How do we solve the challenge of data interoperability in e-mobility?

A collaboration between:

EY Building a better working world

eurelectric powering people

Contents

Preface

E-mobility is about so much more than the technological switch from combustion engines to electric vehicles (EVs).

It is about connecting the worlds of transport, energy and the built environment. It's about the future value — personal, environmental and commercial — that innovation and interconnectedness across the e-mobility ecosystem can deliver.

That future state depends on data interoperability and information sharing between stakeholders.

> **The future state of e-mobility depends on data interoperability and information sharing between stakeholders.**

Getting there is a challenge.

Every stakeholder in the EV ecosystem generates data. It's the commodity that each player wants, but another player owns. They worry about sharing proprietary data, loss of competitive advantage, and cyber and privacy risks.

But, if we share data in a non-discriminatory and standardised way, it will help us to build a sustainable future and improve the overall EV experience. And, together, we can unlock value from a raft of new opportunities, where:

- **EV drivers** can access public or private charging points, at any time, to connect, charge and pay. Or they plug in at home or work to smart charge while providing balancing capacity to the local grid. They share their vehicle and battery data with e-mobility service providers (eMSPs) and charge point operators (CPOs) in return for reliable route planning and other value-add services.
- **CPOs** get data from grid operators on grid connection capacities to make better decisions on where to site and operate charging infrastructure. They interconnect with eMSPs to provide the best charging experience for users.
- **eMSPs**, integrated into the charging ecosystem, provide charging and other value-add services to customers. They interconnect with EV navigation systems and with other ecosystem participants, including CPOs.
- **Roaming platforms** connect CPOs with eMSPs and facilitate interoperability.
- **Distribution system operators** (DSOs) make significant investments in the electricity grid and play an important role in connecting charging points to distribution grids. Data provides DSOs with the potential for real-time insights into grid performance and empowers them to engage in proactive grid management and better EV integration.
- **Urban planners** better understand EV hotspots and usage trends, helping them to strategically deploy infrastructure in areas where it is most needed and best serves the community.
- **Automakers** grant access to in-vehicle data, allowing other third-party service providers to detect and rectify faults or improve battery design and overall performance.

Ultimately, standardised communications across the ecosystem, and software and hardware interfaces, enable consistent data sharing and data flows.

This, in turn, eliminates the need for proprietary systems and custom-charging solutions.

It reduces the complexity and cost of installing charging stations, making it more economically viable for businesses and governments to invest.

It creates space for innovation, healthy competition and the power of market dynamics.

And, above all, the EV user – the owner of in-vehicle data – is firmly in the driving seat, able to participate in and direct the evolution of an enhanced EV experience.

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About this report

This report delves into the future digital EV ecosystem.

It explores why we must unlock data and dismantle barriers to interoperability. It acknowledges that differing levels of data-transfer maturity result in inconsistencies and a lack of connectedness, which frustrate the customer journey. It considers consistency through standardisation and regulation to impose frames of reference while preserving market dynamics. It identifies how we can release future value through collaboration to benefit all stakeholders.

Curated by EY professionals with extensive experience in the energy, automotive, government and technology sectors, this study also draws on the insights of experts at the European energy industry body Eurelectric and its members.

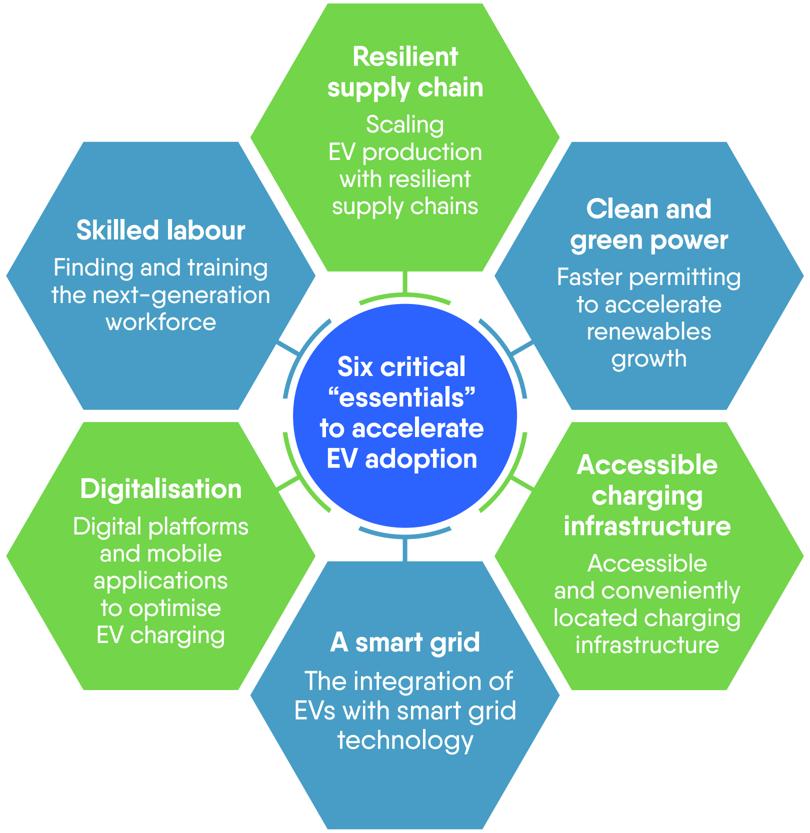
Chapter

1

Progress report: the future connected e-mobility ecosystem

In our 2023 report *Six essentials for mainstream EV adoption*, we identified six essentials[1] to speed up e-mobility. These non-negotiables unite transport, energy and the built environment in an interdependent ecosystem. This integration of disparate systems can only be enabled by digitalisation and data transfer.

The six essentials to accelerate EV adoption

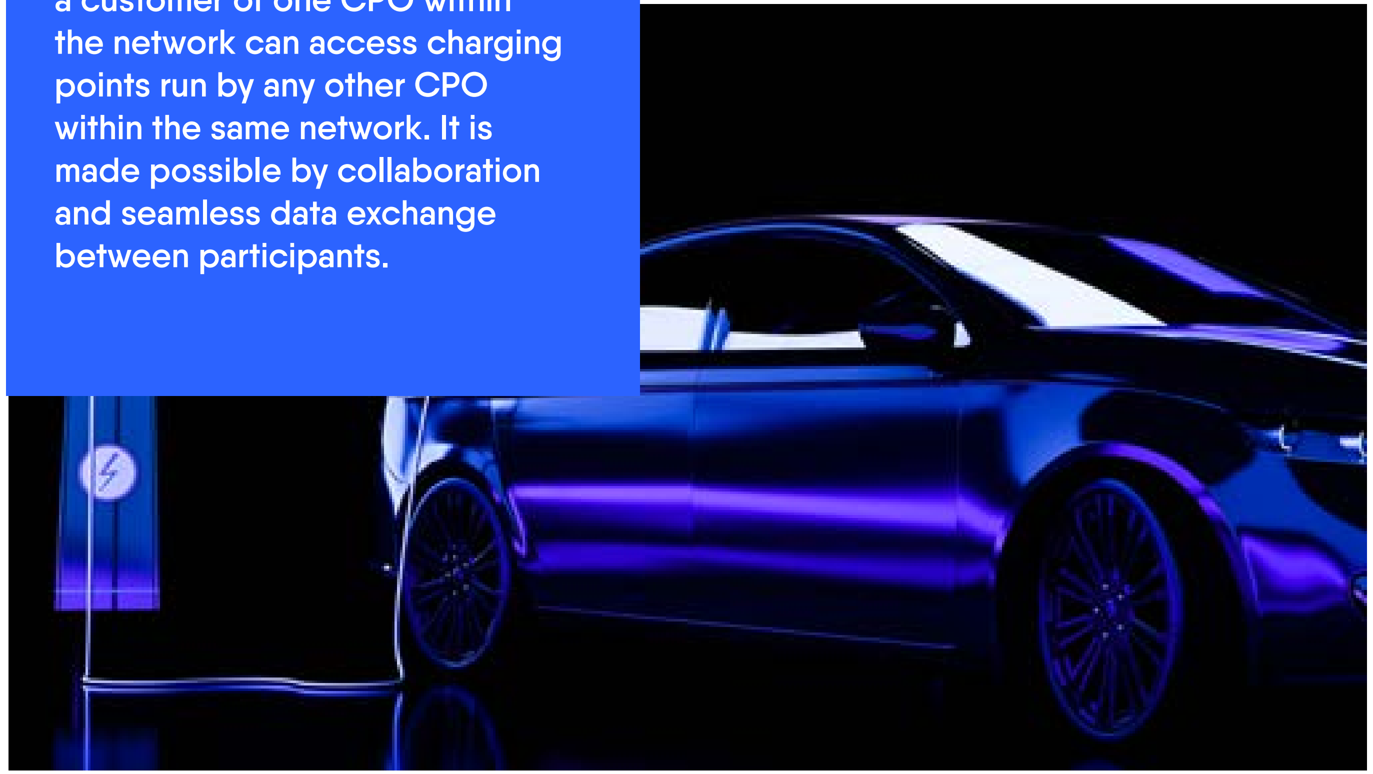


Source: EY/Eurelectric report on Six essentials for mainstream EV adoption.

If we fail to make these connections, the transition will be prolonged. Environmental targets to cut greenhouse gas emissions by at least 55% by 2030, as defined in the EU's Fit for 55 package, will be missed. And overall costs will escalate.

Gireve in France, and Hubject and SMART/LAB in Germany, already enable interoperability between eMSPs and CPOs. It means that a customer of one CPO within the network can access charging points run by any other CPO within the same network. It is made possible by collaboration and seamless data exchange between participants.

But, if we succeed, the future digital e-mobility ecosystem will be fully connected, integrated and interoperable. And, across an intricate network, EVs, EV manufacturers, smart-charging stations, service providers' charging systems, energy providers and intelligent grid systems will communicate seamlessly and exchange information in real time. They will provide freedom of choice to consumers, better services and cost savings, as well as competition among providers, innovation and scalability.



[1] Six essentials for mainstream EY adoption, EY — Eurelectric report, 2023.

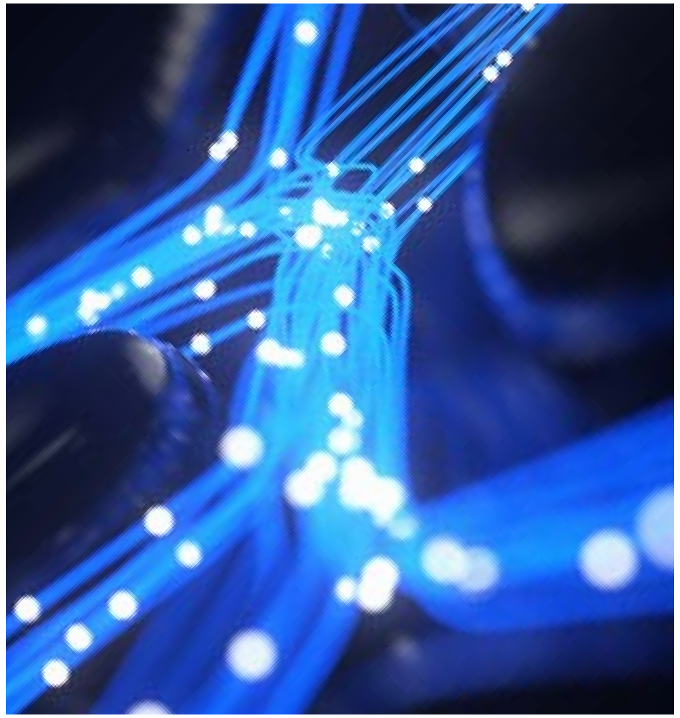
Where we're at

EV stocktake reveals positive growth

Across all markets, whether early EV adopters or latecomers, countries are following the same S-curve growth trajectory. Acceleration comes once EV adoption reaches 10%. So, by 2030, we confidently expect EV sales to outstrip sales of all other vehicles.[2]

> **Acceleration comes once EV adoption reaches 10%. So, by 2030, we confidently expect EV sales to outstrip sales of all other vehicles.**

- Globally, EV sales account for 16% of all vehicles sold. More than 14.1 million new EVs took to the roads in 2023, taking total stock above 40 million.
- In Europe (the EU 27 plus the UK, Norway and Switzerland), battery EVs (BEVs) and plug-in hybrid EVs (PHEVs) accounted for more than one in five new cars sold in 2023. Between January and November, sales grew by 25% to account for 23% of all vehicle sales, up from just over 21% in 2022.[3]
- Sales of zero-emissions heavy-duty vehicles (eHDVs) are up in Europe. Over 7% of van sales are now electric, while electric trucks represent 1.5% of the market, a jump from just 0.4% in 2022. Electric bus sales increased to 14% of the market, with strong growth in France, Spain and Germany.[4]



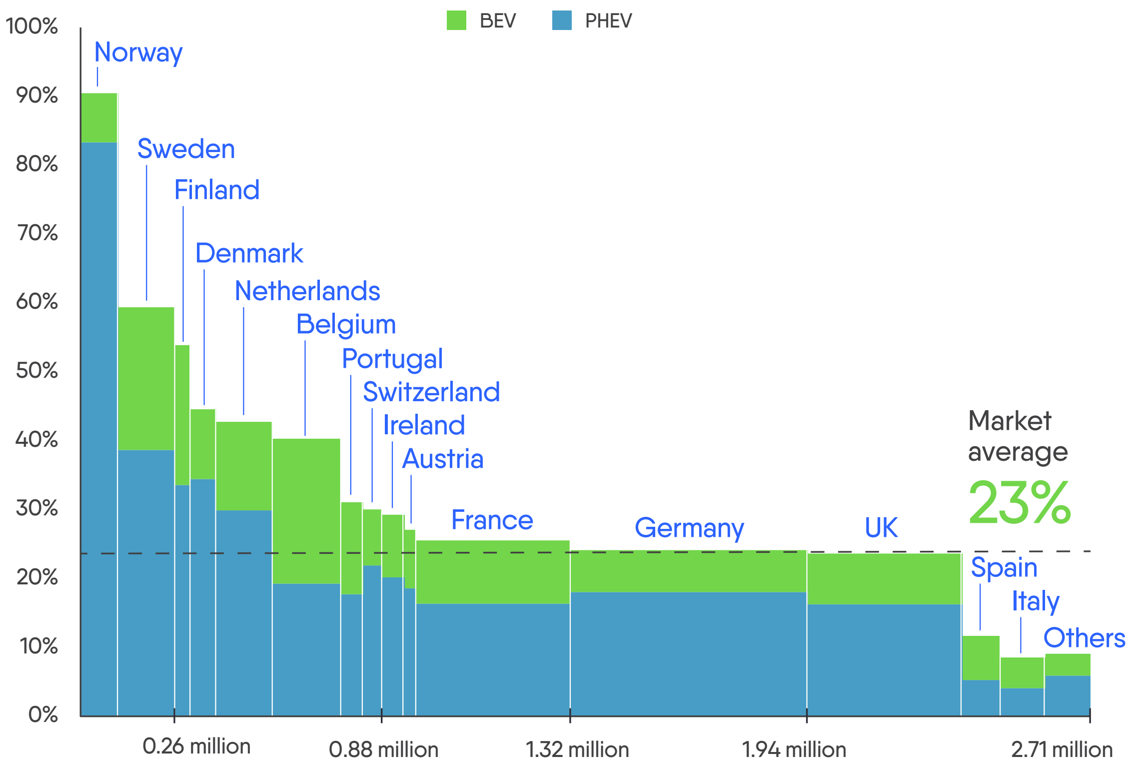
[2] EY Mobility Lens Forecaster, 2023.

[3] Press_release_car_registrations_November_2023.pdf (acea.auto), ACEA, December 2023.

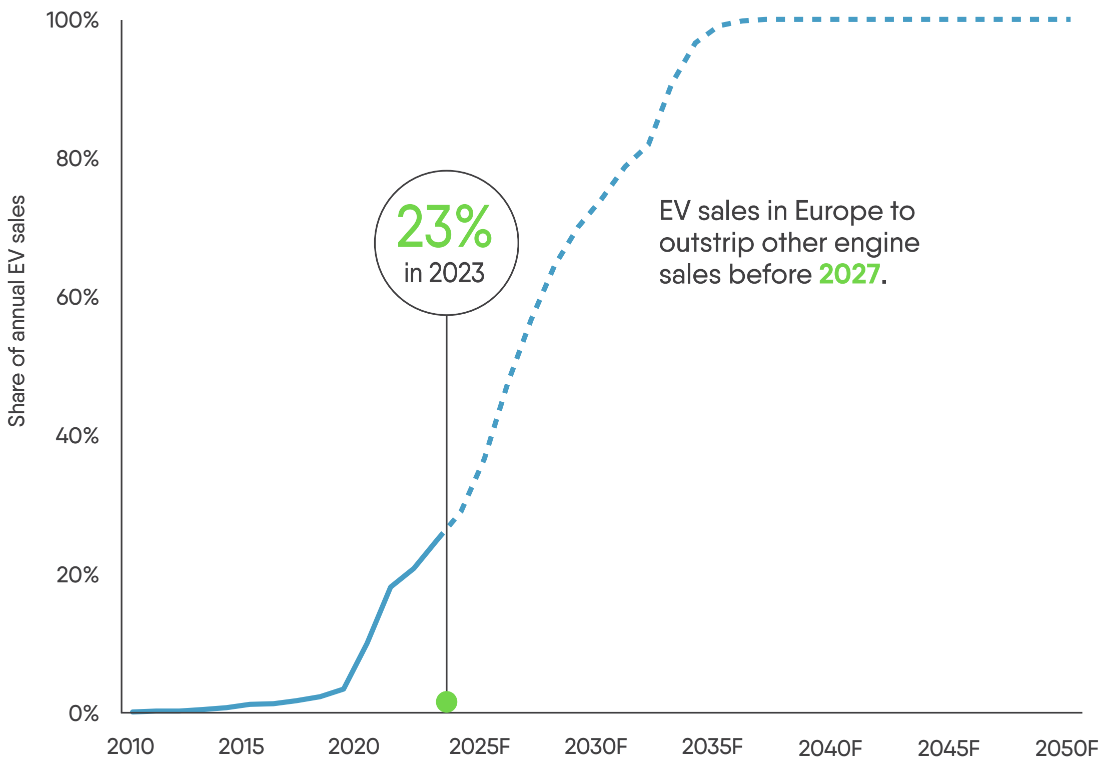
[4] Press_release_commercial_vehicles_Q1-Q3_2023.pdf (acea.auto), ACEA, October 2023.

A steep trajectory of EV adoption is outpacing predictions, with sales set to outstrip all other vehicles by 2027

New EV sales in Europe (Jan–Nov 2023)



EV adoption in Europe (% sales 2010 to 2050)



Source: EY Knowledge analysis of the European Automobile Manufacturers' Association (ACEA) data and the EY Mobility Lens Forecaster 2023.

EY estimates that there will be more than 75 million EVs on Europe's roads by 2030. The analysis is supported by the improving choice and economics of EVs versus petrol and diesel alternatives. But, to encourage greater customer EV uptake, automakers must do more to increase the range and availability of affordable and mid-sized EVs. Meanwhile, battery costs are falling again, following unprecedented price rises in 2022, which further points to escalation in EV numbers.

Infrastructure is keeping up

The widespread adoption of EVs is accompanied by the simultaneous expansion in the public network of fast chargers.

> **In Europe, the number of non-residential charging points increased from around 530,000 in 2022 to 744,000 in 2023.**

In Europe, the number of non-residential charging points increased from around 530,000 in 2022 to 744,000 in 2023. Rollout of fast and ultrafast direct current (DC) chargers gathered pace, increasing 77% to more than 100,000, with the build-out of alternating current (AC) chargers jumping 36%.[5]

Progress is fast. And it is expected to accelerate. The adoption of the Alternative Fuels Infrastructure Regulations (AFIR) into law will see fast public charging stations for cars and vans installed every 60 kilometres along the EU's main transport corridors — the Trans-European Transport Network (TEN-T). For eHDVs, complete network coverage is expected by 2030.

Additionally, AFIR sets power output targets across publicly accessible charging stations for every BEV and PHEV sold.[6] Already, every Member State, except for Malta, meets the target for total power output. This is positive news indeed. But, because AFIR power output targets are a function of the number of EVs registered in a country, as EV uptake accelerates, there must be an ongoing and proportional increase in the number of public charging stations available.

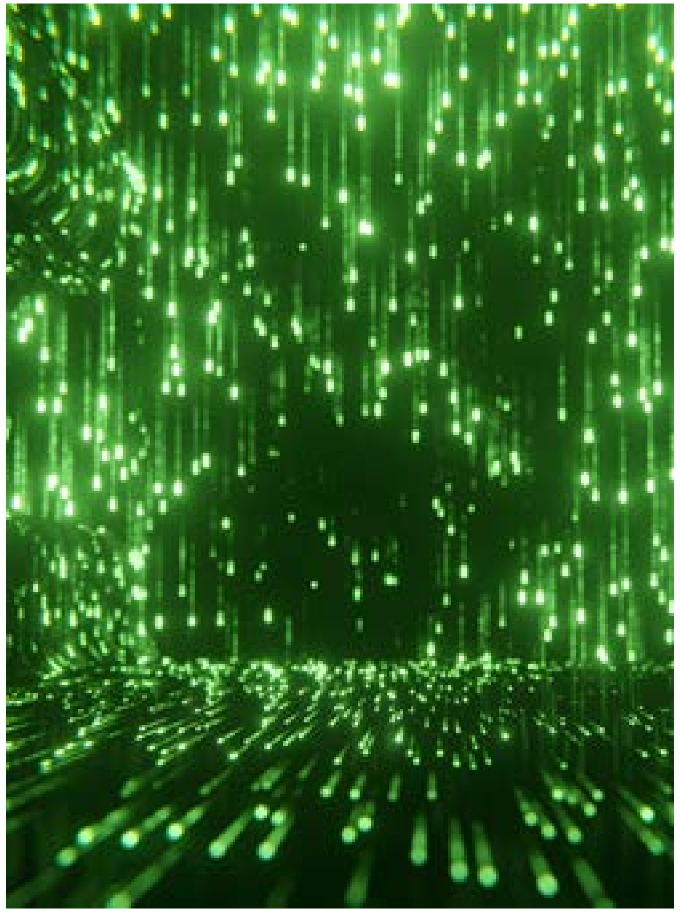
Technological advances mean fast chargers now have a power rating

10 times higher

than five years ago, meaning charging times are significantly reduced too.

Democratisation remains a challenge. If EV charging is to work for all, then faster installation of charging facilities, outside TEN-T, is needed to complement rising EV adoption rates. It must extend to workplaces, apartment blocks and commercial destinations, as well as fast-charging high-power hubs that will take the place of petrol stations today.

Geographically, there are huge disparities too. In 2023, around 78% of Europe's charging infrastructure was located in just seven countries: Belgium, France, Germany, Italy, the Netherlands, Sweden and the UK.

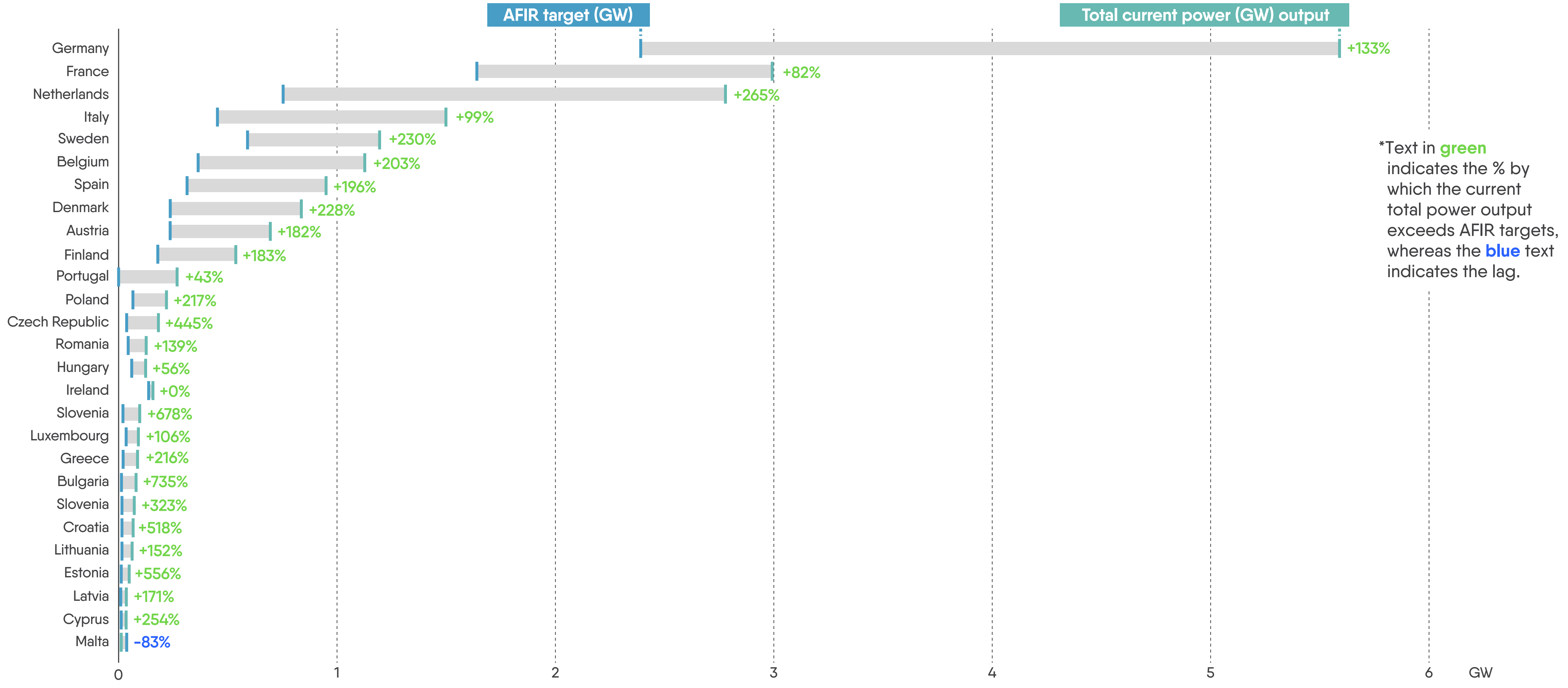


[5] EU alternative fuel infrastructure", European Alternative Fuels Observatory, European Commission, accessed 10 January 2024.

[6] AFIR prescribes that for each light-duty BEV registered in a country, a total power output of at least 1.3kW, and for each PHEV, a total power output of at least 0.8 kW, is provided through publicly accessible recharging stations. For example, an expected increase in a country's BEV stock from 100,000 in 2023 to 500,000 in 2025 will require the total power output to increase from 169,000kW in 2023 to 650,000kW in 2025, an increase of ~200%.

Member States are ahead of the AFIR fleet-based targets for total power output

Total power output per AFIR fleet-based target for Member States



Source: EY Knowledge analysis of data from European Alternative Fuels Observatory. Graphic adapted from SEI.

New service opportunities

In 2030, once we have more than 75 million EVs roaming across different networks in Europe, as predicted by EY,[7] the relationship between the vehicle and the charging infrastructure becomes irrefutable.

Rapid uptick in EV demand further underscores the importance of interoperability between all ecosystem stakeholders to ensure that:

- EV and battery data is made available to users, CPOs and eMSPs in an easy and non-discriminatory way to support an improved charging experience.
- Chargers are appropriately located in areas with high demand and offer easy access and convenience, based on user data and charging behaviours. This will loop back into increased EV adoption as confidence in the availability and reliability of infrastructure grows.
- The EV charging event, which is informed by various data sources, is managed effectively.
- Customers can access infrastructure seamlessly, using their preferred authorisation and payment model.

As new services emerge, they will improve the overall customer experience, making EV ownership better, more efficient and greener than before. User data will inform personalised recommendations and targeted services, while predictive maintenance and remote diagnostics will address safety and wear and tear on the vehicle, improving user confidence.

A report by the International Energy Agency[8] finds that new services could save the global EV industry more than US$4bn by 2030 through reduced costs and greater efficiencies.

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New services: Who's doing what?

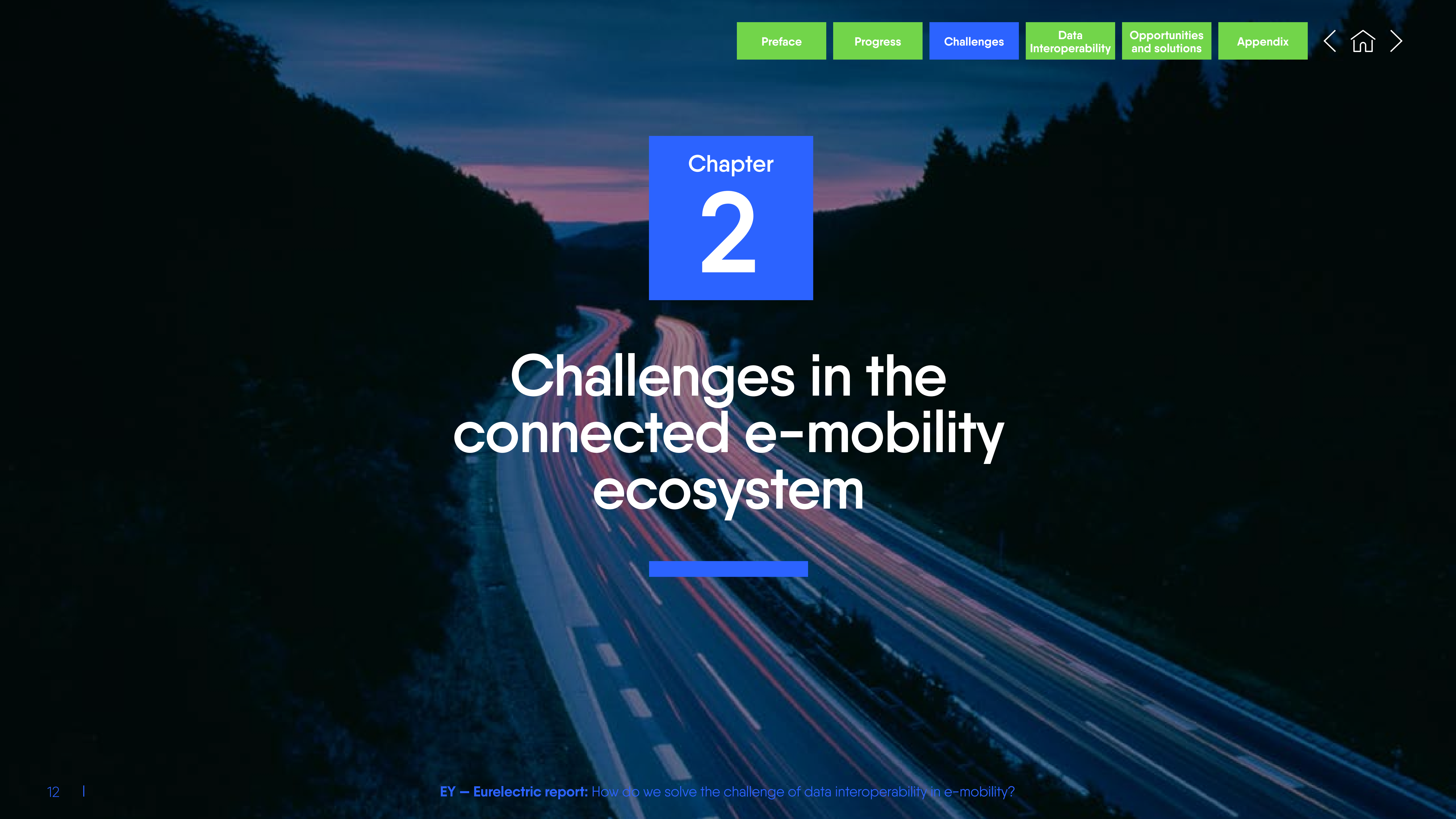
Co Charger is a platform enabling EV drivers to share their home charging point with others. The entire process is handled by an app. The charging point is listed with a per-hour fee for plugging in. It helps users to locate it, reserve it and pay.

The Octopus Electroverse app provides seamless access to 500,000 charging points across Europe. It filters results to locations powered by green energy.

ChargeFinder helps drivers to locate charging points based on connector type, speed, network provider and cost. It provides live data on charging point availability and route planning, and suggests alternative charging points if your first choice is busy.

[7] EY Mobility Lens Forecaster, 2023.

[8] IEA (2023), Global EV Outlook 2023, IEA, Paris https://www.iea.org/reports/global-ev-outlook-2023, License: CC BY 4.0.



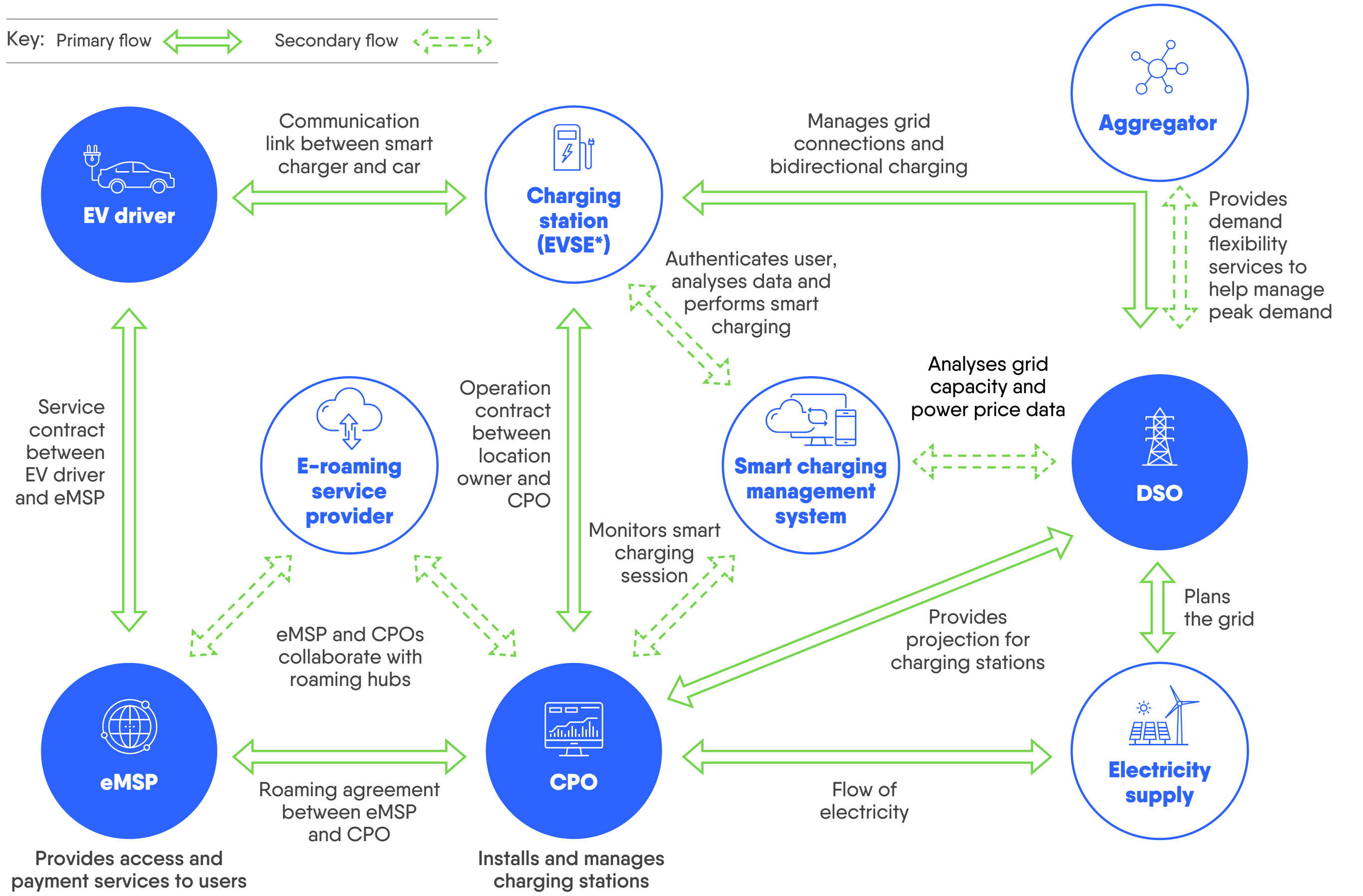
Chapter 2

Challenges in the connected e-mobility ecosystem

The connected e-mobility ecosystem is a complex web of multiple providers, each with a vested interest in its success. They are directly and indirectly linked in the delivery of services to enable the smooth and seamless flow of electrons to and from the vehicle. And that depends on the fair and interoperable exchange of data between parties.

The connected e-mobility ecosystem

Relationships in the digital e-mobility ecosystem



*EVSE — EV supply equipment

Today, regulations and standards exist to support data sharing across participants in the e-mobility ecosystem.

They include the Renewable Energy Directive (RED), AFIR, the Energy Performance of Buildings Directive (EPBD) and the Data Act. Collectively, they allow data to flow and be exchanged, enabling services such as bidirectional charging, roaming and support for drivers in locating available charging infrastructure.

Regulations and standards support data exchange

- The **RED**[9] mandates real-time access to basic battery and EV information, including state of charge, state of health and capacity. Manufacturers must provide this information to battery owners, users and third parties, without discrimination or cost.
- The **AFIR**[10] promotes a competitive and open market for EV charging. It mandates ad hoc charging at publicly accessible charging points without the need for a pre-existing membership or a contract with an infrastructure operator, as well as the provision of information for users on the availability and location of charging infrastructure.
- The **EPBD**[11] mandates pre-cabling and recharging points for EVs, to ensure that the 'right to plug' becomes a reality and that building owners, tenants, managers and third parties have access to their buildings' system data for smart and bidirectional charging.
- The **Data Act**[12] provides high-level principles for data sharing across sectors. As these are high-level principles, the subsequent proposal on access to **in-vehicle data** needs to set out that manufacturers must enable easy and non-discriminatory access to all relevant battery data by the EV user.

[9] EUR-Lex - 32023L2413 - EN - EUR-Lex (europa.eu) Article 20a Facilitating system integration of renewable electricity.

[10] EUR-Lex - 52021PC0559 - EN - EUR-Lex (europa.eu).

[11] "Commission welcomes political agreement in new rules to boost energy performance of buildings across the EU", European Commission, 7 December 2023.

[12] "Regulation (EU) 2023/2854 on harmonised rules on fair access to and use of data and amending Regulation (EU) 2017/2394 and Directive (EU) 2020/1828 (Data Act)", Council of the European Union, European Parliament, 22 December 2023.

However, e-mobility is complex, and these regulations and standards, though supportive, do not provide all of the answers. Beyond data sharing, challenges remain, which must be resolved if the anticipated growth in EV numbers is to be accommodated. They include:

Roaming and payments

Roaming denotes EV drivers' freedom to charge their vehicles at any charging station, in any country, irrespective of charging network, using a single app, account or payment method.

Though many CPOs and eMSPs are already connected via roaming platforms, which gives customers easy access to charging points, this is not available everywhere across Europe. For seamless and standardised charging experiences, further investment must be made in the expansion of EV charging roaming networks.

"For seamless and standardised charging experiences, further investment must be made in the expansion of EV charging roaming networks.

eMSP enables roaming across c. 600,000 charge points

- **EnBW mobility+** provides access to and payment at around 600,000 charge points throughout Europe. At EnBW fast-charge points, authentication and the charging process start automatically once the car is connected.

Standards and communication protocols

Standards and communication protocols are the building blocks for efficient and safe communications in the EV charging ecosystem. They make it easier for CPOs, eMSPs and EV drivers to control who can access the charging stations and to manage the amount of electricity that is being used.

For drivers, standards that enable consumer-facing and systems-management interoperability improve the EV experience. Users benefit from greater choice and better pricing, as well as assurances that their vehicles will be compatible with charging hardware and software. Standards also streamline the payment process, for quick and seamless transactions.

For CPOs and other service providers, adherence with standards enhances coordination between participants. It means a more secure and efficient exchange of information, such as billing details and user credentials, and helps to guard against unauthorised access or malicious attacks.

Communication standards

- **Charger-to-network communications**
  Charging stations communicate with a CPO's backend systems and roaming platforms (publicly accessible charging points), using a communication protocol.
- **Network-to-network connection**
  Allows CPOs, eMSPs and roaming platforms to coordinate and share data, enabling users to roam the network. It means EV drivers need only one membership to access a large network of chargers.
- **Vehicle-to-charger communications**
  Permits communications between charging stations and vehicles.

Standards are integral to smart charging too. They allow optimisation of the EV charging process, with dynamic adjustments in response to signals about grid capacity and electricity rates. They also enable plug-and-charge capabilities: The EV is recognised by the charging network; the driver connects the EV charging cable to the charging point, and the vehicle starts to charge automatically, without the need for a payment card or mobile app.

While the EV and charging industries are advancing rapidly, challenges created by the absence or inadequacy of standards and protocols can impact interoperability, compatibility and the overall growth of the EV ecosystem. Efforts towards standardisation are being made. But global harmonisation remains elusive, leading to regional variations in regulations and technologies.

Key challenges include:

- **Charging connector standards**: Different regions and vehicle manufacturers have adopted different charging connector standards, such as Combined Charging System (CCS) and CHAdeMO. This diversity can lead to compatibility issues for EV users travelling across regions.
- **Smart charging features**: A lack of standardised protocols for demand response and grid integration, and other smart charging capabilities, may limit the potential benefits of a smart and flexible charging infrastructure.
- **V2G standards**: Non-standardised protocols for vehicle-to-grid (V2G) communications and integration with the electrical grid can limit the widespread adoption of bidirectional charging and energy sharing.
- **Software updates and upgrades**: With over-the-air software updates becoming commonplace for EVs, standardised processes are needed for secure and efficient updates across different vehicle models and manufacturers.
- **Pace of innovation**: Standardisation efforts, and the pace of technological innovation in the EV industry, must align to avoid fragmentation and potential obsolescence of some technologies.

Connecting charging infrastructure to the grid

DigiKoo describes itself as the digital core of energy infrastructure provider Westenergie. It has developed an automated grid information access service, which allows utilities to quickly and securely share grid data to support connection requests for future EV charging stations.

The charging infrastructure network must be scaled quickly but is hindered by delays in handling network connection requests. Inefficient processing and lack of transparency about available grid capacity mean the connections queue gets longer. Until the DSO responds with information for each location, the CPO cannot proceed.

To help them identify and prioritise charging locations, CPOs are calling for:

- Better coordination and tracking of connection requests
- Heat maps to understand capacity constraints
- Transparency over connection costs
- A central point of contact
- A streamlined process across municipal bureaus and departments to negotiate and speed up installation

In addition, industry participants want national road maps that will help them to decide where best to site and develop charging infrastructure for all transport segments, especially for public transport and commercial fleets.

Evidence points to regional disparities across Europe's highways in approving connection requests. It can vary from five months in Spain to 20 months in Portugal, according to a 2023 report by the Council of European Energy Regulators.[13] In France, it is around 14 months; in the Netherlands, it averages 13 months. Low voltage projects may be quicker to connect.

[13] "CEER Report on Electric Vehicles: Network Management and Consumer Protection", CEER, 8 August 2023.

Smart grid integration

Today, many private EV charging points are dumb. They are not integrated into a smart ecosystem, so EVs charge at their maximum rate and only stop when the battery is full.

> **Smart EV charging can flatten the energy demand curve. It integrates charging data with grid management systems.**

Smart EV charging can flatten the energy demand curve. It integrates charging data with grid management systems.

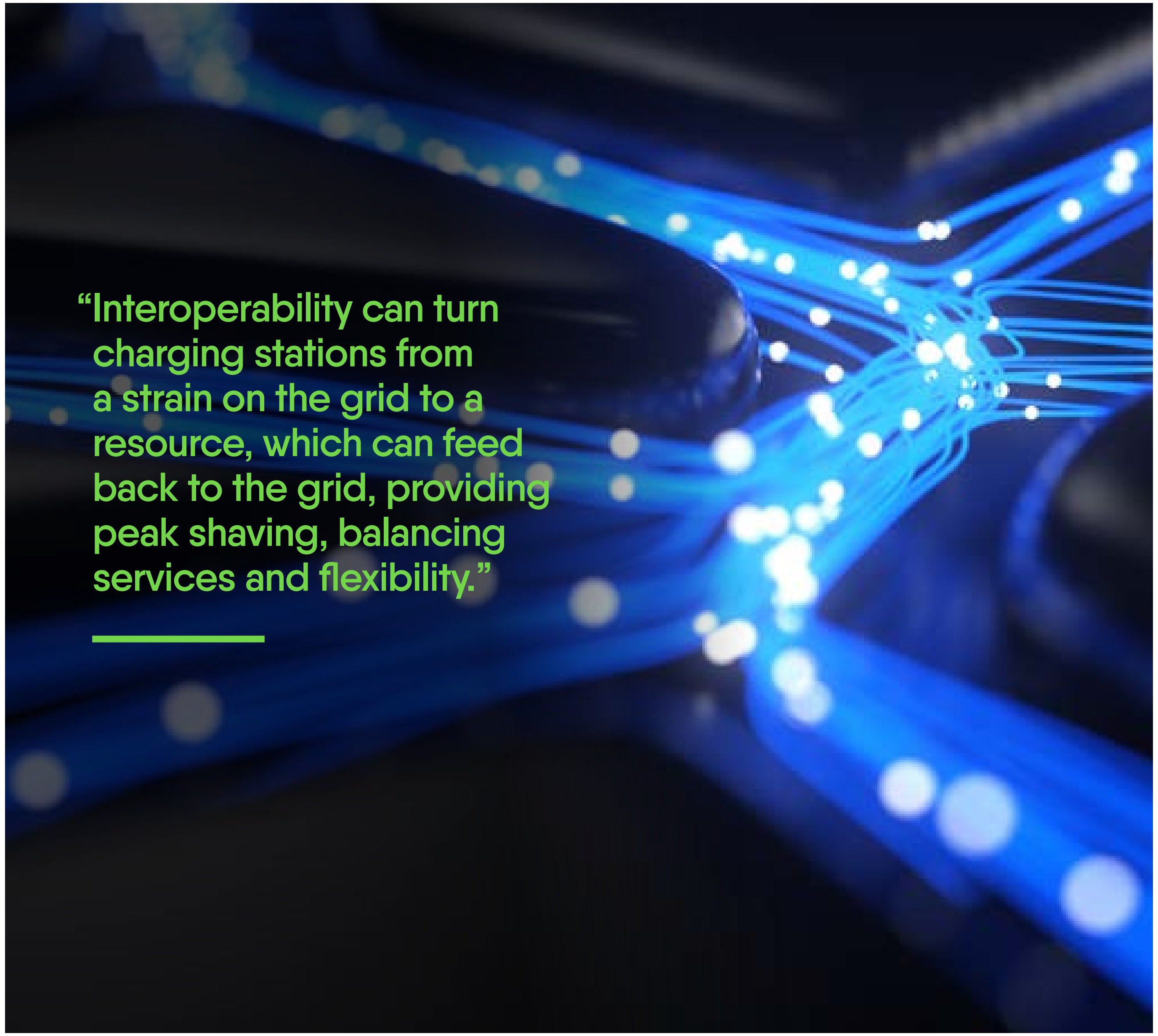
It establishes communications and a flow of data between the charger, the vehicle, the CPO and the energy provider. Instead of charging until the battery is full, smart EV charging allows operators to optimise the time and duration of charge and to adjust energy consumption.

Smart energy management is an extension of smart charging. It optimises energy consumption based on grid constraints, availability of renewable resources, pricing, owner preferences and driver needs. For CPOs, faced with increased energy demand due to exponential growth in EV adoption, smart energy management allows them to determine the best and cheapest time to charge vehicles.

For private or fleet charging, it opens up capabilities such as demand-side flexibility, which allows CPOs, or other service providers, to manage site-level limitations to energy capacity. It means they can reduce or vary charging capacity at individual charge points at times of localised grid congestion, or integrate power from onsite solar panels or batteries to increase availability.

For DSOs, smart grid integration and demand-side response can also reduce the costs associated with electricity grid reinforcement.

Going beyond smart grid integration, V2G capabilities will allow EVs to receive signals to push stored electricity from the EV battery to the grid for local balancing and frequency regulation purposes. Vehicle-to-home (V2H) is a further extension, using bidirectional charging to transfer energy stored in the EV battery to the home, and vice versa. Although not widely feasible today, standards or platforms will help to better manage EV charging and future increased load.



Data sharing, privacy and cybersecurity

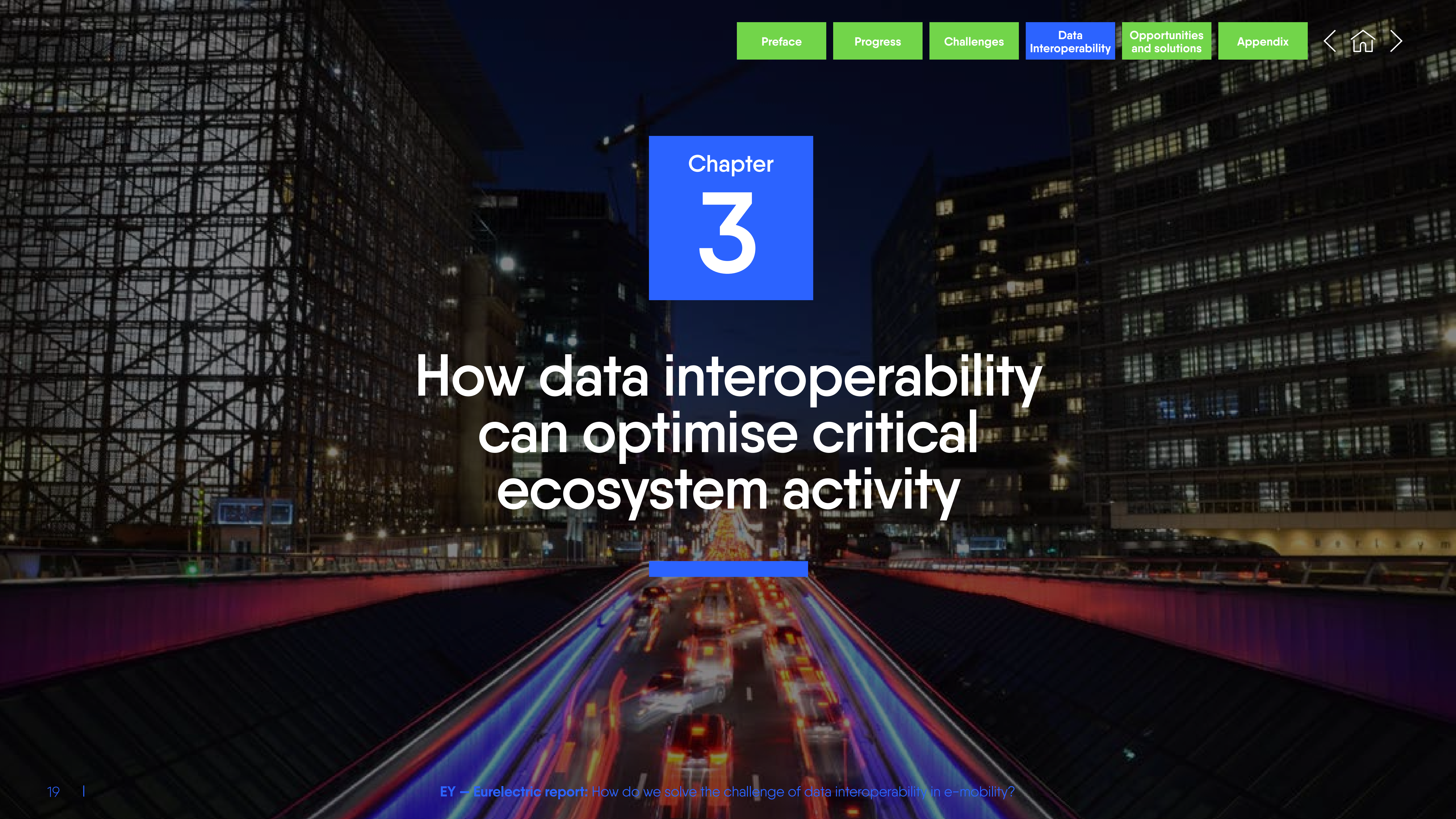
For an ecosystem reliant on data, digital infrastructure and data security are fundamental. Connected devices, including EVs and charging infrastructure, collect and store vast amounts of personal information, vehicle details, charging patterns and billing information.

For shared EV charging infrastructure, various challenges arise which relate to data security. These include privacy concerns, identity theft, network vulnerabilities and the potential for data breaches.

To build trust and keep the EV ecosystem secure, it is crucial to use robust security measures, such as encryption, anonymisation, continuous monitoring and intrusion detection. This permits secure communications and data exchange between the EV and the charger.

The future state: a connected and interoperable EV ecosystem

Seamless EV driver experience	Charging infrastructure where it is needed	Grid integration and stability	Standardised protocols and regulation	Fleet management and optimisation	Future innovation and integration
Real-time alerts help drivers to locate available charging infrastructure and plan routes.	Infrastructure is sited in areas of highest demand to optimise usage.	Unidirectional and bidirectional charging, enabled by data exchange between the grid and the EV battery, help to balance load, level out localised congestion, integrate renewables and enhance grid stability.	Data sharing and privacy concerns are resolved, allowing greater collaboration among ecosystem participants.	Integration of telematics, performance and charging data allows predictive maintenance, route optimisation and scheduled charging for eHDVs and other fleet vehicles.	Ongoing integration of EVs with new technologies, like V2G, smart charging, blockchain and artificial intelligence (AI), extend the possibilities and resilience of e-mobility.
They use any network and pay without the need for multiple subscriptions.	Competition among operators encourages faster deployment and enhanced charging solutions.		Standardisation removes the need for proprietary Interoperable charging systems, creating a better user experience.		



Chapter

3

How data interoperability can optimise critical ecosystem activity

Within the future EV ecosystem, data interoperability promotes collaboration and information sharing between stakeholders to enable services and facilities that support EV rollout. Where data is withheld, or formats are inconsistent, there may be knock-on ramifications for efficiency across the network, ultimately impacting the overall customer experience and value.

We have assessed the maturity of data transfer between stakeholders in three key e-mobility activities. For each, data interoperability is critical to enabling the future state.

Exploring data interoperability across three principal e-mobility activities

Data interoperability can resolve many challenges within the e-mobility ecosystem and improve the customer experience.

1 Charging station optimisation

Strategically located charging stations, which are accessible, renewably powered (where possible), reliable and scalable

2 Intelligent grid integration

Seamless integration of EV charging with the energy grid for flexibility purposes

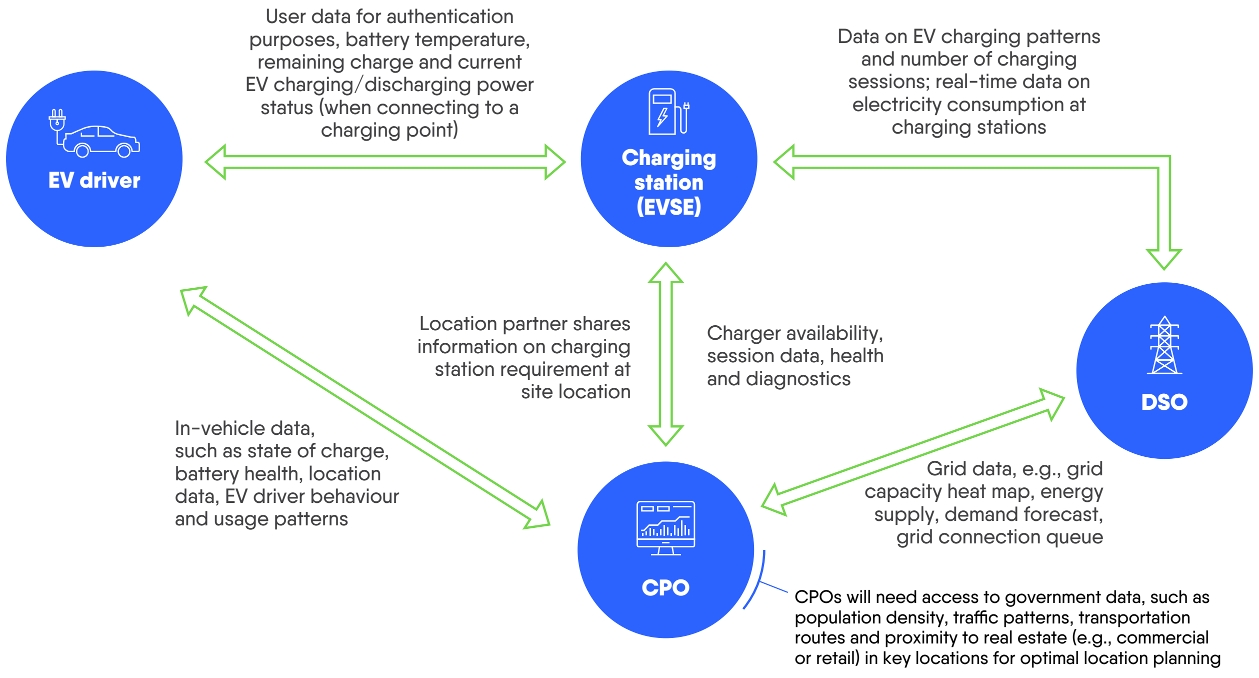
3 Optimised charging experience

User-friendly, consistent and seamless access to charging infrastructure across different charging networks

No. 1: Charging station optimisation

Strategically sited charging stations provide EV users with easy access and convenience, reducing range anxiety, enhancing the driver experience and encouraging widespread EV adoption. They enable a more sustainable and efficient transportation ecosystem, increase use of the charging infrastructure to maximise return on investment, reduce queuing to recharge and minimise the impact on the grid. This is critical for both current demand patterns and future mobility trends, and can be scaled to accommodate evolving technologies.

Charging station optimisation: key interactions and data transfer



Charging station optimisation: key interactions

Party 1	Party 2	Data transfer	Data interoperability maturity
EV driver	CPO	EV usage patterns, charging behaviour data and in-vehicle data, such as state of charge, battery health, location, engine performance and current EV charging/discharging power status (when connecting to the charging point).	Sharing EV driver-usage data is relatively new. Original equipment manufacturers (OEMs) still own key data, such as real-time battery usage and engine performance data, which they claim as proprietary data. More policy development and greater stakeholder collaboration are needed. The EU Data Act entered into force in January 2024. It supports data sharing, with due consideration to user privacy.
CPO	DSO	CPO provides projections on charging station's electricity demand and receives data on grid conditions, availability of renewable energy sources, energy demand forecasts and instructions for optimising grid connections (e.g., grid capacity heat maps).	There are well-established communication protocols in place, such as the Open Smart Charging Protocol (OSCP), which is used to communicate real-time predictions of local electricity grid capacity to the CPO. Countries such as Sweden are advocating for universal adoption of Open Automated Demand Response (OpenADR) as the protocol for DSO and CPO communications. However, collaboration between DSOs and CPOs needs to increase for optimised charging location planning relative to grid capacity.
Government bodies, navigation providers	CPO	Population density, traffic patterns, transportation routes and proximity to key locations, petrol stations and commercial/retail real estate.	Some countries, such as Finland, regulate traffic and location data sharing between CPOs and associated agencies; others, such as the UK, enable open public access. For instance, in July 2023, the UK mandated CPOs to provide open access to static and dynamic data about their charge points, including their location and availability, and mandated the Open Charge Point Interface (OCPI) protocol. Greater collaboration among agencies, CPOs and stakeholders is needed for a standardised EV data-sharing ecosystem that allows efficient charge point deployment.
EVSE	CPO	Operators transmit real-time data on charging station status, availability and maintenance needs to a central monitoring system.	Communication protocols are relatively harmonised. There is high adoption of open protocols by international organisations. Open Charge Point Protocol (OCPP) is the de facto protocol for communications between EV chargers and charging stations. Adopted by more than 200 automakers and charging solution providers in 160 countries, it provides standardised real-time inputs to optimise charging stations.
Location partner	CPO	Location partners share information on charging station needs at site locations, operation of charging infrastructure and location-related data, and receives data on access to reports and statistics, prices (fees) for charging, etc.	Data transfer between location providers and CPOs is advancing. As the EV charging ecosystem evolves, we expect more standardised data formats, improved cybersecurity measures and enhanced data privacy protections.

Full maturity | Advancing | Medium maturity | Progressing | Low

No. 2: Intelligent grid integration

An intelligent grid integrates energy demand and supply. It receives and sends signals to users and providers, and adjusts load to maintain security of supply at an appropriate price.

Within the parameters of grid connection capacity, charging hubs provide the best available power output to each charging point via smart charging.

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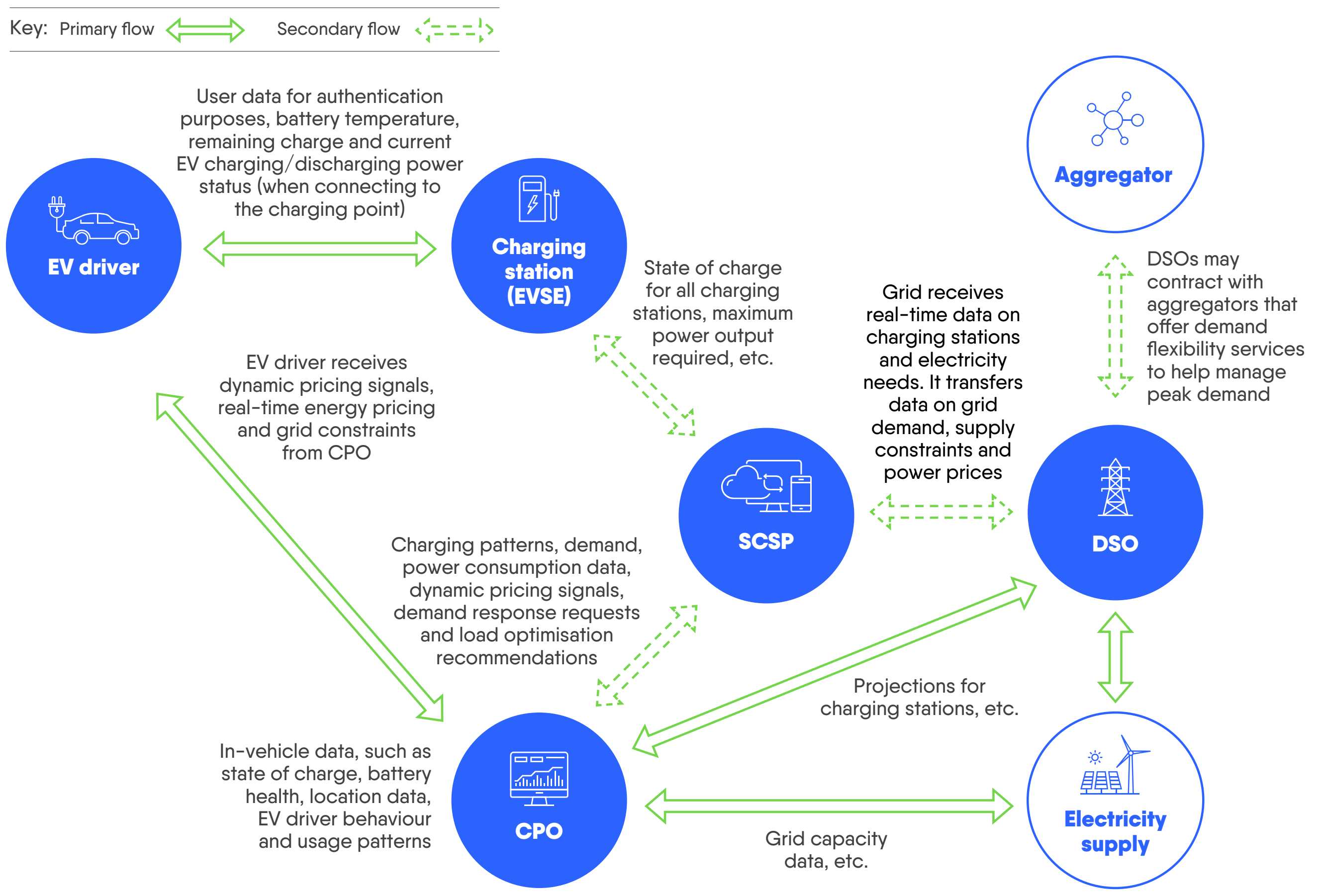
Private smart charging enables energy optimisation, which allows EVs to react to energy price, grid capacity and availability of renewables to initiate charging. Ultimately, it will enable bidirectional V2G and V2H charging, allowing EV owners to participate in and sell their stored battery energy to the energy markets. It will support dynamic energy pricing. CPOs will enable grid services, such as frequency regulation and voltage support. Utilities will plan for future energy demand, manage peak load for grid stability, integrate renewable energy sources and, potentially, scale down grid reinforcement activity and lower investment costs.

While many of these initiatives are still some way off, they are very real possibilities, and will be enabled by data interoperability between the energy provider and ecosystem participants. The overall value will be greater efficiency and reliability for all stakeholders.

No. 2: Intelligent grid integration

Intelligent grid integration: key interactions and data transfer



Intelligent grid integration: key interactions

Party 1	Party 2	Data transfer	Data interoperability maturity
EV driver	EVSE	User data for authentication, battery temperature, remaining charge and current EV charging/discharging power status (when connecting to the charging point).	Despite EV drivers' consent, sharing key real-time data, such as state of charge and battery usage is restricted. It is owned by OEMs and is considered propriety data. This creates a barrier to data sharing for intelligent grid integration.
EV driver	CPO	EV driver shares charging preferences, schedule flexibility and vehicle state with CPO. EV driver receives dynamic pricing signals, real-time energy pricing and grid constraints from CPO.	Sharing EV driver-usage data is relatively new. The EU Data Act supports sharing with due respect to privacy. However, more policy development and greater stakeholder collaboration are needed for seamless data sharing.
DSO	CPO (parties can interact via a smart charging service provider (SCSP)	CPO sends data on charging station requirements, charging patterns, electricity consumption forecast, etc. to DSO and receives from DSO dynamic pricing signals, demand response requests, and load optimisation recommendations direct or via SCSP.	Data transfer between the DSO and CPO usually takes place via a SCSP, using OSCP and OpenADR protocols. As SCSPs are relatively new players, there is currently no standardised protocol for data transfer between the CPO, SCSP and DSO. Data-sharing practices differ according to contracts drawn up between the three parties.

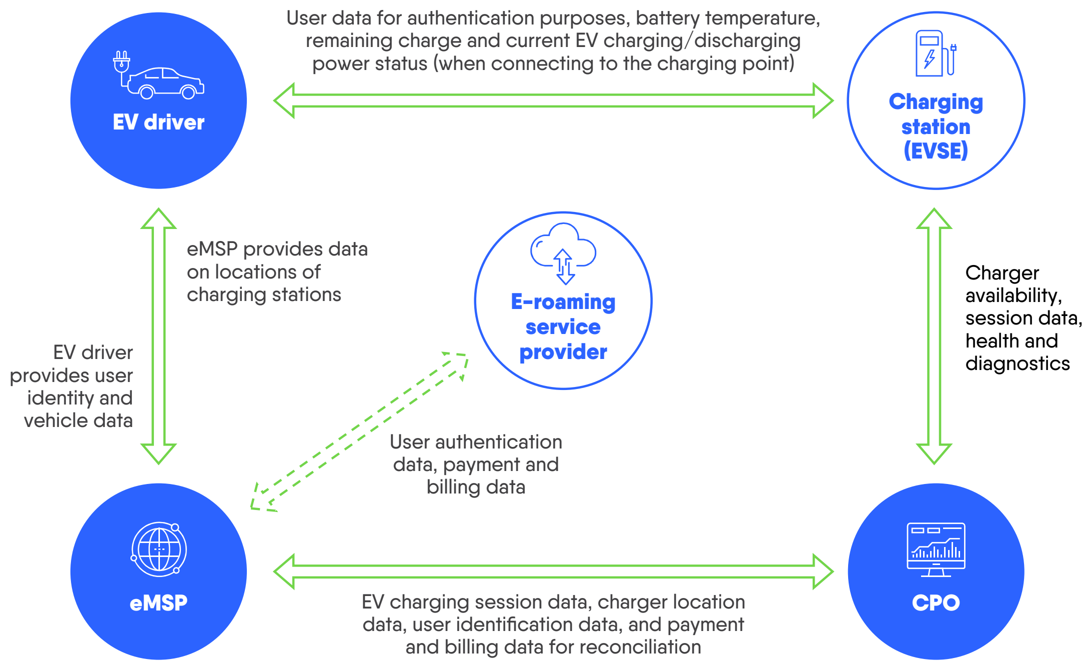
Full maturity | Advancing | Medium maturity | Progressing | Low

No. 3: Optimised charging experience

An optimised charging experience offers user-friendly, consistent and seamless access to charging infrastructure across different charging networks. The interoperability between data systems contributes to a better user experience for drivers, who benefit from real-time information on charging station availability, pricing and compatibility with their vehicles. This information empowers drivers to make informed decisions and plan their routes efficiently, reducing range anxiety and promoting EV adoption.

Interoperability allows drivers to initiate charging sessions remotely, manage payments and track their charging history via an app. This network-agnostic approach eliminates the need for multiple accounts and offers simple authorisation and standardised payment processes.

Optimised charging experience: key interactions and data transfer



Optimised charging experience: key interactions

Party 1	Party 2	Data transfer	Data interoperability maturity
EV driver	eMSP	eMSP receives queries from EV users for nearby charging stations, charging and payment authentication requests, and transaction information. eMSP sends list of available charging stations, pricing information, network details and billing information.	EV users typically interact with eMSPs via dedicated mobile apps or web portals. With consent from the EV driver, relevant in-vehicle data can be shared with the eMSP. Users can use the eMSP platforms to locate available charging stations, pricing, billing details, etc.
eMSP	CPO	Contract between CPO and eMSP for sharing relevant data, such as EV charging session, charger location, user identification, and payment and billing for reconciliation.	Direct connection between the CPO and eMSP is via OCHP and OCPI communication protocols. OCHP is designed for direct communication between CPOs and eMSPs. However, consumer interoperability is limited, as many EV charging points are not part of roaming platforms or eMSPs. Each player requires settlement information in different formats, and the format for CPOs is not standardised.
eMSP	E-roaming platform providers (eRPP)	eMSP provides data on user identification, vehicle details, charging preferences, charging session data and billing data to eRPP.	eMSPs establish roaming agreements with eRPPs so that their users can access charging infrastructure provided by other eMSPs within the roaming network. Communication between eMSPs and eRPPs typically relies on standardised protocols and formats to ensure interoperability. A standards battle is ongoing between the OCPI, Open Clearing House Protocol (OCHP), Open InterCharge Protocol (OICP), and eMobility Inter-operation Protocol (eMIP), with no clear winner. The OCPI has the edge, given its business model flexibility and maturity. The International Electrotechnical Commission (IEC) 63119 protocol, which is under development, might result in a technically superior and globally representative protocol, with IEC sponsorship.

Full maturity | Advancing | Medium maturity | Progressing | Low

Chapter
4

What’s the answer? Industry opportunities and solutions

Transformation is the opportunity to rewrite the way things have always been done, and to optimise. Already, EV uptake is advancing towards mainstream adoption. If we are to maintain momentum, and keep EV drivers onside, every interaction must be configured around the customer journey. From purchase or lease, through EV usage and management, to end-of-life decommissioning, we must deliver a hassle-free and green driver experience.

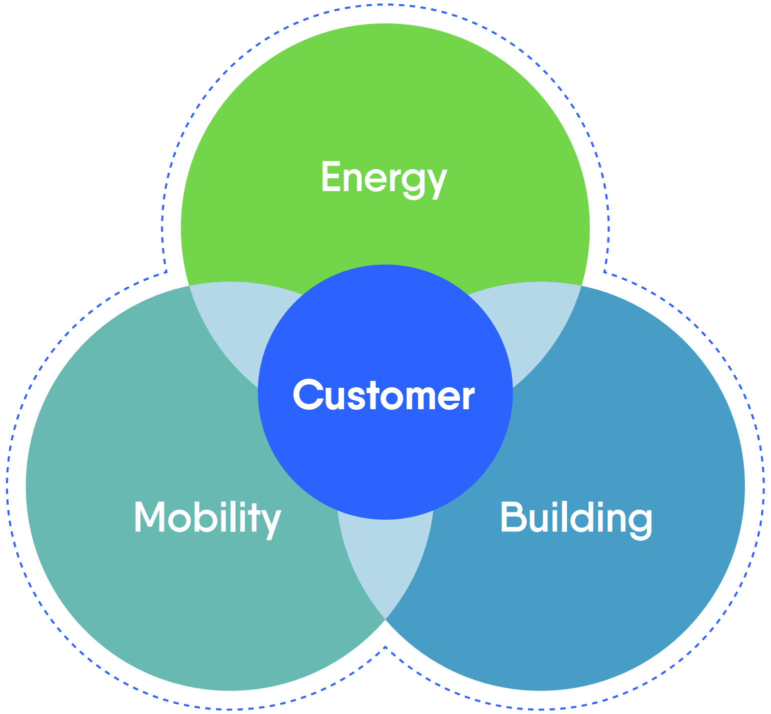
> "If we are to maintain momentum, and keep EV drivers onside, every interaction must be configured around the customer journey.

As the energy, mobility and building ecosystems converge, we must not lose sight of the customer

Dynamic load management
Balance energy demand optimally across the charging network

Route planning
Plan journeys with EV charging in mind

Apps for unified experience
Apps as a single platform for direct payments, energy management, access charging stations, etc.



Smart grid planning
Monitor the grid to anticipate future use, design and investment needs

Intelligent third-party partnerships
Partner with retail and other businesses to offer destination charging and integrated services

Charging infrastructure planning
Plan and optimise site location to increase utilisation and ROI

As we advance, the disparate worlds of energy, mobility and building are converging, and an ecosystem of ecosystems is beginning to emerge. Where they intersect, data flows between players. The customer sits at the centre, the fulcrum around which the ecosystems pivot.

Across this complex and crowded space, the interconnections between players, and the challenges presented by data interoperability, must be resolved.

How to enable the evolving ecosystem

We are asking a lot of industry participants to get us to an end state that enables both frictionless connectivity between EVs, energy and the built environment, and accelerated scaling of e-mobility.

To get it right, we need the right structural and regulatory mechanisms in place. Some are already on track; others need a kick-start.

Roaming and payments

- Enable non-discriminatory access to all publicly available charging stations, as required by the AFIR.
- Accelerate compliance with ISO 15118 to enable plug-and-charge capabilities as standard. This will allow drivers to charge just by connecting their vehicles. It will facilitate smart charging and enable EVs to share stored energy with the grid.
- Create flexible regulatory frameworks for continuous innovation in user-friendly applications and personalised services to enhance the overall EV ownership experience.
- Make costs transparent to customers at all charging stations.

Standards and communication protocols

- Require automakers to publish a catalogue of existing in-vehicle data points. Giving all stakeholders access to the same data supports fair competition and encourages innovation.
- Make in-vehicle data available to the customer and to third parties. It should be in a standardised format and include, as a minimum, state of battery charge, to inform CPOs and grid networks about likely demand and potential for flexibility services.

Connecting charging infrastructure to the grid

- Comply with the AFIR (Article 5.8), which requires that all new and renovated publicly accessible charging points are capable of smart charging.
- Mandate grid capacity heat maps at the distribution level via national access points. They should identify congestion in local areas and associated connection costs to inform planning decisions for charging infrastructure. These should be available on an open and non-discriminatory basis to all data users.
- Implement streamlined notification procedures to simplify the permitting and connection process for charging infrastructure.
- Municipalities to ensure the adequacy of public charge points on the street and in residential and commercial areas.
- Establish a national task force to assess and reinforce the grid in readiness for truck charging.

Smart grid integration

- Prioritise investment for real-time data transfer between the CPO and the DSO and agree data format and method of transfer.
- Integrate smart-charging infrastructure with renewable energy sources to enhance access to charging facilities and encourage customer adoption of EVs.

Data sharing, privacy and cybersecurity

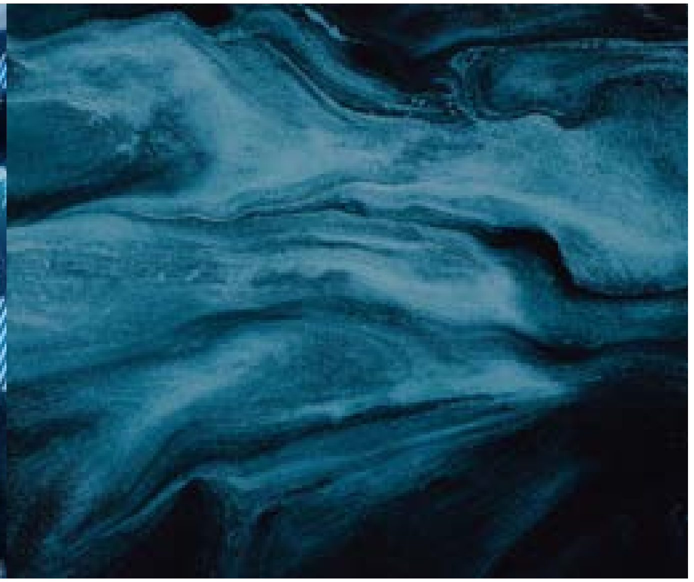
- Introduce standardised data collection to remove inconsistencies.
- Agree the principle of open and non-discriminatory access to data at a reasonable cost, ensuring that the original data owner does not suffer disproportionate economic disadvantage and is fairly rewarded for data shared. It should cover, as a minimum, cost of data adaptation and transfer.
- Create standardised agreements for customer consent.
- Agree common data sets to be transferred between counterparties.
- Guard against the unnecessary transfer of personal data by adhering to relevant standards and protocols, including the General Data Protection Regulation (GDPR).

Commercial opportunities

By getting the mechanics of data interoperability right, connections will form across conventional demarcation lines. Players will venture away from their distinct and mainstream activities in energy, mobility and the built environment. They will explore new commercial opportunities, cross into adjacent services, and compete to win over the customer and capture value.

Businesses are already weighing up ancillary activities to pursue in this new and dynamic environment. We're seeing automotive companies, such as Tesla, Volkswagen and Volvo, cross over into energy provision, battery services and solar solutions. At the same time, leading energy companies are building out charging infrastructure and e-mobility services to compete alongside CPOs. Meanwhile, CPOs and other infrastructure owners are entering into partnerships with retailers, such as fast-food restaurants and coffee outlets, to site their infrastructure in high-traffic areas to offer additional value to customers.

Expect to see greater cross-over and innovation as the customer journey is redesigned and commercial lines are redrawn. We envisage value-add touchpoints — which may be physical, digital or enabled by artificial intelligence (AI) — and multichannel and interactive experiences that boost customer engagement. We will see players merge and acquire the assets and capabilities that allow them to operate in the extended ecosystem.



> Players will explore new commercial opportunities, cross into adjacent services, and compete to win over the customer and capture value.

To succeed in the e-mobility space, irrespective of industry segment, five key building blocks must be in place.

1 | Control tower

A control tower is the corporate vantage point. It provides visibility across the commercial landscape, offering a deep understanding of the ecosystem and competitive environment, with a watchful eye on emerging technologies and business opportunities too. It ensures you have the capabilities and skills to realise your e-mobility vision, and helps with identifying partners aligned with the business strategy. On your unique points of differentiation, the control tower ensures you are strategically positioned to win over customers.

2 | Customer proposition

Using segmentation and analytics, you define your customer base and understand their needs. This informs, in turn, your product and service development and targeting activity. Your data monetisation strategy helps you to identify and realise routes to future value creation.

3 | Dataspace

You identify the optimal data architecture, taxonomy and governance for your business, to lay the foundation for a robust dataspace. This secure environment acts as a centralised hub where data from diverse touchpoints is carefully curated, integrated and managed. Within this dataspace, you create targeted strategies that allow you to own the customer relationship and to scale. Establishing a digital innovation platform (DIP) amplifies the significance of the dataspace. The DIP can help you unlock the value in existing data and processes, reducing costs and providing you with limitless scale and innovation at speed. For example, an EV operations centre can provide visibility of charging patterns and energy demand patterns, which will allow utilities to plan grid upgrades and extensions. Or provide CPOs with real-time insights into the health and state of each of the charge points, their use and performance, as well as energy consumption and costs.

4 | Data privacy and legal, commercial and regulatory diligence

In terms of your data monetisation strategy, understand the limitations and opportunities of data. Be clear on customer consent and your obligations under GDPR and other rules. Determine how you will contract with third parties on data.

5 | Trust and cybersecurity

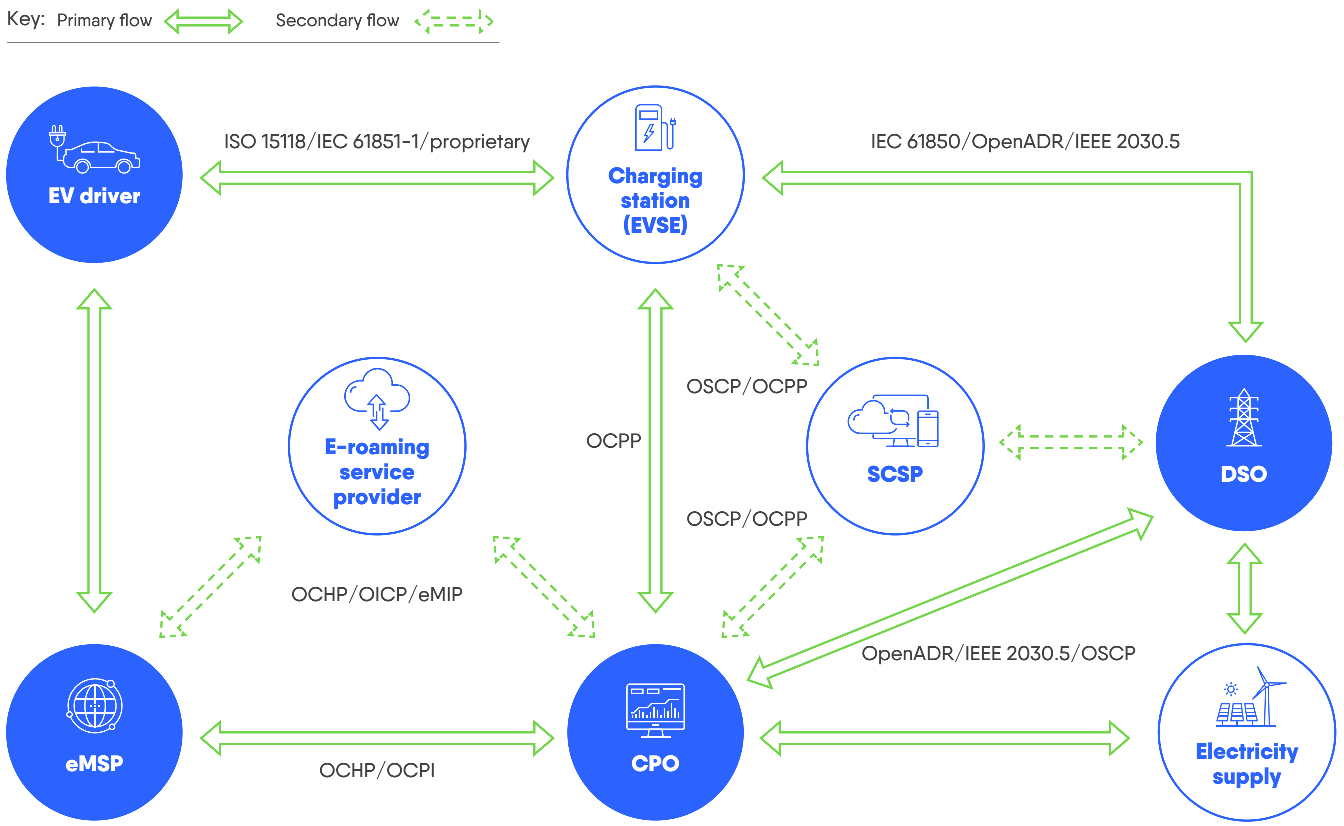
In a decentralised and increasingly complex energy system, issues will arise around data governance and trust. Multiple connection points, and exchanges of operational and customer data, including identity and payment information, create opportunities for cybersecurity breaches. A cybersecurity culture, that extends to supply chains, is integral to trust. It is, effectively, your licence to operate.

What next?

Progress is being made, but there's a long road ahead. With growing maturity among intersecting players in the e-mobility ecosystem, unlocking data and dismantling the barriers to non-discriminatory data exchange will create the right conditions for interoperability and optimise the customer experience.

Appendix

Charging standards and protocols



Communication protocols such as ISO 15118 and OCPP are widely adopted, and are helping to accelerate EV adoption

Actors	Protocols	Description	Current status
EV – EVSE	ISO 15118	This protocol is an international standard that defines the communication between EVs and charging stations. It defines communication protocols, interfaces and payment methods for a seamless and interoperable charging experience for EVs at any compliant charging station. This standard enables smart charging systems to remotely monitor and control the charging process.	The standard is active and accepted internationally. ISO 15118 is also a key element in the 'plug and charge' function for identification, authentication and payment.
EV – EVSE	IEC 61851-1	IEC 61851 sets international requirements for conductive charging systems for electric cars. This standard is divided into sections, each addressing a distinct aspect: general system requirements, connector types, and testing and certification criteria.	It is a mature and widely adopted protocol that is essential for ensuring interoperability and safety between EVs and charging stations. While some parts of this standard are developed, others are still in development.
EVSE – CPO	OCPP	OCPP is an EV charging communication protocol between an EV charging station and a central management system. Smart EV charging systems use OCPP to communicate with smart charging stations and enable features such as remote start/stop for charging, real-time monitoring of charging status, and billing for the energy consumed.	It has emerged as a free-to-use, must-have standard for ensuring interoperability among EV charging manufacturers, charging network operators and software providers. However, not all EV chargers and management software support OCPP.
EMSP – ERSP	OCHP	The OCHP is an open-source protocol that enables simple and uniform communication between a charging management system and a clearing house system.	It connects 1,000+ companies in 52 nations, making EV charging easy and seamless for all users.
EMSP – CPO	OICP	Open InterCharge Protocol (OICP) was developed by Hubject. It enables communication between eMSPs and CPOs via Hubject to enable EV drivers to charge at any given location. Users can also view real-time availability of chargers and pricing information, and can easily initiate and terminate charging sessions.	This standard has become popular with some players such as ChargePoint and EV Box adopting it; however, others such as Tesla and BMW have not yet complied with it.

Some protocols, such as OICP, eMIP and CHAdeMO are specific to platform providers and countries that are yet to expand their reach

Actors	Protocols	Description	Current status
EMSP – CPO	eMIP	eMIP is an open communication protocol developed by Gireve (France) enabling roaming of charging services via clearing house data, access to charging point databases, and smart charging features.	Currently, the roaming platform operates in 28 countries.
EV – EVSE	OCPI	OCPI supports connections between eMSPs and CPOs, allowing EV users to access different charging points and streamline payments across jurisdictional borders. This helps to support EV uptake through roaming. OCPI supports the most functionalities, including smart charging, among different roaming protocols.	It is commonly used in the EU.
EVSE – DSO CPO – DSO	OpenADR	OpenADR is an open and secured foundation for interoperable information exchange to facilitate automated demand response. It is used to send information and signals between DSOs/utilities and energy management and control systems to balance demand during peak times.	The standard is getting widely adopted globally.
EVSE – DSO	IEEE 2030.5	IEEE 2030.5 enables utility management of distributed energy resources, such as EVs, through demand response, load control and time-of-day pricing.	It is commonly used in California.
CPO – DSO	OSCP	OSCP communicates predictions of locally available capacity to charging station operators. The current version contains use cases with more generic terms to allow integration of solar PVs, batteries and other devices. However, the use of OSCP is still limited.	Compared with protocols such as OCPP, CCS and CHAdeMO, OSCP is not used as extensively.
EV – EVSE	CHAdeMO	A protocol originally developed in Japan that accompanies its specific CHAdeMO plug, allowing physical bidirectional DC charging.	The CHAdeMO fast charging standard is prevalent in Asia, specifically in Japan and China.