



WBCSD Value framework for sustainable charging infrastructure

BUSINESS CALL TO ACTION

As a driver of an EV, this Value Framework resonated with me as I know first-hand the shared value yet to be broadly realized across the mobility, energy and real estate sectors. The necessary industry action required to bridge this gap is addressed in the provided highly relevant use cases and serves as a key tool to accelerate decarbonization strategies within cities and business.

Peter Oosterveer

Chief Executive Officer and Chairman of the Executive Board, Arcadis

There is no Planet B, and we must act now to make mobility more sustainable. Acceleration of electric mobility is undoubtedly a key part of it, and it can only be successful if it goes hand in hand with the development of the relevant charging infrastructure. An infrastructure that can ensure efficiency and convenience, while meeting users' expectations.

Andrian Cainarean

Head of Mobility Partnerships and Energy Transition at Arval BNP Paribas Group

With a rising number of electric vehicles (EVs) on the road, there is a critical need to have the right EV charging infrastructure in place and the right power capacity to support. Combining intelligent EV charging, power management and energy storage solutions delivers real customer benefits and ensures smarter and more sustainable energy management for the grid.

Craig McDonnell

Senior Vice President and General Manager, Energy Transition & Digital, EMEA at Eaton

We are proud to support the launch of WBCSD's Value Framework for sustainable charging infrastructure. Electric vehicles may be silent but the path to net-zero mobility must be loud and clear. Smart technologies are critical to the growth of sustainable charging infrastructure, especially in urban environments. EDP has been actively working to provide and develop the right solutions, leading this transition with two major commitments. First, electrifying 100% of our light duty vehicle fleet, and 50% of our heavy-duty fleet by 2030. Second, doubling the number of charging points installed across Portugal, Brazil and Spain in 2025. We are committed to accelerating the expansion of electric mobility. This is a challenge that increasingly requires cooperation between companies, sectorial organizations and policy makers. We encourage other companies in this ecosystem to join us.

Miguel Stilwell d'Andrade

CEO of EDP

As we already entered the Decade of Action, even with the progress made so far, it is crystal clear that additional actions are needed to fully capitalize on the current momentum and to push 100% EV fleet adoption into the exponential growth rate needed to meet the Global Goals.

Alberto Piglia

Head of e-Mobility, Enel X

Light weight solutions are critical to extend the range of electrified cars and help to save energy. In addition, specialized materials such as polyamide compounds enable fast and safe charging.

Frederique van Baarle

Head of High Performance Materials Business Unit, LANXESS

Mercedes-Benz AG is accelerating from EV-first to EV-only: That means by the end of this decade Mercedes-Benz will be ready to go 100% electric – where market conditions allow.

Ola Källenius

Chairman of the Board of Management, Daimler AG and Mercedes-Benz AG

Microsoft is pleased to announce our collaboration with the World Business Council for Sustainable Development (WBCSD) at COP26. Microsoft is committed to supporting the automotive industry through its shift to connected, electrified vehicles and intelligent transportation systems driven by the need for our world to significantly reduce carbon emissions. As a member of WBCSD and its Mobility Decarbonization partner coalition, Microsoft hopes to help grow EV fleets by aligning automotive, energy, real estate and public sectors on common technologies, a common data model and policies that support efficient energy and transport integration.

Sanjay Ravi

General Manager of Automotive, Mobility & Transportation Industry, Microsoft

We still have some way to go to get the infrastructure in place and its important energy networks. We need to work with governments to map out where critical infrastructure is needed to enable a faster rollout of charging points.

Duncan Burt

Chief Sustainability Officer, National Grid

Faced with climate change and global warming, the world needs transport not only to be smart and safe, but to be sustainable and integrated. Sustainable charging infrastructure is an important building block to complement zero-emission public transit.

Marjan Rintel

Chief Executive Officer, Nederlandse Spoorwegen (NS)



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1 Executive summary



1 Executive summary

The fast electrification of automotive manufacturer portfolios is essential for achieving net-zero emissions by 2050.¹ It must be supported by equally fast deployment of charging infrastructure. Policy support and cross-sector collaboration is needed to improve the business case, minimize the financial risk and unlock significant private and public investments that allow for a timely, sustainable and equitable transition.

Vehicle electrification is a priority for road transport decarbonization. Light-duty electric vehicle (EV) sales saw 43% growth in 2020 despite a declining automobile market, with growth continuing in 2021 for the European Union, China and US. As governments worldwide set target dates for the ban on internal combustion engine (ICE) cars and many automotive manufacturers embrace commitments to carbon neutrality, the fast-paced development of zero-emissions vehicle technology along the supply chain continues unabated.

Successfully achieving net-zero emissions in 2050 for road transport means a fast technology transition coupled with wide strategic alignment across the value chain and ambitious policies that provide clarity and reduce investment risks. Although slow EV uptake in developing countries and securing battery production capacity are crucial issues that the sector needs to address, the most important challenge right now is coordinating efforts across sectors to deploy sustainable charging infrastructure as quickly as possible.

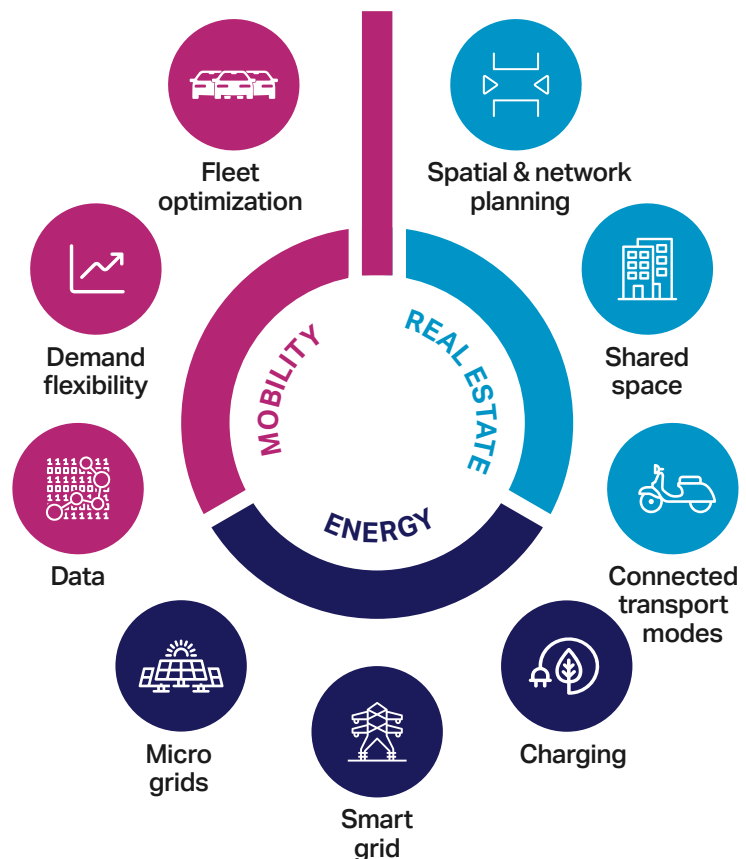
To do so, governments and businesses must come together to build the business case for optimal real estate, energy and transport system integration. This would allow accommodating the expected demand from electric vehicles on the grid and ensuring a positive customer experience. Empowerment of EVs to actively participate on energy markets, will provide the flexibility needed to, improve the efficiency of energy systems, allowing all value chain actors to achieve climate neutrality in the most cost-effective manner.

The aim of this value framework is to help businesses and governments align on a common pathway for the fast deployment of sustainable

charging infrastructure in line with a 1.5°C scenario for transport. It focuses on improving the business case through creation of shared value. The framework provides an overview of the ongoing changes in the industry, identifies domains for urgent transformation and proposes a technology and policy framework for bridging the infrastructure gap to net-zero mobility.

The value framework supports a regulatory model that creates sustainability and financial incentives for companies to connect charging and smart grid technologies across the EV value chain. At an overarching level, we propose nine key action areas:

Figure 1: Charging infrastructure value framework overview



MOBILITY

Address the needs of various types of EV fleets by setting fuel economy standards and incentive schemes that differentiate user groups, stimulate fleet electrification and help the development of EV second-hand markets, grid balancing and shared infrastructure.

Agree on data sharing principles

By collaborating on defining a common digital framework for tailored infrastructure planning and needed data for energy flexibility market participation.

Allow and incentivize consumer flexibility By establishing regulation that enables and incentivizes energy market participation and stimulates enabling technology investments.

ENERGY

Incentivize and facilitate charging integration by creating legal requirements for network preparation and charging point installation. This includes minimum public charging infrastructure, real estate regulation and establishing the “right to charge” for communities that may not be able to afford the cost of adoption. It also encompasses streamlining charging integration processes and establishing public-private financial mechanisms to bridge the investment gap.

Encourage the deployment of smart grid technology by establishing a favorable regulatory framework that incentivizes smart grid technology adoption, such as managed charging, smart metering, building energy management systems and advanced network management tools, including mandating the deployment of smart charging and introducing an innovative and dynamic tariff system.

Maximize charging from renewable energy sources (RES) by setting low-carbon energy requirements for buildings, removing existing barriers to local RES consumption and incentivizing the deployment of microgrid technologies such as energy management systems and storage.

REAL ESTATE

Establish coordinated strategic planning and management practices, with governments taking a leading role in strategic planning, ensuring sustainable infrastructure deployment through advanced planning, analytics and mobility management tools.

Share space and charging infrastructure By proposing incentives and space access policies that promote shared and accessible overnight charging infrastructure.

Connect transport modes By coordinating spatial and mobility planning to develop mobility charging hubs that optimize the charging cost, improve accessibility and increase options for charging placement.

We expect the framework to evolve in parallel with the value chain and with the development of the regulatory environment, while existing experiments and demonstration projects will provide new knowledge and evidence.



② What is at stake?



2 What is at stake?

Transport is responsible for 24% of direct carbon dioxide (CO₂) emissions from fuel combustion, with road vehicles accounting for nearly three-quarters of transport CO₂ emissions.¹

By 2030, cities will be home to 68% of the global population and motorized mobility will increase by 41%.⁴ Without immediate action, both factors will significantly increase congestion in cities, reduce air quality and contribute to climate change and global warming due to increased greenhouse gas (GHG) emissions. One immediate task for decision-makers is to promote investments in solutions that combine reduced GHG and

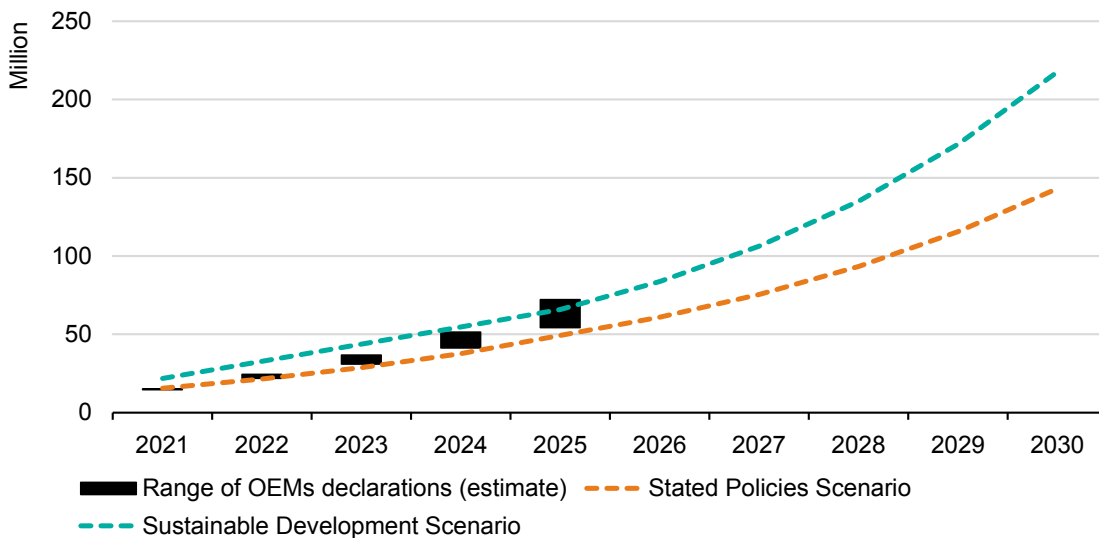
air pollution emissions with greater energy efficiency.⁵

EVs have no tailpipe emissions, consume less energy and emit fewer life-cycle GHGs compared to vehicles with internal combustion engines (ICE).² In acknowledging the opportunity EVs present, businesses and governments are massively pivoting their strategies toward wide adoption of EVs. Commercially available EV models are rapidly increasing, while concerns about battery range and higher prices are decreasing.³ Sales of electric passenger vehicles in early 2021 were more resilient to the impacts of the COVID-19 economic downturn than sales of ICE vehicles.⁴ The global stock of electric cars increased by over

40% year-on-year in 2020 and hit 10 million EVs on the road, for which battery electric vehicles (BEV) accounted for two-thirds.⁵ EV sales have since continued to surge, with growth in all three top auto markets: China, the US, and Europe. Sales increased by 160% in the first half of 2021 from a year earlier, to 2.6 million units, representing 26% of new sales in the global automotive market.⁶

The increasing EV model offering, more stringent fuel economy standards and government incentives have all induced steep growth in EV sales.⁷ Thanks to available electrification technologies, clearer policy directions and zero-carbon city initiatives, numerous fleet

Figure 2: Original equipment manufacturer (OEM) announcements compared to electric light delivery vehicle (LDV) stock projections in two International Energy Agency (IEA) scenarios, 2021-2025



IEA. All rights reserved.

operators are now paving the way for large-scale EV adoption by committing to electrifying their vehicle fleets. To do so, big corporate buyers have placed large – 100,000 unit – orders, considerably affecting EV market growth.⁹ Vehicle electrification seems to have gained unstoppable momentum and the question is no longer “whether to electrify” but rather “how to support a fast and sustainable transition” or “what happens the day after vehicle electrification”.

The rapid development of sustainable and inclusive charging infrastructure currently represents a major gap for most of the actors involved in this complex value chain to cover.¹³ Local stocks of public chargers reached 1.3 million in 2020, out of which 900,000 are slow chargers and 400,000 fast chargers.

According to the International Energy Agency’s (IEA) Sustainable Development Scenario, the world requires more than 200 million charging points by 2030. This includes 20 million public slow chargers and almost 4 million public fast chargers, corresponding to installed capacities of 150 GW and 360 GW, providing 155 TWh of electricity; and over 140 million home chargers and 50 million workplace chargers, with installed capacity totaling 1.2 TW, providing 400 TWh of electricity in 2030.¹⁴ **To achieve this, stakeholders need to invest more than USD \$100 billion in charging hardware by 2030(14) along with significant investments in transport infrastructure and energy system decarbonization.¹⁵**

Further potential to reduce the transport carbon footprint lies in increased shares of renewable energies in the power production mix and overall grid decarbonization to power EVs. **The energy sector, including grid operators and renewable energy generators, is playing a key role in enabling further transport decarbonization along the EV value chain, demanding significant investments to accommodate the expected number of EVs on the grid.**



③ A profound value chain change



③ A profound value chain change

Accelerating the uptake of electric vehicles calls for the entire value chain to collaborate to improve the business case by deploying a charging infrastructure that is timely, sustainable and inclusive by design.

Accelerating the deployment of sustainable charging infrastructure is a complex task and no single actor, or even group of actors, can solve it alone. As outlined in our [Vision 2050 refresh](#), three common factors drive and shape system transformations: macrotrends, innovations and enablers. These three factors together catalyze transformation and help business take the lead in supporting change.

At WBCSD we believe business has a critical role to play in scaling up the EV value chain. Many of our member companies are making ambitious commitments to electrify 100% of their fleets by 2030 and support the change with efficient energy and transport integration along with positive user experiences for fast adoption. A group of energy, mobility and real estate companies joined [WBCSD's Mobility Decarbonization project](#) to **collaborate on improving the business case for charging infrastructure to help bridge the investment gap.**



④ Value framework for sustainable charging infrastructure



4 Value framework for sustainable charging infrastructure

The value framework for sustainable charging infrastructure uses a business model canvas and system transformation theory to identify how to create shared value at the intersection of the mobility, energy and real estate sectors.

The optimized operation of electric fleets, which reduces the total cost of ownership and emissions, generates shared value in the transition of the global fleet to EVs – all while supporting the deployment of connected charging infrastructure that is accessible, sustainable and low cost by design. Shared charging infrastructure increases the value of space, while strategic planning and connecting transport modes ensures accessibility and increased use.

The value framework outlines macrotrends in the evolving EV value chain, defines a common vision based on the shared value concept and identifies key domains for change, technology enablers and related actions. It is based on more than 30 business and expert discussions and workshops with actors across the mobility, energy and real estate sectors. We aim for the value framework to continue to evolve and expand as our project welcomes new members, seeks alignment at national and regional levels, digs deep into the economics of specific use cases, and seeks demonstration and validation in a proof-of-concept setting.

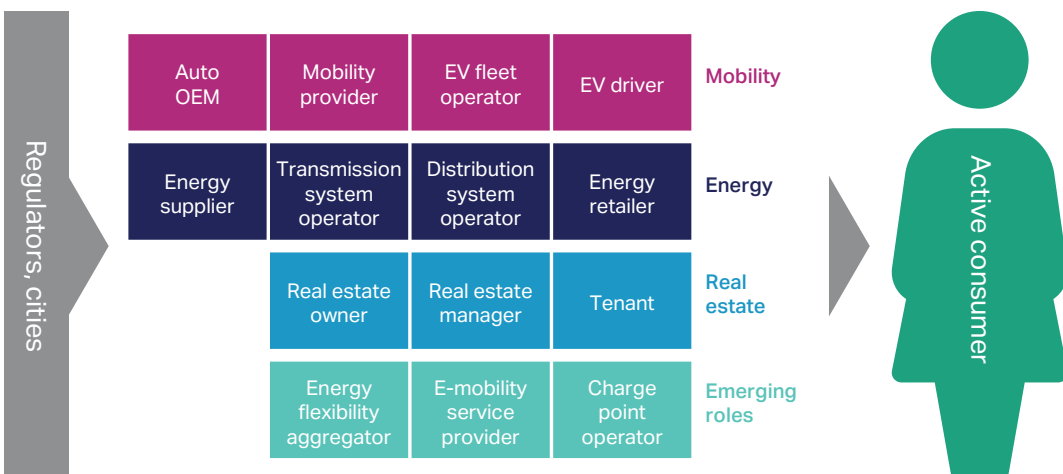
EVOLVING EV CHARGING VALUE CHAIN

The new electromobility value chain demands interaction with a diverse group of players across sectors. EV charging lies at the intersection of three sectors – mobility, energy and real estate – each with a paramount

role in facilitating transition to sustainability. **With the evolving value chain, new market roles emerge: active consumers, energy flexibility aggregators, e-mobility service providers and charging point operators.**

Active consumers, also referred as prosumers, are consumers who additionally take part in production. Active consumers in the EV value chain both consume and act as electricity providers. It can be an individual or a business that either injects electricity into the grid or does not consume grid electricity at the time when it typically would, thereby engaging in an activity usually referred to as “demand response” or “demand flexibility”. When an active consumer performs a demand response action, they simply decrease, change electricity source or shift energy consumption to another period.

Figure 3: Evolving EV value chain



EV fleets can act as active consumers and help balance the load by not consuming electricity at times of peak demand. Similarly, the real estate sector can respond to demand by offering renewable energy source (RES) generation or controlling a building's electricity generation use, or controlling charging or storage consumption. Active consumers will play a key role in providing the electricity system, particularly low-voltage grids, with the flexibility needed to balance increased EV consumption and the share of renewable electricity in the overall electricity system. **Seamless active consumer energy market participation plays a key role in efficient transport and energy system integration.**

Energy flexibility aggregators gather energy capacity from active consumers and offer it either to the energy market or for distribution and ancillary transmission system operator services. They either have direct communication with active consumers or act through intermediaries, such as e-mobility service providers. System operators procure or perform part of this role for grid management, while charge point operators procure or perform this role to optimize the total cost of ownership (TCO) of charging. Energy flexibility aggregators:

- Gather close-to-real time consumption data;
- Predict available capacity in the future;

- Schedule and activate active consumer consumption adjustments;
- Connect available energy capacity with energy trading platforms or receive signals from distribution system operator and transmission system operator (TSO) network management systems;
- Report and compensate active consumers for their participation.

E-mobility service providers (EMSP, sometimes EMP) are companies offering EV charging services to drivers. EMSPs enable access to a variety of charging points in a geographical area, help drivers find charging stations, start charging events and take care of billing.

Charge point operators (CPOs) primarily operate chargers, including providing charging IT infrastructure, gathering real-time information and ensuring the optimal operation of EV charging stations. Some CPOs also install and own the chargers. CPOs can optimize their businesses with a focus on operational excellence, smart energy management, monitoring and control, interoperability and integration with roaming EV platforms.⁹ By performing smart energy management, CPOs can take part in the energy flexibility aggregator role.

EMERGING BUSINESS MODELS

Business expansion strategies include either investing in adjacent businesses or integration along the value chain. EV infrastructure business models are taking shape from a variety of public or private partnerships:¹⁰

Standalone – a business model that passes infrastructure and service costs directly to consumers through charging rates

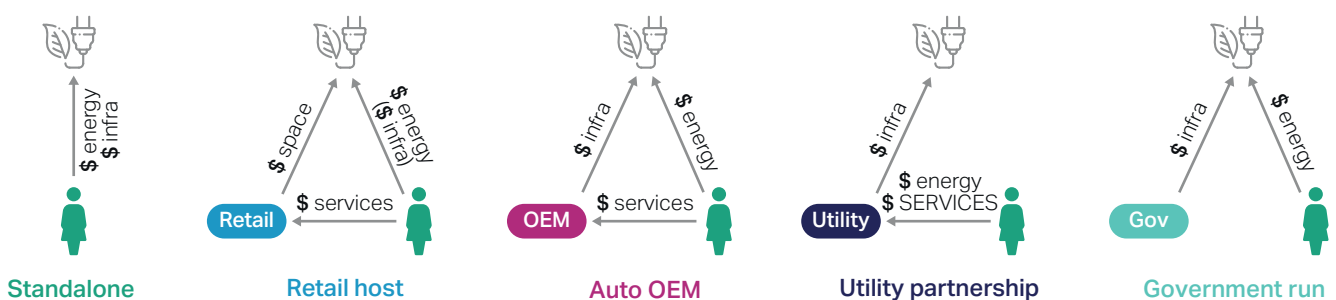
Retail host – a business model where real estate owners, such as retail businesses, provide space to other entities to install and operate EV charging stations. In exchange for space provided, they monetize the investment on the increased foot traffic.

Auto OEM – a business model where original equipment manufacturers (OEMs) in the automotive sector help finance infrastructure investments and recover costs through EV car sales prices or aftermarket services.

Utility partnership – a business model where energy retailers install and manage charging stations and provide energy services.

Government run – a business model where governments or local authorities subsidize investments for use cases that are underused or to speed up deployment. Governments or local authorities support the deployment of charging

Figure 4: Partnership types



infrastructure through direct investments to deploy publicly accessible chargers or by providing incentives for drivers of electric cars to install home units.

Accelerating the deployment of charging infrastructure requires a mixture of private- and government-run business models. Governments play a critical role in the rapid deployment of EVs where clean vehicle policies require the strategic management of actions at different administrative levels, beyond the central government level, including supra-national, national and local/city authorities at once.

SHARED VALUE IN MOBILITY TRANSITION

Addressing the gap in available charging infrastructure requires improving its business case while ensuring social inclusivity and system sustainability by design.

Balancing electricity demand and supply is increasingly a challenge for the smooth integration of variable renewables-based, distributed energy generation and the electrification of multiple end-use sectors. **Electromobility is a powerful resource to**

decarbonize the transport sector, provide flexibility services to the energy system and balance electricity demand and supply.¹¹

The share of EV charging during peak demand could rise as high as 4-10% by 2030 in major EV markets.¹⁹ Readily available technologies such as smart charging provide an opportunity to add flexibility services to the energy system by avoiding electricity consumption during peak demand periods, along with other grid-balancing services. Further development of vehicle-to-grid (V2G) and microgrid systems brings the potential to unlock more storage reserves for energy grid balancing. The uptake of EVs therefore brings opportunities for balancing the energy systems,²⁰ while coordinated action can support energy system decarbonization.²¹

A multi-stakeholder effort can ensure the transition to a sustainable mobility system that leaves no one behind. An equitable transition would mean infrastructure that is accessible, from the perspective of improved user experience and cost. The rise of densely populated urban

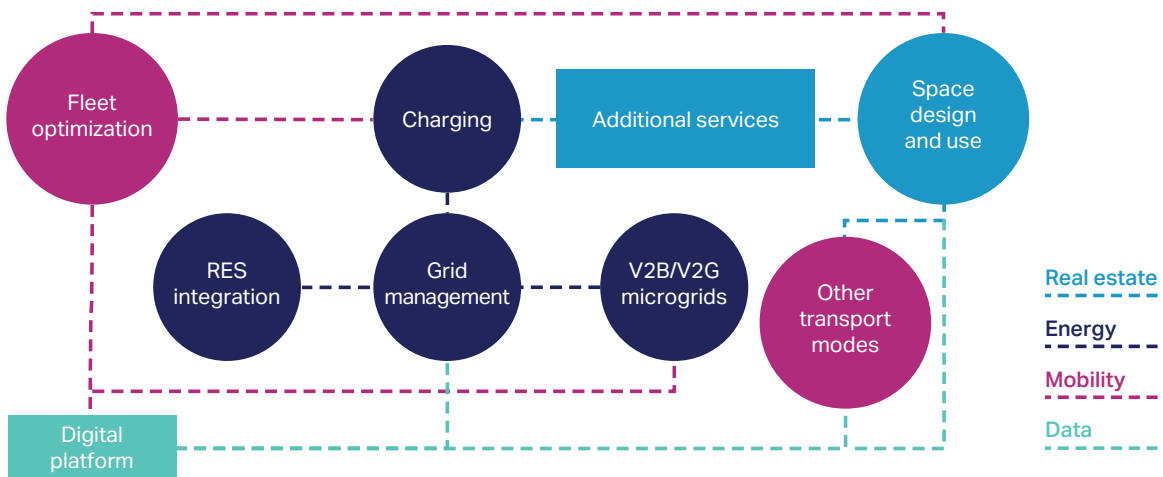
areas will result in many “homeless cars” – drivers with no parking or charging opportunities. Affordable public infrastructure and shared semi-private infrastructure will play an important role in equitably answering charging demand. Premises with capabilities to charge vehicles will face even stronger demand and charging infrastructure will play a key role in creating more value for real estate properties.

Addressing this demand can create opportunities by sharing space to increase foot traffic, sharing charging infrastructure to increase use, and integrating transport modes to provide wider accessibility. Real estate actors can also benefit from local energy optimization by aligning renewable generation, storage technologies, charging and electricity consumption in building.

In doing so, they can increase real estate energy independence, help decarbonize EV charging, provide resiliency to the electric power system and ensure future-proof investments.

Our [EV guide](#) analyzes different fleet use cases to identify the potential and challenges of fleet

Figure 5: Mobility, energy and real estate value intersections



transition to electric vehicles. In collaboration with businesses and partners, such as EV100, we are continuously adding additional EV fleet use-cases to our online [case study repository](#) to share best practices and experiences in transitioning to electric fleets. As EVs achieve TCO parity with ICE vehicles when their daily use is high, ride-hailing, corporate fleets and delivery fleets are evident solutions that have the potential to scale up faster.¹²

EV fleets can help to establish a cohort of early adopters that can stimulate the conditions needed for mass electrification across society.¹³ EV fleets can lower technology costs, promote the development of second-hand vehicle markets and increase charging station use. They have predictable consumption patterns, and data and technological know-how to support grid balancing with energy flexibility services.

We therefore focus **shared value** in the global fleet transition to EVs on three interrelated business cases:

- A) **Economically and environmentally efficient EV fleets**
- B) **Accessible, smart and low-cost charging infrastructure by design**
- C) **Shared energy- and mobility-integrated space**

Failure to recognize shared value in the global fleet transition could lead to sub-optimal system design, making charging infrastructure less accessible and inclusive and more expensive. It could also lead to not realizing the maximum EV carbon reduction potential due to slower EV fleet adoption and RES integration.

AREAS FOR INFRASTRUCTURE IMPROVEMENT

User experience, government policies and lifetime economics plays a key role in driving further EV adoption. Seamless user experience, especially the availability of charging infrastructure, is critical for user acceptance. The lifetime economics of EVs determines if a business transition will be successful and is dependent on vehicle purchase cost and residual value, operating costs, its useful life, financing models, emissions costs, government incentives, and operational fit.

Mass uptake of EV fleets is conditional to bridging the short-term financial gap, removing the operational barriers, including interoperability, optimizing the charging cost and minimizing the overall carbon footprint with the use of renewable energy sources.

Bridging the short-term financial gap

Vehicle TCO has already proven lower for several light-duty fleet use cases characterized by high mileage, financial incentives, and reduced energy and maintenance costs. The upfront vehicle cost of EVs is however still higher in the short term, compared to ICE vehicles, demanding a larger upfront investment. Technological development and increasing economies of scale should result in vehicle purchase price parity in the 2020s.²⁴ The financial gap should decrease in the long term because of the increased use and lower costs of renewable electricity, charging, batteries and emissions, and by generating value from active participation of consumers in grid balancing.²⁵ Short-term financial support and new ownership types, such as leasing, will play a key role in actively shifting consumer mindsets from purchase cost to lifetime cost.

Setting-up a charging network, including charging installation, grid infrastructure and power generation, equally demands high upfront capital investments. Current low infrastructure use rates and the complexity of planning for future EV power and electricity demand bring uncertainty to investments. Accelerating sustainable infrastructure deployment requires unlocking the business case for charging infrastructure and bridging the short-term financial gap.

Charging costs

Charging costs for the user include the amortization of investments in charging stations, energy costs and network costs. Investments in charging stations includes cost of labor, materials, permits, taxes and hardware. The costs depend on the type of charging station (e.g., level 1, level 2 or DC charging), number of stations on location and the location itself, which defines network strength and permitting costs. In the US market, for example, the hardware cost of a single port electric vehicle supply equipment (EVSE) unit ranges from USD \$600 to USD \$800 for level 1, USD \$900 to USD \$3,000 for level 2, and USD \$28,000 (50 kW) to USD \$140,000 (350 kW) for DC fast charging. Installation costs vary greatly from site to site, with a ballpark cost range of USD \$400 to USD \$900 for level 1, USD \$700 to USD \$4,000 for level 2, and USD \$17,000 to USD \$65,000 for DC fast charging.¹⁴



Charging infrastructure and grid costs

With the wider uptake in electric vehicles and the integration of distributed energy sources, distribution system operators must manage increased peak power and variability, especially on low-voltage networks. This can significantly increase installation and network costs if not managed properly. An inclusive transition to electric vehicles implies the availability of cost-efficient charging infrastructure for all, including users lacking space for a private charging point, and fleet sharing and taxi drivers who will rely more on publicly available infrastructure. It is critical to ensure the fair distribution of the cost of upgrading and decarbonizing the grid, not transferring it to EV drivers, and allowing charging where consumers need it at a fair cost.

Infrastructure permitting process

Currently it takes months, if not years, between initiating a charging station installation and the day the station is available for charging. The process is also often intricate, expensive, and may feel overwhelming for cities and operators alike.¹⁵ This can become even more complicated where tenants are not the owners of the real estate, causing unclarity in cost ownership and permit process delays. Local government bureaucracy, slow permit processes, and frequent site redesign to secure the necessary permits for construction also add to overall construction costs.¹⁶ The availability of suitable space for charging infrastructure and increasing land prices are posing additional challenges for a fast and equitable transition.

Use case: Streamlining permitting processes

California is an EV market trailblazer. Although it has the highest penetration of electric cars in the US, its permit process for new charging stations takes about 70% longer and costs 30% more than the rest of the nation. Timelines have ranged from two weeks to a year. To address this issue and expedite permit processing, the state of California:¹⁷

- [Developed a guidebook](#) to offer a shared foundation to streamline the planning, permitting, installation and ongoing operation of electric vehicle charging stations and their supporting equipment;
- Developed electric vehicle charging station accessibility regulations;
- Introduced a new bill in the California State Assembly aimed at streamlining the permitting process by zone – any authority having jurisdiction automatically deems any application complete after 5 business days and approved after 15 business days if regulators find no issues and approve of construction.

Interoperability

There is a lack of commonly accepted standards regarding communication between vehicles, charging infrastructure and energy networks that limits charging station accessibility, efficient system digitalization for payments and charging station energy management. The lack of standardized charging infrastructure deteriorates the user experience and slows down EV adoption. It also poses a challenge for real estate owners when deciding whether to invest in charging infrastructure and what type of technology to deploy.

Connectivity

Despite having available technologies in place, the ability to book or reserve charging capacity using a connected service is still inadequate. Resolving this issue by

agreeing on common principles and incentivizing connectivity would allow for a significant increase in demand determinism, which in turn allows for greater infrastructure design. Governments can also use connectivity as a tool to implement policy in urban areas with shared charging infrastructure to ensure equitable or even prioritized access to facilities in support of transportation policy.

Infrastructure fit for user needs

No one charging solution fits all; different vehicle types and sizes each require a different solution. There is a need to better understand the charging behavior of different EV fleets, while making sure that the charging technology deployed creates a positive user experience.

Seamless payments

A positive charging experience requires adequate access to charging stations, payment options, and pricing transparency. A lack of payment interoperability increases the cost of implementing and maintaining credit card readers, and upfront and running costs to manage more than one payment mechanism. As many companies have their own cards or keys, EV drivers will either have to join multiple platforms or risk being unable to charge. Additional challenges include high and opaque roaming tariffs and a lack of flexibility in incorporating new services and business models in roaming protocols.¹⁸

Efficient energy and transport integration

The clean energy transition will be a success if all end-users benefit from playing a part in it, either through smart charging or active energy market participation. Currently the costs of enabling vehicle-grid integration (VGI) and the costs of setting up a site for participation in the dispatching services market make this technology uncompetitive even where participation is technically feasible. Apart from outdated regulations that limit small load participation, small active consumer participation relies on digital technology for resource management and activation, reducing the marginal cost of individual resource connection and efficiently engaging active consumers in market participation.

While network operators are increasingly paying the power intensive industry to provide demand-side-response activation by reducing or shifting the consumption of large industry loads, the engagement of smaller consumers still presents a challenge. Along with decreased charging costs from smart charging contracts, infrastructure

operators should enable and reward EV drivers for using their vehicles as a decentralized energy resource that can flexibly adapt its electricity flows in response to prices and incentives. When EV drivers do so, they optimize their energy use while supporting the cost-effective penetration of variable renewables in the system and avoiding unnecessary grid investments. While individual incentives can prove too small to encourage behavior change for active demand response participation, the deployment of smart metering, new business models and further development of digital technologies, such as intelligent dispatch algorithms and automation technologies, can support seamless participation and the achieving of critical scale.

CHARGING INFRASTRUCTURE USE CASES

The configuration and specification of EV charging infrastructure varies, depending on use case, customer needs, and the parties involved.

Understanding the needs of each fleet and the different charging use cases is important to enable a seamless fleet transition to electrification.³¹

The table below presents an overview of the most common use cases for charging, including home charging, workplace charging, semi-public charging, public charging, mobility hub and highway charging. We distinguish use cases by fleet users, typical locations, charging profile (e.g., night, day or fast charging), and charging technology typically deployed. We have rated each charging use case by its ability to provide energy flexibility services. The table further summarizes key benefits and challenges of various charging use cases. It highlights the importance of deploying each charging type and key areas that need action to improve the business case and maximize user experience.

Different fleets will rely on different charging places, depending whether it concerns a corporate fleet for operations, a corporate fleet for employee commute, a ride-hailing service, a delivery fleet, and so on.

Figure 6: Charging infrastructure use cases

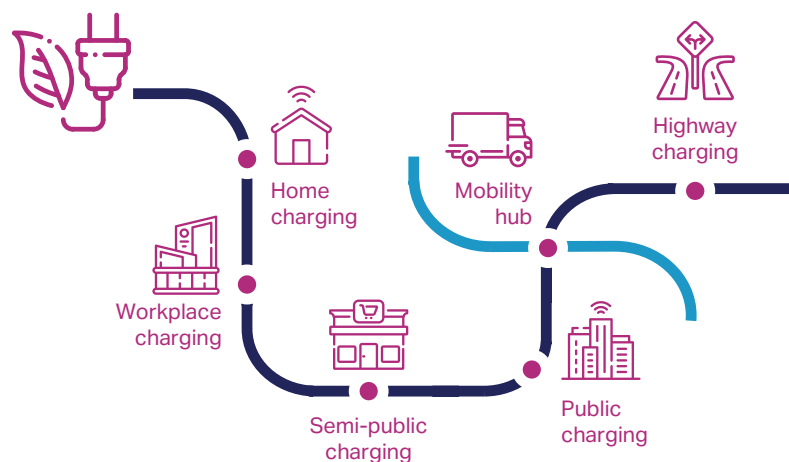


Table 1: EV charging use cases

	Home charging	Workplace charging	Semi-public charging	Public charging	Highway charging	Mobility hub
Fleet users	Corporate Leased & rented Ride-hailing	Corporate operations Corporate employees	All fleet types	All fleet types	All fleet types	All fleet types
Locations	Individual or multi-dwelling Residential parking	Office buildings Corporate parking Depots	Retail buildings Sports/entertainment Service facilities Airports, etc.	Last-mile charging Near commercial areas Public parking	Intercity Interstate	Transport nodes Delivery nodes Park & ride
Charging profile			 recommended	 recommended		 recommended
Technology	Slow	Slow	Slow (fast)	Fast/slow	Fast	Fast/slow
Charging flexibility	High Evening peak shaving Wind charging	Medium PV charging Building energy man	Medium PV charging Building energy man	Medium PV charging Local grid optimization	Low high (storage) High-power charging Local wind balancing	Medium high (storage) High-power charging Local wind balancing
Key benefits	Most cost-efficient and convenient charging option High flexibility potential	Maximizing the use of solar energy	New commercial services while charging	"Homeless fleet" charging Reduce charging anxiety On-the-go charging	Extending EV use-cases with range ICE-like customer experience	Cost, space and energy network optimization
Key challenges	"Homeless fleets" Securing private charging in densely populated areas	Different charging profiles Avoiding daily energy demand peak	Overnight accessibility and maintenance	Appropriate technology EVSE coverage Cost	Large investment cost and underuse leading to inadequate network coverage	Large investment cost Lack of coordinated planning
Enabling technology	Smart charging BEMS Storage PV	Smart charging BEMS Storage PV	Smart charging Smart parking BEMS Storage PV	Fast charging Smart charging Smart parking Storage PV	Fast charging + storage Advanced network planning Wind generation	Fast & Smart charging Storage PV & wind Advanced network planning

TECHNOLOGY ENABLERS

As vehicle value chains change, new technologies have the potential to offer better performance and new market value streams. Innovation refers to the implementation of new ideas to create value – both across products and across processes, management and business models, and in finance, policy and society as a whole.¹⁹ Technology innovation that supports the scaling-up of EVs centers on enabling seamless user experience and the efficient integration of transport and energy through improved planning, increased system intelligence and empowering consumer flexibility.

Digital systems for sharing data

As outlined in our [Enabling data-sharing: Emerging principles for transforming urban mobility](#) and [Sustainable mobility: Policy making for data sharing](#) reports,










data is central to the future of interconnected mobility value chains and can unlock an array of opportunities and benefits.²⁰ Assuming sufficient charging infrastructure exists, comprehensive, real-time data on the location, availability and speed of charging stations – matched with anticipated vehicle fleet demand and range needs – is key to making the system work.²¹ Data sharing, which incorporates privacy and cybersecurity by design, is a key enabler in the design and management of charging networks that address the needs of EV drivers. Providing the charging infrastructure needed to meet rising driver demand or requests guarantees the business case for investment and ensures that EV chargers are in good locations. Accommodating the increasing number of EVs and the amount of distributed generation on the energy grid also requires shared

data. It brings understanding of user needs and supports the shaping of evolving charging optimization programs that are convenient, attractive and rewarding for EV users and enable spatial planning.²²

Data intelligence software

Apart from digital systems for sharing data, development of data intelligence knowledge within the organization and development of the software for big data analysis, modelling and prediction are needed to master complex system planning. Data intelligence software can allow for advanced network planning, predicting energy consumption and generation, the structuring of effective incentive systems to balance supply and demand, and optimal fleet management. The availability of large time-series data and the use of artificial intelligence is needed to maximize the intelligence of the prediction models.

Figure 7: Enabling technologies

								
Data	Fleet optimization	Demand flexibility	Charging	Micro grids	Smart grid	Spatial & network planning	Shared space	Connected transport modes
Data intelligence Digital systems for sharing data	Fast and slow charging	Demand flexibility systems Virtual power plants	Unidirectional controlled charging (V1G) Vehicle-to-grid (V2G) Charging point management software	Building energy management systems EV battery repurposing Renewable energy sources	Smart metering Power management technologies Storage technologies	Advanced network and spatial planning tools Smart parking systems	Charging station safety	Integrated fleet management solutions Modular charging technologies

Demand flexibility

Demand flexibility involves customer or automation systems that facilitate vehicle-grid integration (VGI). VGI technologies include smart charging (also referred to as V1G) and bi-directional technologies such as vehicle-to-grid, vehicle-to-home or vehicle-to-building (often referred to as V2G or V2X). VGI is one of the most promising sources of flexibility for the operation of low-, medium-, and high-voltage networks through their capacity to store energy and due to their highly decentralized and distributed nature. They provide distribution grid operators with a tool to balance electricity demand and consumption and therefore lower grid charges for consumers. At the same time, EV owners can realize greater economies by participating in ancillary, or wholesale, markets.

Shifting EV fleet energy consumption to off-peak hours also absorbs excess renewable energy production, thereby reducing overall emissions and costs for fleet owners. Already back in 2016, as part of its proposal for electricity market design to eliminate barriers to demand-side

flexibility, the European Commission calculated that stakeholders in Europe could save EUR €5.6 billion annually by avoiding investments in unnecessary grid reinforcements, back-up generation capacity and fuel costs.²³

Demand flexibility provides grid balancing and enables active consumers to earn revenues on energy and ancillary markets or optimize their energy and connection costs. Several technologies, also further presented in this chapter, enable this critical active consumer participation, including storage, distributed generation, smart charging, building energy management systems, and virtual power plants.

By lowering peak power demand and shifting charging to when cheaper renewable energy generation is available, building energy management systems enable **building energy optimization**, which can lower the real estate cost of power connection and optimize building energy costs. A critical part of efficient transport and energy integration is **distribution system balancing**, by shaving peak charging consumption and responding

to distribution system operator activation requests or dynamic price signals. Smart charging technology is a key element in enabling such services, incentivizing end-consumers with lower grid connection and energy costs.

On the opportunity side, active consumers can also engage in the provision of **ancillary TSO services**, namely primary, secondary or tertiary reserves. These reserve products help TSOs balance grid frequency and power. The reserve types differ in their technical requirements, including speed of activation and activation profile. Active consumers participating on these markets receive remuneration in the form of capacity reserve payments, activation payments and energy payments, depending on the type of activation. Due to its fast start and ability to constantly adapt energy charge or discharge, batteries are in a unique position to provide reserve capacity for all ancillary markets, especially frequency reserve. Active consumers can also engage its remaining flexibility in **energy market trading**, namely day-ahead and intraday market.

Figure 8: Intra-day charging profile adjustment to renewable energy generation

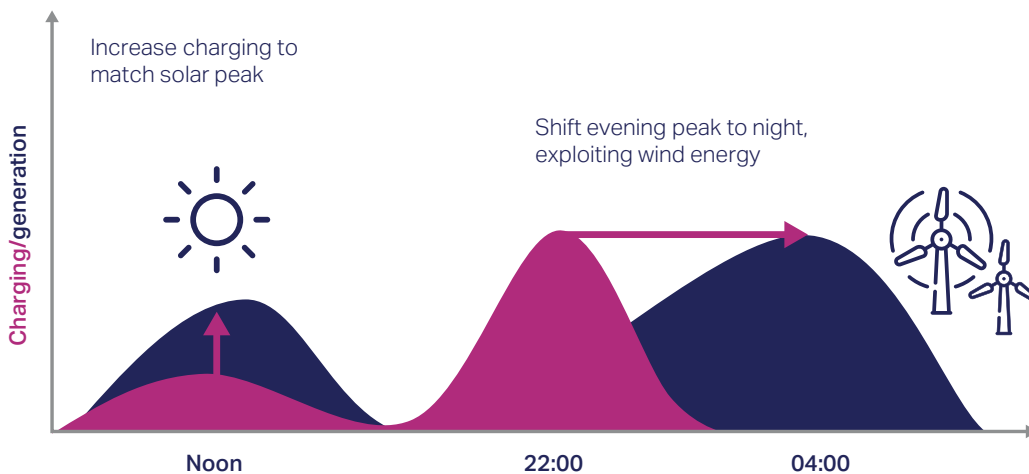
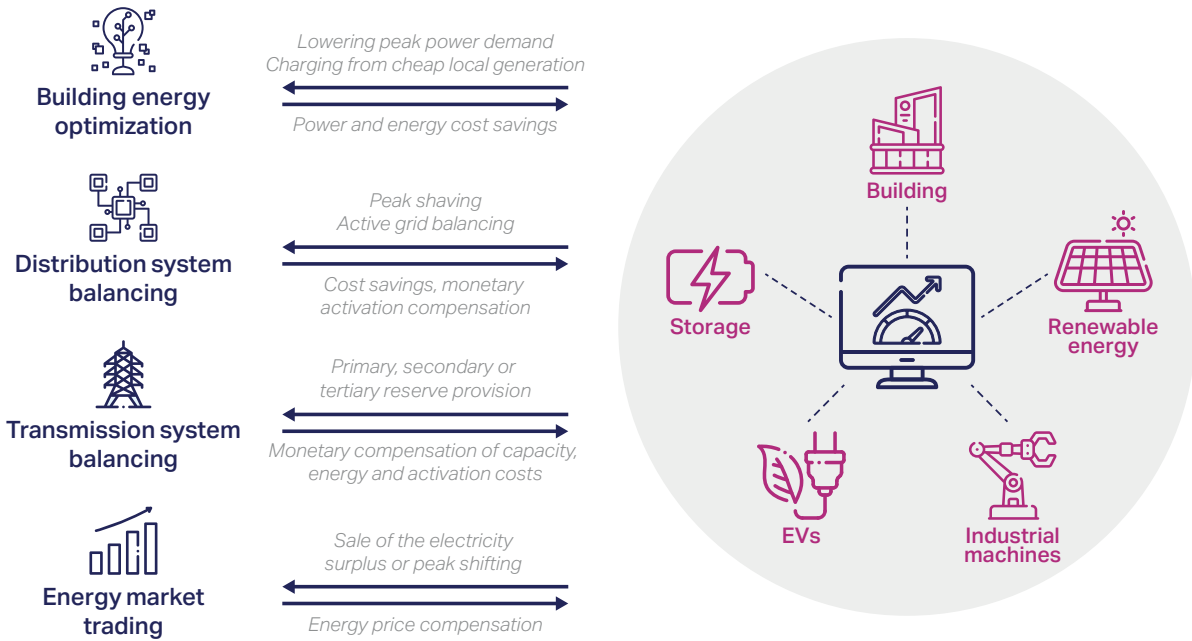


Figure 9: Demand flexibility technologies and markets



Demand flexibility allows for different levels of driver participation, varying by level of automatization and system data intelligence. Drivers or fleet managers can be passively involved, for example by specifying conditions in energy contracts and automatically adjusting the power level of smart charging. They can also be actively involved by defining their preferences and managing activations. With the increased amount of flexible energy sources we can build more robust activation system. *Table 2* presents different levels of consumer participation through managed charging.

Table 2: Levels of managed charging; California Energy Commission, in Myers (2019), SEPA

Source: California Energy Commission²⁴

Basic	Customer manual opt-in or opt-out of a managed charging event (e.g., adjusting their consumption pattern)
Good	Automate user preferences during managed charging program enrollment
Better	Use standards to ensure interoperability and automated inputs across location types (e.g., where there may be more local grid constraints) to improve customer experience.
Superior	Leverage intelligence throughout the network to improve predictive capabilities and optimize load forecast estimates over time and location (i.e., to minimize charging disruptions except where most needed)

The efficient integration of active consumers in the demand response market also relies on the ease of use and cost of energy management, communication and activation technologies per kW of connected capacity. Technologies

such as smart charging, energy management systems and virtual power plants lower technology costs for individual load connections and enable the reaching of the needed scale for energy market participation.

Unidirectional controlled charging (V1G)

Unidirectional controlled charging (V1G) or smart charging refers to the ability to control the time, rate and duration of EV charging and to optimize electricity system needs. It requires a power system operator, an aggregator or a local automation system to send dispatch signals to the electric vehicle's onboard control or charger, or an energy management system, allowing it to manage charging demand.²⁵ As such, it can control, slow, accelerate, stop or postpone the charging of the vehicle. This is most suitable for slow charging technologies, where momentarily unavailable charging is not critical for driver operations. A study in Great Britain shows that smart charging can reduce the percentage of networks that require intervention from 28% to 9%.²⁶ Smart charging technology is the first step on the innovation path to vehicle-to-everything (V2X) capability.

Fast and slow charging

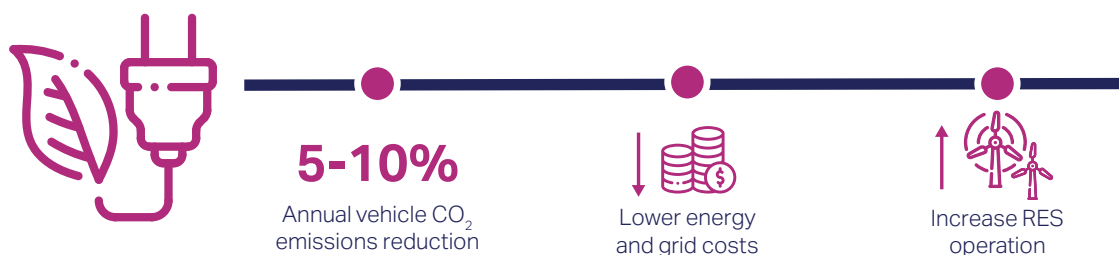
Slow chargers are generally alternating-current (AC) units that charge approximately 160 km in eight to ten hours, presumably while the car remains parked for longer periods of time. Fast charging, by contrast, is required when a vehicle is on the move. In the case of fast charging, drivers pay a premium for a charge in an hour or less, allowing them to continue a trip. In addition, there are ultra-fast charging points, which can provide up to 700 kW of power and can charge 80% of the capacity in just six minutes. As the EV customer base expands and it becomes possible to electrify more use cases, demand for public fast charging increases.²⁷ It is important, however, to note that the time of charge is dependent on the full battery capacity and the current battery charge percentage.

Vehicle-to-grid (V2G)

V2G technology allows for the bi-directional exchange of electricity. It can thus turn EVs into distributed energy producers. V2G services could unlock up to 600 GW of flexible capacity distributed across the main EV markets in 2030 and

moderate intermittency of variable renewables during peak demand.²⁸ The potential of V2G technology lies in providing a larger amount of capacity for grid balancing and for trading on ancillary and wholesale markets. According to a recent study by E.On Drive, Nissan and Imperial College, the potential CO₂ reduction per year and per electric vehicle is 60 metric tons. At the same time, it lowers the power grid's operating costs, provides financial benefits to EV fleet operators and helps reduce overall electricity system costs.²⁹ Realizing the benefits of V2G to boost the value of EV grid services will require overcoming demand-side and consumer-side barriers. Demand-side barriers include, among others, the availability of vehicles and infrastructure that support bidirectional flow capacity and the removal of regulatory barriers to participate on flexibility markets (ancillary or spot). Consumer-side barriers include, among others, adequate active consumer incentives, achieving critical mass for reliability and familiarizing consumers with the concept for further consumer trust.

Figure 10: Benefits of a smart charger



V2G use case

There are concerns that V2G applications impact the number of charge/discharge cycles, which negatively affects battery longevity. Recent studies on the impact of VGI on batteries, however, show that this impact is minimal, further paving the way for V2G adoption.

Nuvve, Nissan and Enel have come together to deploy 10 Nissan e-NV200 EVs (24 kWh), 10 Enel V2G chargers (10 kW) and a Nuvve aggregator at a utility customer site in Denmark. It started on 6 September 2016 and has been in successful operation for more than 5 years, logging more than 250,000 hours of V2G operation (10 EVs) delivering frequency regulation (regulation per second) to the Danish TSO of an average of 118 hours per week (heavy energy flow).

The Danish Technical University, an independent third party, analyzed these EV batteries. The results show that after 5 years the batteries degraded by 7% to 12%, of which V2G impact was in the range of 1%-2%. The main degradation comes from aging, driving and fast charging.³⁰

Building energy management systems

A building energy management system (BEMS) is a sophisticated and advanced control system in residential and commercial buildings that ensures energy efficiency. As buildings become energy hubs, with renewable energy, energy storage and EV chargers, they must play a vital role as flexibility assets to help ease the integration of growing levels of variable renewable generation into electricity grids. BEMS functionalities include the optimization of building and plant operations, the provision of energy management information, the remote monitoring and automatic control of services and functions of one or several buildings, such as automatic running of appliances, and the monitoring of building status and environmental conditions.

In the context of managing EV consumption, a BEMS enables local energy grid optimization, including charging, storage and renewable production, and can optimize the electricity consumption of other appliances. This integrated system connecting assets on the energy level in a safe and intelligent manner effectively allows for the increased

uptake of local renewable energy sources. Such a system also allows for the demand-side management of smaller loads by reducing the marginal cost of connecting a new device and eliminating the need for a dedicated control unit with outside communication channels.

Virtual power plants

A virtual power plant is a network of decentralized, medium-scale power generating units such as wind farms, solar parks, and combined heat and power (CHP) units, as well as flexible power consumers and storage systems. The virtual power plant controls the interconnected units through the central control room but they nonetheless remain independent in their operation and ownership. The objective of a virtual power plant is to relieve grid loads by smartly distributing the power generated by the individual units during periods of peak load. Additionally, energy exchanges trade the combined power generation and power consumption of the networked units in the virtual power plant.³¹ Virtual power plants therefore enable more advanced managed charging events, enabling multi-asset control and optimization.

Storage technologies

Storage technologies can support balancing increasing electricity generation from distributed, variable energy sources, deployed either on the grid, building or embedded in the charging stations. With an increasing supply of electricity from fluctuating renewable energies, such as wind farms or solar power stations, they can help stabilize power grids, levelling out energy fluctuations with virtually no loss—a role that is partly fulfilled by fossil power plants at present.³² The use of energy storage can support the power capacity and energy management challenge in buildings and avoid or defer huge CAPEX required for grid upgrade. It can help reduce capex and postpone grid upgrade investments, reduce energy bills by taking control of energy supply, gain reliability and independence and avoid potential peaks in grid supply, harness the full potential of renewable energy sources.

EV battery repurposing and recycling

While the falling price of lithium-ion batteries enhances EV growth, life-cycle concerns, including scarce material supply and battery disposal, pose a threat to EV market sustainability. Recycling and repurposing are therefore essential to EV market growth. Many “spent” batteries still have up to 70-80% of their capacity left, which is more than enough for other uses. After breaking down, testing and repackaging the batteries, they can serve an additional 6 to 10 years in a lower power, stationary application, storing energy from solar panels for use in off-grid or peak demand-shaving applications. McKinsey estimates that by 2025, second-life batteries may be 30% to 70% less expensive than new batteries, thus requiring significantly less capital per usage cycle.³³ However, battery pack designs have varied sizes, electrode chemistry, and format (cylindrical, prismatic and pouch) to best suit a given EV mode, which increases refurbishing complexity due to a lack of standardization and fragmentation of volume. Falling costs of new batteries may diminish the cost differential between used and new batteries; therefore, the market performance of second-life batteries will flourish if this gap remains sufficiently large. The lack of regulations is creating regional differences in whether recycling or reuse is the dominant pathway to choose and creates uncertainties for OEMs, second-life battery companies, and potential customers. Targeted actions from suppliers, end-users and regulators would help overcome these second-life EV battery market challenges and enable a sustainable second-life battery industry to thrive.³⁴

Advanced network and spatial planning tools

Advanced network planning, and spatial planning tools support the strategic management of mobility, energy and real estate needs. Future energy network planning should incorporate smart grid modernization efforts such as flexible energy management, smart metering infrastructure, grid automation and distributed energy resources, while also balancing electric power quality, supply and cost.³⁵ Accessible shared data condition advanced planning tools, which are paramount to sustainable system design and the maximization of shared value. Advanced spatial planning tools can also support city authorities to better plan the location of new charging infrastructure and help develop the investment case for surrounding real estate.³⁶

Smart grid technology

Smart grid technologies, such as smart meters and building energy management systems, allow for more efficient network monitoring and management. Grid power management technologies can reduce power losses on the existing network, optimize investments, improve the balancing of local supply and demand, and increase grid capacity to absorb local renewable energy. Intelligent network management systems and distributed energy aggregation platforms, also called virtual power plants, support close to real-time management of the grid and distributed energy source portfolios.

Smart parking systems

There could be more than 1 million on-street smart parking spaces globally by 2026, reducing the congestion and pollution associated with “cruising” for a vacant space.³⁷ It is possible to perfectly integrate a smart parking system with EV charging stations to make them even more useful and efficient. Smart parking systems allow for the monitoring of the occupation of the parking slots and can manage and integrate parking data relating to specific vehicles. Smart parking can introduce variable pricing, based on speed of charging, which network strength conditions. Adjusting the pricing and speed of charging in an urban area is a means to direct drivers to charge in-location, which relieves congestion on the grid or on the street.

Charging point management software

The automation of charging, scheduling, data sharing, contracting and payments will be key to optimizing EV driver experiences and minimizing barriers for EV driver participation on energy markets. Charging point management software, which collects all data relating to the chargers, including device operational “health” and use, such as length of charge, volume of vehicles using the charger, types of vehicles charging, etc., supports automation. Analyses of these data points empower business decision-making to enhance station management optimization, proactively optimize the entire network infrastructure based on customer behavior, charge point use, and energy management, which can significantly reduce TCO and support better planning of charging infrastructure. For example, a usage heatmap makes it easy to see which sites get the most traffic and which the least, allowing operators to move chargers to new locations to maximize revenues or open a completely new EV charging station where the market is thin.³⁸

Charging station safety

Charging safety, including safety-certified equipment and good illumination, protecting against vandalism while enabling easy access for all, is important for positive user experience. In particular, charging stations that are outdoors require protection from the weather. Cities, counties and municipalities will need to avoid the dangers of electrocution associated with chafed cables, vandalism and copper theft that damage charging station devices. They can curb this through periodic inspections, signage and safety training to protect the public and the electric vehicle owners who use them.

battery swapping could solve issues of charging availability, space and charging time, battery safety challenges and the need to have universal battery standards among OEMs will pose a challenge to mass deployment. In-road wireless charging is enabled by copper coils under road surfaces that can transfer power to vehicle receivers. Vehicle receivers installed in every vehicle transmit energy directly to the engine and battery. The potential of in-road wireless charging lies especially in its automation, its applicability to a range of vehicle types, and the extent to which it saves time and space.

Alternative propulsion technologies

The current value framework addresses the urgent need to deploy the infrastructure to support the expected scaling-up of light electric vehicles. Alternative propulsion technologies, such as hydrogen, provide great potential in further improving the vehicle carbon footprint. As technology maturity enables the use of hydrogen technology in more vehicle segments, governments and the value chain must seek to deploy supportive infrastructure and shorten time to market for these technologies as well.

Alternative charging technologies

To address challenges of charging station availability and time spent charging the vehicle, innovative technologies such as battery swapping and in-road wireless charging are emerging. While battery swapping technology has not yet received serious consideration in Europe and the US, China officially recognized battery swapping stations as an important part of new infrastructure construction in 2020. Battery swapping could provide a similar user experience as petrol stations while providing easy replacement of damaged batteries. China supports the uptake of battery swapping stations by establishing regional pilots and encouraging companies to develop new battery charging and swapping technologies. While



NINE KEY ACTIONS TO UNLOCK SHARED VALUE FOR EV CHARGING INFRASTRUCTURE

At a more fundamental level, we propose nine key enabling actions to support the accelerated deployment of efficient EV fleets and sustainable charging infrastructure. They champion the creation of shared value and help businesses across the value chain

and policy-makers understand how, where and when they can act to support change and play a leadership role.

The following business recommendations take a global perspective. With regional and

national differences, the project seeks to expand collaboration and welcomes engagement from the private and public sectors in further shaping locally informed technology and policy frameworks and helping form national business coalitions for action.



Fleet optimization

ADDRESS THE NEEDS OF DIFFERENT EV FLEETS

EV fleets can stimulate the conditions needed for mass electrification across society, conditioned to improve fleet operational efficiency and reduce their total cost of ownership. At 63 million vehicles, fleets account for 20% of the total European vehicle park, represent more than 40% of total vehicle kilometers, contribute half of total emissions from road transport³⁹ and should play an even ever-larger role in transport of goods and people in the future.

Key business actions

- Develop further understanding of fleet charging requirements, including the needed technology and charging locations for similar fleet types, operational schedule, and charging profile flexibility and requirements to scale up fleets
- Collaborate with local authorities and energy and real estate companies to deploy fast and slow charging infrastructure and plan the energy and mobility network that optimizes fleet operations
- Promote investments in the development of interoperable and modular vehicle technologies that enable economies of scale and development of secondary vehicle market

Key policy-maker recommendations

- Ensure clear global standards along with credible solutions to abate emissions across the EV value chain
- Differentiate the user groups and prioritize high-impact segments such as EV fleets
- Collaborate with businesses to identify incentive schemes that can promote the scaling up of fleets and enable spillover effects in the EV value chain, such as the development of secondary EV markets, energy grid balancing and promoting shared infrastructure



Data

AGREE ON DATA SHARING PRINCIPLES

Shared fleet data, including anticipated charging demand and range needs, enables tailored infrastructure deployment that optimizes fleet TCO. It supports the identification of charging hotspots and better plans for efficient energy and mobility network integration. The real-time measurement and sharing of expected charging profiles enables fleet participation on wholesale and ancillary energy services markets.

Key business actions

- Collaborate on a shared digital framework that allows for the aggregation of new sources of data from connected infrastructure, vehicles, smartphones and more
- Build internal data intelligence capacity and further invest in the development of enabling technologies, such as secure and intelligent fleet management and advanced grid planning and management systems
- Share EVSE use data with cities and energy companies to further improve network and spatial planning that addresses business needs and enables scaling up

Key policy-maker recommendations

- Ensure local authorities play a leading role, either as conveners of different parties, as users of shared data or setting the right framework to attract the private sector in sharing data to create shared value
- Collaborate with businesses to define a digital framework to share real-time measurement and charging profile data to enable fleet participation on wholesale and ancillary energy services markets
- Ensure seamless charging infrastructure connectivity through e-roaming



Demand flexibility

ENGAGE AND INCENTIVIZE FLEXIBLE CONSUMERS

EVs can facilitate the integration of variable renewable sources, support the management of peak power demand on distribution grids or act as a backup energy reserve for transmission system operators. With its distributed and flexible nature, EVs have the unique ability to offset the variability of distributed renewable generation and effectively balance the grid. Similarly, it is possible to transform buildings into decentralized flexible energy assets, enabling generation from other distributed energy sources and optimizing its consumption. Active consumer participation on flexible markets helps to generate new revenue streams to improve the business case for EVs and accelerate investments in clean energy technologies behind the meter. Active consumer demand response participation conditions its ability, ease and user motivation.

Key business actions

- Innovate and deploy technologies that focus on reducing the cost of connecting users to the energy market and facilitate user participation through automated and integrated energy management systems
- Innovate on business models that enable seamless consumer engagement and ensure their remuneration
- Collaborate with stakeholders to validate the shared value of EV demand flexibility, build consumer trust, establish a common understanding on active consumer flexibility profiles, and structure effective incentive systems that maximize shared value for the entire value chain

Key policy-maker recommendations

- Establish a stable, clear and favorable regulatory framework that creates and regulates, technically and economically, the services that the flexible assets, including EVs, connected to the network can provide
- Update national energy market regulations to remove barriers for participation of flexible assets
- Establish suitable financing mechanisms that shorten market entry for enabling technologies, including efforts to scale user acceptance, and stimulate the procurement of technologies that result in optimal energy transport integration



Charging

INCENTIVIZE AND FACILITATE CHARGING INTEGRATION

The financial sustainability of charging infrastructure is currently inadequate to develop the infrastructure in a time-sensitive manner that would allow for the unlocking of mass market adoption. Enabling demand flexibility to improve the infrastructure business case, short-term financial support to enable minimum and equitable infrastructure deployment, is needed.

Key business actions

- Collaborate with governments to define user needs and clear stakeholder responsibilities, including cost ownership for infrastructure connections
- Lead by example by deploying charging stations in employee parking lots and share space for charging installation at other commercial buildings
- Co-invest and cooperate with other partners to share charging facilities, especially in cases where there are complementarities with respect to their charging profiles

Key policy-maker recommendations

- Create legal requirements for network preparation and installation of charging points, including the deployment of minimum public charging infrastructure networks, the implementation of charging in both new and refurbished buildings, and the adaptation of real estate regulations with a "right to charge" to facilitate the ownership cost dilemma
- Update regulations to support the development of flexible markets, including setting the price signals or special contracts to fully exploit the potential of smart charging
- Streamline authorization processes that impact the time to market of the charging infrastructure and vary between cities and towns even within the same country
- Establish collaborative public-private investment schemes for installation and grid connection for private, commercial and public charging, including the development of new financial mechanisms that can address short-term funding calls and ensure affordable public charging



Smart grid

ENCOURAGE THE DEPLOYMENT OF SMART GRID TECHNOLOGY

Smart grid technology, such as smart charging, smart metering, energy storage, building energy management systems and advanced network management tools allow to accommodate for the forecasted increased power variability on the grid. Without increased grid intelligence, the energy sector will not be able to efficiently balance flexible new consumption and generation, especially on the low-voltage level. It is necessary to balance power variability to efficiently integrate renewable energy sources and EVs to avoid a significant grid reinforcement and subsequent increase of EV charging costs.

Key business actions

- Further invest in internal digital competences and the deployment of digital technologies that provide advanced planning and network strength visibility, support intelligent load balancing and increase the efficiency of existing grid infrastructure
- Collaborate with other businesses and local governments to develop a framework for the optimal exploitation of smart charging and other smart grid technologies
- Engage with businesses and EV drivers to define suitable smart charging engagement programs that ensure continuously positive user experiences

Key policy-maker recommendations

- Ensure technology procurement programs stimulate investments that allow for digital technology deployment and shorten time to market for smart grid technologies
- Mandate the deployment of smart charging, which is readily available and enables the flexible integration of EVs into the power system and thus supports the integration renewable energies and grid efficiency
- Introduce innovative and dynamic tariff systems that rely on intelligent power monitoring on the low-voltage level and encourage the right demand flexibility actions



Micro grids

MAXIMIZE CHARGING FROM RENEWABLE SOURCES

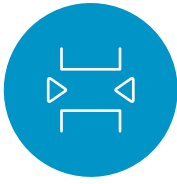
Charging vehicles using local renewable energy sources minimizes emissions. At the same time, the distributed nature and the charging flexibility of electric vehicles puts them in a unique position to support further penetration of the renewable energy sources needed to reach net-zero emissions for both mobility and energy. Due to the variable production of renewable energy sources, buildings equipped with storage technologies and local energy management systems will be key assets in balancing the local grid and helping to accelerate uptake of variable generation. Microgrid technologies also help manage real estate energy costs by storing cheap renewable electricity and lowering peak power demand. V2G technology can further amplify local energy optimization by using vehicle batteries to support grid balancing.

Key business actions

- Strengthen the reliability of technology solutions that leverage batteries as back-up solutions, and find sustainable storage options, such as second lives for EV batteries
- Deploy workplace charging that aligns time of charge with sun energy generation and deploy microgrid technologies such as storage and energy management systems to adjust electricity and store it at times when renewable energy is abundant
- Innovate on business models to include integrated energy offerings and carbon labeling that promotes the use of renewable electricity

Key policy-maker recommendations

- Establish regulatory frameworks that set low-carbon energy requirements for buildings, ensure grid connections, and establish energy pricing and taxation environments that avoid the curtailment of renewable energies
- Ensure that EVs consume mainly renewable electricity when it is abundant thanks to integrated planning of mobility and renewable production through smart charging
- Stimulate the development and deployment of affordable energy management solutions and shorten time to market for solutions that improve sustainability and the potential of batteries for storage



Spatial & network planning

ESTABLISH COORDINATED STRATEGIC PLANNING AND MANAGEMENT

The scale and complexity of the charging infrastructure challenge is too large for companies to solve in silos. Much of China's rapid EV growth consists of a clear strategy, consistent planning, coordinated actions and supportive policies.⁴⁰ This requires coordinated, overarching approaches to charging infrastructure development at local, national and international levels that consider both technical and market requirements and support the planning of efficient and inclusive transport, energy and built environment integration. It is necessary to incorporate social equity and justice as central tenets in infrastructure and mobility planning. It also requires advanced planning tools to account for ambiguities in mobility, space and energy demand evolution.

Key business actions

- Further invest in the development and deployment of advanced planning, analytics and mobility management tools
- Collaborate with governments, cities and industry peers across sectors to establish a common understanding of consumer and infrastructure needs and agree on shared data that can support the right decisions
- Collaborate with the local or central coordination authority to use digital technologies to define network and mobility hotspots and support the identification of suitable financing mechanisms to deploy infrastructure upgrades

Key policy-maker recommendations

- Take or mandate a leading role in strategic planning and alignment with the needs of EV fleets while ensuring social equity by leveraging the advanced planning, analytics and mobility management tools of businesses
- Ensure coordinated charging infrastructure development that optimizes transport and energy integration, removes implementation barriers such as authorization processes and unclear ownership costs, and relies on efficient financial mechanisms
- Implement regular monitoring of the charging infrastructure installation and expansion plans



Shared space

SHARE SPACE AND CHARGING INFRASTRUCTURE

Increased population density in urban areas, varying strengths of energy networks and increasing real estate prices are posing challenges in finding suitable spaces for charging infrastructure. An equitable transition must ensure affordable charging solutions for "homeless cars". At the same time, charging infrastructure can steer the development of new mobility as well as social hubs. Positive user experience encompasses seamless charging as well as the quality and usefulness of time spent while charging. Sharing space for charging infrastructure can therefore increase foot traffic and steer the development of new business models for services that improve the overall user experience and the return on infrastructure investment.

Key business actions

- Deploy or share space for charging to exploit opportunities related to increased foot traffic and the development of new services
- Provide overnight access to charging infrastructure to increase use and shorten return on investment, while improving charging station availability
- Collaborate with EV fleets that have complementary charging profiles and co-invest in private or semi-private infrastructure to decrease investment costs and increase use

Key government actions

- Propose incentives and space access policies that also promote shared and accessible overnight charging infrastructure
- Bring business investment clarity through new, strategic, multi-mobility and social hub planning that considers energy, transport and real estate development
- Set EV charging infrastructure installation targets and incentivize the development and deployment of technologies that enable safe charging, create energy flexibility revenues, and support efficient fleet coordination



Connected transport modes

CONNECT TRANSPORT MODES

Widespread near-home, overnight charging offered on an economically sustainable basis will play a key role in improving EV economics for many drivers.⁴¹ Access to public transport and other forms of intermodal mobility can substitute for the lack of available space and presents a key pillar for improving the overall efficiency of road transport. It is paramount in making the overall system more efficient and convenient for the end-user by increasing access to charging points in a future mobility as a service system.

Key business actions

- Collaborate with local authorities to identify space for mobility hubs, thereby optimizing network strength, charging convenience and local RES production
- Propose modular charging technology that can serve different transport modes and therefore facilitates real estate investment decisions by offering a future-proof and high-use solution
- Further invest in the development of integrated mobility fleet management solutions

Key government actions

- Help real estate owners develop mobility hubs by coordinating energy network, spatial and mobility planning
- Invest in public transport networks that efficiently connect larger mobility and social hubs
- Regulate and encourage the coordinated deployment of intermodal, first-mile and last-mile mobility solutions



5 Conclusion



5 Conclusion

As the number of affordable EV models increases and user acceptance of and business commitment to electrification grow, addressing the gap in available charging infrastructure deserves immediate attention from all value chain stakeholders. Addressing charging needs will demand a 20-fold charging point increase by 2030, all while accommodating the impacts of the increasing number of EVs and renewable power generation on the electricity grid.

Achieving resilient, sustainable and inclusive charging system design will require a profound system transformation. It demands the creation of the shared value inherent in technology innovations, business collaboration and policy support. Businesses and policy-makers should promote investments and policies directed at achieving environmentally and economically efficient EV fleets; accessible, smart and affordable charging and grid infrastructure; and the enabling of a shared and integrated mobility space. Cross-sector collaboration is fundamental in aligning common technology and policy frameworks that can help business and policy-makers understand how, where and when they can act to unlock shared value.

The value framework proposes nine key actions to accelerate the deployment of sustainable charging infrastructure. It recognizes the importance of a coordinated, overarching approach to charging infrastructure development at local, national and international levels that considers both technical and market requirements. It further supports the planning of efficient and inclusive transport and energy integration, including policy planning for minimum real estate and public charging targets and supportive grid upgrades.

It extends from the notion of charging point availability and calls for ambitious public procurement programs to reduce investment risks and shorten time to market for technologies that support grid balancing, maximize user experience and consume mainly renewable energy sources, including smart charging that

enables the flexible integration of EVs into the power system and thus supports the integration of renewable energies and grid efficiency. It recommends removing barriers, incentivizing demand flexibility and local energy management, and shortening time to market for solutions that improve sustainability and the potential of batteries for storage.

Only by taking actions to allow the creation of shared value can the mobility, energy and real estate sectors move together and find new revenue streams and financing mechanisms to accelerate deployment.

We invite partners throughout the EV value chain to [join us](#) and drive this critical work forward.



Endnotes

- ¹ International Energy Agency (IEA) (2020). *Tracking Transport 2020*. Retrieved from <https://www.iea.org/reports/tracking-transport-2020>.
- ² WBCSD (2020). *Driving the change: Switching to electric*. Retrieved from <https://wbcسدtools.org/goev/>.
- ³ Chu Y. (2021). *How China promotes new energy vehicles: Historically, now, and in the future*. International Council on Clean Transportation (ICCT). Retrieved from <https://www.itf-oecd.org/sites/default/files/docs/china-promotes-new-energy-vehicles-historically-future.pdf>.
- ⁴ Hildermeier, J., Jahn, A. & Rodriguez, F. (2020), "Electrifying EU city logistics: An analysis of energy demand and charging cost". RAP, ICCT. Retrieved from <https://www.raponline.org/knowledge-center/electrifying-eu-city-logistics-analysis-energy-demand-charging-cost/>.
- ⁵ International Energy Agency (IEA) (2021). *Global EV Outlook 2021*. Retrieved from <https://www.iea.org/reports/global-ev-outlook-2021>.
- ⁶ Skidmore, Z. (2021). "Electric vehicles surge in 2021". Power Technology. Retrieved from <https://www.power-technology.com/news/electric-vehicle-sales-surge-in-2021/>.
- ⁷ International Energy Agency (IEA) (2021). *Global EV Outlook 2021*. Retrieved from <https://www.iea.org/reports/global-ev-outlook-2021>.
- ⁸ International Energy Agency (IEA) (2021). *Global EV Outlook 2021*. Retrieved from <https://www.iea.org/reports/global-ev-outlook-2021>.
- ⁹ driivz (n.d.). "EV Charging Glossary". Retrieved from <https://driivz.com/glossary/charge-point-operator/>
- ¹⁰ PWC (2021). "Electric vehicle infrastructure – A new mindset". Retrieved from <https://www.pwc.com/us/en/industries/industrial-products/library/electric-vehicles-charging-infrastructure.html>.
- ¹¹ International Energy Agency (IEA) (2021). *Global EV Outlook 2021*. Retrieved from <https://www.iea.org/reports/global-ev-outlook-2021>.
- ¹² WBCSD (2020). *Driving the change: Switching to electric*. Retrieved from <https://wbcسدtools.org/goev/>.
- ¹³ Uber (2020). *SPARK! Partnering to electrify in Europe*. Retrieved from https://d1nyezh1ys8wfo.cloudfront.net/static/PDFs/Uber_Spark_report.pdf?uclid_id=cb44232f-c7db-49a4-ad41-ffb001b9a04c.
- ¹⁴ Nicholas, M. (2019). "Estimating electric vehicle charging infrastructure costs across major U.S. metropolitan areas". Working paper 2019-14. International Council on Clean Transportation (ICCT). Retrieved from https://theicct.org/sites/default/files/publications/ICCT_EV_Charging_Cost_20190813.pdf.
- ¹⁵ Rajon Bernard, M. (2021). "Key strategies to help cities overcome the charging challenge quickly, easily, and at lower cost". International Council on Clean Transportation (ICCT). Retrieved from <https://theicct.org/blog/staff/key-strategies-help-cities-overcome-charging-challenge-quickly-easily-and-lower-cost>.
- ¹⁶ Rajon Bernard, M. (2021). "Key strategies to help cities overcome the charging challenge quickly, easily, and at lower cost". International Council on Clean Transportation (ICCT). Retrieved from <https://theicct.org/blog/staff/key-strategies-help-cities-overcome-charging-challenge-quickly-easily-and-lower-cost>.
- ¹⁷ Air Resources Board (2021). *Q12021 Electrify America Report to California*.
- ¹⁸ Plug in America (2018). *AchiEve Policy Toolkit*. Retrieved from <https://pluginamerica.org/policy/achieve-policy-toolkit/>.
- ¹⁹ WBCSD (2021). *Vision 2050 - Time to Transform*. Retrieved from <https://www.wbcسد.org/contentwbc/download/11765/177145/1>.
- ²⁰ WBCSD (2021). *Enabling data-sharing: Emerging principles for transforming urban mobility*. Retrieved from <https://www.wbcسد.org/Programs/Cities-and-Mobility/Transforming-Urban-Mobility/Digitalization-and-Data-in-Urban-Mobility/Resources/Enabling-data-sharing-Emerging-principles-for-transforming-urban-mobility>.
- ²¹ WBCSD (2021). *Enabling data-sharing: Emerging principles for transforming urban mobility*. Retrieved from <https://www.wbcسد.org/Programs/Cities-and-Mobility/Transforming-Urban-Mobility/Digitalization-and-Data-in-Urban-Mobility/Resources/Enabling-data-sharing-Emerging-principles-for-transforming-urban-mobility>.

- ²² Clean Energy Ministerial (CEM) (2020). "REPORT LAUNCH: CEM Horizontal Accelerator - EV and power system integration". Retrieved from <http://www.cleanenergyministerial.org/news-clean-energy-ministerial/report-launch-cem-horizontal-accelerator-ev-and-power-system>.
- ²³ AVERE (2021). *UNLEASHING THE FLEXIBILITY OF ELECTRIC VEHICLES. Targets and policy recommendations for the AFID and EPBD revisions*. Retrieved from <https://www.aver.org/wp-content/uploads/2021/03/Joint-recommendations-AFID-and-EPBD-targets-final.pdf>
- ²⁴ Myers, E. (2019). *A Comprehensive Guide to Electric Vehicle Managed Charging*. Smart Electric Power Alliance (SEPA). Retrieved <https://sepapower.org/resource/a-comprehensive-guide-to-electric-vehicle-managed-charging/>.
- ²⁵ International Energy Agency (IEA) (2021). *Global EV Outlook 2021*. Chapter 5. Retrieved from <https://www.iea.org/reports/global-ev-outlook-2021>.
- ²⁶ Crozier, C., Morstyn, T. & McCulloch, M. (2020). "The opportunity for smart charging to mitigate the impact of electric vehicles on transmission and distribution systems". *Applied Energy*, volume 268, 15 June 2020, 114973. Retrieved from <https://www.sciencedirect.com/science/article/abs/pii/S0306261920304852>.
- ²⁷ Kane, S., Manz, F., Nägele, F. & Richter, F. (2021). "EV fast charging: How to build and sustain competitive differentiation". McKinsey.
- ²⁸ International Energy Agency (IEA) (2021). *Global EV Outlook 2021*. Chapter 5. Retrieved from <https://www.iea.org/reports/global-ev-outlook-2021>.
- ²⁹ Hampel, C. (2021). "Analysis on the savings potential of V2G technology". Retrieved from <https://www.electrive.com/2021/01/11/analysis-on-the-savings-potential-of-v2g-technology/>.
- ³⁰ Thingvad, A. & Marinelli, M. (2018). Influence of V2G Frequency Services and Driving on Electric Vehicles Battery Degradation in the Nordic Countries. Retrieved from <https://drive.google.com/file/d/1ETqDnjq33ddybF2aX7ePrGiOnGXLJS2/view>.
- ³¹ Next Kraftwerke (2021). "Virtual Power Plant. How to Network Distributed Energy Resources". Retrieved from <https://www.next-kraftwerke.com/vpp/virtual-power-plant>.
- ³² <https://www.carbontrust.com/news-and-events/insights/new-study-reveals-embedded-storage-can-impact-transmission-system-demand>
- ³³ Engel, H., Hertzke, P. & Siccardo, G. (2019). "Second-life EV batteries: The newest value pool in energy storage". McKinsey. Retrieved from <https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/second-life-ev-batteries-the-newest-value-pool-in-energy-storage>.
- ³⁴ Engel, H., Hertzke, P. & Siccardo, G. (2019). "Second-life EV batteries: The newest value pool in energy storage". McKinsey. Retrieved from <https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/second-life-ev-batteries-the-newest-value-pool-in-energy-storage>.
- ³⁵ EATON (n.d.). "Electric distribution system planning fundamentals. What is electric distribution system planning?" Retrieved from <https://www.eaton.com/us/en-us/products/utility-grid-solutions/cyme-power-engineering-solutions/electric-distribution-system-planning-fundamentals.html>.
- ³⁶ Uber (2020). *SPARK! Partnering to electrify in Europe*. Retrieved from https://d1nyezh1ys8wfo.cloudfront.net/static/PDFs/Uber_Spark_report.pdf?uclid=cb44232f-c7db-49a4-ad41-ffb001b9a04c.
- ³⁷ WBCSD (2021). *Enabling data-sharing: Emerging principles for transforming urban mobility*. Retrieved from <https://www.wbcd.org/Programs/Cities-and-Mobility/Transforming-Urban-Mobility/Digitalization-and-Data-in-Urban-Mobility/Resources/Enabling-data-sharing-Emerging-principles-for-transforming-urban-mobility>.
- ³⁸ Inbar, S. (2021). "EV-charging station management best practices". Retrieved from <https://drivvz.com/blog/ev-charging-station-management-best-practices/>.
- ³⁹ Eurelectric (2021). "eVision – Accelerating E-mobility in Europe". Retrieved from <https://evision.eurelectric.org/>.
- ⁴⁰ Chu Y. (2021). *How China promotes new energy vehicles: Historically, now, and in the future*. International Council on Clean Transportation (ICCT). Retrieved from <https://www.itf-oecd.org/sites/default/files/docs/china-promotes-new-energy-vehicles-historically-future.pdf>.
- ⁴¹ Laisi, V. (2020). "Here's why e-mobility must be at the heart of the green recovery". World Economic Forum (2020). Retrieved from <https://www.weforum.org/agenda/2020/06/e-mobility-heart-of-green-recovery/>.

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ABOUT WBCSD

WBCSD is the premier global, CEO-led community of over 200 of the world's leading sustainable businesses working collectively to accelerate the system transformations needed for a net zero, nature positive, and more equitable future.

We do this by engaging executives and sustainability leaders from business and elsewhere to share practical insights on the obstacles and opportunities we currently face in tackling the integrated climate, nature and inequality sustainability challenge; by co-developing "how-to" CEO-guides from these insights; by providing science-based target guidance including standards and protocols; and by developing tools and platforms to help leading businesses in sustainability drive integrated actions to tackle climate, nature and inequality challenges across sectors and geographical regions.

Our member companies come from all business sectors and all major economies, representing a combined revenue of more than USD \$8.5 trillion and 19 million employees. Our global network of almost 70 national business councils gives our members unparalleled reach across the globe. Since 1995, WBCSD has been uniquely positioned to work with member companies along and across value chains to deliver impactful business solutions to the most challenging sustainability issues.

Together, we are the leading voice of business for sustainability, united by our vision of a world where 9+ billion people are living well, within planetary boundaries, by mid-century.

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