging to illustrate the principles.

The following is intended as an illustrative example, rather than a definitive statement of how the MSA must change in future.

The purpose of this example is to illustrate how the needs of the site (number of EV chargers and grid capacity) can evolve over the course of a single concession.

Consider the case where a 15-year LDV charging concession is awarded for part of the Berchem Luxembourg site:

- In 2029, a new concession tender will need to be released for Berchem Luxembourg. In one scenario, one CPO will be selected for deploying LDV electrical infrastructure during concession period occurring between 2029 and 2044. More details on the number of concessions per site are discussed in section 6.1
- Looking at the electrical demand projections, the required number of LDV charging points in 2029 is 40. It may therefore be desirable for the selected CPO to be required to install, as a minimum, a certain number of charging points, to reach the projected required number of 40. Taking into account the 6 chargers already on the site, this means potentially up to 34 charging points, coming with a required electrical grid connection of 5 MW.
- By the time the concession contract(s) end in 2044, around 108 additional LDV charging points will be needed on the site to meet demand. This will come with the need of minimum 15 MW of grid connection capacity, as presented in Figure 4-3.

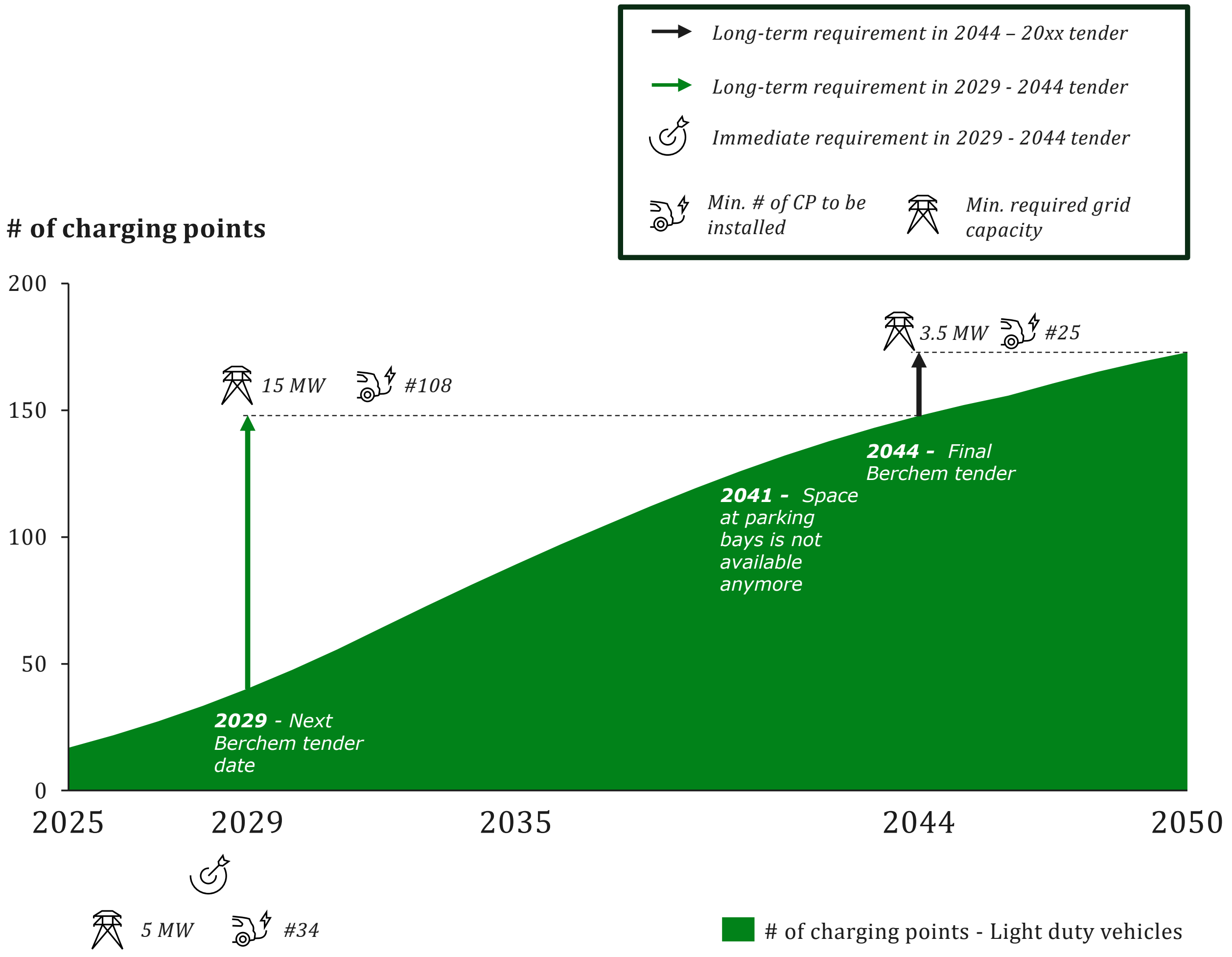


FIGURE 4-3 – NUMBER OF CHARGING POINTS AND REQUIREMENT FOR CONCESSION TENDERS - **BERCHEM LUXEMBOURG (CARS / VANS)**

In this example, a concession contract released in 2029 could therefore contain the following feature:

- A request to install immediately 34 LDV charging points, alongside a grid connection provision of 5 MW.
- The requirements to install, by 2043, 108 additional LDV charging points, alongside an additional grid connection provision of 15 MW.

In 2041, available space at LDV parking bays will not be enough anymore. In 2044, a new Berchem tender shall be issued, to install the planned remaining 25 charging points required.

In this illustrative example, the option taken is a single CPO getting a 15-year concession for LDV charging on the MSA: number of concessions and concession duration are discussed in sections 6.1 and 6.2. Another concession framework for an iterative increase of charging infrastructure provision is presented in section 6.3.

5. CASE STUDY OF THE TRANSITION FOR THE BERCHEM MSAS: HOW THE ENERGY TRANSITION WILL AFFECT THE PHYSICAL LAYOUT OF THE MSAS

This section aims to apply the demand modelling from section 3 and the spatial and timebound analysis from section 4 to the Berchem MSA sites as an example of how the energy transition may affect MSAs in Luxembourg. This approach can be used as a reference point for how the layout and electrical power requirements may be met by similar sites.

The section covers the following:

- Expected evolution of required number of fossil fuel pumps, electric charging points, and electric charging demand at the site.
- Site design aspects that have been considered in the site layouts in order to adhere to European/Luxembourgish regulations and maximise the efficiency of the on-site energy transition. Both charging and fuel provision have been addressed. A full removal of fuel infrastructure and construction of charging points only on the site has not been considered as part of this analysis because this approach would forgo either fuel or charging sales significantly beyond what is needed by a staggered approach.
- Multiple site layout options for both Berchem sites are presented with respect to substation installation. Options 1 and 2 include a smaller substation at each site, and Option 3 includes one larger substation at Berchem France to cover power needs from both sites (this may need the use of the existing pedestrian tunnel, or directional drilling to place cables underneath the motorway, which has been achieved before for MSAs in the UK, but the feasibility of this would need to be confirmed by the DSO in Luxembourg).
- Layout options with respect to the predicted charging demand as addressed in section 3. This analysis concludes that two smaller substations (one at each site) is more practical than one larger substation on the Berchem France site. While a single substation serving both MSA directions has the advantage of providing flexible power allocation when needed (option 3), substation layout Option 2 allows for enough LDV and HDV chargers to be installed to meet the demand modelled earlier in the report.

Table 5-1 below gives an overview of the Berchem Luxembourg and France sites today. This is the basis of the following analysis.

TABLE 5-1 – SUMMARY OF METRICS OF BERCHEM LUXEMBOURG AND FRANCE AS OF END 2024

	Berchem Luxembourg	**Berchem France**
Total # car parking bays	168	191
# LDV charge points	6	6
# LDV fuel pumps	27	20
Total # HDV parking bays	72	96

	Berchem Luxembourg	Berchem France
# HDV charge points	0	0
# HDV fuel pumps	24	24

5.1 CHANGES IN THE INFRASTRUCTURE REQUIREMENTS AT THE MSAS OVER TIME

5.1.1 ILLUSTRATION FOR THE CASE OF **BERCHEM LUXEMBOURG**

The following graph presents the projected decommissioning timeline for fossil fuel pumps at the Berchem Luxembourg MSA site over the 2025-2050 period:

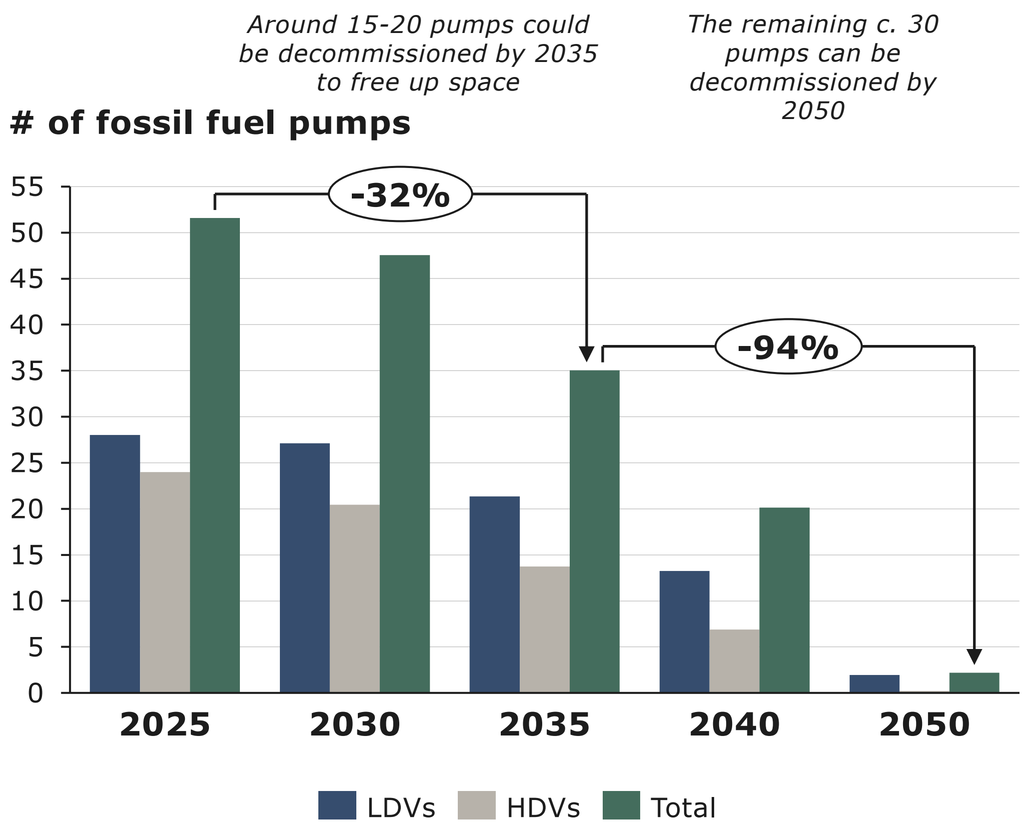


FIGURE 5-1 – PROJECTED NUMBER OF REQUIRED FOSSIL FUEL PUMPS - **BERCHEM LUXEMBOURG**

The forecast indicates a significant reduction in fossil fuel infrastructure need, with an initial 32% decrease in total pumps by 2035, followed by a further reduction resulting in a 94% overall decrease by 2050, which will free up additional space for chargers.

The following figure illustrates the anticipated growth in electrical charging demand at the Berchem Luxembourg MSA site from 2025 to 2050. This charging demand was computed using **the Mid scenario** previously presented in **Section 3 - Quantifying future needs.**

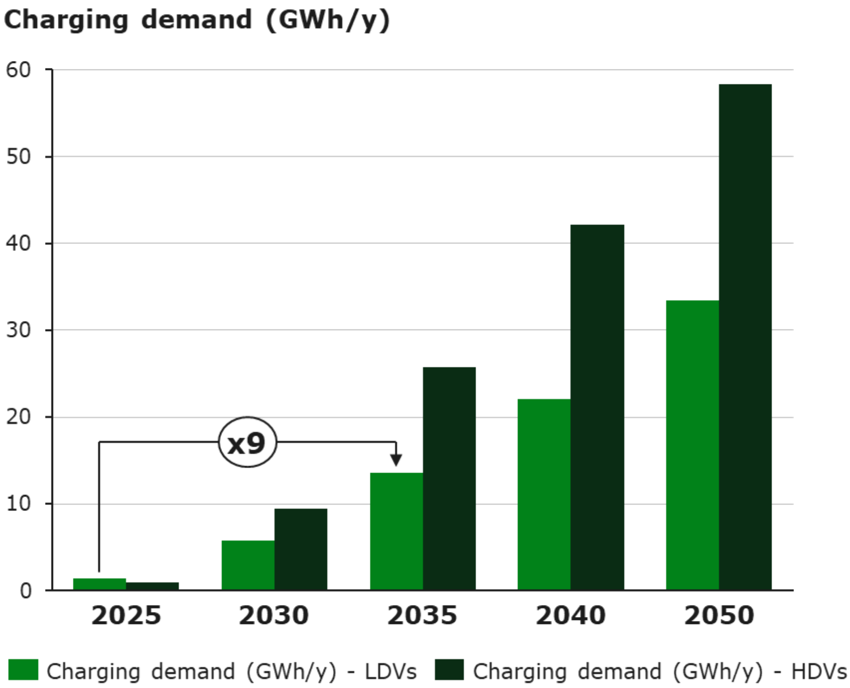


FIGURE 5-2 – PROJECTED ELECTRICAL CHARGING DEMAND - **BERCHEM LUXEMBOURG**

The forecast reveals a nine-fold and 25-fold increase in demand from LDV and HDVs, respectively by 2035, with particularly steep growth in HDV charging requirements. By 2050, the total charging demand is expected to reach approximately 92 GWh/year, with HDV charging representing the majority of this consumption. The data demonstrates the substantial infrastructure scaling required to meet the rapidly evolving needs of electric vehicle adoption.

The associated planned number of required charging points for both LDVs and HDVs is presented in the next graph, Figure 5-3.

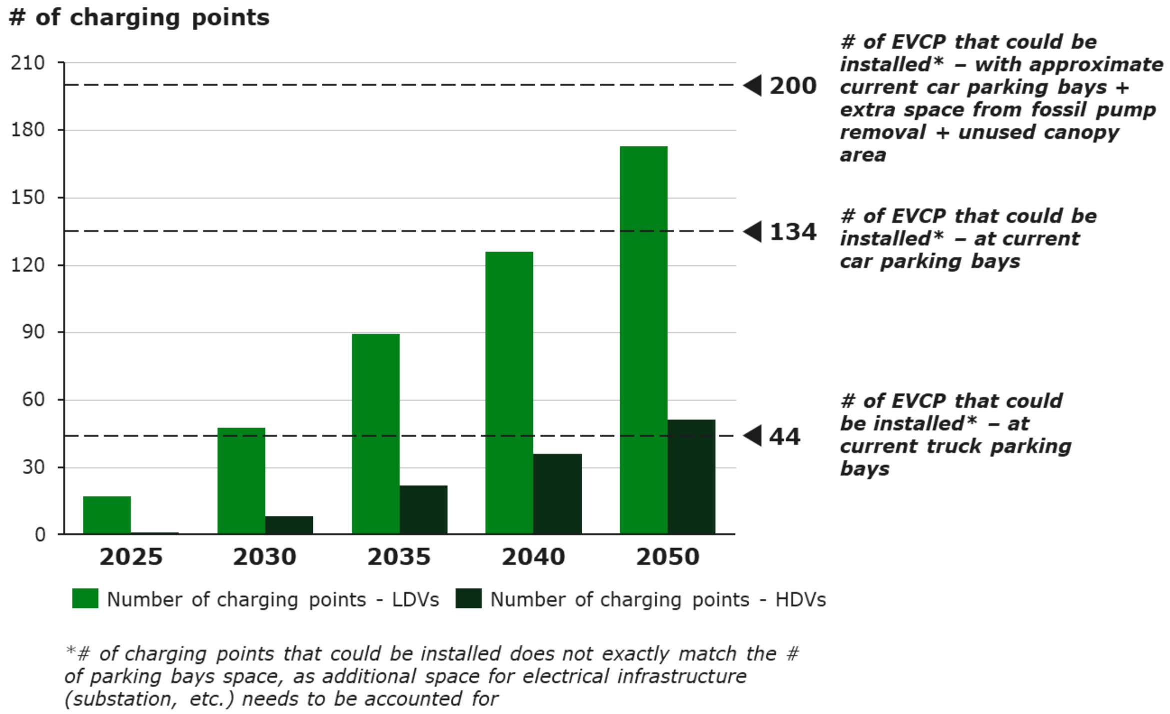


FIGURE 5-3 – PROJECTED NUMBER OF REQUIRED CHARGING POINTS - **BERCHEM LUXEMBOURG**

The projections indicate that demand for car and van charge points will exceed the site's physical capacity, with every existing car parking bay requiring a rapid charger by 2041. Extra space from fossil fuel pumps removal and current unused canopy would however allow the installation of the required number of charging spaces for 2050.

For HDV facilities, the current parking area appears adequately sized to accommodate the most of the projected charging needs, with approximately 20 Megawatt Charging System (MCS) chargers required by 2035, and 51 by 2050.

The required number of charging points for cars and vans was derived from the electrical demand presented in Figure 5-2 using a number of charging points to charging demand ratio.

TABLE 5-2 – NUMBER OF CHARGING POINTS TO CHARGING DEMAND RATIO

Metric	Unit	2025	2030	2035	2040	2050
Car and van Charging point to charging demand ratio	number /GWh/year	10	7	6	5	4

As more high-powered charging points are installed over time, the overall system becomes more efficient, requiring less total infrastructure per vehicle served: 10 charging points need to be installed for every GWh of yearly car and van electrical demand in 2025, compared to 4 charging points in 2050.

The accelerating transition toward fleet electrification and the associated charging infrastructure deployment at MSA sites necessitates comprehensive grid connection capacity planning.

The following figure shows a projection of required grid connection power (measured in MW) for charging electric vehicles at the Berchem Luxembourg MSA site from 2025 to 2050.

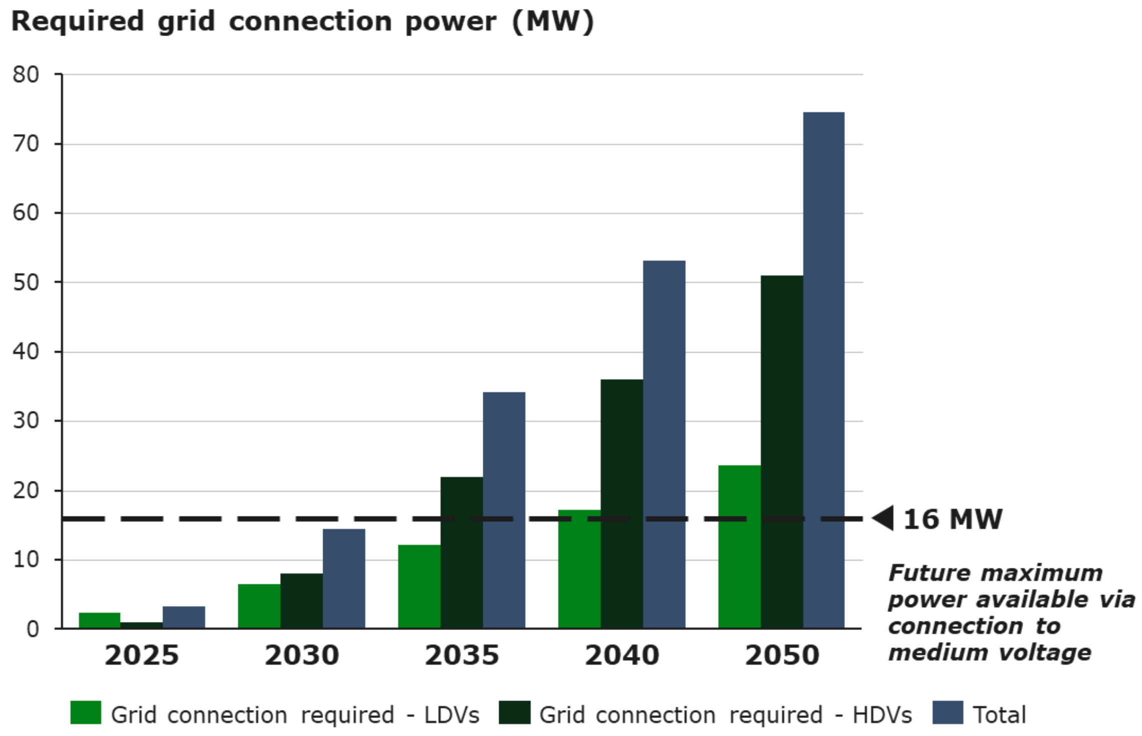


FIGURE 5-4 – REQUIRED GRID CONNECTION POWER – **BERCHEM LUXEMBOURG**

The maximum future available power at each of the MSAs in Luxembourg is 16 MW (medium voltage, with additional work needed if the connection is requested): a horizontal dashed line indicates the maximum future available[98] grid capacity at the MSA site. The projections show an increasing power demand over time, starting from around 3 MW in 2025 and rising significantly to approximately 75 MW by 2050. The demand grows for both LDVs and HDVs, with HDV charging requiring[99] more power than LDV charging from 2030.

Notably, the total required power is projected to exceed the available grid capacity of 16 MW in ca. 2031, suggesting that grid infrastructure upgrades will be necessary to meet future charging demands at this location.

5.1.2 ILLUSTRATION FOR THE CASE OF **BERCHEM FRANCE**

A similar analysis was done for the Berchem France MSA site. The following graph presents the projected evolution of needs for fossil fuel pumps at the site for the 2025-2050 period:

[98] Maximum power available at the MSA site, with additional work needed if the connection is requested, via connection to medium voltage – data provided by Luxembourg Government.
[99] Even though far fewer charging points are required for HDVs, the assumed charging size of each point is more important (1 MW, against a repartition of 150 kW and 300 kW for LDV charging points), and the diversity factor (what percentage of available charging cap. is used at peak demand time) considered for HDVs is also more important (100% against 70% for cars), leading to larger a power requirement for HDVs.

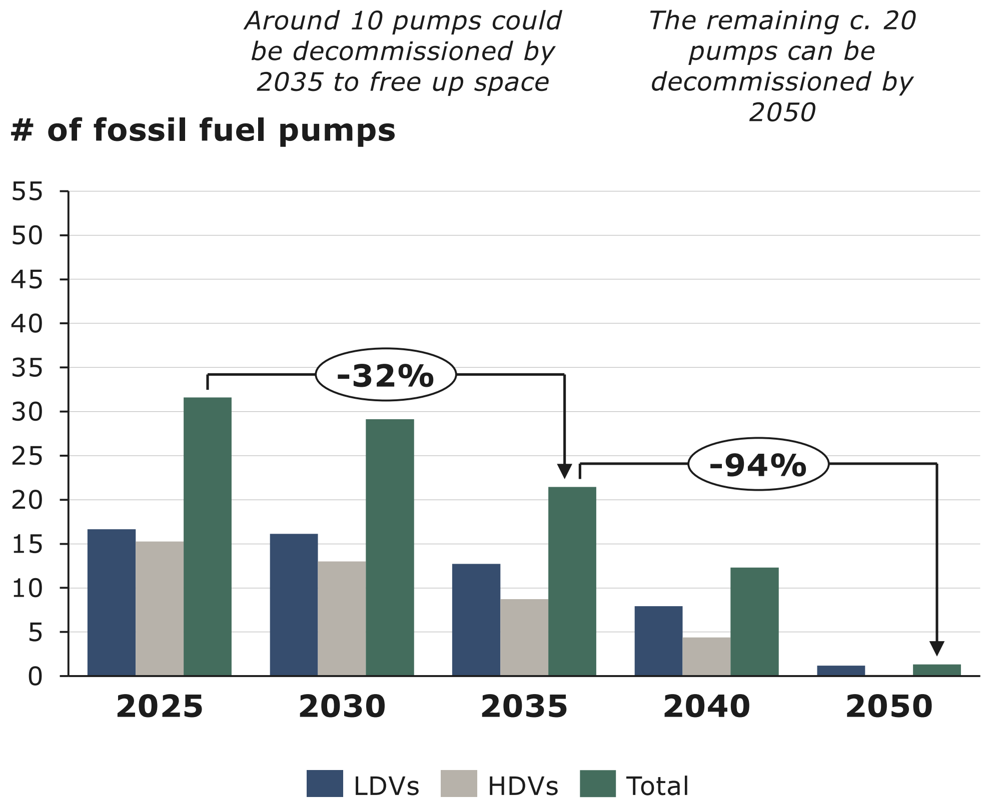


FIGURE 5-5 – PROJECTED NUMBER OF REQUIRED FOSSIL FUEL PUMPS - **BERCHEM FRANCE**

The forecast predicts a notable reduction in fossil fuel infrastructure, comparable to the proposal for Berchem Luxembourg, as it assumes the same vehicle conversion rate to electric mobility. Figure 5-6 depicts the expected increase in electrical charging demand at the Berchem France MSA site between 2025 and 2050.

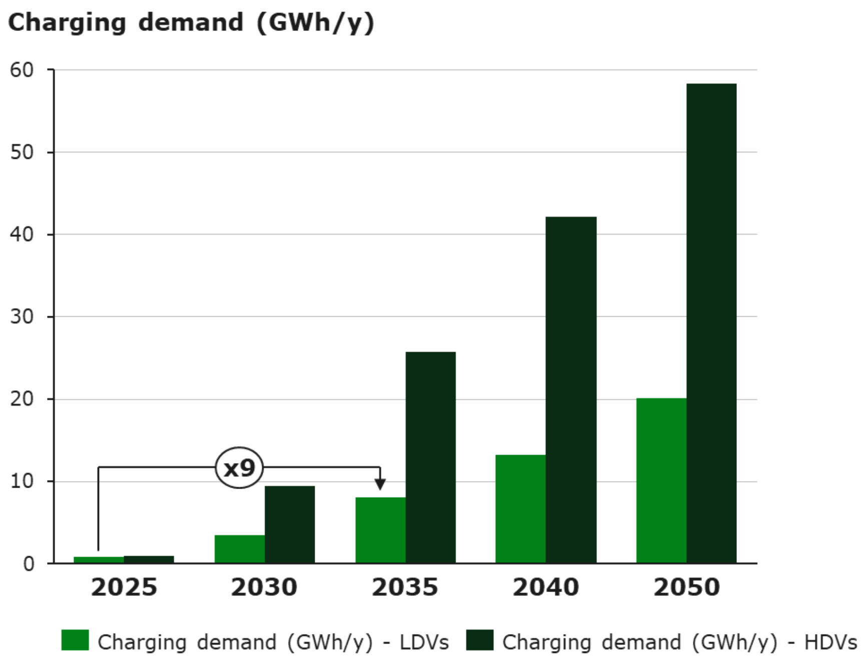


FIGURE 5-6 – PROJECTED ELECTRICAL CHARGING DEMAND - **BERCHEM FRANCE**

Similar to Berchem Luxembourg, the forecast predicts a substantial rise in demand by 2035, with particularly rapid growth in passenger vehicle charging requirements. By 2050, the total charging demand is expected to reach approximately 78 GWh/year, accounting for ca. 80% of the total projected at Berchem Luxembourg.

The associated planned number of required charging points for both LDVs and HDVs is presented in Figure 5-7.

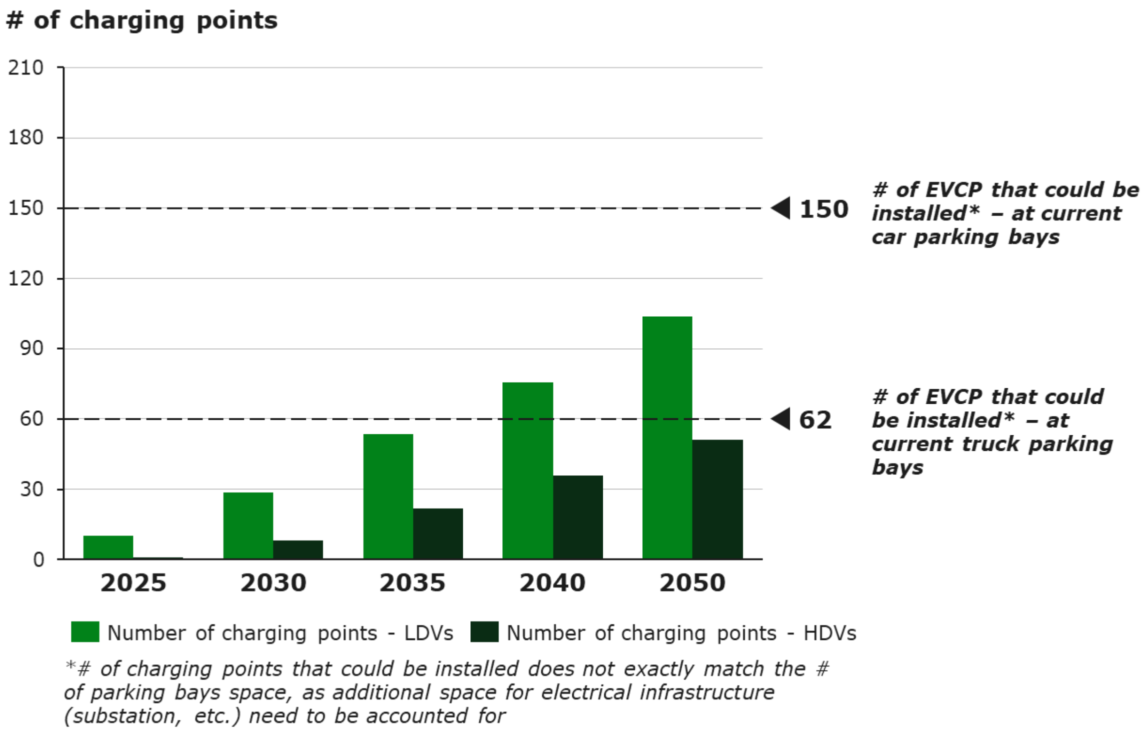


FIGURE 5-7 – PROJECTED NUMBER OF REQUIRED CHARGING POINTS - **BERCHEM FRANCE**

The site will not face similar challenges to Berchem Luxembourg regarding electrical charging infrastructure. Car and van charging demand will not exceed the site's spatial capacity in by 2050, thanks to enough existing space to accommodate for future electrical demand. The existing HDV parking area also appears sufficient to meet projected charging requirements.

The grid connection requirement the Berchem France MSA site is presented in the next figure.

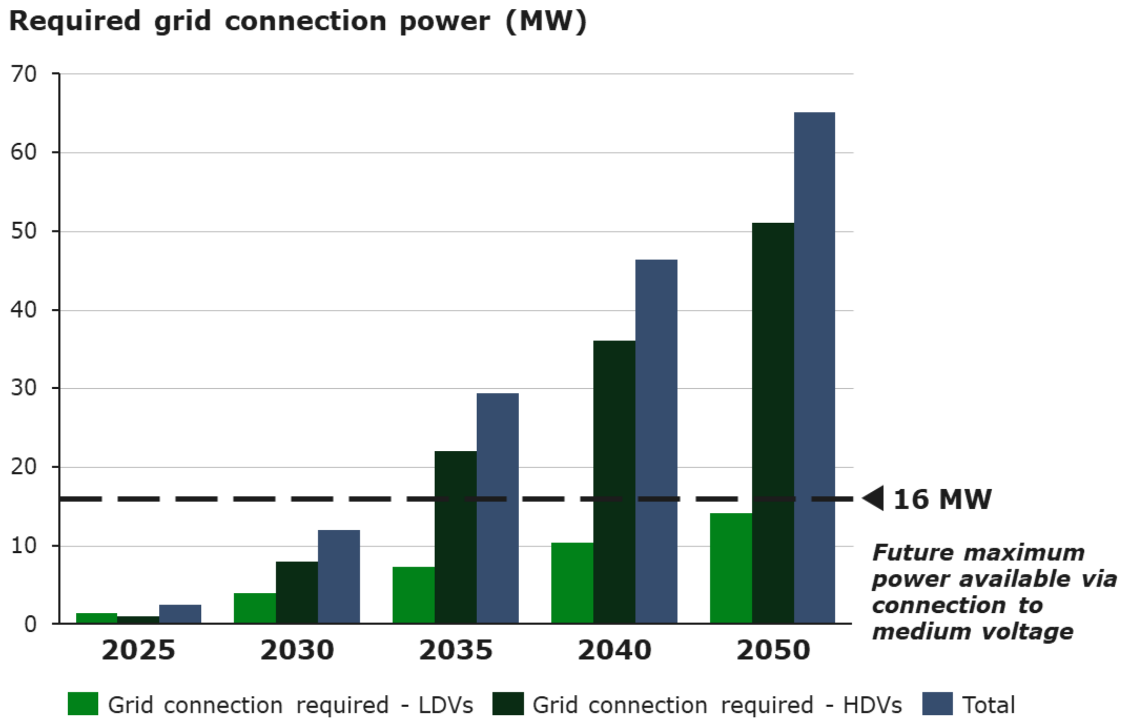


FIGURE 5-8 – REQUIRED GRID CONNECTION POWER – **BERCHEM FRANCE**

This site shows similar infrastructure limitations, though with a different timeline. The power capacity limit is expected to be reached by 2032, which is slightly later than at Berchem Luxembourg where it will happen ca. 2031. By 2050, the site is expected to require a connection of ca. 65 MW.

5.2 SITE DESIGN CONSIDERATIONS

Charger types considered in this analysis:

In order to make best use of the available space at the space-constrained MSAs, a range of charger types are included.

LDVs:

Cars and other small LDVs:

- Bay: charger is installed at one end of a parking bay.
- Lane: chargers are installed in rows of approximately 3 (similar to fuel pumps at a refuelling station) - cars pull in next to a charger.

Large LDVs and cars towing caravans:

- Drive-through: longer bays that can be driven through (i.e. enter and exit in the same direction) with a charger installed between spaces

HDVs:

- Drive-through: longer bays that can be driven through (i.e. enter and exit in the same direction) with a charger installed between spaces. In this analysis, all HDV chargers are modelled as MCS (i.e. 1MW power) chargers as base case given the expected focus of the MSAs on long-haul traffic. However, CPOs should be given the flexibility to specify a mixture of charging powers (for example, complementing the MW chargers with some overnight 100 kW CCS chargers).

MSA visit duration:

- For HDVs, stop times may not increase significantly with the rollout of electric HDVs as charging is likely to be completed as part of a driver's mandated short break.
- For LDVs, the stop length of the various customer types should become simplified: either the customer stops for the shop area and the stop length will not change, or the customer stops to charge their car for ca. 30 minutes. This likely increases the average stay of a car driver. As a result, the car park may become more congested as EV infrastructure is rolled out and parking bays are converted to charging bays. This underscores the importance of having high-power charging available and suggests that time limitations may be required to ensure throughput of customers at the MSA. As discussed in section 6.8, gathering data on stop times and customer behaviour could be included in the concession contracts in order to monitor site business.

This is discussed further in section 6.8.

Shop & restaurant:

- We assume shop & restaurant are well-sized to meet the needs of the sites today and will not change considerably through the time horizon of this analysis. The provision of facilities is discussed in section 6.8.

Charger layout & operation:

- As discussed earlier in the report, minimum safety distances between refuelling infrastructure and EV charge points are not standardised across Europe (and are different between fuel types, and are not explicitly prescribed by Luxembourgish documentation (see footnotes 94 and 95)). Similarly, the minimum safety distance between a substation (a set of equipment reducing the high voltage of electrical power transmission to that suitable for supply to consumers) and refueling infrastructure is not clearly defined.
  - As a result, some existing parking spaces (40+ for Berchem Luxembourg) between the existing LDV and HDV fossil fuel infrastructure may not be suitable for installing charge points today, subject to detailed site assessment. These parking bays may be the last to be electrified (i.e. by 2050) if the existing fossil fuel infrastructure is removed.
  - A detailed site assessment should also be undertaken for the substation placement, to ensure local and EU safety regulations are adhered to.
- Bay charging should be prioritised for LDV charging due to its simple integration into the site. This may remove some of the existing pedestrian paths, but these can potentially be replaced with on-road paths with road markings (subject to assessment by concession holders/planners). While bay chargers are the most effective charging solution, 5-6 drive-through chargers should be installed in the

short-term to service large vans and towing vehicles who cannot use parking bays[100].

- The booking system currently employed by HDV charger providers such as Milence may not be applicable to MSAs, as there is little scope to ensure certain areas are gated[101] at MSAs. Another booking system may be employed and signage used to indicate to HDV drivers if there are charging spaces at the MSA before they arrive. This could be achieved through apps such as HDV Booking[102] and TRAVIS[103], which aim to establish international platforms to reserve public charging points for HDVs.
- A mix of charger powers will be required for cars stopping to charge at MSAs – both 150 kW and 300 kW. However, charging at speeds above 150 kW is likely to continue to be reserved for premium cars, as it needs an 800 V system (standard is 400 V) as well as an internal converter which are both expensive and seen as surplus to requirements by most vehicle OEMs. A split of 70% 150 kW chargers and 30% 300 kW chargers within the car charging area would therefore be prudent. In practice, this mixture would be optimized by the CPO, but the Luxembourg Government could allow for this when providing sufficient grid capacity for the car CPO concession area (the topic of grid capacity is discussed elsewhere).
- For HDVs, although this analysis has assumed that all chargers will be MCS, the organisations installing chargers may deem it appropriate to install lower-power CCS chargers or low-power overnight charging, depending on their priorities and financial analysis.
- The modelling in section 3.3 assume a relatively high level of utilisation upon installation. In practice, CPOs may choose to install additional chargers at the outset to group the capital outlay into one, rather than iterations of installations. This would reduce queuing and increase convenience for HDV drivers but would mean that the utilisation of the HDV chargers would initially be lower.
- Up to 33% of HDV and 20% of LDV parking space could be lost from the installation of charging infrastructure (such as power cabinets). This is broadly aligned with a study by Vinci Autoroutes for France[104]. As a result, there may be a shortage of non-charging HDV parking in the late 2030s and 2040s. Additional sites such as a potential safe and secure parking along the TEN-T network can act as overflow depending on current HDV parking utilisation. There may also be a limit on LDV parking in the future. As a result, data collection on parking

---

[100] Vans are expected to make up ca. 10% of the LDV parc between 2025 and 2050. Large vans and SUVs towing caravans are expected to be less than this, with caravan registrations comprising ca. 0.2% of all new LDV registrations in Europe in 2023. Sources: https://www.e-c-f.com/wp-content/uploads/2021/08/E.1.0_CY2023.pdf, https://www.acea.auto/pc-registrations/new-car-registrations-0-8-in-2024-battery-electric-13-6-market-share/

[101] https://milence.com/press-release/milence-opens-one-of-europes-largest-public-charging-hubs-for-electric-heavy-duty-vehicles-in-belgium-at-the-port-of-antwerp-bruges/

[102] https://www.daf.com/en/news-and-media/news-articles/global/2024/27-08-2024-daf-joins-international-platform-for-booking-charging-stations

[103] https://www.yourtravis.com/knowledge/first-bookable-truck-charging/

[104] https://public-content.vinci-autoroutes.com/PDF/TTE-ENEDIS-VA_RECHARGE%20ITINERANCE%20%20POIDS%20LOURDS_mD_240308.pdf. This report estimates that heavy duty vehicle chargers require between 17% and 33% additional space than a parking bay alone.

utilisation is suggested as an addition to the concession contracts or as part of the national road authority role: this is discussed in more details in section 6.11. Based on this data, MSA operators and the Luxembourgish government can decide whether or not to expand existing MSAs or build additional sites.

- A substation will be required to supply the sites with adequate power, likely in the voltage range 110 kV[105]. Due to the spatial constraints of the sites, a gas-insulated substation will be required to minimise its footprint[106]. This type of substation is more expensive than an air-insulated substation, therefore the space-cost trade-off must be considered carefully in site plans.

Transition of existing fuelling infrastructure:

- In order to address the demand for charging at Berchem Luxembourg by 2050, space will be required beyond the existing parking spaces for cars. This will likely be required around 2040 and is recommended to be made available by removing the refuelling infrastructure on the site. The Berchem France site may also choose to remove their refuelling infrastructure depending on how charging demand evolves with time.
- By 2040, the business case (only considering the concession fee revenues, no other State revenues) for the fuel pumps at both sites will have significantly decreased due to low fuel demand (a predicted drop of 72% compared to 2025 demand), therefore its partial replacement with charging infrastructure might present an attractive approach. Please see section 6.10 for the full analysis.
- The removal of fuel infrastructure could be carried out:
  - All at once: As discussed in charger layout considerations, the minimum distance between charge points and fuel infrastructure (pumps, underground tanks) could mean that this fuel infrastructure inhibits the installation of ca. 40 charge points (depending on exact safety distances mandated in Luxembourg) at Berchem Luxembourg if not removed.
  - In a staged approach, to remove the fuel pumps gradually.

More details on the replacement of fuel pumps by EVCPs are available in section 6.10. Additional criteria such as the disruption caused by the civil work to remove the pumps and install the new charge points will also have to be considered ahead of planning.

Peak charging demand:

- Analysis in section 3.1.3 shows that MSAs currently have a maximum of 11 peak days (charging demand is at least double average daily demand) per year, equating to ca. 3% of the year.
- This work assumes that a similar ratio of peak/average demand is maintained with time for LDV charging needs, resulting in similar charging profiles on a larger scale as more charge points are installed.

---

[105] https://www.creos-net.lu/fileadmin/dokumente/downloads/20240315_Network_Development_Plan_2024-2034_-_Electricity_Transmission_Grid.pdf
[106] https://www.nationalgrid.com/electricity-transmission/substation-configuration-and-build-types

- This means that the number of LDV charge points required to meet LDV charging demand at the MSAs (see section 3.3 and 3.4) is likely to be able to meet demand without significant waiting times 97% of the year.
- A number of options are provided in section 6.8 to help mitigate any issues that may arise when demand is high.

5.3 SUMMARY OF SUBSTATION LAYOUT OPTIONS

In order to meet the power requirements at each MSA, a substation will be required. The exact technical specifications are not determined here but based on similar substation sites in the UK[107], and assuming a gas-insulated system to maximise compactness[108], two substation layout options are available at each direction of the motorway. Both substation options at Berchem Luxembourg are relatively small and would only serve Berchem Luxembourg itself. For Berchem France, one substation that would only serve its own MSA and one substation that could serve both Berchem Luxembourg and Berchem France were considered. While detailed economic modelling is out of scope in this study, a substation that can serve both Berchem Luxembourg and Berchem France would be inherently more expensive, as tunnelling may be required for cabling to reach the other side of the motorway (although there is an existing pedestrian tunnel). This additional cost may be factored into future design decisions. A combination of lane and bay charging solutions for LDVs are proposed in all scenarios to aid traffic flow: the logic being that those who want to charge only (and likely use high-power charging) will use lane chargers, whereas those who want to visit the shop or restaurant will use a bay charger. The site layout options are listed below in Table 5-3Table 5-3.

TABLE 5-3 – SITE LAYOUT OPTIONS FOR BERCHEM LUXEMBOURG AND BERCHEM FRANCE

Option	Substation at Berchem Luxembourg?	Substation at Berchem France?	Comments
1	✓ (North side of site)	✓ (Centre of site, near refueling station)	Maximises car charging area
2	✓ (East side of site)	✓ (Centre of site, near refueling station)	Maximises HDV charging area
3	X	✓ (South of site, in HDV parking area)	Might not to be feasible due to potential tunnelling required for cabling[109]

[107] https://ukpowernetworks.opendatasoft.com/explore/dataset/grid-and-primary-sites/table
[108] https://www.tdworld.com/substations/article/55138424/burns-mcdonnell-why-gas-insulated-switchgear-gis-substations-are-key-to-meeting-accelerating-us-power-demand
[109] While a pedestrian tunnel does exist between the two Berchem sites, using this for underground cabling would present some practical issues, such as the temporary closure of the tunnel while the substation is installed, and in the case of any maintenance. As a result, additional tunnelling should still be considered for this substation layout option.

Table 5-4 and Table 5-5 illustrate the impact of each of the substation layout options on the **maximum** number of car, van, caravan, and HDV charge points available across both Berchem sites in 2050. The number of LDV (i.e. car and van, including cars towing caravans) and HDV charge points required to meet demand in the **Mid demand scenario** (as modelled in section 3) is also shown below.

TABLE 5-4 – SUMMARY OF THE CHARGING PROVISION IMPLICATIONS OF THE SUBSTATION LAYOUT OPTIONS IN 2050 FOR BERCHEM LUXEMBOURG

	Option 1	**Option 2**	**Option 3**	**Demand modelling (mid scenario)**
# bay charge points **for which there is space on the site**	134	105	134	
# lane charge points **for which there is space on the site**	72	72	72	
# caravan/large van charge points **for which there is space on the site**	5	6	6	
# total number of LDV charge points **for which there is space on the site**	211	183	212	
Total number of LDV charge points required by expected 2050 demand				**173**
# total number of HDV charge points **for which there is space on the site**	44	51	51	
Total number of HDV charge points required by expected 2050 demand				**51**

At the **Berchem Luxembourg** site in 2050, layout options 2 and 3 mean that there is adequate space for the required LDV and HDV charge points, with option 1 being 7 HDV spaces short of sufficient for the modelled demand. Table 5-4 highlights that the removal of fuel infrastructure to make way for the LDV lane chargers is required before 2050. However, in substation layout options 1 and 3, more than 75% of the LDV charge points required in 2050 can be met without the removal of fuel infrastructure, meaning this site work will likely not be required until at least 2040, at which point the business case for the fuelling stations will be poor due to low levels of fuel demand. Option 3 may require tunnelling under the motorway or the use of the existing pedestrian tunnel to allow the substation to serve both sides, which could be very costly. The availability of LDV and HDV charging spaces may be used as part of an assessment to find the optimal substation and charger layout configuration.

Table 5-5 illustrates that all substation layout options for **Berchem France** provide significantly more charge points for LDVs than required in the central demand modelling scenario for Berchem France, and the removal of fuel infrastructure (to be replaced with LDV lane chargers) will not be required to meet this demand by 2050. Layout options 1 and 2 exceed the modelled required number of HDV chargers, but option 3 means that there are 6 too few in 2050. Similarly to Berchem Luxembourg, Berchem France’s site evolution can be assessed using these inputs as metrics to determine optimal site configuration.

Although all site layouts mean that there will be a loss of parking spaces due to the need for a substation and the additional space required for charging equipment, Table 5-4 and Table 5-5 demonstrate that in 2050 there is adequate space for the charge points needed and some non-charging parking spaces at both sites for LDVs, and only a small shortage of HDV chargers in option 3. However, this notably includes the conversion of fuel infrastructure to chargers for LDVs and HDVs. Given that most demand up to the early 2040s can be satisfied without this conversion, it is likely that parking spaces will be constrained, especially at Berchem Luxembourg, in the 2040s. This underlines a reliance on other secure parking areas nearby to take on this overspill.

TABLE 5-5 – SUMMARY OF THE CHARGING PROVISION IMPLICATIONS OF THE SUBSTATION LAYOUT OPTIONS IN 2050 FOR BERCHEM FRANCE

	Option 1	**Option 2**	**Option 3**	**Demand modelling (mid scenario)**
# bay charge points **for which there is space on the site**	134	134	153	
# lane charge points **for which there is space on the site**	50	50	50	
# caravan/large van charge points **for which there is space on the site**	6	6	6	

	Option 1	**Option 2**	**Option 3**	**Demand modelling (mid scenario)**
# total number of LDV charge points **for which there is space on the site**	190	190	209	
Total number of LDV charge points required by expected 2050 demand				**104**
# total number of HDV charge points **for which there is space on the site**	75	75	45	
Total number of HDV charge points required by expected 2050 demand				**51**

Due to its prioritisation of LDV charger provision as well as allowing for ample HDV charging, substation layout Option 1 is the most effective according to this analysis. This option is therefore the best approach, according to these metrics, for progression as the basis of site evolution plans and is included in the next section.

5.4 LAYOUT MAPPING

Charging layouts are optimised based on the area of the MSA. Bay charging is assumed for most of the LDV charging in the car park to minimise disruption and maximise the number of charge points available, with lane charging installed in small areas of the car park to allow for large vans/caravans to charge. Lane chargers for LDV charging and drive-through charging for HDV chargers are assumed to replace the fuelling infrastructure when it is removed. All HDV charging is drive-through charging due to manoeuvrability requirements for large vehicles.

Figure 5-9 shows an indicative diagram of site layout 2 with one small substation at on each side of the motorway, maximising HDV charger installation at Berchem Luxembourg and France. The areas for different charging types are highlighted in different colours. The non-highlighted areas are the motorway between the two MSAs and the roads around the MSAs, and are not part of the individual concessions. Two other site layout options exist and are laid out in the appendix.

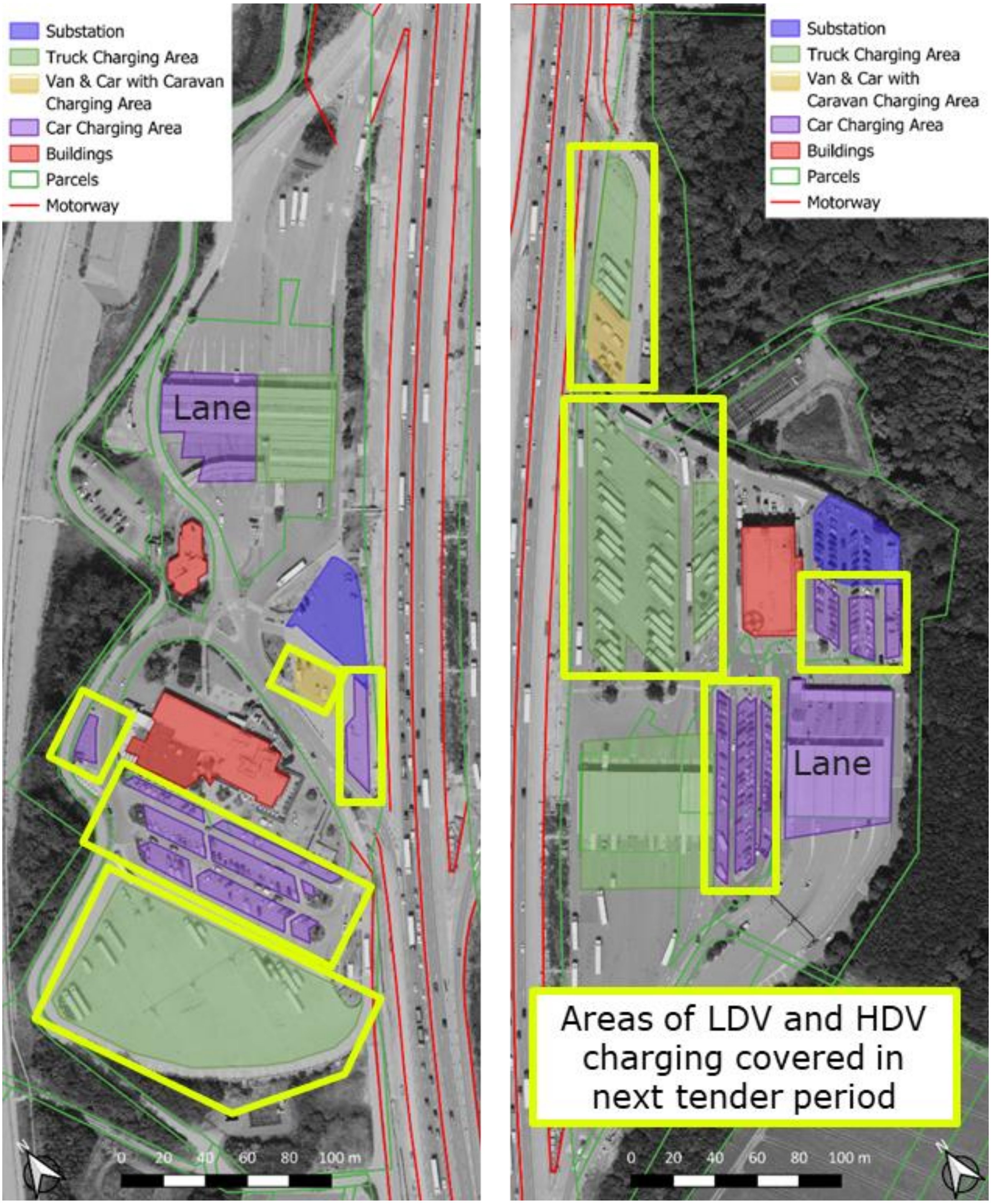


FIGURE 5-9 – MAP OF THE BERCHEM SITES FOR SUBSTATION LAYOUT OPTION 2 IN 2050. PLEASE NOTE: THIS IS NOT A TECHNICAL DRAWING.

Highlighted in boxes in Figure 5-9 are the LDV and HDV charging areas that could be covered by the next Berchem tenders as outlined in section 6 – as shown, this area makes up the majority of the LDV and HDV parking areas on this site. As a result, the whole parking area would therefore be considered as affected surface in the concession contract. In the mid demand scenario, for Berchem France (left), only 60% of this space is needed for car charging, whereas for Berchem Luxembourg (right), all the available car parking spaces must have LDV charge points installed in order to meet demand. To satisfy the additional demand from 2040s onwards, the refuelling infrastructure could be removed from Berchem Luxembourg and replaced with lane charging for LDVs and HDVs. Under the mid demand scenario, this is not required for Berchem France.

6. KEY CONCESSION CONTRACT CONSIDERATIONS FOR FUTURE MSAS

The transition towards the future state of MSAs and their concessions requires various changes such as the stakeholders involved, the contracts binding them, and the structuration of revenues. This chapter explains the rationale behind the key potential approaches presented in chapter 4. This is achieved by listing the main options available in each case, and investigating their pros and cons.

The following subjects are covered:

- The advantages and disadvantages from **switching to longer concession duration, compared to shorter concession**.
- **The concessions scope possibilities**; the options considered are multi-concessions on an MSA, a single general concession with several subcontractors, or a joint venture between companies.
- **The stakeholder in charge of the grid connection upgrade**, with the option of the responsibility going either to the government, the CPO(s) or the distribution network operator.
- **The use case and pros and cons of the various charging types considered for the charging points in the MSA**, which will all be required to address completely the electricity demand.
- Other suggested changes for future concessions, **including modification to fees structure and award criteria to maintain the same revenues for the government, as well as low carbon obligations and maintenance scope.**
- **The facilities needed at the MSAs to accommodate the customer needs.**
- Considerations on **the existing SuperChargy charging network** and on **the future of the existing fossil fuel pumps.**
- Suggestions on **data collection** which would improve planning conditions for electric vehicle infrastructure.

The chapter ends with a reflection on the short-term actions to take ahead of the next concession contract tendering, to close the uncertainty of some elements and refine decisions to be made.

6.1 NUMBER OF CONCESSIONS PER SITE

Each MSA site currently has one concessionaire, who in turn might have subcontractors, in charge of the fuel dispensing, shops and site maintenance. For each MSA, there is also a contract in place with Chargy for EV chargers. Given the predicted growth in charging demand and the specialised nature of charging installations, the number of concessions per site could be kept higher than one. This is one of the options considered, alongside a single operator approach.

TABLE 6-1 – CONCESSION SCOPE POSSIBILITIES

<table>
<tr><th>Proposed options</th><th colspan="2">Conclusions</th></tr>
<tr><td rowspan="2">One concession per MSA site
Tender answered by a single operator</td><td colspan="2">Description
Concession scope for MSA includes shop, restaurant, traditional and alternative fuelling activities. Only one operator is responsible for the overall handling of the site, including cleaning and maintenance responsibilities.
Option of design already deployed
<u>Model often used in France</u> – Total has equipped several MSA sites with electric chargers, for example on the A10 for the MSA of "Aire de Limours"</td></tr>
<tr><td>Pros
• Simplified tendering process.
• Optimised operational handling of the site (only one responsible).
• Single point of contact for the authorities.
• All services are performed, including less attractive concessions.
• Diversified revenue streams for the concession holder.
• Potential to incentivise integrated planning and operation across all elements of the MSA.</td><td>Cons
• Significantly restrains the number of participants to the MSA tender by excluding pure-play CPOs, reducing competition and therefore potentially the quality of the concession offers.
• Creates a local monopoly.
• Possible slower deployment of electrical infrastructure due to exclusion of pure-play CPOs – the site is effectively constrained to be operated by a fossil fuel major who may be inclined to keep operating traditional fuelling activities as long as possible. Under-deployment of EV charging infrastructure may make the MSAs unattractive to customers and reduce revenues in the long term.
• If this option resulted in slower deployment of EV charging infrastructure, this could result in lower revenues to the Luxembourg Government, especially in the medium term and long term.</td></tr>
</table>

<table>
<tr><td rowspan="2">One concession per MSA site
Tender answered by several companies through a JV / partnership agreement</td><td colspan="2">Description
Two or more companies create a Joint Venture or partnership to answer the call for tenders. The joint venture is the concession holder and is thus responsible for the overall handling of the site, including cleaning and maintenance responsibilities.
Option of design already deployed
<u>The Joint Venture / Partnership option is uncommon but not unknown</u> - Shell signed in 2017 a partnership with the CPO Ionity, to deploy at least 400 charging points on European highways. Several charging points in different MSAs were deployed, for example on the A11 for the MSAs of “Chartres Gasville” and “Chartres Bois-Paris”, in France.</td></tr>
<tr><td>Pros
• Efficient process when answering multiple tenders, especially across several countries.
• Opportunity to benefit from business plan synergies between classical and alternative fuel operations.</td><td>Cons
• Administrative process might be heavier for the companies forming the joint venture.
• The oil & gas company and CPO are likely to be competitors, so may not wish to work together. The CPO could be reluctant to create such a partnership with an oil & gas company[110].</td></tr>
<tr><td>Multiple concessions</td><td colspan="2">Description
Each MSA site has several concessions:
• one concession for the fossil fuel refuelling area (which could be combined with the shop/restaurant concession)
• new dedicated concession scopes for electrical infrastructure, separating charging infrastructure dedicated to light-duty and heavy-duty vehicles (given CPOs typically specialise in either LDV or HDV charging, such as Ionity and Milence, respectively).
Allocation of cleaning and maintenance responsibilities has to be carefully considered; the options are discussed later.
A solution with a single CPO for each vehicle category (LDV and HDV) has been considered as several players for each category could result in greater complexity and higher overheads. In principle, the same CPO could win the tenders for both the LDV and HDV charging, but given the specialisation of some CPOs in either LDV or HDV charging, it is suggested that the concessions for LDV and HDV charging are kept distinct. A single CPO could also bid for both charging concessions and then subcontract one of them to a partner that complements their speciality.
Option of design already deployed</td></tr>
</table>

[110] Note that this situation is different to a fossil fuel major partnering with a convenience store operator, since the fossil fuel major and convenience store operator are not direct competitors, whereas a fossil fuel major and a pure-play CPO are more directly in competition.

<table>
<tr><td rowspan="2"></td><td colspan="2"><u>Developing model in Germany, with Fastned expansion</u>–In Herbolzheim (Breisgauallee 4, 79336 Herbolzheim) fuelling activities are dealt with by Shell, while Fastned operates 6x300 kW CCS chargers.</td></tr>
<tr><td>Pros
• Gives rise to increased competition for the EVCP concession as pure-play CPOs as well as companies with the potential to bid for several concessions, including the EVCP concession, can participate to the tender/ This can potentially bring stronger offers and faster deployment of infrastructure.
• Allows an alternative model for the charge point concession areas whereby the concessions are linked to charge point deployment rather than the whole area. This would allow for rolling concessions and therefore potentially allow for greater flexibility in charge point deployment. This is discussed in more detail in section 6.3.
• Specialisation of each holder in their respective traditional activity.
• Provides the option (if this is desirable) to have different concession lengths for different parts of the site, e.g. a longer</td><td>Cons
• Requires careful definition of the responsibilities of each concession holder.
• Additional administrative complexity associated with having two CPOs on site (one LDV, one HDV), along with the other concession holders for shop/restaurant and fossil fuel area.
• Potential risk of an increase of overhead cost. In principle this could impact the price and/or competitivity and lead to slightly lower revenues for the government, although this impact could be offset if this arrangement resulted in faster deployment of charge points (and therefore greater electricity sales).
• Requires more administrative work from the state for overall management.
• Potential risk of certain concessions on the MSA not being sufficiently attractive to operators. However, this risk should be balanced against the high risk of exclusion of players which cannot provide all the concession services from running the concession if a single concession option is used. Furthermore, this could be checked in a consultation with EVCP stakeholders beforehand to ascertain whether or not this poses a significant risk and how the concession structure can be</td></tr>
</table>

	concession for the charging areas to give a good business case for initial investment, and a shorter concession for the fossil fuel pump area to give flexibility on removal date (no upfront investment is needed for the fossil fuel pump area).	designed to mitigate this risk: consortium of companies (e.g. including a traditional fossil-fuel pump operator and pure-play CPO) encouraged to bid could mitigate this risk. Standalone EVCPs and petrol stations are common elsewhere, and if necessary the shop concession could be combined with one of the other concessions to improve the business case. • Signage may need to be provided centrally by the Luxembourg government, such that all the facilities are appropriately signposted to customers.

6.2 CONCESSION DURATION

The default concession length for MSAs in Luxembourg has been 10 years but 4-year contracts were recently introduced to provide more flexibility. The merits and drawbacks of shorter vs longer concession contracts are discussed next.

TABLE 6-2 – PROS AND CONS OF SHORT VERSUS LONG CONCESSIONS

Proposed options	Conclusions	
Longer concession	***Description*** This table compares the pros and cons of **longer concessions** (e.g., 15 years).	
	Pros • Better business case for concession holder(s), possibly leading to a decrease in price (making the MSAs more attractive) and more attractive offers / higher revenues for the Luxembourg Government. The point about attractiveness of the business case particularly	**Cons** • Lock-in of particular players on site for a longer period, which reduces potential for competition during that period. • If concession is linked to particular area of the site rather than to charger deployment, the contract will likely need some way to keep some flexibility in charger deployment, to allow CPOs to

<table>
<tr><td></td><td>refers to the CPOs as, unlike the fossil fuel operators, the CPOs must make significant investments in new infrastructure upfront, and need enough time to get a good return on those investments.
Longer concessions could be linked to charger deployment rather than a particular area of land, as discussed later in section 6.3.
Avoids the need to re-tender the fossil fuel area in e.g., 10 years, when the business case for operating the fossil fuel pumps may be much less attractive to operators.
For later concessions (e.g., a concession starting in c. 2035-2040), a longer concession could enable the fossil fuel major to decommission the pumps (due to low demand) and replace with EVCPs, since a longer concession would give more time for this investment to be recouped.</td><td>install chargers in response to demand. A challenge here is that even with a long concession (e.g., 15 years), the business case for charger deployment may become less attractive later in the contract (e.g., when there is only 5 years left for operate the chargers).
Potentially less flexibility for fossil fuel operators who would need to commit to a long contract, with the potential for revenues from fossil fuel sales to fall significantly – and in an uncertain manner – over the length of the contract.</td></tr>
<tr><td rowspan="2">Shorter concession, with book value or fair value of charge points paid by new concessionaire to previous concessionaire</td><td colspan="2">Description
This table compares the pros and cons of shorter concessions (for example a 4-year concession) with each new concessionaire compensating the previous one for a portion of the investment in the charging points.</td></tr>
<tr><td>Pros
Potential for increased competition as the concession holders change more frequently.
Potential for increased flexibility, for example in the fossil fuel case the Government has more flexibility as to when the</td><td>Cons
For the CPO case in particular, less good business case compared to longer duration option, which may lead to lower revenues and less attractive offers for the Luxembourg Government.</td></tr>
</table>

	fossil fuel concession is changed if this is re-tendered more frequently.	• Complexity because of specific software used by CPO for their equipment. • Increased administrative work for the State as concessions need to be re-tendered more frequently. • Low incentive for innovation as there is insufficient time to recoup the benefits of this. • Lower incentive on maintenance and cleaning. • The new concessionaire might need to compensate (and thus pay) unwanted assets.

A key decision for a multi-concession site is whether or not the concessions should have the same length.

Aligned concession periods streamline administrative processes, reducing the complexity of contract management and oversight responsibilities for the concession authority.

However, there are inherent differences between the CPO and fossil infrastructure. The CPO will be required to make upfront investments in new infrastructure and have enough time to receive a good return on these investments. This is less the case for the fossil fuel area, where upfront investment in building new infrastructure is not required. Furthermore, as outlined above, there are pros to having shorter concessions that are specific to fossil fuel infrastructure. Hence, there can be arguments for different concession lengths, e.g., one option is a long CPO concession to improve the business case for initial investment, and a short fossil fuel concession to maximise flexibility.

6.3 CONCESSION FRAMEWORKS LINKED TO CHARGER DEPLOYMENT RATHER THAN SITE AREA

The previous sections assumed a situation where the concessions are linked to an ***area*** of the site, rather than to ***EVCP deployment***. The charging concessions would no longer be about an area of the car / HDV park but only for the chargers to serve the bays in a particular area of the car / HDV park. The problem with this is that the business case for the CPO to invest in charge points later in the concession contract may be poor, and this option does therefore not necessarily provide sufficient flexibility to respond to increases in EV charging demand. For example, if an EV charging concession area ran from 2029 – 2044, then even if demand for EV charging becomes very high in 2039, the CPO may still not wish to invest because they only have 5 years left on the concession contract. This could lead to loss of revenue for the Luxembourg Government due to under-provision of EVCPs on the sites.

If we consider as an example a portion of the site (e.g., the car park) that is set aside as a car charging area, there is another way in which this area could be run: instead of issuing a 15-year concession for the whole area, a 15-year concession is issued for the deployment of an initial number of charge points. Once the utilisation of these charge points reaches a certain threshold, a new concession could be issued for another batch of charge points, also for 15-years. At the end of each 15-year charging concession, the charging area in question can be re-tendered. The situation is shown in the figure below.

This approach brings major advantages: the Luxembourg Government is not locked into a single CPO forever (as the concession contracts end after 15 years) but at the same time, the CPO always has a good business case to invest, since they are guaranteed a 15-year concession for each group of chargers that they install.

Since an additional concession is issued each time an additional bank of chargers is needed (which may be every few years as demand grows rapidly), it would be necessary to design this framework to minimise administrative complexity for the Luxembourg Government. One way in which this could be done is in the following steps:

- The Luxembourg Government issues a call for tender for the charge point concession. Different CPOs compete for award of the tender.
- The winning CPO must install a certain minimum number of chargers to meet initial demand but is then placed on a **framework agreement**. The framework agreement means that when utilisation rises above a pre-agreed threshold, the CPO can automatically install a new bank of chargers, under a fresh 15-year concession contract. The terms of each new 15-year concession contract would be set out in the framework agreement. Therefore, this option – despite the multiple EV charging concessions – would only incur a very small amount of extra administrative complexity. It would also potentially generate significant extra revenue for the Luxembourg Government by allowing more agile deployment of EVCPs in response to demand.
- Once the 15-year concessions end, the charging areas can be re-tendered to a new CPO. For example, if the first bank of chargers under this framework was installed by the selected CPO in 2029, then in 2043 a new award process would be launched, and the selected CPO would take over the first bank of chargers installed in 2044 when the 2029 concession ends. The new CPO could also take over the other banks of chargers when their concession ends, thus avoiding additional administration each time a concession ends.

This option could be deployed for both the LDV and HDV charging areas.

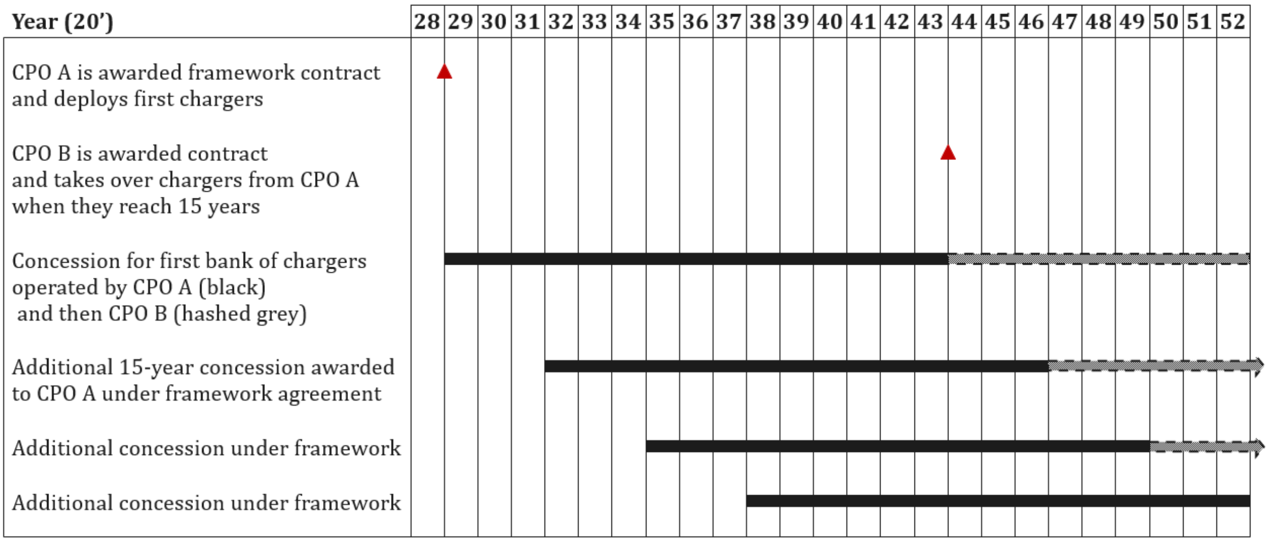


FIGURE 6-1 – CONCESSIONS FOR CHARGE POINTS UNDER A FRAMEWORK – ILLUSTRATION BASED ON 15-YEAR CONTRACT

Management of grid upgrade and civils

As chargers are installed in banks every few years, steps could be taken to minimize disruption when this happens. One approach is that the underground ducting for cables on the site is installed for the whole area all in one go. In this way, when new banks of chargers are installed, disruption is minimised as it is not necessary to dig trenches across the site – just to thread the cables through the existing ducting.

With this approach, it may also be advantageous for the grid connection for the whole site to be owned by a 3rd party (e.g., the Luxembourg Government), with the investment recouped through fees charged to CPOs elsewhere. This would avoid complexities associated with grid connection ownership when there are multiple CPOs on site (e.g., when the concessions of CPO A and CPO B overlap in the diagram above). Financing of the grid upgrade is discussed further in the following section.

Pros of this approach

- Provides greatest flexibility to respond to changes in charging demand by ensuring that there is always a good business case for the CPO to respond to changes in demand by installing additional EVCPs.
- Because of this, likely to provide largest EV charging revenue to Luxembourg Government.

Cons of this approach

- Increased administrative burden for the Luxembourg Government, but this could be minimized with use of a framework contract whereby new EV charging concessions are awarded to the CPO semi-automatically as utilisation crosses a certain threshold, with pre-defined conditions for each concession as set out in the framework contract.
- Cleaning responsibilities need to be well-defined, since the CPO would only be awarded concessions for chargers covering part of the concession area at a time.

One option would be for this cleaning to be arranged by the highway authority. Other options for division of cleaning responsibilities on the site are discussed later under "Potential obligations for concessionees".

- Potential for more frequent disruption to the MSA as chargers are installed every few years. However, this disruption can be minimized as described above.

This approach is notably used for the deployment of charge points by some local authorities, for example in the United-Kingdom[111].

6.4 FINANCING OF GRID UPGRADE

The grid connection upgrade is a key element for the future expansion of the charging infrastructure. It comprises:

- A high-voltage cable (e.g., 35 kV) linking the site to the power distribution system,
- A potential upgrade of the distribution system local substation to increase its capacity,
- A potential addition of a new substation on the distribution network, if the nearest substation cannot be upgraded or is too far of the MSA.

In some rare cases, a direct connection to the electricity transport network, with the addition of a dedicated substation at the MSA, may be needed. These multiple components make the upgrade costly, and three options can be considered for meeting this cost, the advantages and disadvantages of which are described in the table below.

The charge point operator will also usually have its own transformer(s) on-site[112], cabling to feed the power cabinets and feeder pillars next to each charging bay – this equipment is not part of the grid connection and would instead be owned by the CPO.

TABLE 6-3 – OPTIONS FOR THE GRID CONNECTION UPGRADE

Proposed options	**Conclusions**	
Government	***Description*** The Luxembourg government pays for the upgrade and charges fees to the operator. These would likely need to be over the order of 2 to 3 cents/kWh[113].	
	Pros	**Cons**

[111] Based on ERM experience of EVCP contracts in the United Kingdom
[112] As an example, the grid connection for the whole site might come in at c. 35 kV. This would then be stepped down to c. 10 kV, and a series of 10 kV cables would distribute the power to banks of chargers on the site. This would then be stepped down to the appropriate voltage with small substations near the bank of chargers themselves, and then distributed to the feeder pillars and power cabinets. The power may be moved most of the distance around the site at a higher voltage (e.g. 10 kV) to minimise Ohmic power losses.
[113] For example, with a grid connection capex of 250 EUR/kW; linear ramp-up of grid connection utilisation over 30 years to a maximum value of 15%, and a fee (in 2025 cents) of 2.5 cents/kWh, the real terms IRR to the Luxembourg government is c. 3.7%. This is comfortably in excess of the Luxembourg Government's long-term bond yield (i.e. cost of capital) which is 2.6% in *nominal* terms at time of writing, or below 1% in real terms (with a long-term Euro inflation expectation of around 2%).

	• CPO concessions will need to include minimum charge point investment requirements, but this is only possible if sufficient grid capacity is available. Hence, if the government is responsible for this, they can only enforce the minimum investment requirements if the grid capacity is provided. This creates symmetry of obligations within the contract. • Smooth integration in the already existing system of concessions. Indeed, the government can directly take charge of the grid connection upgrade, and the CPOs will only be required to handle the installation of the charging points, their own transformer and their connection to the distribution network. • Upgrade in line with the energy strategy of the country and the ambition for EV uptake. • Could give better visibility to the CPO in a detailed tender. • Make tenders easier to compare as CPOs would work on the same power capacity assumption. Otherwise, adding in the grid connection upgrade, another parameter would be added in the contract. All other parameters being equal, a situation may emerge where CPO A commits to increase the grid connection	• Less control given to the CPO and government having to plan the right MW themselves (however design decisions could be in consultation with CPO(s)) • Investment by the government which requires dedicated funds. • Given the government investment, the tender will need be carefully designed to follow EU rules on public procurement, to ensure that the contract is free of State aid. Legal advice will be required.[114] • Responsibility given to the government to organise the distribution of the grid capacity between the involved CPOs in case of multiple concessions. • Lead to higher fees for the CPO to compensate for the grid connection upgrade and a fair distribution of the financial burden between CPOs (in case of shorter concession and/or multiple concessions). This in turn may lead in the worst-case scenario to a higher charging price compared to a scenario where the CPO is responsible for the grid upgrade. • The government may need the agreement of the concession holder for the operation for the areas in their responsibility. This would advocate for a

[114] If the public tender rules are not found to be enough for compliance, and if legal advice concludes the investment would constitute State Aid, there would be broadly two routes for State Aid approval: 1) by way of a formal notification to and approval by the EC of the measure of State aid or 2) or through safe harbour provisions in the form of Block Exemption Regulations, where measures are deemed automatically approved as long as they comply in full with the requirements of the Block Exemption Regulation.

	by 5 MW grid connection while CPO B only commits for 1 MW, but this leads to a higher increase in the charging price set by CPO A compared to CPO B. The evaluation of tenders would thus appear more difficult. • Upgrade can start in the preparation phase (see key actions in section 6.12). • The grid connection will last longer than the concession duration and longer than the lifetime of the chargers. A third party owning the grid connection in perpetuity therefore has a better business case for installing it than the CPO who will only own the connection for the lifetime of the concession.	share of the responsibilities between the CPO(s) and the government depending on the work to be done. In this system, the CPO is responsible for the grid connection in its concession area (connection between the charging points and the smaller substation), and this responsibility is transferred to the next concession holder. The government remains responsible for the remainder of the grid connection, its maintenance and its upgrade.
Charging Point Operator	***Description*** The charging point operator pays for the upgrade, either as part of an extended concession or is compensated back by the new operator at the end of the concession.	
	Pros • Direct contact between charging point operator and the DSO. • Better balancing of the capacity available / capacity required by the bays. • In a long-term concession scenario, the CPO could make a sufficient return on its investment for the grid connection upgrade. The grid connection could then become property of the state. However, for the following concession, an agreement would need to be offered to the new CPOs if	**Cons** • Two charging point operators (light and heavy-duty vehicles) would make it complex to manage. • High cost unsuitable for smaller stakeholders of the sector. • Compensation at the end of the concession would need to be precisely assessed (and split if relevant). • CPO could be inclined not to plan for the long-term, and to prefer a smaller upgrade. • In case of multiple CPOs, this would create complexities in

	another upgrade of the grid connection is required.	sharing responsibility for investment and electricity distribution. A possible arrangement would be a proportional sharing of the investment based on the number of EVCP installed, and of the costs based on electricity sold.
Distribution System Operator	***Description*** The distribution system operator pays for the upgrade, and charges fees for using it.	
	Pros • Independent 3rd party, which may be advantageous in the situation where the CPOs onsite are competitors. This would represent the best solution for the question of distributing electricity between multiple CPOs. • The grid connection will last longer than the concession duration and longer than the lifetime of the chargers. A third party owning the grid connection in perpetuity therefore has a better business case for installing it than the CPO who will only own the connection for the lifetime of the concession. Furthermore, if the grid connection is owned by a 3rd party this avoids administrative complexity as charging concessions on the site end. • Better visibility and control for the charging operators. • Payment for the CPO the coming as OPEX instead of a high CAPEX.	**Cons** • Not a party in the concession contract, and so minimum investment requirements in the contract for the CPO would need to be contingent upon provision of adequate grid capacity by the DSO. • This scheme may need changes in the regulatory and legal framework so that the DSO can make the investment in advance.

	• Adaptable to any change in the system of concessions.	

6.5 POSITIONING OF CHARGERS ON THE SITES

Existing charge points at Luxembourgish MSAs are bay chargers. However, to provide adequate charging for a range of vehicle types and customers, several charger layout approaches will likely be required on the MSA sites. The three primary options are laid out in Table 6-4.

TABLE 6-4 – OPTIONS FOR CHARGING TYPES

Proposed options	Conclusions	
Bay Charging	***Description*** Chargers are installed in the existing parking bays, with a charging pillar at the front of each parking space.	
	Pros • EVCPs can be installed within existing parking spaces, minimising (but not removing) the need for civil works • EVCPs at the front of bays is a space-effective solution that means the greatest number of chargers can be installed • Due to the lower requirement for civil works, building costs will be lower	**Cons** • Any vehicles towing a trailer or caravan, as well as large vans, cannot use bay chargers due to maneuverability issues • Not suitable for HDV charging • In case of high demand, a traffic jam may occur as charging bays offer limited space to overtake a car waiting for a bay to be free.
Lane Charging	***Description*** Chargers are installed in rows with cars being able to pull up next to a charger. Lane charging is installed with canopies in the style of traditional fuel pumps, allowing several vehicles in a row to charge while vehicles can overtake at the side to access charging or leave the area.	
	Pros • Towing vehicles and large vans can more easily use lane charging • If lane charging is part of initial site plans, it can be as space effective as bay charging • Lane allows a better flow of the vehicles as they provide more space for	**Cons** • Lane chargers require a larger footprint than a bay charger • Significant building work would be needed to adapt parts of the car park to be lane charging • Installing lane charging increases the cost of

	maneuverability and overtaking other vehicles.	civil works compared to bay charging • Not suitable for HDV charging
Drive-through charging	***Description*** Drive-through charging is specifically designed to remove any manoeuvrability issues for BEV HDVs. All bays are one-way only with a single charging point between entry and exit of the bay.	
	Pros • Only suitable solution for heavy-duty vehicle charging • Allows simple ingress and egress to charge point	**Cons** • Not considered for car charging due to the different power requirements of the vehicle types, space constraints and additional cost

6.6 FEE STRUCTURE AND AWARD CRITERIA

As the MSAs transition, the concession revenues for the Luxembourg Government need to be maintained. The fee structure of the MSAs therefore needs to be considered. The following table outlines considerations around the MSA fee structure.

TABLE 6-5 – MSA FEE STRUCTURE

Parameter type	Characteristics
MSA fee structure and award criteria	**Indicative fees (fictive)** Monthly fee: • 10,000 € for refuelling area, 1,000 € for restaurant, 2,000 € for shops Annual fee (conditions upon which bidder is selected): • % of shop and restaurant revenues (7% is the minimal value in recent concession tenders. Fictive values taken for modelling: 9.5% and 7.0 respectively%) • Bid of €/l for fuel (0.02€/l is the minimal value in recent concession tenders. Fictive value taken for modelling: 0.15 €/l) Award criteria • Bidders need to prove their operational and technical capacity to operate the MSA. Beyond this check, the selection is based on MSA total fees the Grand Duchy would receive given the % indicated by the bidder for both shops, restaurants and fuelling activities.

New proposition

Monthly fee:

- Maintain monthly fees, with discounts available either for the CPO during the first concession period (when demand is still low) or for installation of low-carbon infrastructure (e.g., heat pumps, solar PV, BESS)

Annual fee:

- Include a fee for CPOs on a per kWh basis, which would need to be adjusted based on benchmarks and CPOs' business model.
  - CPOs would not compete on this fee as this could incentivise overpricing of the electricity and be detrimental to Luxembourg's competitiveness, since Luxembourg does not have the same price advantage for electricity as it does for diesel.
  - In the beginning, the precise amount would be set so as not to make MSA charging in Luxembourg uncompetitive, as EVCPs in France, Germany, and Belgium are close enough to present significant competition.
- No change to the bidding system for fuel sales, nor to the shop & restaurant fee system. **Table 6-6 shows an example of the evolution of the total government revenues in the example of Berchem Luxembourg and France with this new format.**

Quantitative award criteria:

- Bidding on the fee on shop, restaurant and fuel;
- Planned provision of EVCPs (with certain minimum installation requirements to meet the expected demand);

Qualitative award criteria (these are examples, not a full exhaustive list of all possible qualitative criteria):

- CPO's charging service offer to the customer (including the visibility of available chargers through their app, or through the vehicle OEM navigation system) to help minimise queuing on-site.
- Quality of architectural project (in the case of a new build)
- Global design of the MSA (in the case of a single concession)
- Customer experience, e.g., activities, how they will give best waiting time, access to call centre, payment options etc. The possible evolutions in the quality and variety of the services are described in section 6.8.
- Low carbon initiatives (such as solar panel, heat pump, or stationary storage installation - please refer to section 6.7).
- Durability and sustainability of the project: actions taken by the bidder to ensure highest level of durability and sustainability of

	the operation of its concession (e.g. use of renewable power, materials used for infrastructure, etc.). • Accessibility: actions and solutions to ensure all concession infrastructure are accessible, notably for people with disabilities. • Maintenance and infrastructure availability: actions, evidence and solutions to ensure a sufficient level of infrastructure availability (e.g. charging infrastructure, fuel pumps). • Product offer, for example use of local products, especially for the shop & restaurant concessions. • Best use of available green spaces, e.g. for picnic tables or other customer facilities.

Based on these new fee structure and award criteria, an example of the total revenues for the Luxembourg government from Berchem France and Berchem Luxembourg was assessed between 2023 and 2050. The revenues were calculated based on fictive fees that would respect the new fee structure (monthly fees are discussed afterwards):

- Restaurant fee: 7 %;
- Shop fee: 9.5 %;
- Fuel fee: 0.15 €/L;
- Electricity fee: 0.05 €/kWh[115] starting in 2030.

For reference, the fees above correspond to ca. 4 € per GJ of diesel and 14 € per GJ of electricity[116]. As explained above, the electricity fee is indicative and should be adjusted based on typical fees CPOs would be ready to pay, so the future concession tender is attractive to bidders.

Overall, revenues from the restaurant fee are negligible compared to the shop, fuel and electricity fee revenues. Similarly, the monthly fees are also negligible in terms of revenue for the government.

A sensitivity analysis was conducted on the fee on electricity to better assess if maintaining the same level of revenues from 2023 to 2050 was possible. Table 6-6 below shows the revenues with the fee structure described above from 2030 to 2050, and the revenues in 2050 with the same fee structure except for electricity (sensitivity).

N.B.: The "total" revenues only consider revenues from the fees directly obtained from the MSA concession, and do not take into account any form of excise duty or other taxes that would be collected from the products sold.

[115] Indicative electricity fee based on: fuel fee (0.15 €/L) represent ca. 10% of the price at the pump (assumption: 1.50 €/L) so electricity fee chosen to meet the same condition (assumption: 0.50 €/kWh based on typical charging prices observed (ad hoc, with CPO subscription or through mobility service provider)).
[116] Assumption: 36.9 MJ / L of diesel (https://www.acea.auto/fact/differences-between-diesel-and-petrol/#:~:text=The%20calorific%20value%20of%20diesel,to%2033.7%20MJ%2Flitre).)

TABLE 6-6 – SITE CONCESSION REVENUES FOR BERCHEM FROM CONCESSION FEES FEE

	2023	2030	2040	2050	2050 - sensitivity
Restaurant fee	*7.0%*	*7.0%*	*7.0%*	*7.0%*	*7.0%*
Berchem - **restaurant** revenues	0.5 M€	0.5 M€	0.5 M€	0.5 M€	0.5 M€
Shop fee	*9.5%*	*9.5%*	*9.5%*	*9.5%*	*9.5%*
Berchem - **shop** revenues	13.7 M€	13.7 M€	13.7 M€	13.7 M€	13.7 M€
Fuel fee per litre	*0.15 €*	*0.15 €*	*0.15 €*	*0.15 €*	*0.15 €*
Berchem - **Fuel** revenues	27.4 M€	22.8 M€	8.2 M€	0.6 M€	0.6 M€
Electricity fee per kWh	*0 €*	*0.05 €*	*0.05 €*	*0.05 €*	*0.10 €*
Berchem - **Electricity** revenues	- €	0.7 M€	2.6 M€	3.9 M€	7.7 M€
TOTAL revenues to Government from Berchem Luxembourg and Berchem France	**42 M€**	**38 M€**	**25 M€**	**19 M€**	**23 M€**
Variation in % compared to 2023 revenues	**/**	**- 9 %**	**- 40 %**	**- 55 %**	**- 46 %**

Note: In the case of government financing the grid connection, a ca 0.02-0.03 €/kWh fee would be added, as discussed in 6.4. This is not included in the table above.

The data presented in the table indicates that, based on the modelling, total revenues are projected to decline by only 10% by 2030 compared to 2023 in this scenario. However, as fuel demand decreases, total revenues are expected to be approximately halved by 2050. The increase in electricity demand only partially offsets the reduction in revenues. This decline can be explained by the levels of fees chosen, but also by the fact that, as explained in section 3.4, while many fossil fuel cars are stopping at MSAs to refuel even if they drive short distances (e.g. commuters, for the price advantage compared to neighbouring countries), the future behaviour of EVs is more uncertain, with medium and long-distance drivers very likely to stop charging in Luxembourg while short-distance drivers are less likely.

It is then unlikely that any adjustments to the fee structure will maintain total revenue levels between 2023 and 2050. Increased fuel, shop and/or restaurant fees compared to the example shown above may compensate for part of the loss in revenues, but this will heavily depend on the government strategy and revenue targets, and the bidder strategies on the future concession tenders. Doubling the electricity fee in the alternative scenario would be challenging to justify and may make charging cost not competitive. This would also not completely compensate for the loss of fuel revenues. The monthly fee can remain unchanged, but an adjustment in the area fee may be required during the first years of concessions of the CPO. Proportionally to the demand increase, the government revenues from electricity fees (set at 0.05 €/kWh) from 2030 to 2035 in Berchem (France and Luxembourg cumulated) are expected to rise from 650 k€/year to 1.6 Mk€/year, to which 240 k€ would be added yearly because of the area fee. As such, to help relieve the corresponding burden for the CPO, an exemption from this area fee during the first years / first concession period could be considered.

-

6.7 POTENTIAL OBLIGATIONS FOR CONCESSIONEES

The future concession contracts may need to contain provision for:

- **Installation of electric vehicle charge points**.
- **Installation of solar panels**.
- **Division of cleaning and maintenance responsibilities** on the site, if the multiple concession option is chosen.

These are discussed in Table 6-7 below.

TABLE 6-7 – POTENTIAL OBLIGATIONS OF THE CONCESSIONEES

Low carbon obligations	**Current obligations** To deploy solar panels wherever it is possible. No obligation to deploy alternative fuel infrastructure (electric charging not part of concession scope).
	Future obligations that could be considered: **Provision of EVCPs:** • Demand for electric vehicle charging at the sites will gradually replace demand for fossil fuels on the sites as the energy transition proceeds. • Therefore, in order to maintain concession revenues from the sites, it will be necessary to install EV charge points on the sites. • However, the future charging demand at the MSAs – and the rate at which it will ramp up – is uncertain. Therefore, we suggest that concession contracts avoid being highly prescriptive in terms of the exact number of charge points that are installed by each year. Instead, the concession could be designed so that the LDV charging concessionaire / HDV charging concessionaire / whole site concessionaire (depending on which option is chosen for number of concessions) is obliged to install a small minimum number of charge points at the start but is then free to install additional charge points at their chosen time as demand increases. • To enable this, it is suggested that (for the multiple concession option) the charge point concession areas cover a sufficiently large portion of the parking areas to allow the CPO to increase the number of parking bays fitted with charge points. This applies to both the LDV charging concession and the HDV charging concession, in the scenario where the sites have multiple concessions. • The concession duration is also important to consider in this context, as discussed earlier. **Solar Panels:** • The most recent tender documents for Berchem (2024) include a clause regarding solar panel installation which requires the

	concessionaire to install solar panels on all existing rooves and canopies, where technically feasible. • Similar obligations could be included in future tenders. This could range from installing solar panels on existing rooves/canopies, to requiring photovoltaic canopies on future charging infrastructure, which has the dual benefit of providing customers with protection from rain or excessive heat when charging. Solar installations can also reduce the electricity consumption (and therefore emissions) of the MSA. • Further work would be needed to understand the feasibility of the installation of this infrastructure (i.e. technical feasibility assessment).
Maintenance scope	**Current state** • The Concessionaire is responsible for the maintenance of all existing installations and for any new installations directly related to the operation of the fuel and related products sales outlet, the shop and the restaurant. • Site entrance lanes and public parking lots are maintained by the State, including repairs, markings and general signage.
	New proposition • In a multiple-concession scenario, concession holders could be responsible for cleaning and maintaining their own areas. Regarding the general areas (areas that do not fall directly under the scope of any of the concession holders, for example the road access to the various areas), the maintenance and cleaning responsibilities could fall under the same scope as the restaurant and shop zone. This concession scope yields the highest revenues and thus is the least burdened by this additional responsibility. • Another option would be for broader concession areas to be defined by the government directly in the tenders, so that all concession holders have a clear area of responsibility in which they must ensure the maintenance and cleaning. There would thus be no "general" areas in this scenario, except those that are currently maintained by the state which would remain under the State's responsibility. • A final option would be for the concession holders to be responsible for the maintenance of their own areas, and for the state to design a company responsible for the cleaning of the overall site. This would avoid the burden of having different cleaning companies on site with different standards/quality of work and risk of conflicts between them.

6.8 PROVISION OF FACILITIES

This section analyses whether additional changes are needed for the MSAs to better cater to future customers behaviour. Looking at customer types and services already provided by the MSAs (refuelling, shops and restaurant), it appears current MSA are already set up to answer the needs of customers stopping for 20-30 minutes. This customer type currently corresponds to a major client base, with a peak in August during holidays, and will become the main one in the future because of longer charging time (compared to refuelling). The conclusion of these considerations is that no major changes are needed because the MSAs already provide high-quality services, but some changes could still be beneficial.

Changes in stop lengths

Because of the energy transition and the switch from fuel to electric vehicles, it is important to consider whether the stop lengths will also be modified accordingly. This could notably be the case if people need to stop for a longer time to charge their vehicles. Since it will depend on the vehicle and the types of users, this needs to be analysed by splitting them into categories.

- For heavy duty vehicles, it is unlikely that the stop lengths will vary significantly. This duration is mainly dependent on the mandatory breaks that the driver has to do regularly (as discussed in section 3.3). This time will also be used for charging the vehicle, and thus the change to charging should not have any effect on the stop lengths.
- For light duty vehicles, this will depend on the user profile.
  - For users visiting the MSAs specifically for the shop and its cheaper products, no change in stop lengths is expected.
  - For people on long journeys, it is likely that the MSA in which they decide to charge will be carefully considered before the trip. This stop will likely last around 30 minutes (as explained in section 3.1.3), which they will try to optimise for example by having lunch or making full use of the available facilities. Since the frequency of these stops will be generally higher than with fuel vehicles, this share of customer should represent a non-negligible customer pool for MSAs. The MSAs will thus have to increase their attractiveness, to ensure these potential clients stop at their MSA and not another one on the trip. Increasing this attractiveness may notably require more space in the MSA, a subject that is discussed in section 4.1.
  - For all other people that were using the MSA for refuelling, they may either stop for longer as the charging takes a longer time, or not stop at all because they would be able to charge in town / at home / at the office. This will likely increase the average duration of a stop, as this will shift the distribution of visitors towards longer stops as less customers stop solely for fuel. Considering the conclusion reached in the previous paragraph, any improvement in the attractiveness of the MSAs will be beneficial to also attract and retain local or regional customers to stop at a specific MSA for charging their vehicle.

The MSA is currently busiest in August, during the holiday period, with the main type of customer already being those stopping for a long period of time. Since this customer base has already been secured by the MSA with the current services there should not be many more potential customers to attract with new services. However, customer needs may change and potential areas of focus for future MSAs are outlined in the next section.

Monitoring

Due to the potential changes in stop length outlined above, as well as the impact of space constraints detailed in section 4.1, the Luxembourg government or the concession holders may introduce monitoring of the parking and charging areas of the MSAs. For example, CPOs will want to ensure that a charging bay is not blocked by a petrol/diesel car. ANPR (automatic number plate recognition) technology could in theory be used to impose fines on customers who park in a space designated for another type of vehicle, or for staying too long in a bay. However, this is not currently possible because fines can only be given by the State and Communal Administrations. Similarly, "idle fees" or overstay charges are already imposed by some charge point providers[117]. During peak demand days for LDV charging, CPOs could also introduce systems to encourage drivers to leave the EV charging bay after they are charged: this can for example be by introducing higher charging fees (in €/kWh) after the vehicles reached 80% state of charge, or after a sufficient amount of time, or introducing a charging fee based on time spent (€/min) after a given duration, which should be enough for the vehicle to be charged. However, this may be difficult practically due to the large volume of traffic from other European countries on Luxembourg's roads. Given the limited space available at MSA sites, this may be an important aspect of managing traffic flows in the future.

Non-Charging Parking As the MSA sites transition towards providing more charging, this could cause issues around non-charging parking provision for customers who do not need to charge but require other facilities from the MSA. This is especially important if fees were introduced for staying too long in a space (as discussed above). Whilst modelling (see section 3.4) indicates servicing peak demand would require most (if not all) parking spaces to have chargers installed and the complete transition of fuel infrastructure to chargers, in practice it is prudent to maintain a number of parking-only spaces. This may be included in the CPO portion of the concession contract, whereby CPOs cannot build chargers on a certain number of spaces. This is especially important if overstay fees for charging bays are imposed: this could bring about significant distrust from the customer if there are no non-charging parking bays to move to once charging is finished. The number of spaces may be more easily determined using data collection, which is discussed later in this section.

Changes in services provided

To evolve alongside the shifts induced by the energy transition, the organisation of space occupied by the MSA will change greatly (notably to accommodate for the new charging points and the equipment required for the upgraded grid connection). In section 4.1, the upcoming space constraints were studied for the installation of LDV and HDV charging points. The conclusion was that for 5 out of the 8 MSAs, space constraints would occur before 2050 when deploying charging points for LDV. This means that the improvement in MSAs attractiveness will in general need to be a qualitative upgrade of the service provided without expanding on the number of services offered (or at the expense of the space given to each service). Notably, sales from the shop are likely primarily dependent on a price advantage compared to other countries, which is not a factor easily influenceable by the MSAs themselves.

[117] For example, https://www.allego.eu/overstay-fee/

For the remaining 3 of the 8 MSAs, as can be seen in the example of Berchem France (see section 5.4 and Appendix G), there is not much space to add another building. However, if that were still the case, services to be added could notably include a garage for maintenance and repair, or a carwash.

In light of the energy transition and climate change, a strong course of action could be to enhance the greenery on the site and place picnic tables under the shade of trees. To better handle hot climates, other ideas would be to reduce the use of concrete when possible and provide a variety of entertainment and environmental facilities on the site, catering to a variety of traveler profiles (tourists, families, etc.) whilst they are charging their vehicle. The same concepts can be applied to overhaul the current children playground. Thanks to the existing underground pedestrian path, these benefits could even be shared between Berchem Luxembourg and France.

Signage

As listed in section 6, in the case of multiple concession holders on one site, the Luxembourg government's Administration des Ponts et Chaussées may need to provide signage for the MSA facilities independently. This is to ensure that all the facilities on the site are appropriately advertised and signposted as parking potentially becomes more complex on MSA sites. This is especially important during peak times such as July and August when there may be significantly higher charging demand than usual (see section 3.1.3). This could include both on-site signage to direct customers to the correct parking areas, as well as external signage that could indicate the number of parking and charging spaces available. Also, using signage on the motorways regarding the level of availability of charging infrastructure on the MSAs could help drivers to choose the adequate MSA for charging during peak days. Section 3.1.3 has shown that peak days were usually concentrated in July-August but with some variations across the MSAs.

Shared infrastructure

As discussed in section 4.1, there will be several days per year during which demand will exceed average daily demand. One way to accommodate this could be to share some infrastructure between LDVs and HDVs on especially busy days. For example, 350/400kW CCS chargers (such as those already installed at many MSAs as part of the SuperChargy network) installed in the HDV area could be opened for use by LDVs with high charging rates to alleviate some of the charging bottleneck. This system could especially be relevant during peak days for LDV charging (e.g. over the summer) which may not be high-demand days for HDVs. This would require the CPO in charge of the HDV chargers to ensure access is provided and safety standards for the car drivers are met. During peak demand days for LDV charging, CPOs could also introduce systems to encourage drivers to leave the EV charging bay after they are charged: this can for example be by introducing higher charging fees (in €/kWh) after the vehicles reached 80% state of charge, or after a sufficient amount of time, or introducing a charging fee based on time spent (€/min) after a given duration, which should be enough for the vehicle to be charged.

These considerations have been made based on the current knowledge of the MSAs available and projections for the consequences of the energy transition. However, to maximise their benefits and better handle the forthcoming changes by reducing uncertainties, the MSAs could start to collect new data. This is discussed in more details in section 6.11.

6.9 EXISTING SUPERCHARGY NETWORK

Thanks to the SuperChargy Network, seven out of eight MSAs already include a few high power (350+kW) charging stations for electric vehicles. The DSO is currently responsible for this network, however there is currently a European call for concession to take over the network, including the 7 MSAs with chargers installed. The next concession will likely begin in June 2025 and renew in 2032. While the current number will not be able to accommodate the future needs, the future of these stations must be defined by this date. Two arrangements are possible, each with its pros and cons:

- If the stations are transferred to the CPO(s) of a MSA selected for the new concession period, then it is likely that this process will be repeated for all MSAs. While these assets are more easily manageable at the MSA level by the respective CPO, this would greatly damage the network aspect of these stations. The administrative burden from repeatedly removing the station from the network for each concession renewal will likely be tedious.
- If the SuperChargy Network is kept intact and managed by a single actor, then all MSAs will have an additional party which complexify all discussions. This is notably the case regarding the grid connection, with the distribution of electricity. It is also true for the scenario where the various CPOs have to share the burden of the investment for the grid upgrade connection. Also, this means that there would potentially be two CPOs for LDVs on the MSA: one from the SuperChargy Network, and the CPO holding the future LDV charging concession. Consultation of potential future charging concession bidders may be done to understand if this situation poses a risk for their bid.

6.10 REPLACEMENT OF FUEL PUMPS WITH EVCPS

As a direct consequence of the discussions in section 4.1 regarding space constraints, a choice will have to be made in MSAs regarding the replacement of fuel pumps by EVCPs. This is a novel consideration as fuel pumps have not previously been removed from sites. In this section, we will look at this subject from both an economic (in terms of government revenues) and an operational perspective.

Economically, any MSA which does not suffer from space constraints for the installation of EVCP has no incentive towards removing the fuel pumps already in place, as long as the fuel demand remains non-negligible (so long as the operation of the pumps remains economically viable). This is the case for Berchem France.

However, for other MSAs like Berchem Luxembourg, the space constraints indicate that at some point, it could become more economically interesting to replace at least some of the fuel pumps by EVCPs. To analyse this scenario, a fee of 0.15 €/L of fuel sold and 0.05 €/kWh of electricity sold was considered (to keep the same fee structure as in section 6.6). This analysis is shown for the case of **LDV refuelling / recharging**, but the same approach could also be taken for HDV refuelling / recharging.

The main hypothesis in this scenario is that parking spaces are replaced by charging bays in priority. When all charging bays are installed, the replacement of fuel pumps by lane chargers is considered from an economic point of view (average yearly fee revenue to the government from a single fuel pump or EVCP).

Please also note that similarly to section 6.6, this modelling only considers direct fee revenues from the MSA and do not take into account any excise duty, redevance or other taxes collected on the fuel and electricity sold.

TABLE 6-8 – EVOLUTION OF THE YEARLY REVENUE FROM FUEL AND ELECTRICITY CONCESSION FEES FOR BERCHEM LUXEMBOURG BASED ON PROJECTED CHARGING AND FOSSIL FUEL DEMAND, FOR THE CASE OF LDVS – ILLUSTRATIVE EXAMPLE

	2023	2030	2041	2050	2050 – with replacement
Fuel fee per litre	*0.15 €*	*0.15 €*	*0.15 €*	*0.15 €*	*0.15 €*
Number of petrol pumps	8	8	8	8	4
Number of diesel pumps	19	20	20	20	10
Yearly fee revenue from a pump	297 k€	236 k€	78 k€	11 k€	22 k€
Electricity fee per kWh	-	*0.05 €*	*0.05 €*	*0.05 €*	*0.05 €*
Number of EVCPs	7	48	134	134	170
Yearly fee revenue from an EVCP	4.8 k€	6 k€	8,9 k€	12 k€	9.8 k€

- From 2025 to 2041, the demand for fuel decreases and the demand for electricity increases.
- Starting 2041, Berchem France hits the space limit for installing new EVCPs (evaluated at 134 in Scenario 1 of section 5.4). However, at this time, the replacement of fuel pumps by lane chargers is not economically viable yet (considering the fee revenues).
- Around 2050, since the yearly revenue from an EVCP has become more interesting than those of a pump, the number of fuel pumps can be reduced to install more EVCPs.
- The last column describes the resulting situation in terms of yearly fee revenues in 2050 if half the pumps are replaced. In this scenario, 36 lane chargers are installed (half the total number of lane chargers that could replace the fuel pump, as explained in section 5.3).
- As demand for electricity increases and demand for fuel reduces, purely from an economic standpoint, it is likely that the remaining fuel pumps would be progressively replaced by EVCPs to better account for the progressive changes in the market.
- **The example shown above is not intended as a precise prediction (or specification of the exact fee), but rather as a demonstration of how, by monitoring charger and petrol pump utilisation, the Luxembourg Government can forecast when it is advantageous from a concession fee revenue perspective to replace fossil fuel pumps with EVCPs and/or to change concession fee to maintain revenues at a reasonable level for the Government.**

The conclusion of this modelling is that in Berchem Luxembourg, purely economically (in the perspective of the fee revenues for the State), EVCPs should replace some of the existing pumps from around 2050, and that the economic viability of a pump continue to decrease after this date. However, since the replacement of fuel pumps by lane chargers would require preparation and non-negligible civil works, this shift would need to be anticipated.

In an operational perspective, while the parking lot is equipped with charging points, this fuel pump area is used in section 5.4 to install lane chargers. Lane chargers provide a different type of service than parking bays, which they complement (as explained in section 6.5). As such, the economic perspective is not the only one to consider, especially for sites where there are no space constraints. Theoretically the lane chargers would indeed not be “economically viable” in the sense used in this modelling, but they could answer a different type of need and thus be a necessary asset to the MSA. This could notably make the MSA more efficient and thus give it a good reputation for the customer, increasing its attractiveness.

In addition, the modelling clearly shows that the demand for fuel pumps drastically decreases over the years, selling ten times less fuel after around 20 years. As the demand of fuel is decreasing, the number of pumps required to meet the demand of the drivers is decreasing as well, assuming that the fuel area is correctly sized for today’s demand. The replacement of some of the pumps before 2050 could then be considered, as it brings operational benefits (less operating expenditures for the same level of fuel supply, no stranded assets). In specific cases, for the same operational or economic reasons, the option to remove part of the fuel pumps before all the parking spaces are replaced by charging bays could also be considered.

6.11 DATA COLLECTION

Today, there is no formal data collection and sharing effort within concessions at MSAs. In the context of planning infrastructure, building a clearer understanding of current traffic stopping and customer purchasing behaviour is a prudent step for the MSAs of Luxembourg to take. This is especially important given the numerous uncertainties that already exist when projecting charging demand and driving behaviours of electric vehicles. As part of the concessions, operators may consider collecting data on the following metrics in order to improve planning conditions for electric vehicle infrastructure and other services:

- Traffic data: count of passing traffic on the main road; count of vehicles entering the MSA, by vehicle type, to understand the proportion of passing traffic that is likely to stop. Additional data on demand fluctuations through the seasons would also help to size the power and capacity requirements of the chargers on site.
- Stop time data: metrics to understand the duration of drivers’ stays by vehicle and fuel type (addressed further in section 4.3.7). Automatic Number Plate Recognition (ANPR) could be used to understand how long EV drivers actually stop.
- Parking spot usage: Cameras could be used to verify the percentage of parking spots/bays used and vary the allocation of space if required.
- Charging data: Statistics on the quantity and duration of each charge could also prove useful, notably to assess the need for new EVCP and discussing with potential other CPOs on the site or with the government.
- Purchase behaviour data: metrics to understand purchasing behaviour of customers (by vehicle and fuel type, if possible).
- Quality and usefulness of services: it could be assessed by comparing the number of customers that use them compared to the total number of customers and/or by a simple poll system after their use.

6.12 NEAR-TERM ACTIONS

Current MSA concession renewals are expected between 2029 and 2031. Several actions may be considered in the short term to prepare for the new concessions, such as:

- **Define the features of the concession contract**, in accordance with the evolution of the strategy for EV and for the MSA and based on the recommendations presented above. An update of the future charging demand modelling close to the renewal date of the concessions is also recommended to account for any unexpected changes in the EV market and increase certainty.
- **Consult with stakeholders ahead of the call of tender for the next MSA concessions.** Given the potential complexity of the future concession arrangements and relatively new nature of the EV charging aspects, it will be valuable to consult stakeholders. This will be an opportunity to refine the contract and tender features while also making the market aware of the upcoming call for tenders. Stakeholders here should include existing concessionaires, pure-play CPOs who may operate on the sites in future, related industry bodies, and parties relevant to the development of safety guidance. One of the aspects that should be tested in this consultation is the attractiveness of the business case for short concessions when compensated by the book value or fair value of the charge points being paid by the new concessionee to the previous concessionee. The impact of using fair value or book value, and of concession length, should be tested.
- **Upgrade the grid connections of the MSAs to facilitate the installation of EVCP, ensuring sufficient capacity for future demand.**
    - For Berchem Luxembourg, the future maximum power available (via connection to medium voltage) of 16 MW will meet demands until the early 2030s, after which upstream reinforcements may be necessary.
    - Ensure the cable and substation are designed to meet the anticipated 2050 demand of ca. 75 MW to avoid additional civil works after upstream reinforcements, contingent on the source of the additional power supply.
- **Consider fast-tracking the build of other parking areas where possible, because parking spaces will be lost on the MSAs due to installation of charging infrastructure.** The substation and power cabinets will take up space that was used for parking, reducing the amount of space available for parking both LDVs and HDVs. This includes the secure HDV parking site at Dudelange.
- **Understand the impact of Alternative Fuels Infrastructure Facility projects.** The HDV charging landscape will evolve significantly with the upcoming announcements of these projects[118]. The Luxembourg government may wish to note which projects will be in and around Luxembourg, and to maintain an understanding of market developments. This may have an impact on the parking provision for HDVs at MSAs.

[118] Funded projects from the Connecting Europe Facility programs, with their main characteristics, are listed on CINEA Project Portfolio - Overview | Sheet - Qlik Sense.

7. APPENDICES

APPENDIX A FUEL PRICE DIFFERENCE FOR LUXEMBOURG & ITS NEIGHBOURS

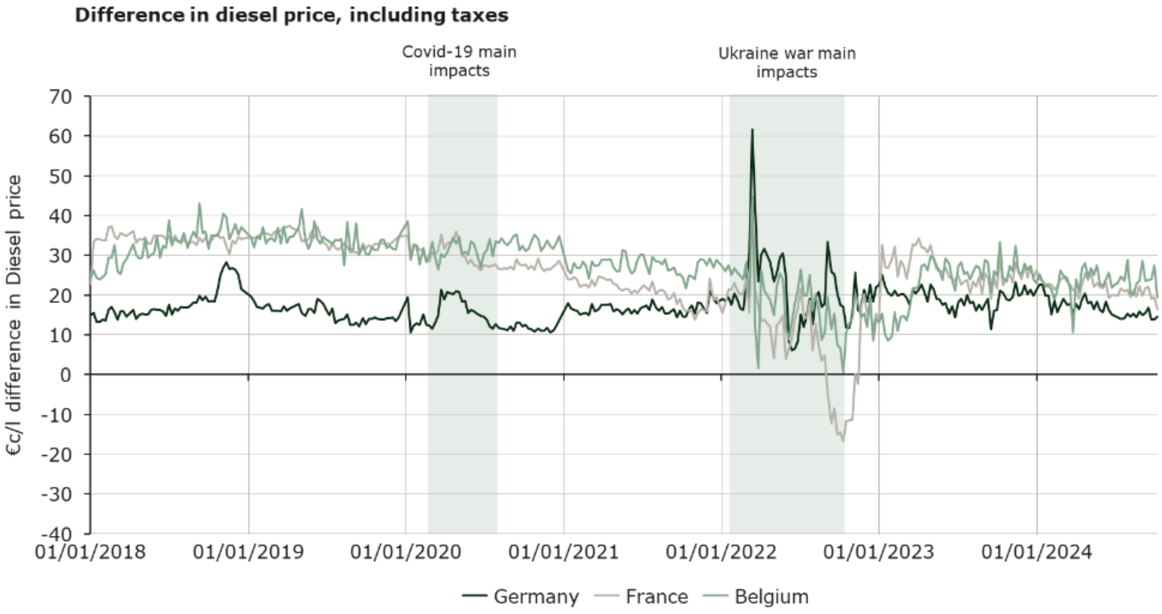


FIGURE 7-1 – DIFFERENCE IN DIESEL PRICE BETWEEN LUXEMBOURG, FRANCE, GERMANY, AND BELGIUM, INCLUDING TAXES BUT EXCLUDING EXCISE DUTY REBATES FOR HDVS

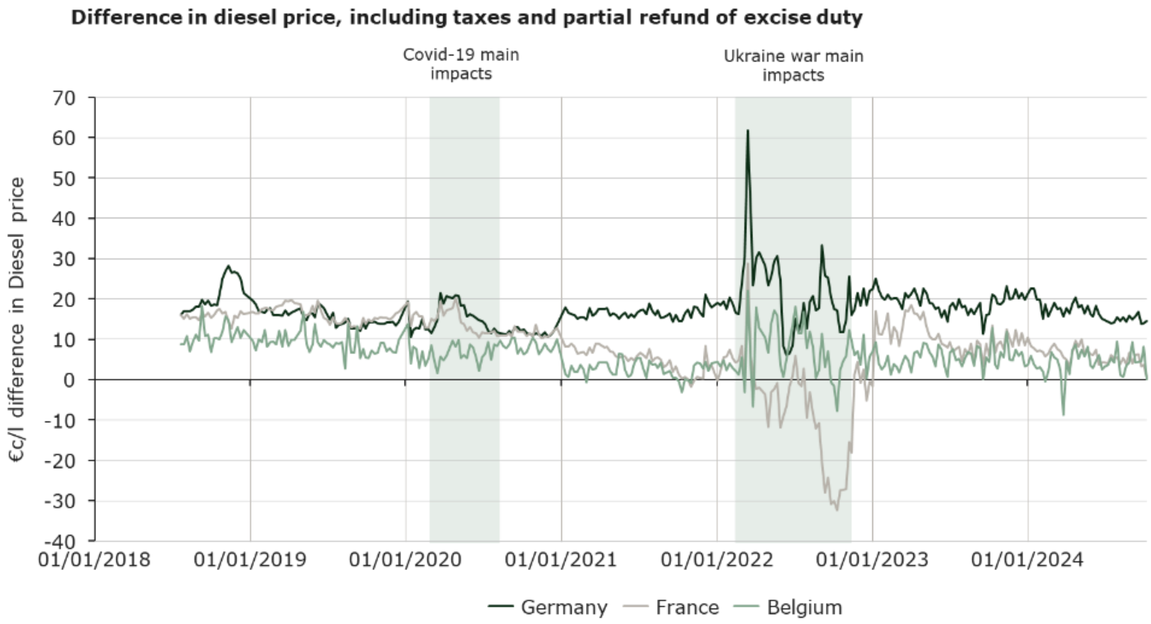


FIGURE 7-2 – DIFFERENCE IN DIESEL PRICE BETWEEN LUXEMBOURG, FRANCE, GERMANY, AND BELGIUM, INCLUDING TAXES AND EXCISE DUTY REBATES FOR HDVS

Traffic flows

Traffic count data is available for a large number of roads in Luxembourg, however only Berchem and Wasserbillig have a camera nearby. Traffic is split into cars (voitures) and vans/trucks (utilitaires), with cars flows showing peaks at commuter times. These flows add to understanding of current refuelling behaviour.

Figure 7-3 shows the traffic patterns in 2023 near the MSAs at Wasserbillig (close to the German border). It demonstrates that there are large peaks for cars at commuting times (6-9am and 3-6pm), with many Germans travelling into Luxembourg City for work each day. The volume of vans and trucks traffic flow is much lower and does not have the same peaks. Similar patterns are observed near the MSAs at Berchem (close to the French border).

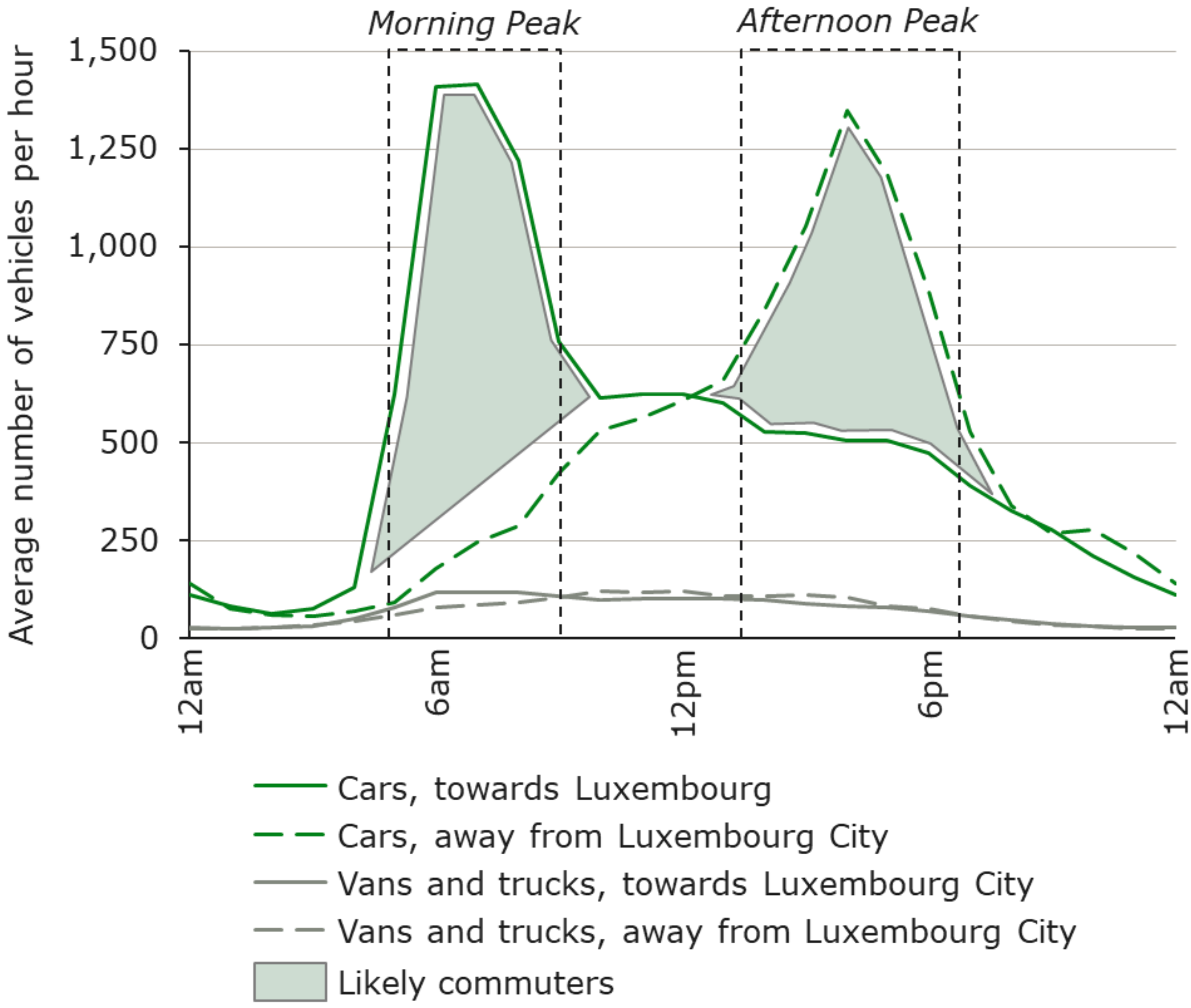


FIGURE 7-3 – ILLUSTRATION OF TRAFFIC PEAKS NEAR WASSERBILLIG IN 2023

APPENDIX B ADDITIONAL ANALYSIS OF MSAS IN LUXEMBOURG, FRANCE, AND GERMANY CHOICE OF COMPARATORS

Eight sites across France and Germany were chosen for analysis as case studies for comparison to Luxembourg's eight MSAs, all on the TEN-T[119] network. Traffic flow data was not readily available in Belgium; hence it was deprioritised for this section of analysis.

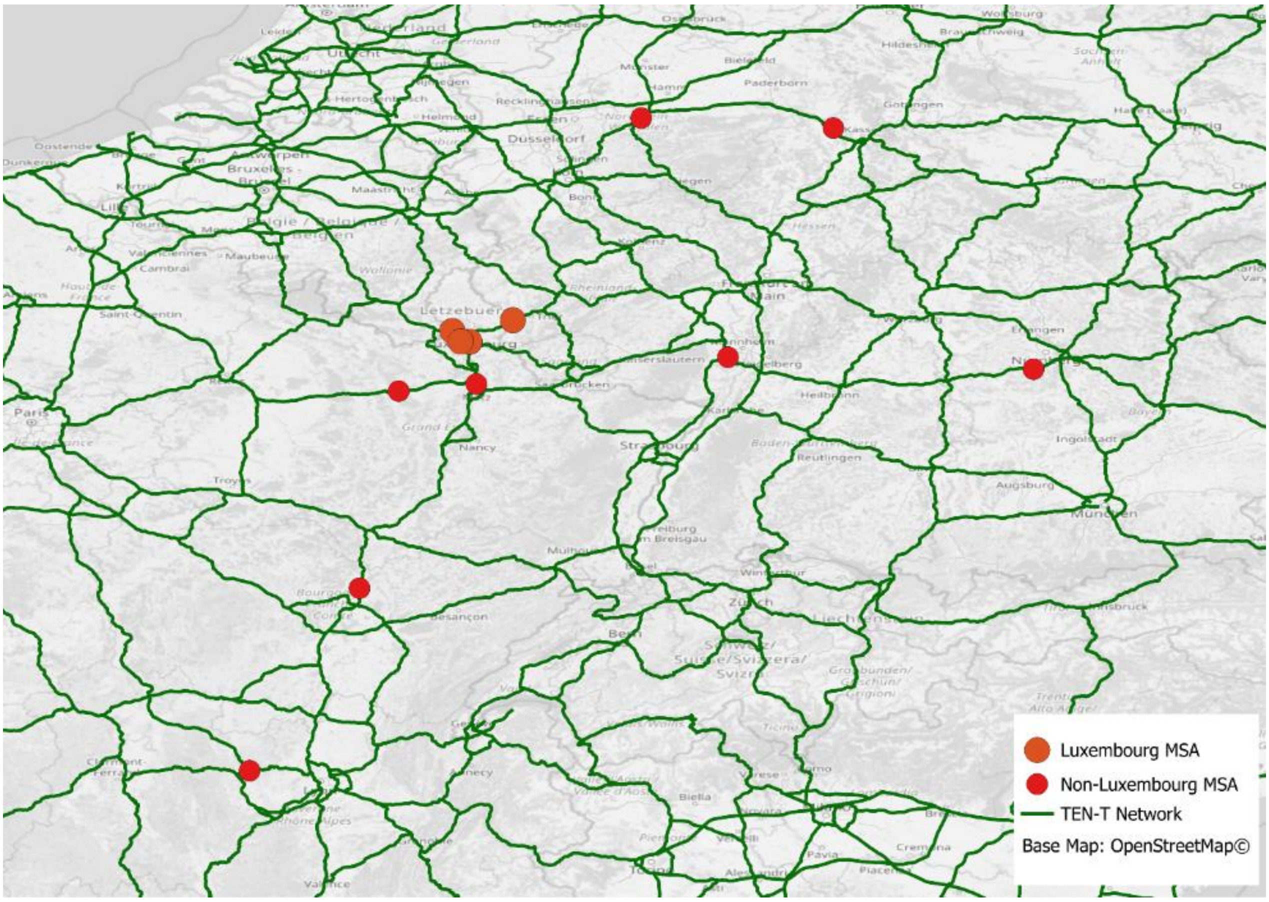


FIGURE 7-4 – MAP OF LUXEMBOURG MSAS AND MSAS OUTSIDE OF LUXEMBOURG CONSIDERED IN THIS ANALYSIS[120]

[119] TEN-T (Trans-European Transport Network) is a network of roads that is prioritised for planning and policy within the EU.
[120] TEN-T network data: https://webgate.ec.europa.eu/tentec-maps/web/public/

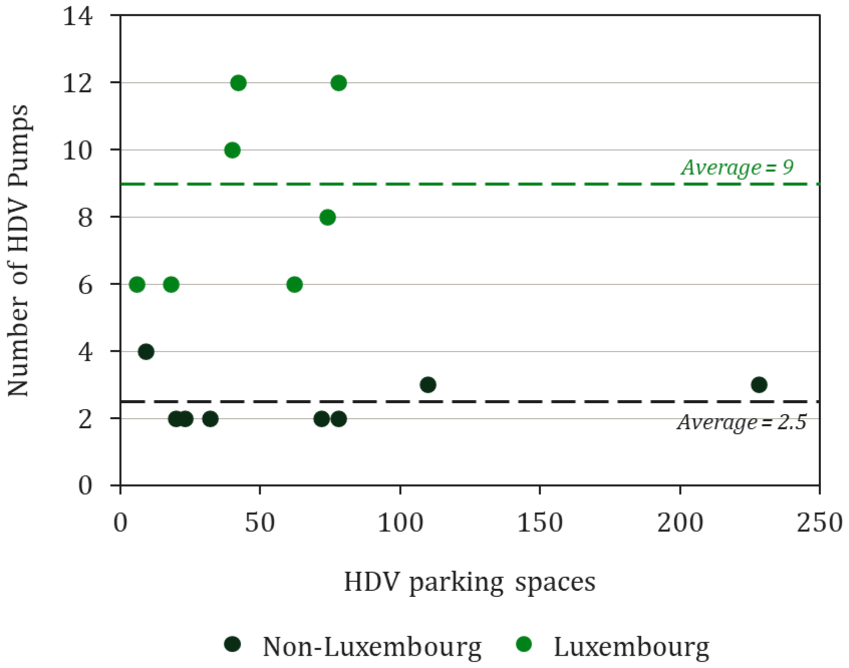


FIGURE 7-5 – PLOT OF NUMBER OF HDV PARKING SPACES AGAINST THE NUMBER OF HDV PUMPS AT MSAS IN LUXEMBOURG (GREEN) OR FRANCE AND GERMANY (BLACK)

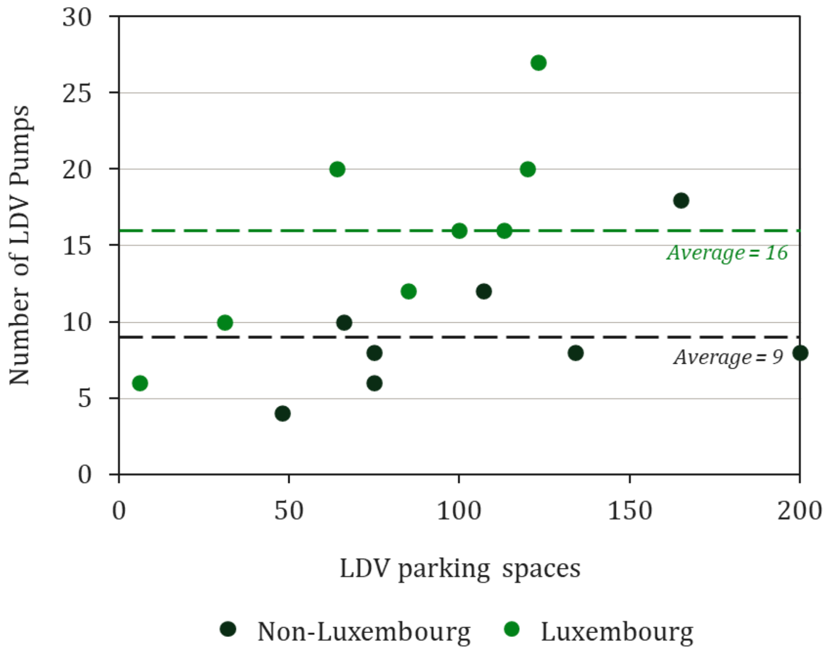


FIGURE 7-6 – PLOT OF NUMBER OF LDV PARKING SPACES AGAINST THE NUMBER OF LDV PUMPS AT MSAS IN LUXEMBOURG (GREEN) OR FRANCE AND GERMANY (BLACK)

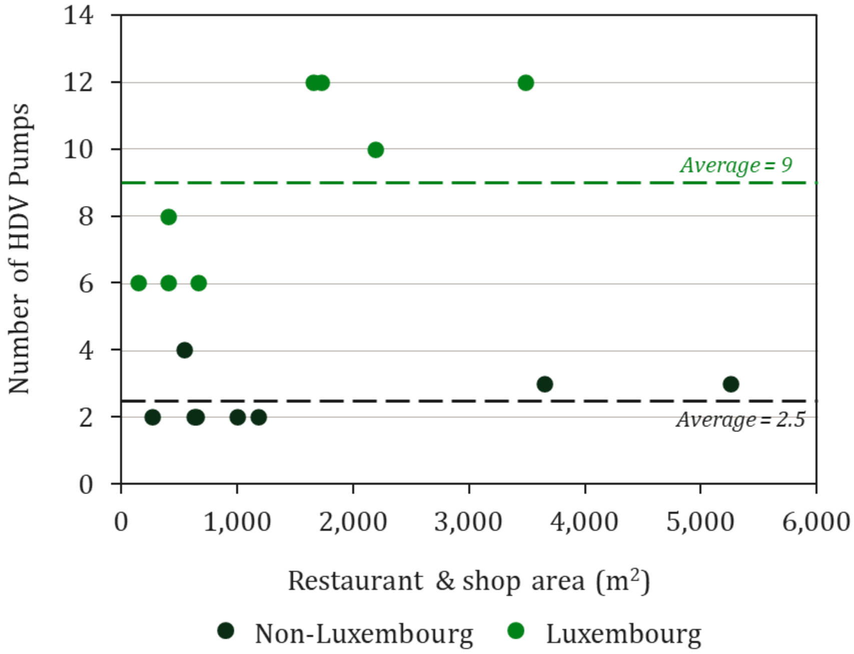


FIGURE 7-7 – PLOT OF RESTAURANT AND SHOP AREA AGAINST THE NUMBER OF HDV PUMPS AT MSAS IN LUXEMBOURG (GREEN) OR FRANCE AND GERMANY (BLACK)

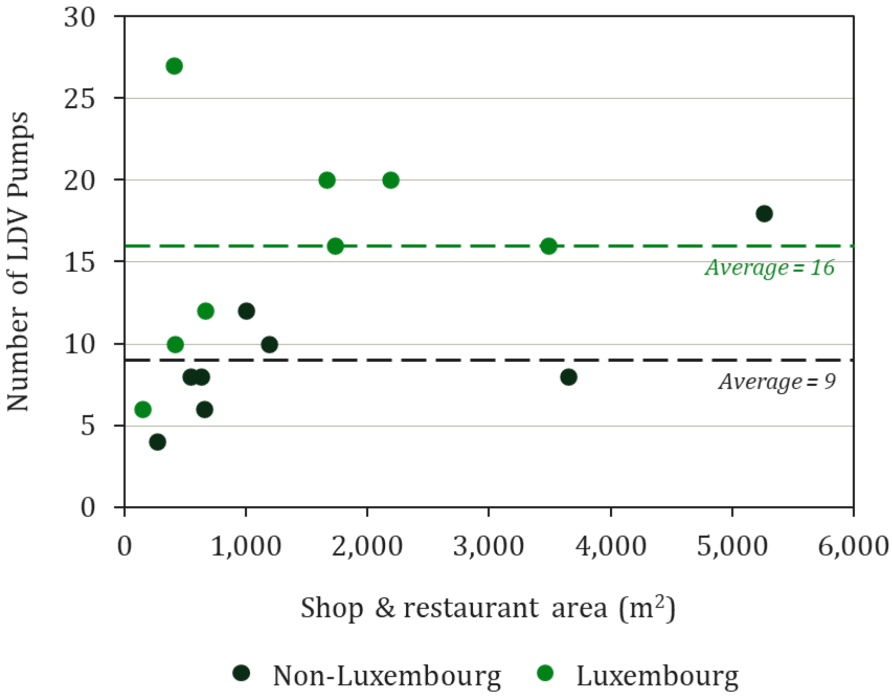


FIGURE 7-8 – PLOT OF RESTAURANT AND SHOP AREA AGAINST THE NUMBER OF LDV PUMPS AT MSAS IN LUXEMBOURG (GREEN) OR FRANCE AND GERMANY (BLACK)

APPENDIX C PEAK CHARGING DEMAND PROFILES

As part of the analysis of current charging demand (see section 3.1.3), charging profiles were produced to understand the temporal distribution of charging demand at each MSA on a day with average demand and on the 10 days with the highest demand. Data for 6 months of charging events from April to September 2024 was made available. The figures below show the number of hours across which daily charging demand is spread.

Normalised Charging Profiles

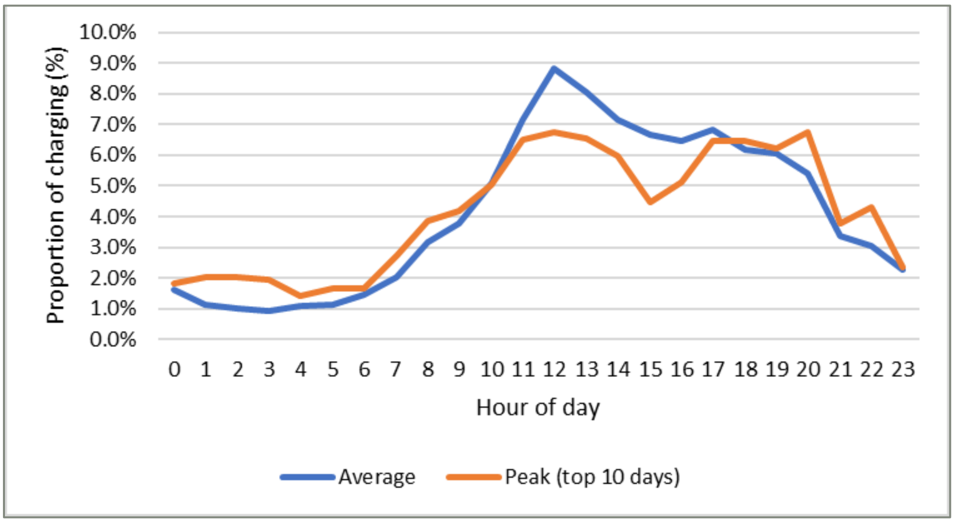


FIGURE 7-9 – NORMALISED CHARGING PROFILES FOR AN AVERAGE DAY AND THE AVERAGE OF THE TOP 10 DEMAND DAYS FOR MSA 1

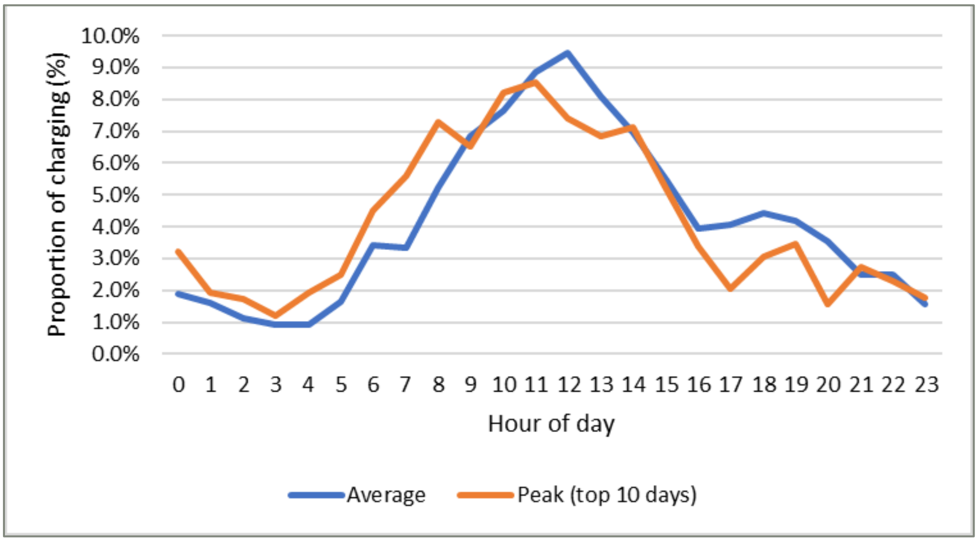


FIGURE 7-10 – NORMALISED CHARGING PROFILES FOR AN AVERAGE DAY AND THE AVERAGE OF THE TOP 10 DEMAND DAYS FOR MSA 2

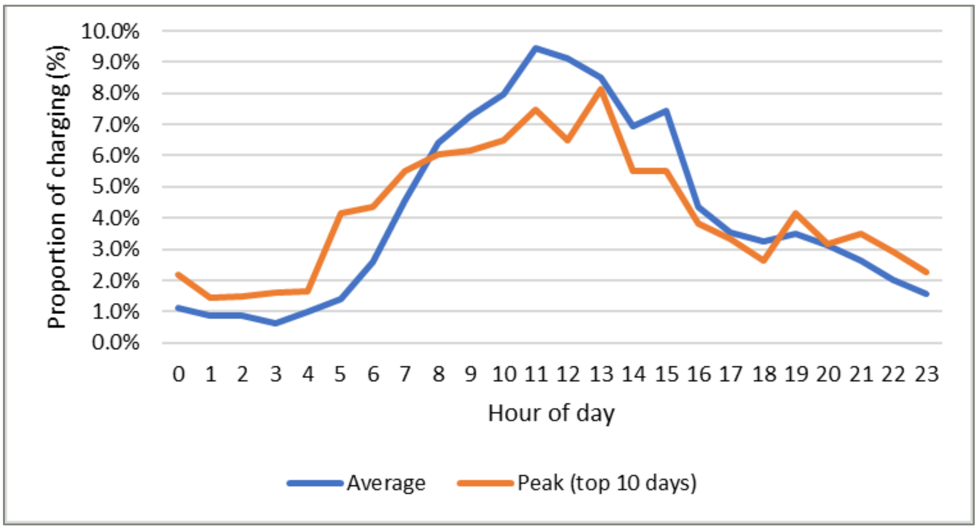


FIGURE 7-11 – NORMALISED CHARGING PROFILES FOR AN AVERAGE DAY AND THE AVERAGE OF THE TOP 10 DEMAND DAYS FOR MSA 3

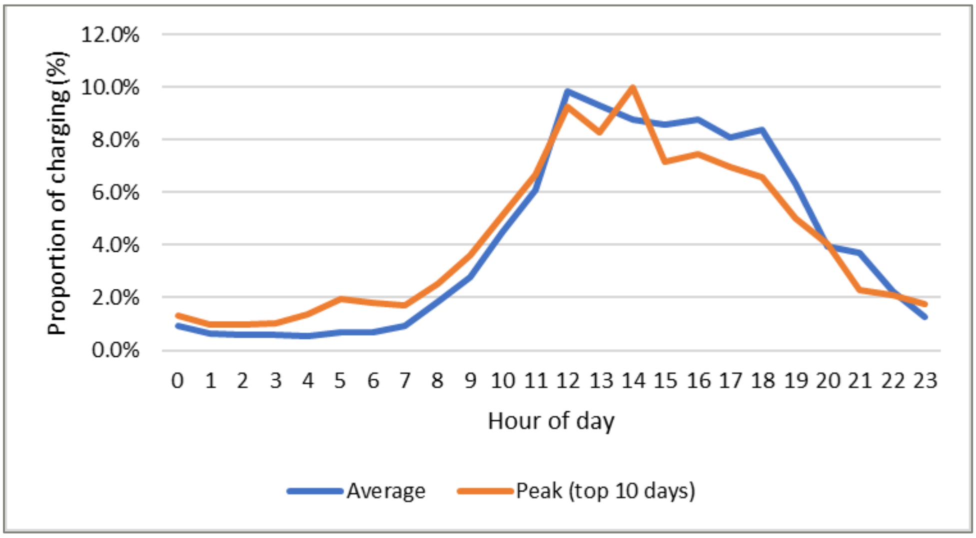


FIGURE 7-12 – NORMALISED CHARGING PROFILES FOR AN AVERAGE DAY AND THE AVERAGE OF THE TOP 10 DEMAND DAYS FOR MSA 4

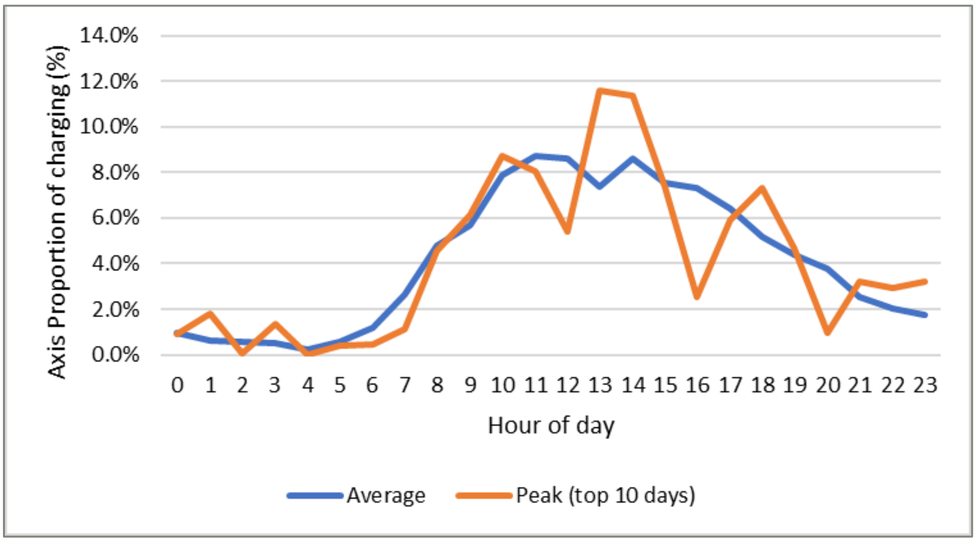


FIGURE 7-13 – NORMALISED CHARGING PROFILES FOR AN AVERAGE DAY AND THE AVERAGE OF THE TOP 10 DEMAND DAYS FOR MSA 5

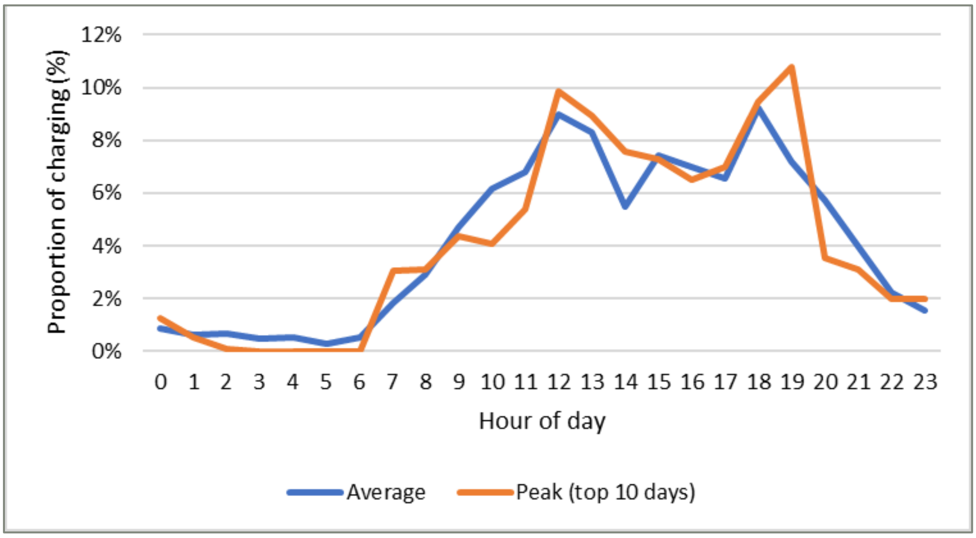


FIGURE 7-14 – NORMALISED CHARGING PROFILES FOR AN AVERAGE DAY AND THE AVERAGE OF THE TOP 10 DEMAND DAYS FOR MSA 6

Charging Profiles (kWh)

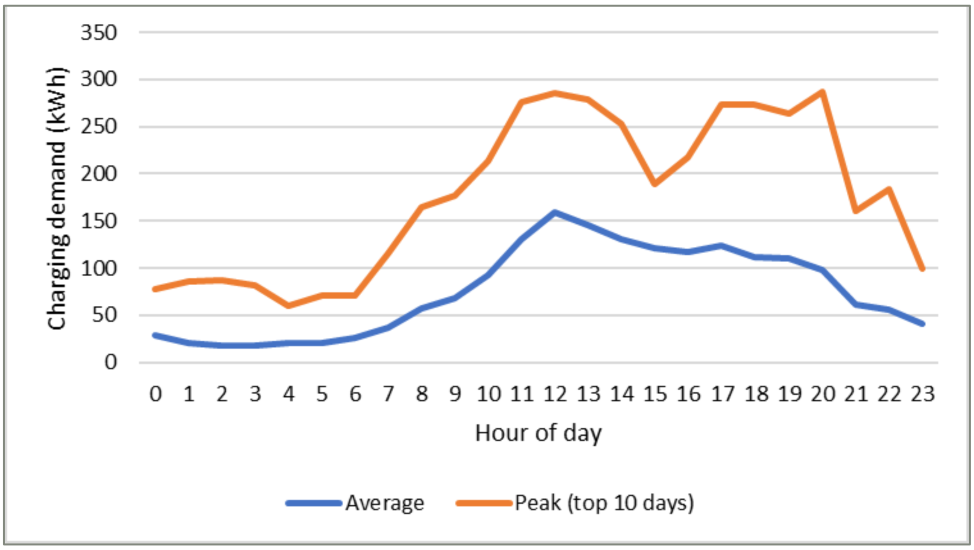


FIGURE 7-15 – KWH CHARGING PROFILES FOR AN AVERAGE DAY AND THE AVERAGE OF THE TOP 10 DEMAND DAYS FOR MSA 1

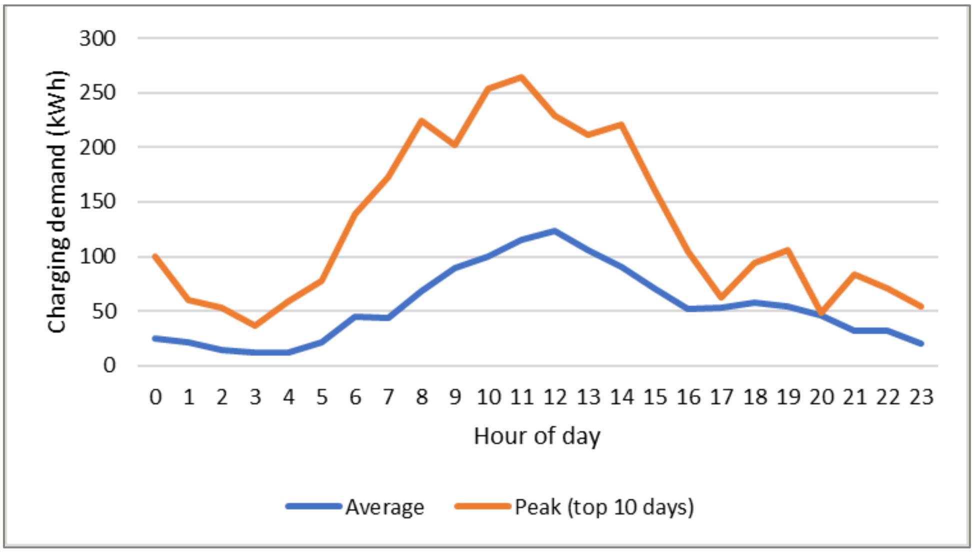


FIGURE 7-16 – KWH CHARGING PROFILES FOR AN AVERAGE DAY AND THE AVERAGE OF THE TOP 10 DEMAND DAYS FOR MSA 2

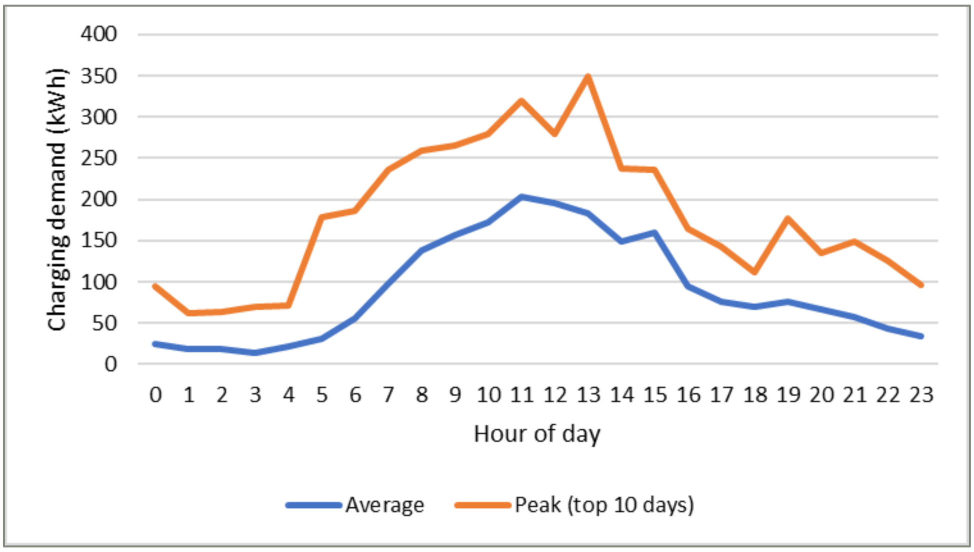


FIGURE 7-17 – KWH CHARGING PROFILES FOR AN AVERAGE DAY AND THE AVERAGE OF THE TOP 10 DEMAND DAYS FOR MSA 3

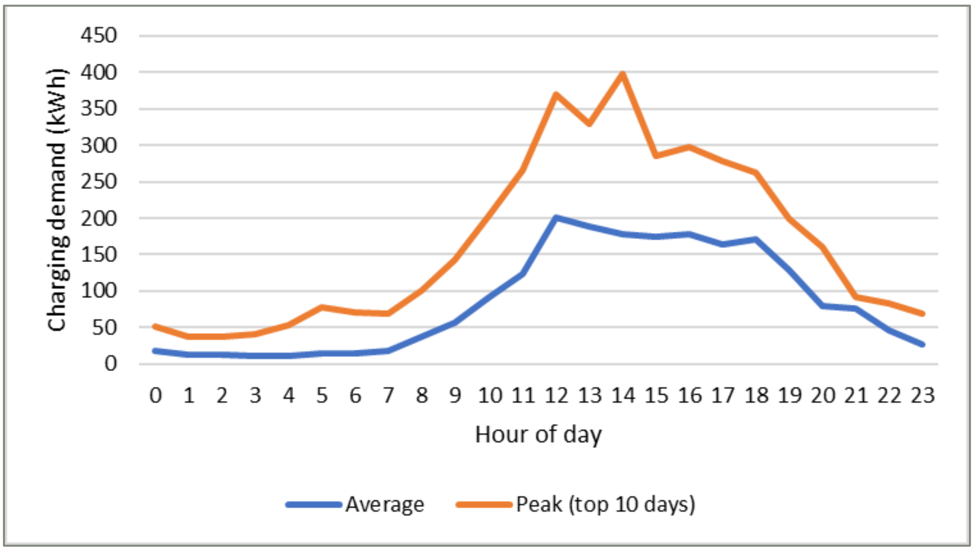


FIGURE 7-18 – KWH CHARGING PROFILES FOR AN AVERAGE DAY AND THE AVERAGE OF THE TOP 10 DEMAND DAYS FOR MSA 4

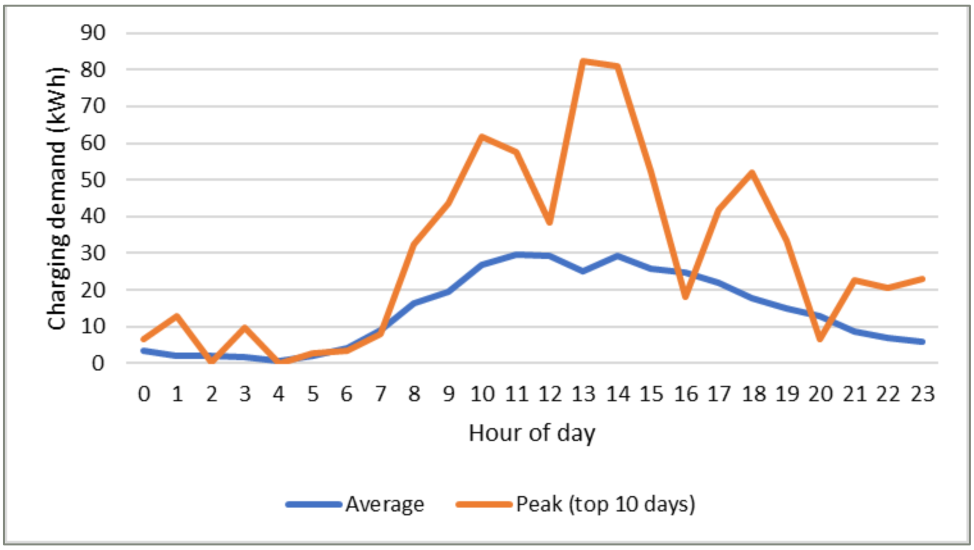


FIGURE 7-19 – KWH CHARGING PROFILES FOR AN AVERAGE DAY AND THE AVERAGE OF THE TOP 10 DEMAND DAYS FOR MSA 5

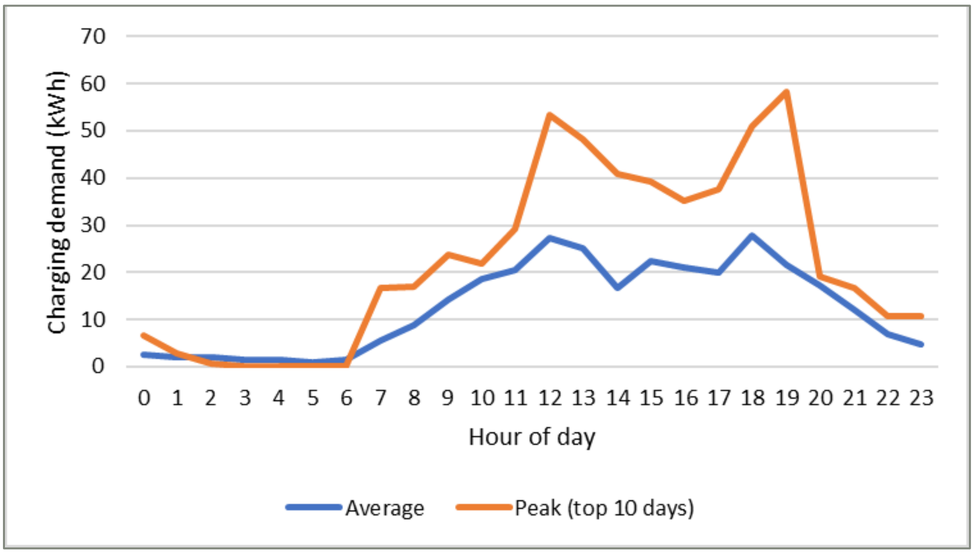


FIGURE 7-20 – KWH CHARGING PROFILES FOR AN AVERAGE DAY AND THE AVERAGE OF THE TOP 10 DEMAND DAYS FOR MSA 6

APPENDIX D LONG-HAUL BEV HGV UPTAKE

The uptake of BEV HGVs over time has been modelled from EU CO_2 performance standard regulations[121], which will have the effect of forcing OEMs to sell artic BEVs into the regional and long-haul markets, with half of new sales expected to be BEV by 2033. Longer-haul HGVs operating in the countries surrounding Luxembourg have more rapid replacement cycle than HGVs in general. This means that we expect most such HGVs to adopt battery electric traction between 2030 and 2040.

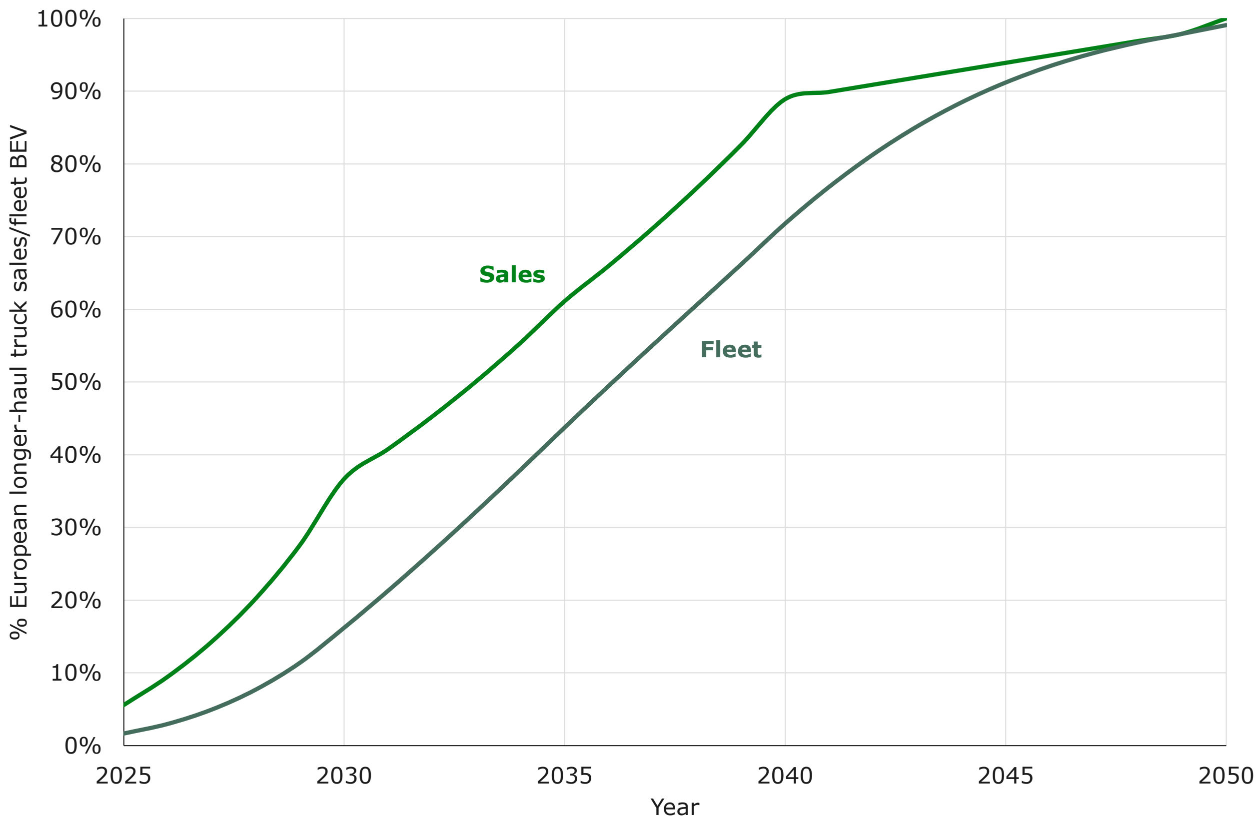


FIGURE 7-21 – EXPECTED PROPORTION OF EUROPEAN LONG-HAUL HGV SALES AND FLEET BEV, 2025-2050

APPENDIX E TECHNICAL DETAIL – CAR AND VAN CHARGING DEMAND MODELLING

TABLE 7-1 – ESTIMATION OF THE CAR AND VAN CHARGING DEMAND AT EACH LUXEMBOURG MSA

MSA	2030	2035	2040	2045	2050
Yearly GWh to charge LDVs					
Berchem Luxembourg	5.7	13.5	22.0	29.0	33.5

[121] https://climate.ec.europa.eu/eu-action/transport/road-transport-reducing-co2-emissions-vehicles/reducing-co2-emissions-heavy-duty-vehicles_en

MSA	2030	2035	2040	2045	2050
Berchem France	3.4	8.1	13.2	17.4	20.1
Capellen Luxembourg	2.4	5.7	9.3	12.3	14.2
Capellen Belgium	3.4	8.0	12.9	17.0	19.7
Pontpierre France	0.4	1.1	1.7	2.3	2.6
Pontpierre Luxembourg	0.7	1.6	2.7	3.5	4.0
Wasserbillig Luxembourg	2.2	5.2	8.5	11.2	12.9
Wasserbillig Germany	2.2	5.1	8.3	10.9	12.6

Method for charging demand modelling for cars and vans:

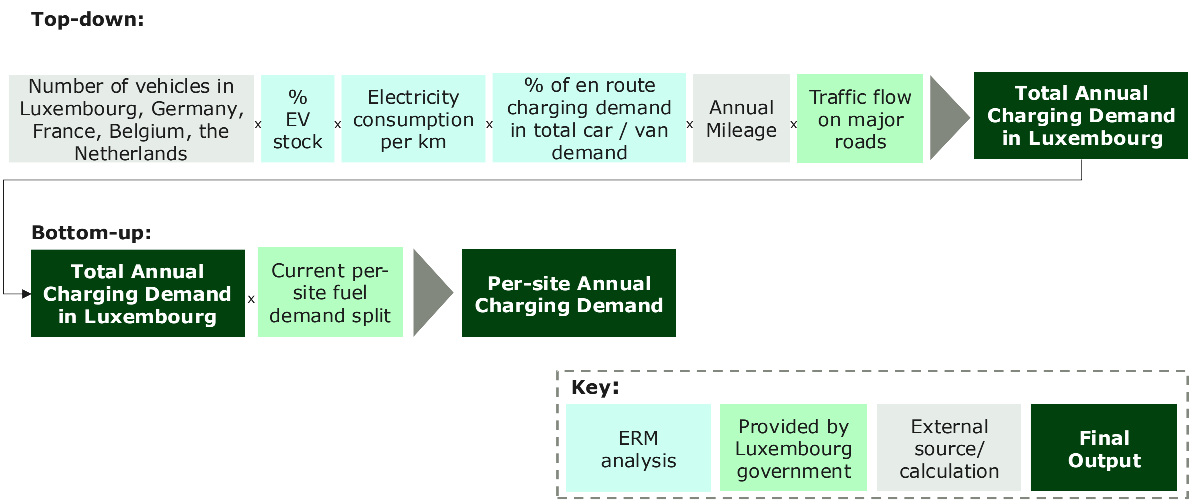


FIGURE 7-22 – ILLUSTRATION OF CAR AND VAN CHARGING DEMAND MODELLING APPROACH

Sources:

- **Number of cars in Luxembourg and neighbouring countries:**
  - Cars: *https://www.statista.com/statistics/452449/european-countries-number-of-registered-passenger-cars/*
  - Vans: *https://alternative-fuels-observatory.ec.europa.eu/transport-mode/road/netherlands/vehicles-and-fleet*
- **% of EV stock:** calculated by ERM based on:
  - UK-based scrappage curve (assume similar across Europe)
  - Total sales remaining constant at 2023 levels *(https://alternative-fuels-observatory.ec.europa.eu/transport-mode/road/luxembourg)*
  - New car sales projected to meet EU targets by 2035 *(https://climate.ec.europa.eu/eu-action/transport/road-transport-reducing-co2-emissions-vehicles/co2-emission-performance-standards-cars-and-vans_en)*
- **Electricity consumption per km:** ERM's proprietary Cost and Performance model
- **% vehicles charging en route:** ERM analysis of car charging behaviour based on data from ICCT reports and internal modelling: Regional charging infrastructure requirements in Germany through 2030, Charging infrastructure to support the electric

mobility transition in France, and ERM analysis of van charging behaviour adapted from Analysis to identify the EV charging requirement for vans (Element Energy) - Climate Change Committee.

- **Annual mileage:** based on 2018 TRACCS data *(https://traccs.emisia.com/)*
- **Traffic flow on major roads:** *https://data.public.lu/en/datasets/pch-comptage-trafic/#resources*
- **Current per-site fuel demand split:** confidential data provided by Ministry of the Economy of Luxembourg

APPENDIX F SHOPS AND RESTAURANTS

A shop and restaurant are included in the concession contract for each MSA. As shown in Figure 7-23, revenues from the shop far outweigh those at the restaurant, and fuel sales generate almost twice the revenue of the shop in 2023.

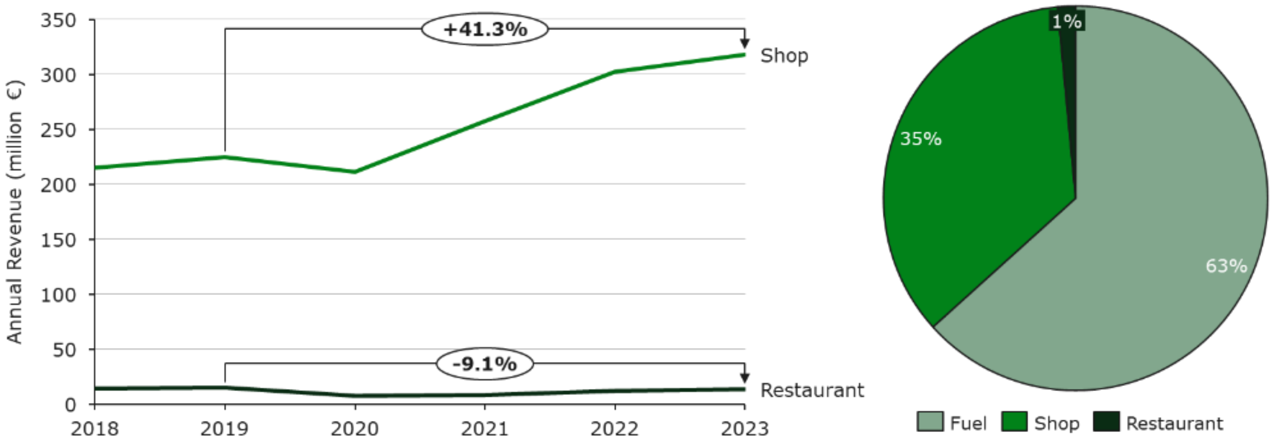


FIGURE 7-23 – TOTAL ANNUAL REVENUE FROM ON-SITE SHOPS AND RESTAURANTS (LEFT), AND THE 2023 DISTRIBUTION OF REVENUES ACROSS ALL LUXEMBOURGISH MSAS (RIGHT)

With the decline of fuel sales as shown in section 3.1.1, shop revenues are likely to constitute a greater proportion of MSA total revenue in the future. Therefore, the space and layout constraints of the shop infrastructure with respect to new charging infrastructure is considered in section 4.

APPENDIX G ADDITIONAL SITE LAYOUT DIAGRAMS

Site layout Option 1:

Shows one small substation at on each side of the motorway, maximising LDV charger installation at Berchem Luxembourg.

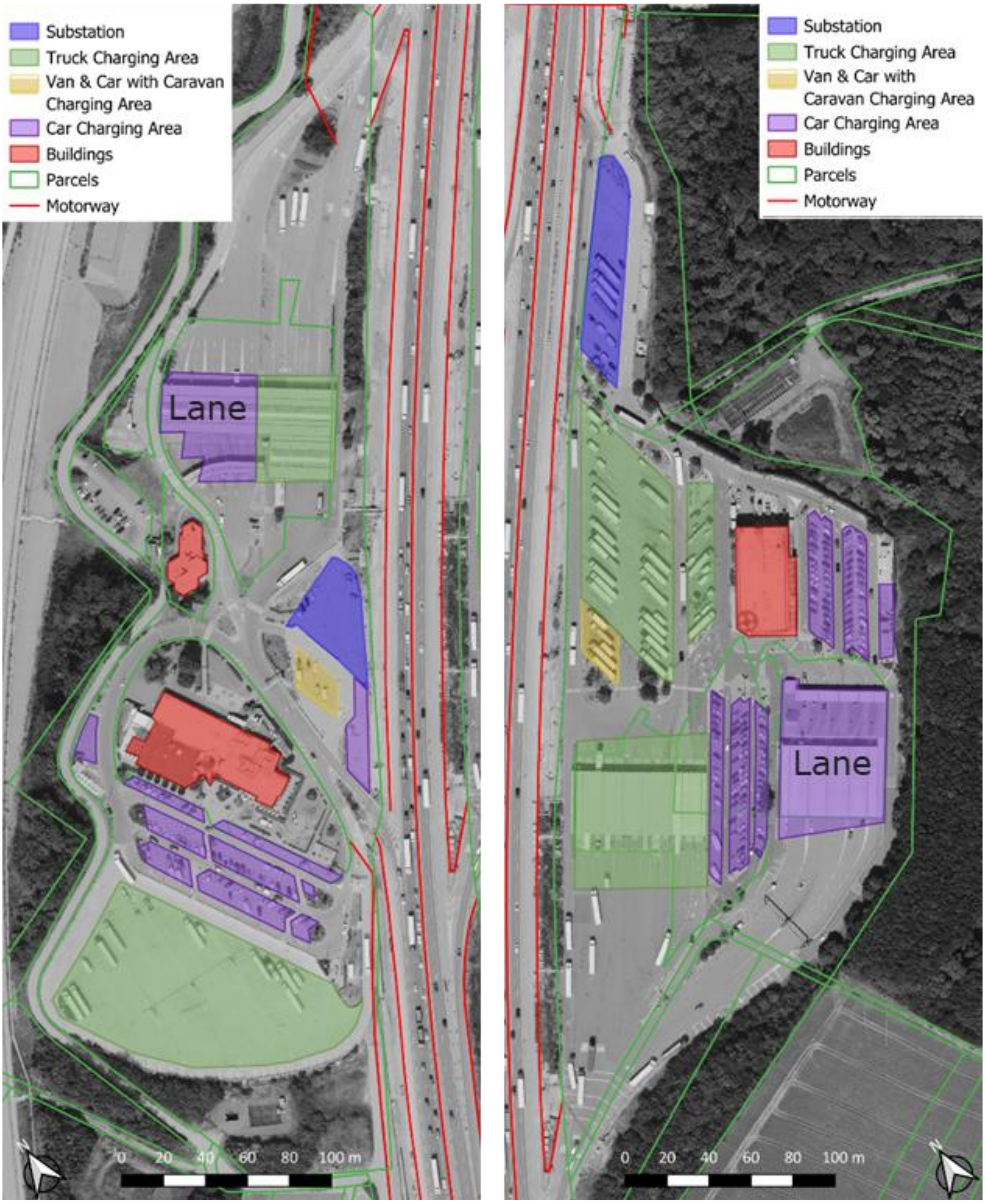


FIGURE 7-24 – MAP OF THE BERCHEM SITES FOR SUBSTATION LAYOUT OPTION 1 IN 2050. PLEASE NOTE: THIS IS NOT A TECHNICAL DRAWING.

Site layout Option 3:

Shows one larger substation at Berchem France services the power requirements for both sides of the motorway.

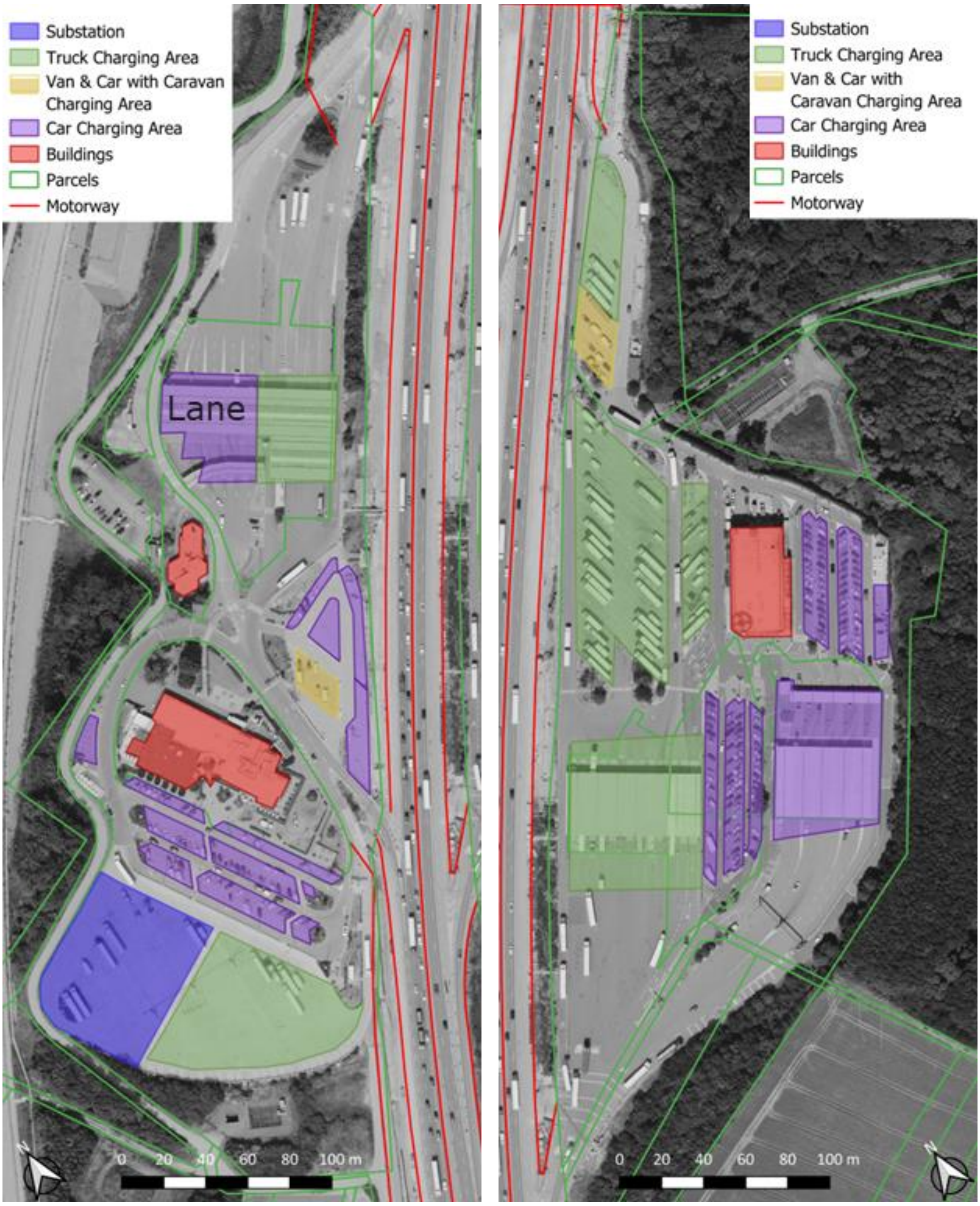


FIGURE 7-25 – MAP OF THE BERCHEM SITES FOR SUBSTATION LAYOUT OPTION 3 IN 2050. PLEASE NOTE: THIS IS NOT A TECHNICAL DRAWING.

APPENDIX H SUMMARY TABLE OF ALL MSA SITES FORECASTED EVOLUTION

The following table provide an overview of how the main constituting blocks of each MSA are expecting to evolve in the coming years.

TABLE 7-2 – EVOLUTION OF THE MAIN CONSTITUTING BLOCKS OF EACH MSA (2030-2050), FOR THE MID SCENARIO[122]

MSA sites	2030	2035	2040	2050
Required # of HDV charging points (MCS)				
Berchem Luxembourg	8	22	36	50
Berchem France	8	22	36	50
Capellen Luxembourg	8	22	36	50
Capellen Belgium	8	22	36	50
Pontpierre France	3	8	13	19
Pontpierre Luxembourg	3	8	13	19
Wasserbillig Luxembourg	8	22	36	50
Wasserbillig Germany	8	22	36	50
Required # of LDV charging points				
Berchem Luxembourg	48	89	126	173
Berchem France	29	54	76	104
Capellen Luxembourg	20	38	53	73
Capellen Belgium	28	52	74	102
Pontpierre France	4	7	10	13
Pontpierre Luxembourg	6	11	15	21
Wasserbillig Luxembourg	18	34	49	67
Wasserbillig Germany	18	34	47	65

[122] This is the results of the model and it does not account for any potential space constraints, which is addressed in details in chapter 4.

ERM HAS OVER 160 OFFICES ACROSS THE FOLLOWING COUNTRIES AND TERRITORIES WORLDWIDE

Argentina
Australia
Belgium
Brazil
Canada
China
Colombia
France
Germany
Ghana
Guyana
Hong Kong
India
Indonesia
Ireland
Italy
Japan
Kazakhstan
Kenya
Malaysia
Mexico
Mozambique

The Netherlands
New Zealand
Peru
Poland
Portugal
Romania
Senegal
Singapore
South Africa
South Korea
Spain
Switzerland
Taiwan
Tanzania
Thailand
UAE
UK
US
Vietnam

ERM's London Office

2nd Floor Exchequer Court
33 St Mary Axe
London
United Kingdom

EC3A 8AA

T +44 20 3206 5200

www.erm.com