# Six essentials for mainstream EV adoption

A collaboration between:

EY Building a better working world

eurelectric powering people

# About this study


Disruptive geopolitics — notably, the war in Ukraine, along with economic headwinds, supply chain disturbances, and climate and regulatory uncertainty — are frustrating efforts to curb greenhouse gas emissions in the transport sector.

Together, they highlight the fragile but interdependent relationships between six essential components of the e-mobility value chain: a resilient supply chain, clean and green power, accessible charging infrastructure, a smart grid, digitalisation and skilled labour.

At the same time, the EV industry is nearing an inflection point. Globally, EV sales doubled in 2021 and jumped 55% in 2022 to account for 13% of all vehicles sales. This trend looks set to continue, making mass-market adoption imminent. It will bring with it irreversible transformation in road transport. But, if the rest of the ecosystem is neither ready nor sufficiently scaled, EV adoption could stutter and fail.

This study examines the role and interaction of these six essentials and explores the need for a collaborative and coordinated response from ecosystem players in pursuit of decarbonisation goals. It is informed by experts at the European energy industry body Eurelectric and its members. It is curated and augmented by EY professionals with extensive experience in energy, automotive, government and technology. It includes experiences and insights from global industry leaders in the ecosystem of supporting businesses, including automotive, utilities, fleet management, city planning and charging infrastructure, as well as experts from industry bodies and trade associations. We thank them for sharing their experiences and opinions so openly with us.

# Foreword

- By 2035, in most developed economies, EVs will be the only choice for customers who want to buy a new car. Europe (EU 27 plus the UK and Norway), the US and China lead the charge. However, customer sentiment is split.
- Some customers take an interest in energy security and sustainability and want to play an active role in the future energy system. They are alert to solutions that cut petrol and gas consumption and deliver economic and environmental value. They are the early adopters, who have got behind EVs, boosting global sales to 13% of total vehicle sales.
- Other customers might like an EV or solar panels to offset the impact of rising inflation and higher energy costs. But they are too expensive. Yet it is precisely these customers that EVs must reach if adoption is to accelerate, and the associated benefits of reduced carbon dioxide ($CO_2$) emissions and a cleaner planet are to be realised. These mass-market consumers — the next 60% of drivers yet to be fully persuaded — need a few ticks in the right boxes before they commit to a purchase. Then there is the remaining 20%, the reluctant adopters, who switch to EVs not because they want to, but because they have no choice.
- Sales figures paint a picture of an EV market gaining traction globally. China is already at 27% EV adoption; Europe has seen two consecutive years of strong growth, reaching 17% in 2021 and just over 20% in 2022; the US is catching up. But are the conditions right for EVs to take off in the mass market?

# Foreword (cont.)

- Accelerated EV adoption must start with setting the ambition and supporting it with mandates or regulation. If that happens, the market can advance with certainty and attract the investment needed to secure a resilient supply chain. And only then can EV costs begin to come down, making them more available and more affordable for all. But the vehicle itself is only part of the story. It must be supported by adequate charging infrastructure, in the places and spaces where people need it. It must be enabled by a smart grid that allows the two-way flow of green energy and supported by digital technologies that make EV ownership simple, flexible and likeable. Get these essentials right, and e-mobility becomes the new normal for road transport.
- Regulators devise the right frameworks. Automakers deliver new powertrains. And utility companies will play a huge role in pushing this fast-maturing industry past the inflection point and into mass adoption. They must engage proactively with city planners and continue to build out networks that allow renewables, and other forms of distributed assets, to connect to the grid. They must manage new load at the point of charging and pursue new technologies that enable the two-way flow of energy across the system.
- EV numbers will continue to rise, a consequence of market dynamics and technological, regulatory and economic drivers. But, as we speed towards the point of no return, utility companies must continue to play their critical role in delivering the EV solution.

# The EV market in numbers

## Where we are

**26.8mn**
global EV stock in 2022

**10.5mn**
Global BEV and PHEV sales in 2022

**13%**
of all new cars sold in 2022 were electric

## Developing EV ecosystem

2035 ban on the sale of new ICE vehicles in the EU

US$1.2tn committed by OEMs through 2030 on EVs, batteries and materials

21 EU Member States offered incentives for the purchase of EVs at the end of 2022, up from 17 in 2021

>300 battery gigafactories in construction or planned around the world with >30 in Europe

>480k publicly accessible charging points in Europe

139 tariffs and services available in Europe for EV smart charging

**>5mn** Public chargers will be needed in Europe by 2035

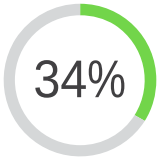
## Growing consumer acceptance

52% consumers plan to buy and EV as their next vehicle

38% of consumers state environmental concerns as the main reason for choosing electric


consumers are willing to pay a premium for EV

## Bottlenecks/pain points




availability of charging stations are the main barriers to EV purchase, followed by range anxiety and cost

Upfront cost of EVs is 30% higher than the equivalent average ICE vehicle

**14.5mn** projected BEV and PHEV sales in 2023

By 2030, EY estimates that sales of BEVs and PHEVs will make up over half of global vehicle sales. That is three years sooner than predicted in 2021. In Europe, that could rise as high as 74% and, in the US, 43%. EV sales in Europe will surpass other powertrains by 2027.


Sources:

- Global EV Sales for 2022, EV-Volumes, 2022
- "Zero emission vehicles: first 'Fit for 55' deal will end the sale of new CO2 emitting cars in Europe by 2035", European Commission, 28 October 2022
- Overview – Electric vehicles: tax benefits & purchase incentives in the European Union (2022), ACEA, 2022
- EY Mobility Lens Forecaster 2022
- The time is now: smart charging of electric vehicles, RAP, 2022
- EY Mobility Consumer Index 2022
- EU alternative fuel infrastructure", European Alternative Fuels Observatory, European Commission, accessed 15 February 2023
- "Exclusive: Automakers to double spending on EVs, batteries to $1.2 trillion by 2030", Reuters, 2022
- EY Charging Infrastructure Forecast 2023

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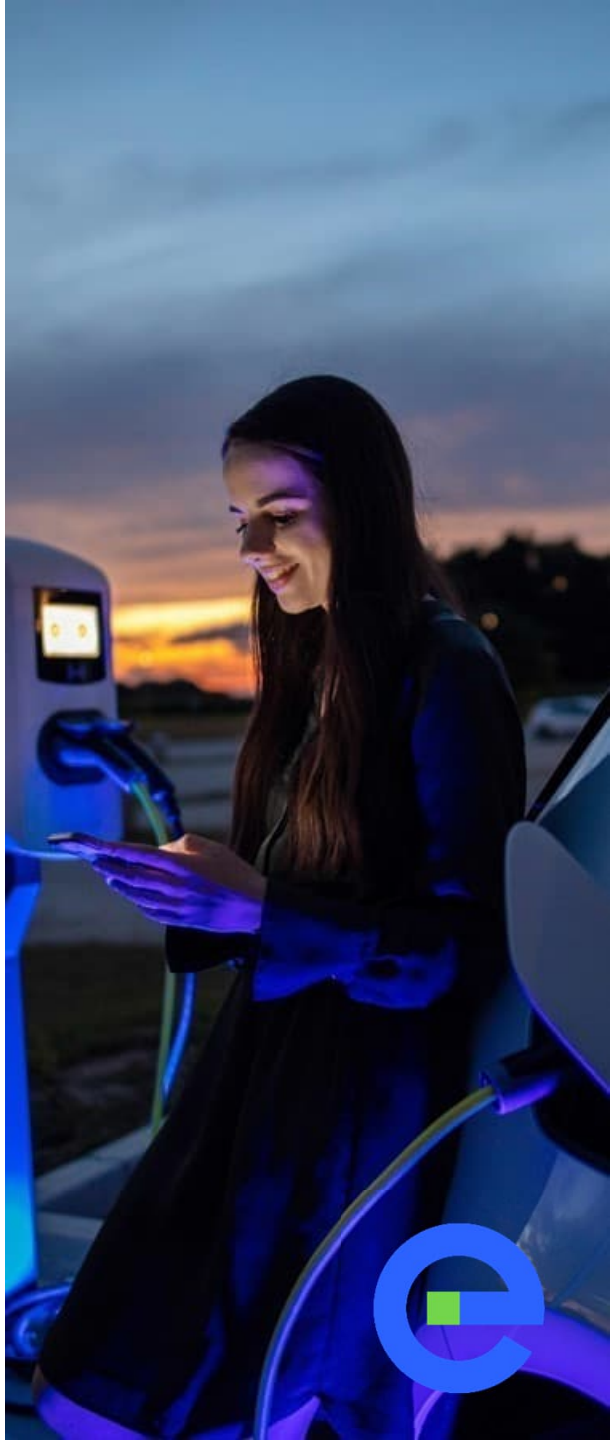
# The global outlook for e-mobility

# EV sales are resilient

Ordinarily, economic headwinds, a cost-of-living crisis and rising energy costs would weaken growth in a new market segment. But that didn't hold true for EVs in 2022.

On the customer side, higher energy costs impacted prices at the charging station. Whether at home or on the public network, it cost more to charge an EV in 2022 than in 2021. British roadside assistance company RAC said the cost of rapid public charging in the UK increased by 42% between May and September 2022.[1]

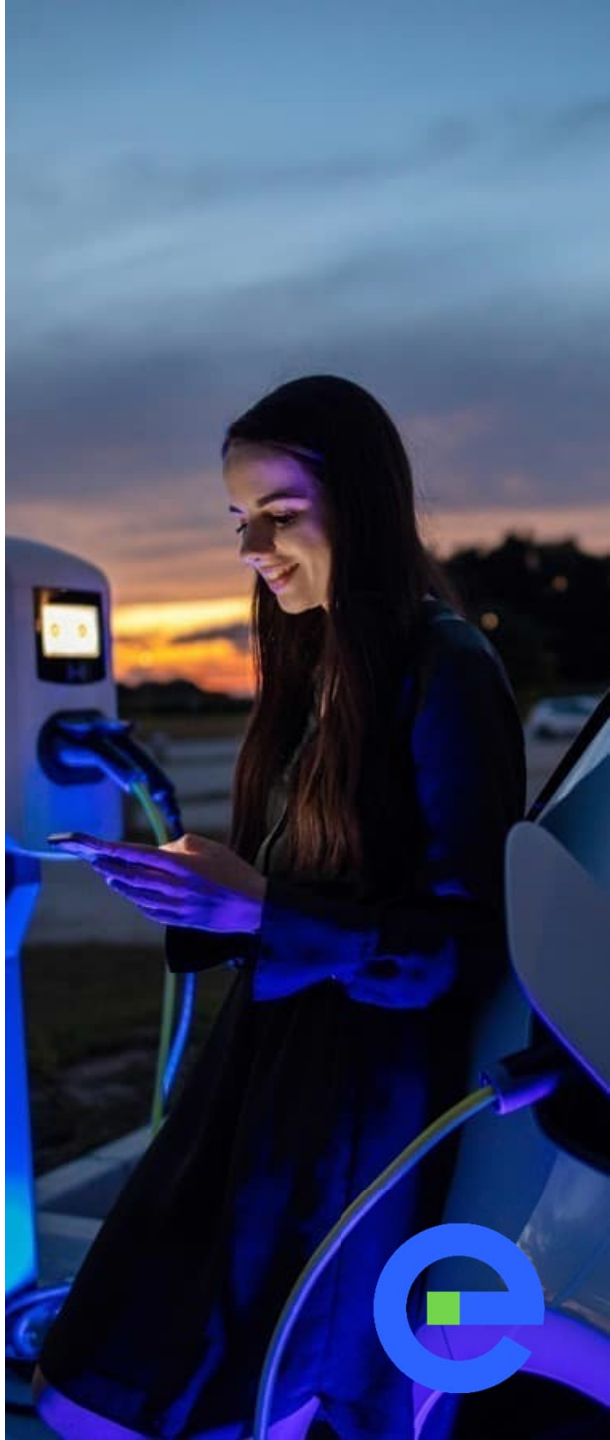
On the industry side, the COVID-19 pandemic and the war in Ukraine disrupted global supply chains. Shortages of chips and escalating prices for semiconductors derailed automakers' production processes, forcing them to scale back EV rollout.



# EV sales are resilient (cont.)

Yet the market continued its upward trajectory. Growth was driven by multiple factors:

- Regulators provided certainty in the future e-mobility direction with commitments and targets. More countries pledged to phase out sales of new internal combustion engine (ICE) vehicles or set ambitious electrification targets for the coming decades.
- Global EV subsidies and incentives reached US$30bn by the end of 2021 and carried over into 2022.[2] In Europe, nearly all Member States now offer some form of fiscal support to stimulate market uptake of EVs.[3]
- Strong societal and political urgency to decarbonise was bolstered by renewed focus on the security of local energy supply and the role of EVs in reducing dependency on fossil fuels.
- Global automakers continued to buy into e-mobility, committing investments of nearly US$1.2tn by 2030 to production facilities, technology, EV batteries, new products and the future supply of raw materials (primarily semiconductors and battery materials).[4]
- Utility investment in EV infrastructure and customer programmes continued to grow, driven by customer demand, revenue opportunities and sustainability goals.[5]



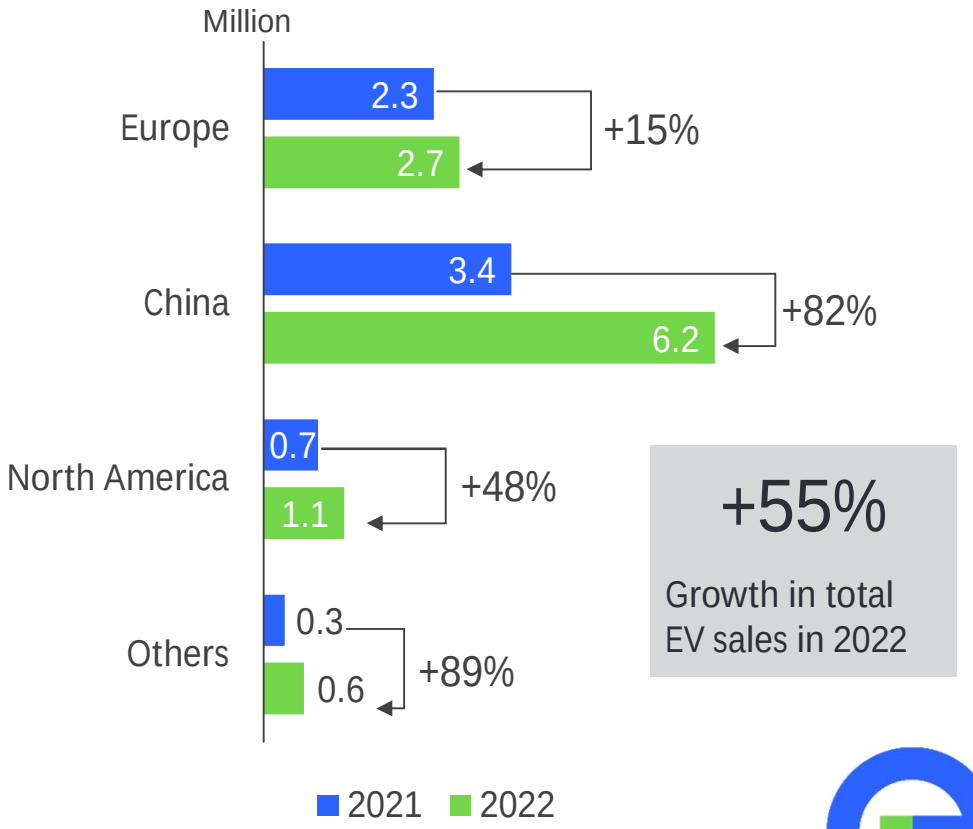
# A bumper year for e-mobility

EV uptake is accelerating much faster than anticipated. We are already moving into mass-market adoption.

Globally, in 2022, 10.5 million new battery EVs (BEVs) and plug-in electric hybrids (PHEVs) were delivered, an increase of more than 55% on 2021, making up 13% of all light-duty vehicles (LDVs) sold.[6] EV stock grew 60% to 26.8 million:

- China is already at 27% EV sales penetration. In 2022, it accounted for 59% of global EV sales. Despite COVID-19 lockdowns and supply chain disruptions, electric passenger vehicle sales increased 82% on 2021.[7] There are now 15 million EVs on the road in China.
- In Europe, EV sales accounted for just over 20% of total vehicles sold in 2022, up from 17% in 2021. In total, 2.7 million were sold. There are now eight million EVs in Europe.[8]
- In the US, EV sales grew 48% in 2022, topping 1.1 million vehicles for the first time.

## BEV and PHEV sales and % growth for 2022 vs. 2021 (million)



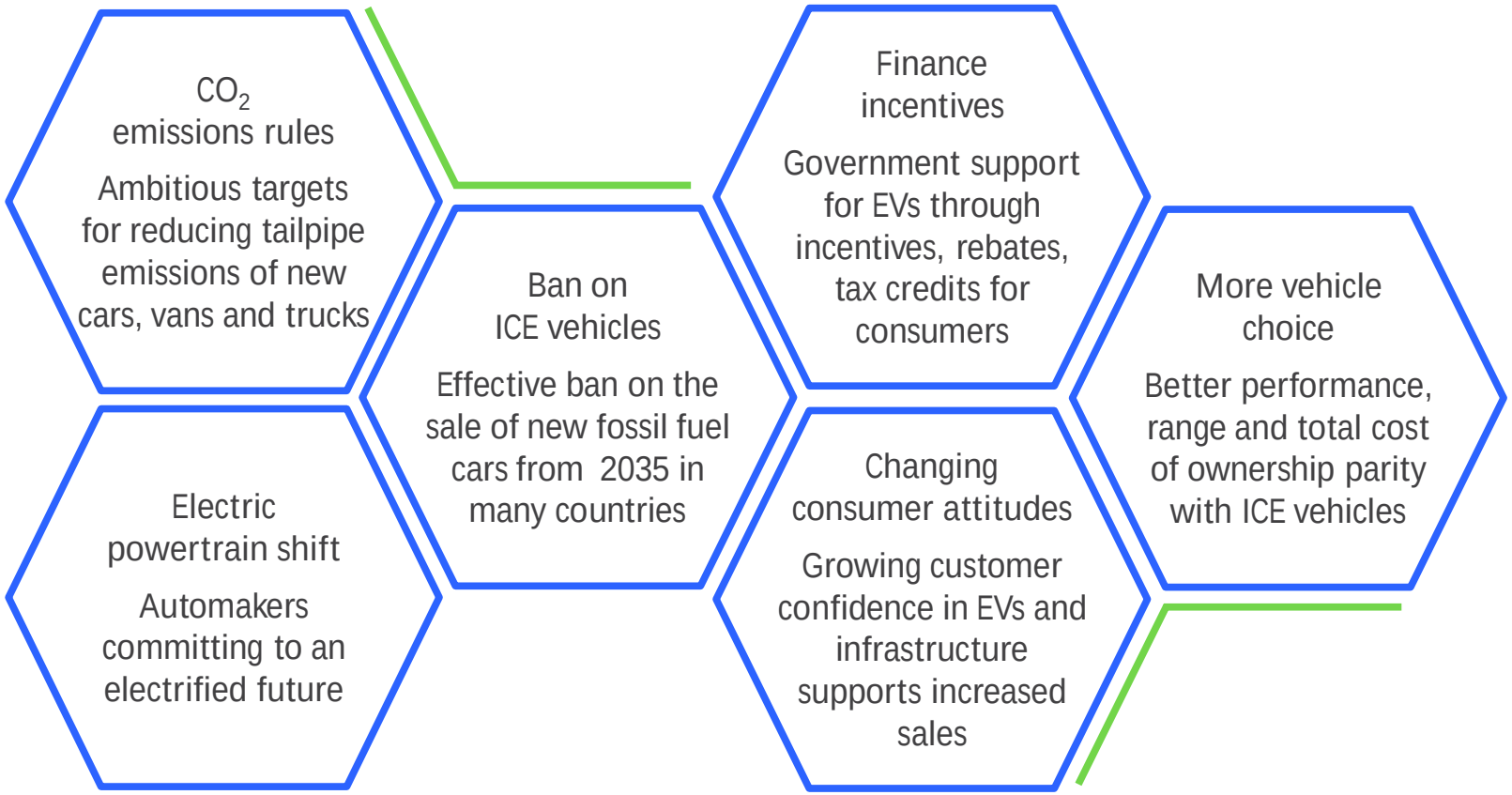

+55%

Growth in total EV sales in 2022

Source: EV Volumes - Global EV Sales for 2022

# EV demand drivers

Industry commentators, in discussion with EY analysts, point to reasons why the EV industry globally has not succumbed to external market headwinds.




Source: EY analysis



# Driver back electric

Supportive regulation, better vehicle choice, shortened charging times and better understanding of e-mobility technology are winning over customers. So, too, is the environmental argument. The EY Mobility Consumer Index[9] finds environmental concerns are the main reason for choosing electric (38%), with penalties on gasoline vehicles also a persuading factor (34%).

The EY Mobility Consumer Index also finds that:

- Fifty-two percent of respondents are leaning towards a fully electric, PHEV or hybrid vehicle as their next purchase — up from 20% in 2020. This is the first time that the balance has tipped in favour of EVs.
- Preferences for fully electric cars have tripled, from 7% in 2020 to 20% in 2022.
- The geographical split has narrowed. European customers are most likely to buy an EV (55%), compared with 54% in the Asia-Pacific region and 39% in North America.
- Twenty-seven percent of respondents say the upfront cost of an EV is a concern, down from 50% in 2021.
- Fifty-four percent of EV owners say retail locations are the most convenient non-residential places to charge.

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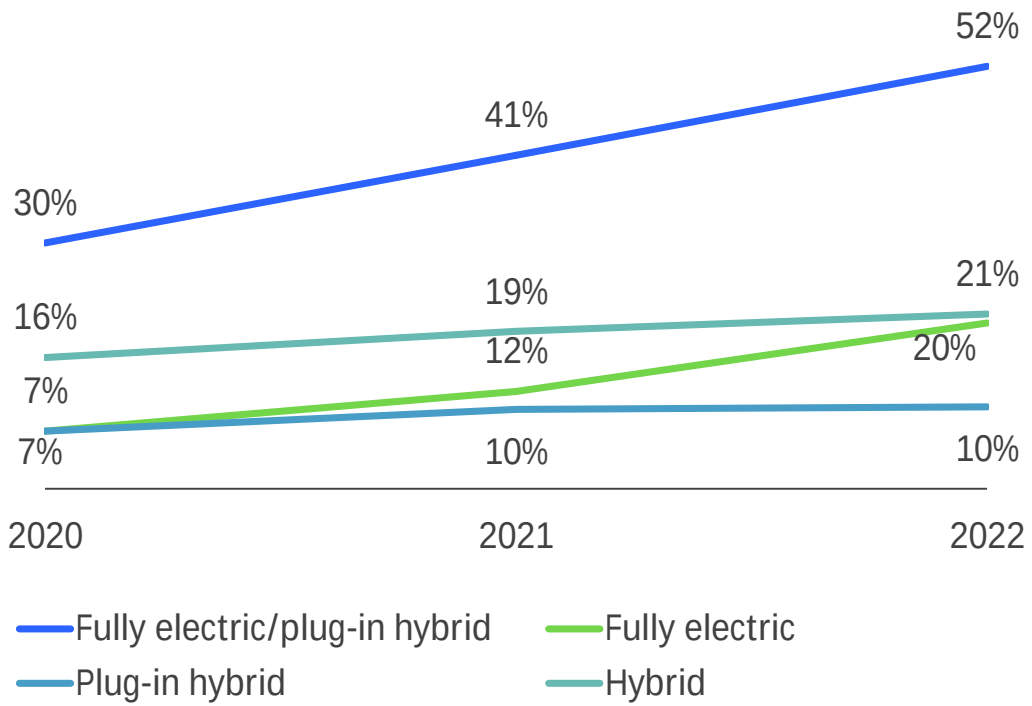
> People are quick to worry. What about my once-a-year, 1,000-mile trip to San Tropez? The everyday reality is that we drive to the supermarket, pop in on mum and dad, visit friends. Most of the time, we’re doing small trips around town, and we’re certainly not using huge amounts of range in one go – and when we do, we can rely on rapid charging on the way.
>
> Natalie Berry
>
> Public Affairs Manager, Fastned

# Driver back electric (cont.)

## EV buying intent — % of respondents planning to buy a car

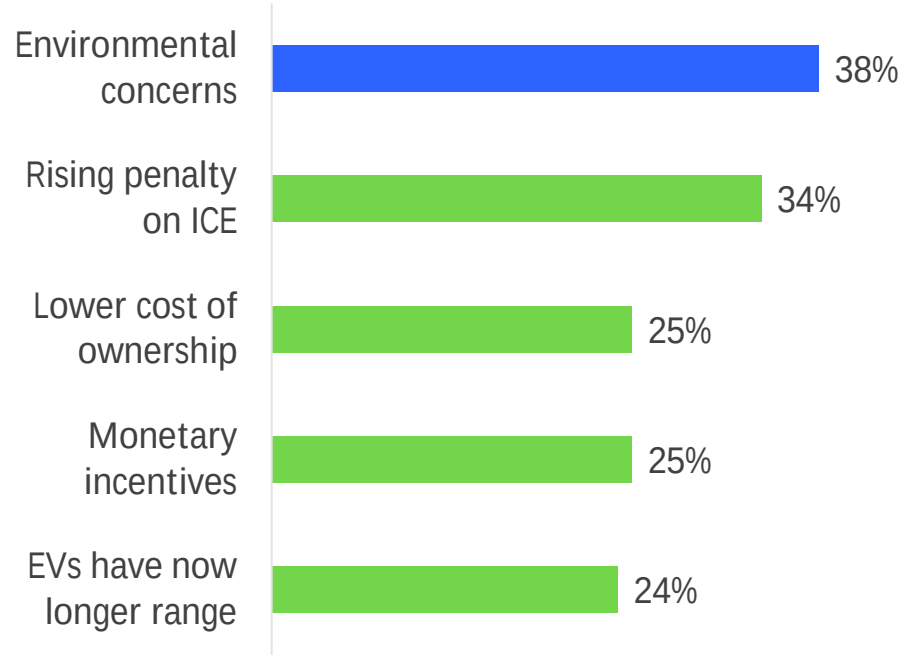
52% of car buyers are leaning towards non-ICE vehicle for their next purchase




Source: EY Mobility Consumer Index 2022

## Top motivations for buying an EV

Environment is the top motivator for consumers buying an EV




Source: EY Mobility Consumer Index 2022

# Momentum builds in commercial market

By 2050, medium- and heavy-duty vehicles are predicted to achieve net-zero global emissions.

Government and corporate efforts to electrify transport provide a solid basis for growth in commercial EV sales. Penetration is likely to increase to around 5% in 2023, up from 3% in 2022 and 1% in 2021.

China leads the way. It will account for around 30% of commercial EV sales in 2023. Germany and France can each expect 7%, with the rest of Europe likely to account for 15%. The US will trail at 6%. Overall, around one million commercial EVs are expected on the roads globally in 2023.[10]

Short-haul trucks, which typically travel within a 250-kilometre radius and cover around 50 kilometres per day, and light commercial vehicles can be charged in depots, making them good candidates for electrification. The number of EV models is increasing, and costs are improving:

- In the US, EV demand already outstrips supply in the commercial sector. This is due, in large part, to the 2022 Inflation Reduction Act (IRA) and other initiatives. They have pushed down the total cost of ownership (TCO), calculated on a dollar-per-mile basis, making EV trucks and vans cheaper than ICE equivalents.
- Across the EU, data from Transport & Environment[11] suggests that light commercial vehicles have already reached, or will reach, TCO parity with diesel when purchase subsidies are included. The average electric van is now 25% cheaper than the average diesel van.

# Heavy-duty potential (cont.)

More electric heavy-duty vehicle (eHDV) models are now available, with electric buses and trucks becoming competitive on a TCO basis.

In Europe, national and city-level targets[12] for public procurement of zero-emission buses, as well as the EU Clean Vehicles Directive,[13] are boosting electric bus sales. Meanwhile, designated routes and mandated driver breaks should make it relatively straightforward to locate truck and bus charging facilities at appropriate intervals along major highways, subject to land availability and grid capacity.

eHDV sales will pick up gradually as battery density improves and demand from long-haul trucking grows.

Successful deployment will depend on proof of economic and societal benefits, growing driver familiarity with EVs, and advances in technology, as well as charging infrastructure that can cater for return-to-base operations.

Around 15,000 eHDVs were sold globally in 2022, up 88% year on year. In 2023, sales of approximately 33,000 vehicles are expected, up 116% year on year. Of total commercial EV sales in 2023, eHDVs will account for around 3%.[14]

# Heavy-duty potential (cont.)

## Characteristics of electric LDVs and HDVs

| | |
|---|---|
| ~5.5x distance travelled | HDVs travel on average ~62,000 miles (99,800 kms) annually, ~5.5x the distance travelled by a typical passenger car. |
| Up to 13x energy usage | The energy usage required for eHDVs can range from 0.5 kWh to 5.2 kWh per mile compared with 0.2 kWh to 0.4 kWh per mile for light-duty EVs. |
| 4x charging capacity | Charging HDVs at more than one megawatt is ~4x the charging capacity of a Tesla Model 3. |
| 3x typical charge time | 80–100 mins to reach 60%–80% of state of charge for an HDV compared with 20–30 minutes for a light-duty vehicle. |
| Complex and heavy charging cables | Need for heavy charging cables with increased size and complexity (i.e., increased weight and cost), or increased charging voltage. |

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> Our mission is to build 1,700 charge points at publicly accessible truck charging pools alongside Europe’s major highways within the next five years — well ahead of the market demand. We expect the battery-electric heavy-duty truck fleet in Europe to grow to more than one million vehicles in the next 10 years.
>
> Koen Noyens
> Head of Public Affairs, Milence

Source: EY analysis

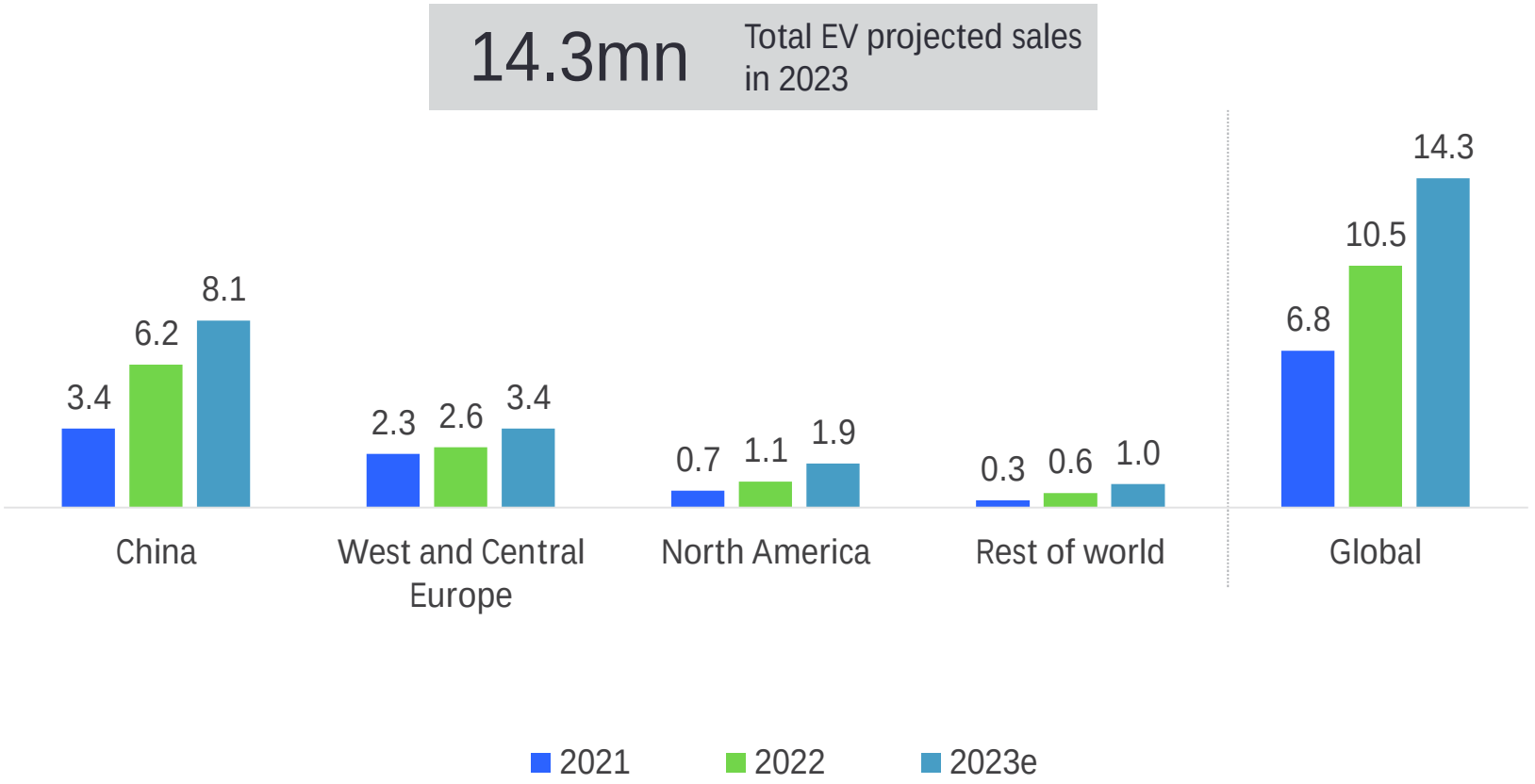
# Conditions align for self-sustaining EV industry (cont.)

We are moving from an incentive and policy-led market to one that is self-sustaining and backed by customer demand. It is helped by price corrections for critical minerals, following record highs in 2022, which will feed through into cheaper batteries and more affordable vehicles. As supply catches up with demand, global sales of plug-in and fully electric vehicles will climb from 10.5 million in 2022 to 14.3 million in 2023:[15]

- In China, EV subsidies have mostly expired. Yet the China Passenger Car Association projects aggressive uptake, with 8.5 million passenger EV sales in 2023, equivalent to around 32% of vehicles sales, and up more than 30% on 2022.[16]
- In Europe, EV sales are projected to climb 30% in 2023 as supply chain bottlenecks ease. Customers who pre-ordered in 2022, to take advantage of existing EV incentives, will boost 2023 sales figures. Momentum is already building. January 2023 registrations of BEVs and PHEVs accounted for 17% of new vehicle sales.[17] Germany, which cut its EV subsidies at the beginning of 2023, prompting a flurry of last-minute purchases in December 2022, expects to see its EV sales increase 26% over 2022.[18]
- In the US, the IRA will help boost sales of passenger EVs to 36 million vehicles by 2030,[19] up from 2.4 million in 2021.[20] New and used EVs, and both passenger and non-passenger vehicles, are eligible for IRA tax credits.

# Conditions align for self-sustaining EV industry (cont.)

## BEV and PHEV sales and outlook for 2023 (millions)




Source: EV Volumes - Global EV Sales for 2022 and Global EV Sales for 2021

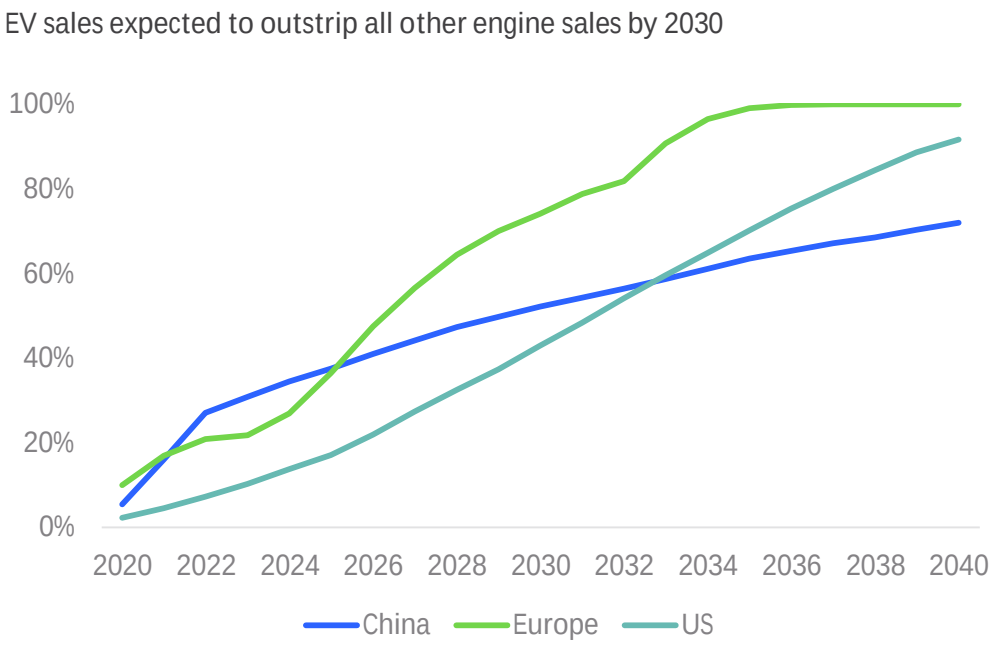
> "The priority is system change and the alignment of conditions across the fiscal, financial, technical and regulatory landscapes. You can have progress in each of these, but you need to prove that together it is cohesive and harmonious and orchestrated in a way that makes sense.
>
> Lucie Mattera
> Secretary General,
> ChargeUp Europe

# EV sales to make up more than half of total sales by 2030

The EY Mobility Lens Forecaster[21] estimates that battery EV sales in Europe will surpass other powertrains by 2027. It is a trend that will be mirrored in China and the US by 2030. Compared with 2021 predictions, Europe and China are already one year ahead of where they expected to be; the US is four years ahead.

By 2030, EY estimates that sales of BEVs and PHEVs will make up half of the global total. That is three years sooner than predicted in 2021.

## Electric light vehicles sales forecast, by region, 2020–40




Global EV sales >50% by 2030

> “The direction of travel is clear; the road ahead is not. The phase-out of ICE vehicles starts in 2035. It might seem a long way off, but we can’t just kick the can down the road and act once the deadline gets closer. We need to start moving now, for the sake of the climate, but also to ensure that this transition is smooth and maximises the benefits for all.
>
> Dominic Phinn
> Senior Policy Manager,
> The Climate Group

Source: EY Mobility Lens Forecaster 2022

# Costs must come down for mass-market EV adoption

Globally, automakers are investing billions in electric powertrains. Greater investment translates into greater vehicle choice. At the end of 2021, more than 450 electric car models were available globally. In the US alone, 134 models will go on sale in 2024, more than double the 2021 figures.[22]

EVs have moved beyond the luxury segment, with more offerings now available at lower price points. But cost remains a barrier to adoption and risks creating a societal divide:

- EVs are 27% more expensive in Europe (€55,800) and 43% more expensive in the US (€63,900) than their ICE equivalents. There are no EVs available for less than €20,000 in Europe or the US today.[23]
- In China, where EVs tend to be smaller than in other markets, and cost less to develop and manufacture, vehicles costing less than €15,000 make up almost 20% of its total EV offering.

# Costs must come down for mass-market EV adoption (cont.)

The TCO gap must be communicated and understood if EVs are to find their appeal in the mass market. Though more expensive upfront than ICE equivalents, EVs are cheaper to operate over the lifetime of the vehicle. And government subsidies, while still available, can be as much as 20% of the purchase price of an EV.[24]

Other incentives, like road access privileges and dedicated parking spaces, make a strong case for switching to EVs too:

- EVs are two to four times more efficient than ICE vehicles, so driving the same distance costs considerably less, creating ongoing fuel cost savings.
- EVs have fewer moving parts than ICE vehicles, so less can go wrong and less maintenance is needed.

Policy thinktank Energy Innovation estimates that the TCO for EV owners is, on average, €6,000 lower than for ICE owners over the vehicle's lifetime.[25]

> "We need more visibility for the overwhelmingly positive aspects of electric mobility and EV charging. We need to talk more about how easy and fun it is to drive an EV and how simple and convenient it is to charge it. Today's public discourse often revolves around presumed limitations in available renewable energy and charging infrastructure. However, these fears are not reflected in the real world. We need to share the positive experiences.
>
> Stephan Wunnerlich,
> Senior Manager, e-mobility, EnBW

# Regulation sets direction

Regulation is a big lever for EV adoption, giving confidence to consumers, automakers and investors about the direction of travel.

In Europe, regulatory interventions build towards 2035, when bans on the sale of new ICE vehicles come into effect in many jurisdictions:

- The Alternative Fuels Infrastructure Regulation (AFIR) ensures that the switch to low-carbon or zero-carbon road travel is supported by adequate charging infrastructure.
- The Renewable Energy Directive requires 32% of energy consumed in Europe by 2030 to be renewable.
- The Energy Performance of Buildings Directive (EPBD) aims to improve energy efficiency in buildings and reduce carbon production. It also includes provisions for EV charging in buildings and the "right to plug."
- CO2 emission performance standards set mandatory reduction targets for cars, vans and HDVs.

> "There's the issue of land. Does the ecology ministry have a problem using five hectares of land for HDV charging and associated renewable generation? Probably. What are the environmental impacts of using land for this purpose, as opposed to other purposes? These, for sure, will be the questions we debate in the coming years around dedicated eHDV charging locations.
>
> Aaron Fishbone
> Director of Public Policy,
> GreenWay Network

# Regulation sets direction (cont.)

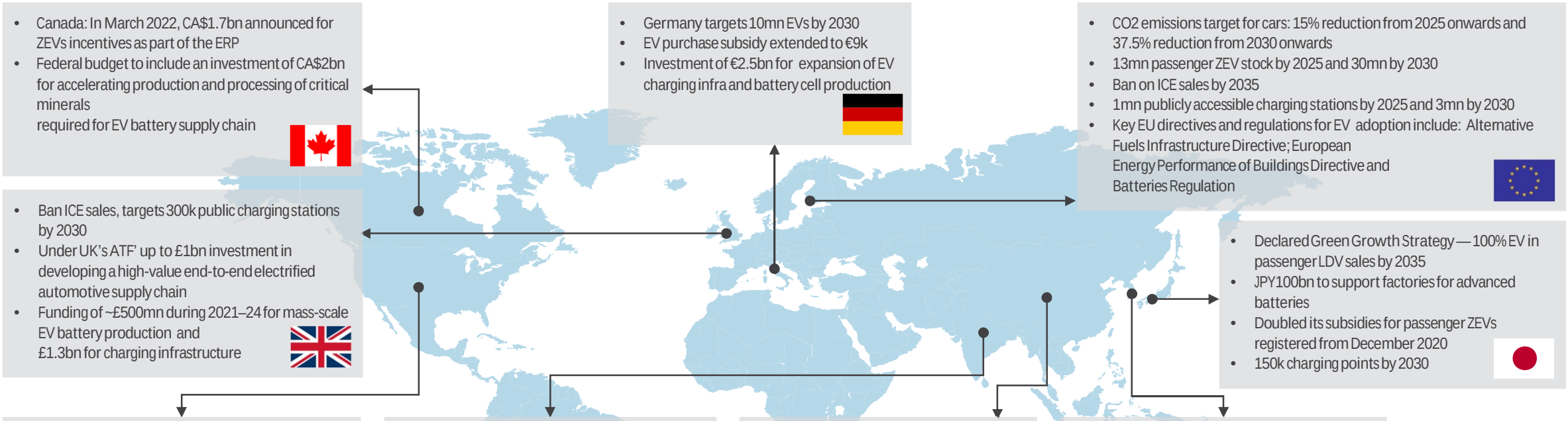
In the US, California leads. It has voted in favour of banning sales of new ICE vehicles by 2035. Already, 16% of new vehicles sold in the state are either zero-emission vehicles (ZEVs) or PHEVs. And six states, which are home to 20% of the medium- and heavy-duty fleet in the US, have adopted California's Advanced Clean Trucks (ACT) rule. It requires manufacturers of Class 2b-8 vehicles to sell zero-emissions vehicles as an increasing percentage of their annual sales from 2024 to 2035.[26]

The IRA and Bipartisan Infrastructure Law further incentivise EV sales in the US. More packages are anticipated this year, including US$80bn to support the EV battery supply chain.

> "We can't wait until 2035 and say, ok, now we go 100% electric. We need clearly defined interim steps, with a trajectory towards 2035.
>
> Philippe Vangeel
> Secretary General, The European Association for Electromobility (AVERE)

# Regulation sets direction (cont.)

## Key transport policies and targets by countries



- Canada: In March 2022, CA$1.7bn announced for ZEVs incentives as part of the ERP
- Federal budget to include an investment of CA$2bn for accelerating production and processing of critical minerals required for EV battery supply chain

- Germany targets 10mn EVs by 2030
- EV purchase subsidy extended to €9k
- Investment of €2.5bn for expansion of EV charging infra and battery cell production

- CO2 emissions target for cars: 15% reduction from 2025 onwards and 37.5% reduction from 2030 onwards
- 13mn passenger ZEV stock by 2025 and 30mn by 2030
- Ban on ICE sales by 2035
- 1mn publicly accessible charging stations by 2025 and 3mn by 2030
- Key EU directives and regulations for EV adoption include: Alternative Fuels Infrastructure Directive; European Energy Performance of Buildings Directive and Batteries Regulation

- Ban ICE sales, targets 300k public charging stations by 2030
- Under UK's ATF' up to £1bn investment in developing a high-value end-to-end electrified automotive supply chain
- Funding of ~£500mn during 2021–24 for mass-scale EV battery production and £1.3bn for charging infrastructure

- Declared Green Growth Strategy — 100% EV in passenger LDV sales by 2035
- JPY100bn to support factories for advanced batteries
- Doubled its subsidies for passenger ZEVs registered from December 2020
- 150k charging points by 2030

- BEV/PHEV/FCEVs to make up 50% of US sales by 2030
- Government's plans to replace its fleet of ~650K vehicles with EVs
- Investment of US$7.5bn in both public charging infrastructure and electric buses
- Build a national network of 500,000 EV chargers across 35 states

- Faster Adoption and Manufacturing of Hybrid and EV (FAME II) scheme outlays INR86bn for purchase of EVs and INR10bn for supporting charging infrastructure
- Incentive of US$2.5bn to promote manufacturing of advanced chemistry cell batteries

- The New Energy Automobile Industry Plan targets 20% of vehicle sales to be ZEVs by 2025
- China plans to build charging stations for 20mn EVs by 2025, according to the National Development and Reform Commission

- South Korea sanctioned Korean New Deal with budget of up to US$17mn for electric cars in 2021 and up to US$33.5mn for hydrogen fuel-cell electric vehicles
- South Korea aims to commercialise lithium-sulphur batteries by 2025, and lithium-metal batteries by 2028

Source: EY analysis

# Put the customer at the heart of transformation

As the adoption curve accelerates, and the EV-buying demographic shifts from a niche audience to a larger group of consumers with more mainstream values and expectations, the evolving EV ecosystem must pivot around:

- Cheaper and more affordable vehicles that provide equal or improved performance
- Brands with which the audience identifies, and which deliver services and products that are relevant and easy to consume
- Accessible and conveniently located charging infrastructure which is available for all

Only by structuring the EV ecosystem around the customer can e-mobility establish itself as the new normal for road transport.

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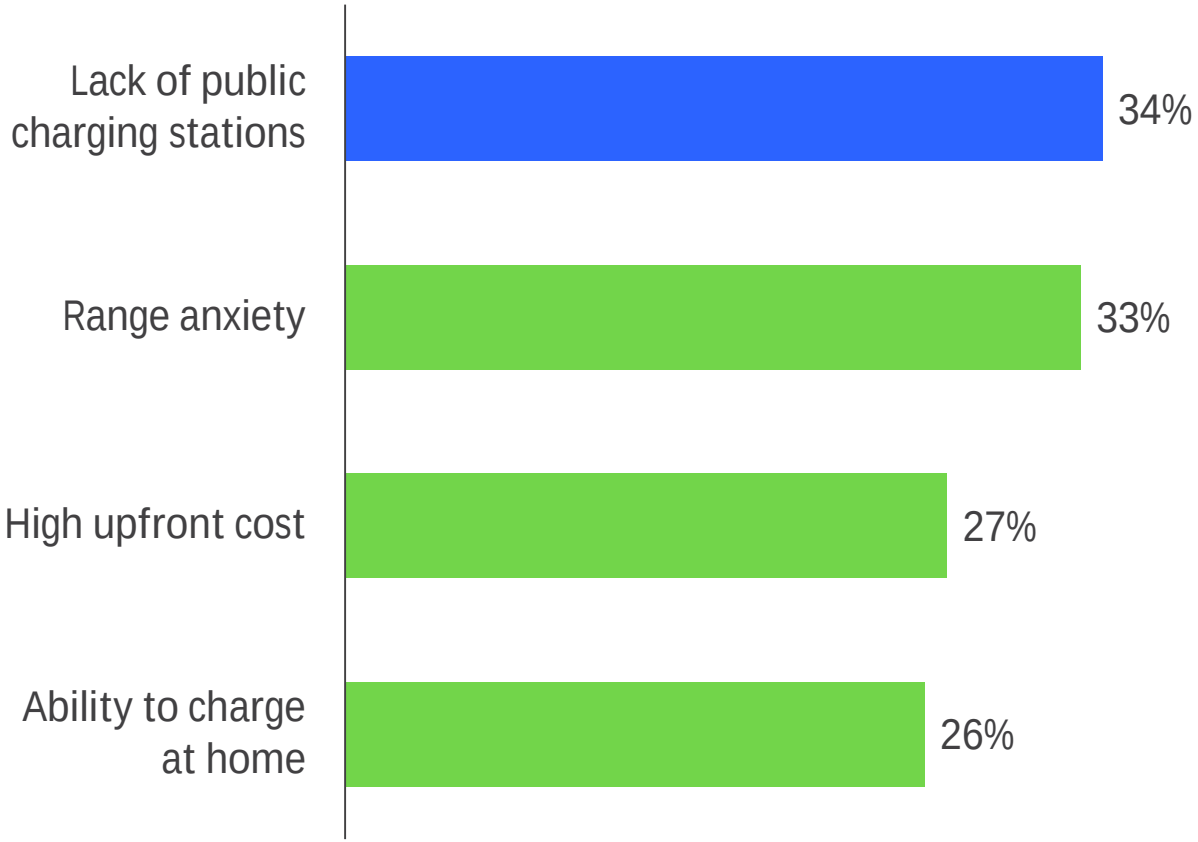
> Driving an EV is an entirely different ball game to driving an ICE vehicle. You’re dealing with kilowatt hours, not gallons or litres. You don’t fill up at a designated location, but charge at home, in the street, wherever you park, whenever you want. It requires a very different mindset. People are not yet aware of the possibilities; they don’t know what the new system will look like in the future. But whatever it looks like, it must work for the customer.
>
> Andrew Horstead
> EY Global Energy & Resources Lead Analyst

# Put the customer at the heart of transformation (cont.)

## Customer concerns about switching to EVs




Source: EY Mobility Consumer Index 2022

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> It's relatively easy to identify where public charging points should be sited. Look at the concentration of traffic. For decades, petrol stations have been located where the demand is, and that’s where charging points should be installed too, besides private charging points at homes, offices and shopping areas where the vehicles are located most of the time.
>
> Petr Dolejsi
> Mobility & Sustainable Transport Director, European Automobile Manufacturers’ Association (ACEA)

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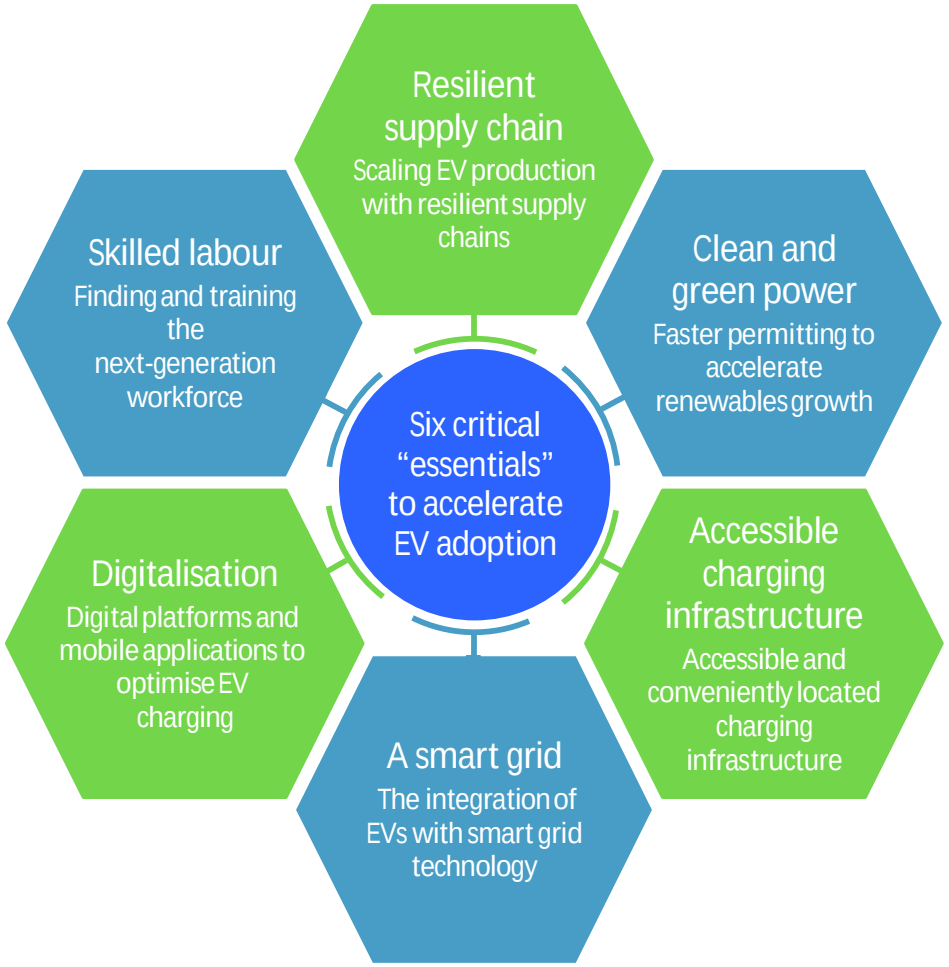
# Six essentials for accelerating e-mobility transition

# What industry must get right for mass-market EV adoption

We are nearing the inflection point in the irreversible evolution of transport. Geographic, technological, legislative and economic drivers show us the direction of travel. However, the transition itself hinges on six essentials. And we must get them right.




Source: EY analysis

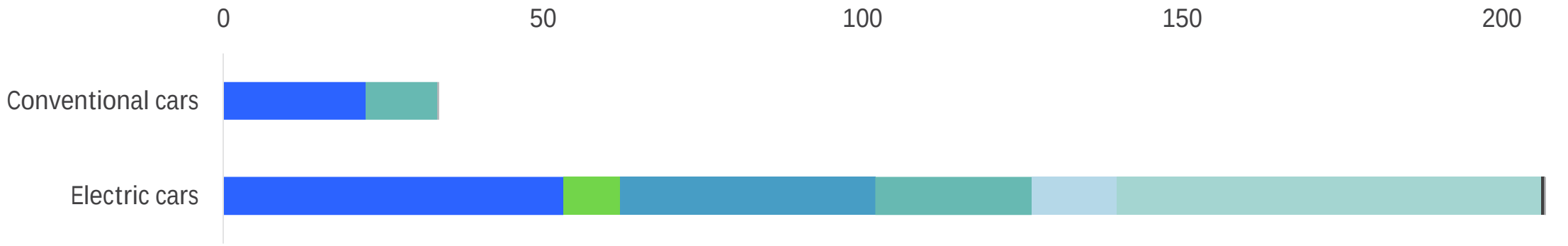
01

# Resilient supply chain

## Response to mineral shortages needed if EV production is to scale

The EV market is gaining traction but is hampered by supply chain constraints. It competes with other energy transition technologies for critical minerals and raw materials that are needed in manufacture. Tightened supply drives up prices, creating challenges for automakers in meeting EV production targets and, ultimately, in delivering affordable vehicles.

### EV critical mineral demand compared with conventional ICE vehicles (minerals kg/vehicle)




| Demand increase in critical metals and minerals between 2019 and 2030 | Copper | Lithium | Nickel | Manganese | Cobalt | Graphite | Rare earths | Others |
|---|---|---|---|---|---|---|---|---|
| | 10x | 9x | 14x | 3x | 3x | 10x | NA | NA |

Source: IEA 2022; Minerals used in electric cars compared to conventional cars, https://www.iea.org/data-and-statistics/charts/minerals-used-in-electric-cars-compared-to-conventional-cars, License: CC BY 4.0, International Energy Agency, 2022

# 01 Resilient supply chain

## Batteries are critical to the EV transition

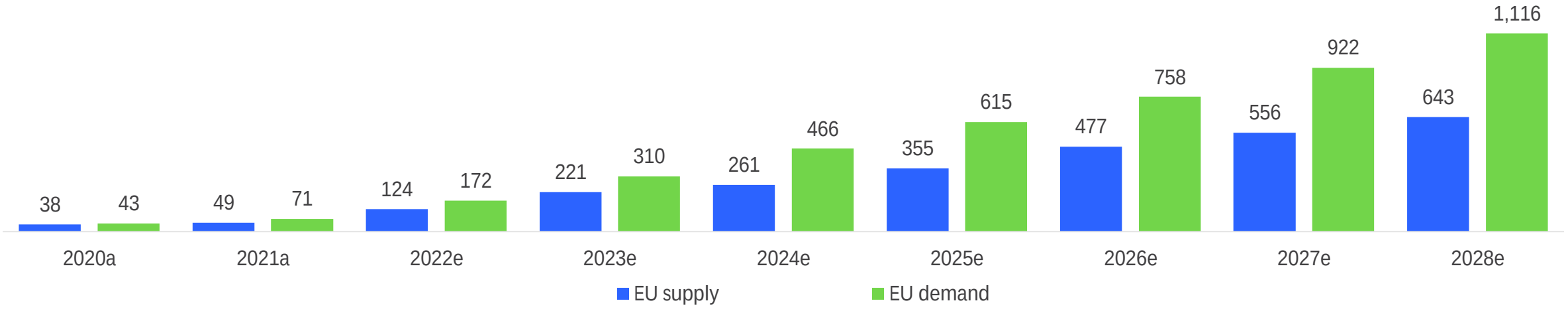
To reduce their dependency on imports of raw materials and batteries, primarily from China, countries in Europe and the US are shifting to domestic or local solutions:

- Automakers are scaling investments and signing long-term contracts in the upstream battery market and along the battery value chain to guarantee the supply of critical minerals.
- Investment in gigafactories is focused on battery recycling, advanced battery chemistries to reduce reliance on minerals and metals, and enhanced battery density and performance.

# 01 Resilient supply chain

By addressing the availability and cost of raw materials in the supply chain, battery prices should fall, allowing automakers to bring down vehicle costs and scale EV adoption into the mass market.

## European EV battery supply-demand outlook (2020-2028e, GWh)




Despite increasing local capacity announcements, a supply deficit is still forecast which has created a race for capacity and opportunities across the value chain

Source: Based on IHS Feb 2022 data excluding net exports and with uplift correction for new announced OEM demand, Bloomberg, IHS Feb 2022, Reuters, EY-Parthenon research and analysis

# 01 Resilient supply chain

## Ways to create a resilient supply chain

- Leverage private investment in sustainable mining of key battery metals.
- Ensure clear and rapid permitting procedures to avoid potential supply bottlenecks.
- Accelerate innovation in alternative battery chemistries that require smaller amounts of critical minerals.
- Expand battery recycling.
- Strengthen cooperation between producer and consumer countries.
- Promote environmentally and socially sustainable practices and encourage knowledge sharing.
- Ensure traceability of key EV components.

02

# Clean and green power

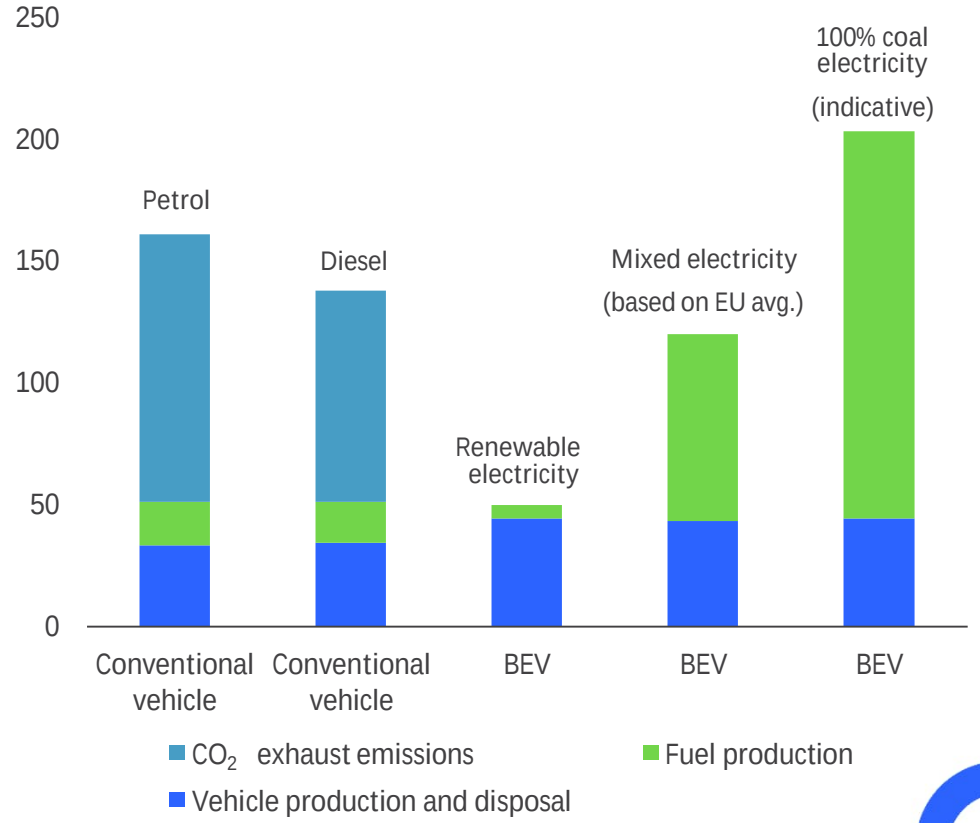
## EVs to become biggest consumers of renewable energy

Clean energy makes transport cleaner. But currently, just over 3% of the transport sector runs on renewable energy. And most of that is biofuels.

With global electricity demand predicted to increase more than twenty-fold by 2030 compared with 2021 levels,[27] EVs may become the biggest buyers of clean electricity. However, to work efficiently and to decarbonise the grid, there must first be adequate renewables availability.

Globally, governments are taking steps to expedite the transition to cleaner- and lower-carbon generation, improving local energy security and reducing costs to consumers in the long run. The US aims for 100% carbon pollution-free electricity by 2035. The EU's REPowerEU plan aims to remove hydrocarbons from its energy mix by scaling and speeding up renewable energy supply. It proposes to increase its headline 2030 target for renewables from 40% to 45%.[28]

### Range of lifecycle $CO_2$ emissions for different vehicle and fuel types ($CO_2$ g/km)




Source: Range of life-cycle CO2 emissions for different vehicle and fuel types, European Environment Agency, https://www.eea.europa.eu/signals/signals-2017/infographics/range-of-life-cycle-co2/view, Last modified 23 November 2020

# 02 Clean and green power

## Ways to decarbonise the grid

- Adopt an electrification strategy.
- Develop a detailed, quantitative pathway to decarbonise the power sector substantially.
- Address permitting barriers.
- Develop a flexibility market to manage intermittency of non-dispatchable power.
- Integrate distributed energy generation (DERs) to enable local energy generation, energy storage or consumption management.
- Integrate smart digital solutions to enable DER owners to monitor and manage their resources in real time.
- Tackle critical materials supply chain issues.

> “
>
> It’s not just about connecting to electricity but proving that the electricity we use to charge the vehicle is coming from renewable sources. It is important to the sustainability of transport and to urbanisation.
>
> Maria Andreeva
> Global eMobility Marketing Strategy Leader, Schneider Electric

# 03 Accessible charging infrastructure

## Making charging infrastructure accessible and convenient for all

The average EV battery range is currently 326 kilometres.[29] That is more than enough for everyday use, as passenger cars travel, on average, 45 kilometres a day.[30] And most drivers — around 80% — charge at home or at work.[31]

However, full-scale EV commercialisation depends on a public network of direct current (DC) fast chargers for the 20% of drivers who can't charge at home or at work, as well as for long-distance drivers and those in need of a quick top-up. Within the next 10 to 15 years, charging infrastructure must be deployed across home, work and public environments, and cater for fleet and commercial use cases too.

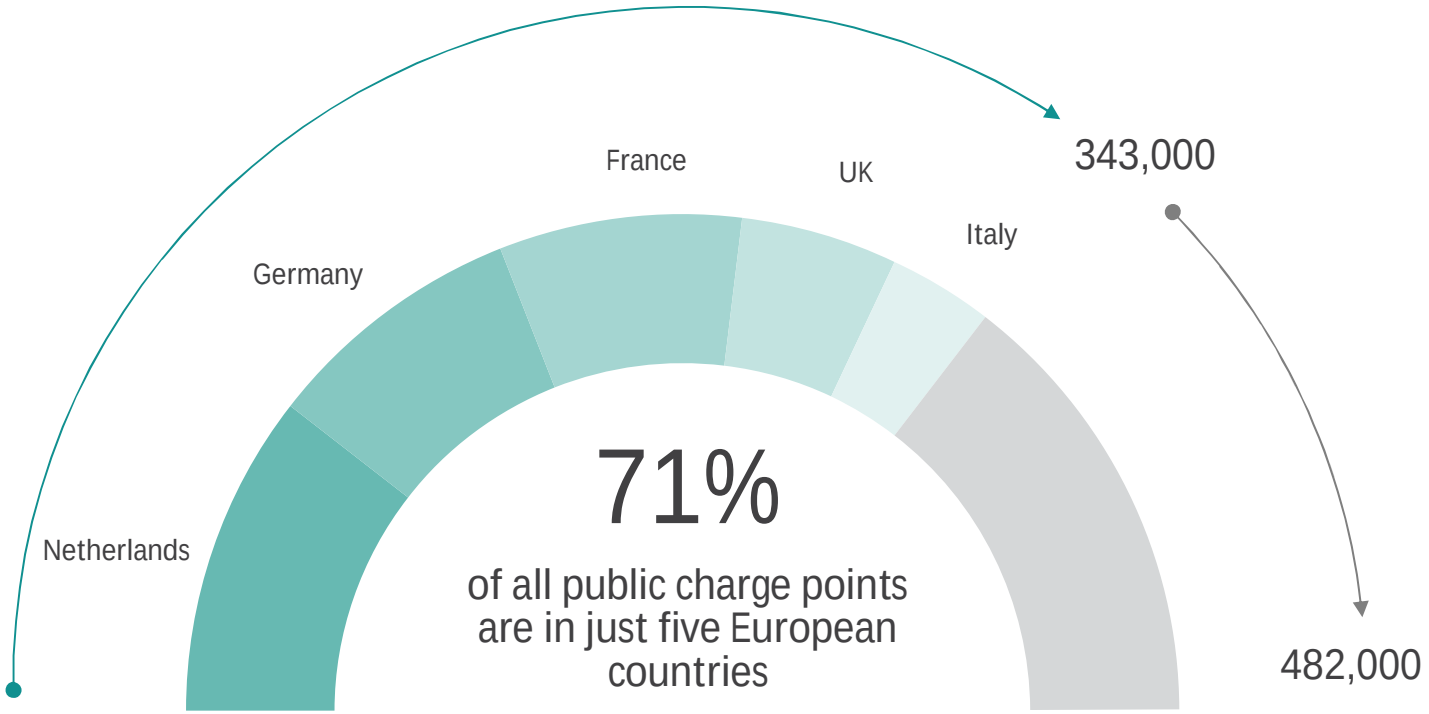
Deployment must also address the uneven distribution of charging points. Five countries — Germany, France, Italy, the UK and the Netherlands — account for 71% of all European charging locations. In the US, the pace of current installation needs to be trebled to meet the goal of installing 500,000 public chargers by 2030.[32]

### EV adoption depends on improved access to charging infrastructure

- For 34% of global consumers, lack of charging infrastructure inhibited an EV purchase in 2022.
- At the grid level, long permitting processes, compounded by lengthy bureaucracy, inadequate coordination between distribution system operators (DSOs) and public authorities, and a lack of digitised and standardised procedures, prolong lead times for installing charging infrastructure.
- Installation risks favouring high-income households with access to home charging over lower-income residents in multi-unit dwellings with potentially reduced access to charging facilities.

# 03 Accessible charging infrastructure

## EV public charge points in Europe




7 EU27 countries have fewer than 1,200 charge points

Source: EU alternative fuel infrastructure", European Alternative Fuels Observatory, European Commission, accessed 15 February 2023

> “
> Cities are leading the upscale of e-mobility. The concern, mostly, is whether we want chargers in our city centres or outside our city centres, aligned with parking policies.
>
> And, if we want them in the city centre, where do we put them, so they do not compromise public space and so that they are accessible for all and that there's equity in their distribution?
>
> Pedro Gomes
> Project Manager & Coordinator, Polis

# 03 Accessible charging infrastructure

## Europe needs 5.2 million non-residential chargers by 2030

Today, Europe has more than 482,000 publicly accessible charging points, and that number is growing. In the past year, the number of DC chargers has increased by 90%. Now, given the accelerated adoption of EVs, the rollout of infrastructure must keep pace. More chargers are needed and sooner than previously estimated.

By 2025, EY estimates that 1 million public charge points will be needed, including at go-to destinations, such as shopping centres, as well as more than 600,000 workplace chargers. These numbers, which come on top of domestic demand for chargers, are based on the expected size of the EV fleet, average daily distance travelled and vehicle battery size.

By 2030, 2.8 million public charge points, and 2.4 million workplace chargers, will be needed. To get close, approximately 670,000 new charge points are needed every year — or 13,000 per week.

By 2040, the total number of residential, workplace and public chargers needed in Europe will top 140 million to service an estimated 239 million EVs. Around €350bn investment will be needed to cover hardware and installation costs, on top of any grid or distribution system upgrades.[33]

Though a significant challenge, rollout can be accelerated by removing regulatory barriers, improving access to land for infrastructure, and enabling faster passage via the permitting and processing channels at local authority level. At the utility level, more timely grid connections will support faster rollout.

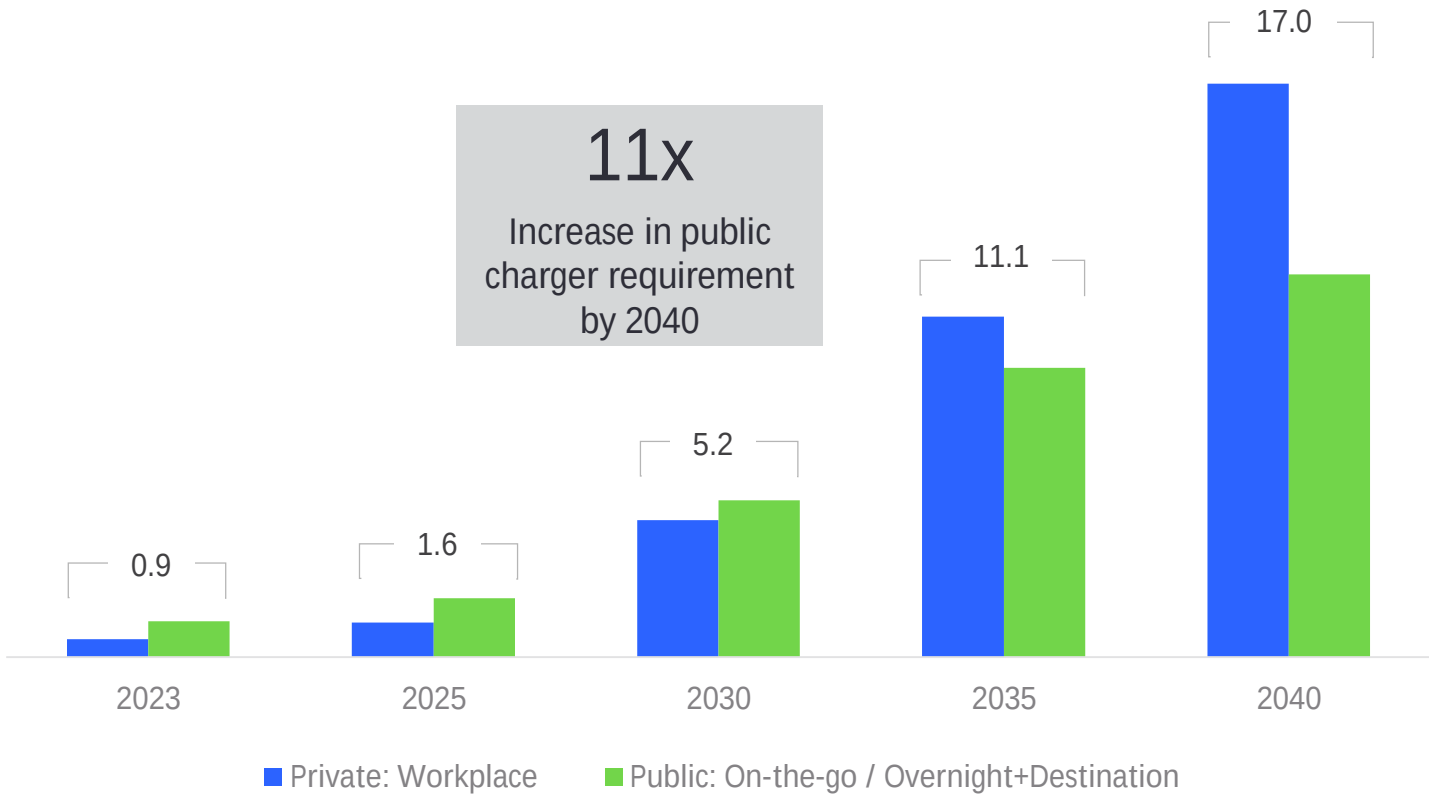
> “Not all cities are equipped to expedite the permitting process for charging infrastructure. They are understaffed and can’t deal with the volume of requests. This is one of their main struggles. So how can we respond quickly to demand for permitting, while making sure that the interests of the city are met?
>
> Pedro Gomes
> Project Manager & Coordinator, Polis

# 03 Accessible charging infrastructure

Ways to navigate the bottlenecks are exemplified by some countries:

- In the UK, regional councils map the distribution grid to local authority-owned land, to identify sites for public charging where people live and work.
- In the Netherlands, regional governments, provinces and municipalities share knowledge and tender jointly for charging infrastructure deployment.[34]
- Spain requires land to be allocated for the installation of charging infrastructure in public spaces.

## Public and workplace EV charging infrastructure (million charging points)




Source: EY analysis - EV Charging Infrastructure Forecast, February 2023

# 03 Accessible charging infrastructure

## Ways to roll out charging infrastructure faster and equitably

- Strengthen cooperation between local authorities, DSOs, charge point operators (CPOs) and public transport operators. At a European level, unite parties in drafting and implementing Sustainable Urban Mobility Plans, with a focus on efficient and transparent tendering processes to proactively plan for and identify sites for charging infrastructure.
- Build capacity within local authorities to manage e-mobility rollout by streamlining and capitalising on diverse funding opportunities, engaging early in projects, adopting digitally enabled strategies and sharing knowledge with other local authorities.
- Prioritise cooperation between DSOs and public authorities in preparing for network development and use hosting capacity maps to make siting decisions more transparent to CPOs.
- Incentivise, via regulation, the installation of charging infrastructure in underprivileged, vulnerable and economically challenged communities.
- Identify opportunities for utilities to partner with big retail chains, hotels and smaller venues to provide consumers with greater charging certainty and choice at go-to destinations.
- Develop proper and standardised tendering processes for acquiring land, while unlocking revenue opportunities for public and private landowners, and creating EV charging hubs in the places and spaces where they are needed.
- Repurpose existing fuel stations as EV charging locations.
- Create a separate vision and plan for installing HDV charging infrastructure in non-urban hubs.
- Develop community or cooperative charging solutions to serve multi-unit dwellings.

# 04 A smart grid

## Integrate EVs with smart grid technology to better manage energy demand

In the US, electricity demand from EVs is expected to add 153TWh by 2030, rising to around 430TWh in 2035. By then, EVs will account for 10% of overall US power demand.[35] In Europe, demand for electricity from EVs is expected to increase by 200TWh, accounting for approximately 5% of total demand by 2030.[36]

Analysis by the IEA reveals that when EV stock exceeds 20% of electricity demand, the need for grid adaptation becomes significant.[37] Other source and load complications arise from increased renewables generation and the rollout of heat pumps.

To cope with increased load and minimise the need for grid upgrades, alternative mechanisms and smarter solutions are emerging. They include:

- Flexible connection agreements
- Procurement of distributed flexibility
- Network tariffs, including time-of-use (ToU) tariffs to incentivise EV owners to charge their vehicles at off-peak hours (at the end of 2021, 139 ToU tariffs and services were available across Europe, specifically for EV smart charging).[38]
- Demand-response capabilities
- Renewable energy and energy storage system
- Bidirectional charging technologies
- Integrated charging networks
- Consumer and fleet management incentives to encourage them to share their charging status

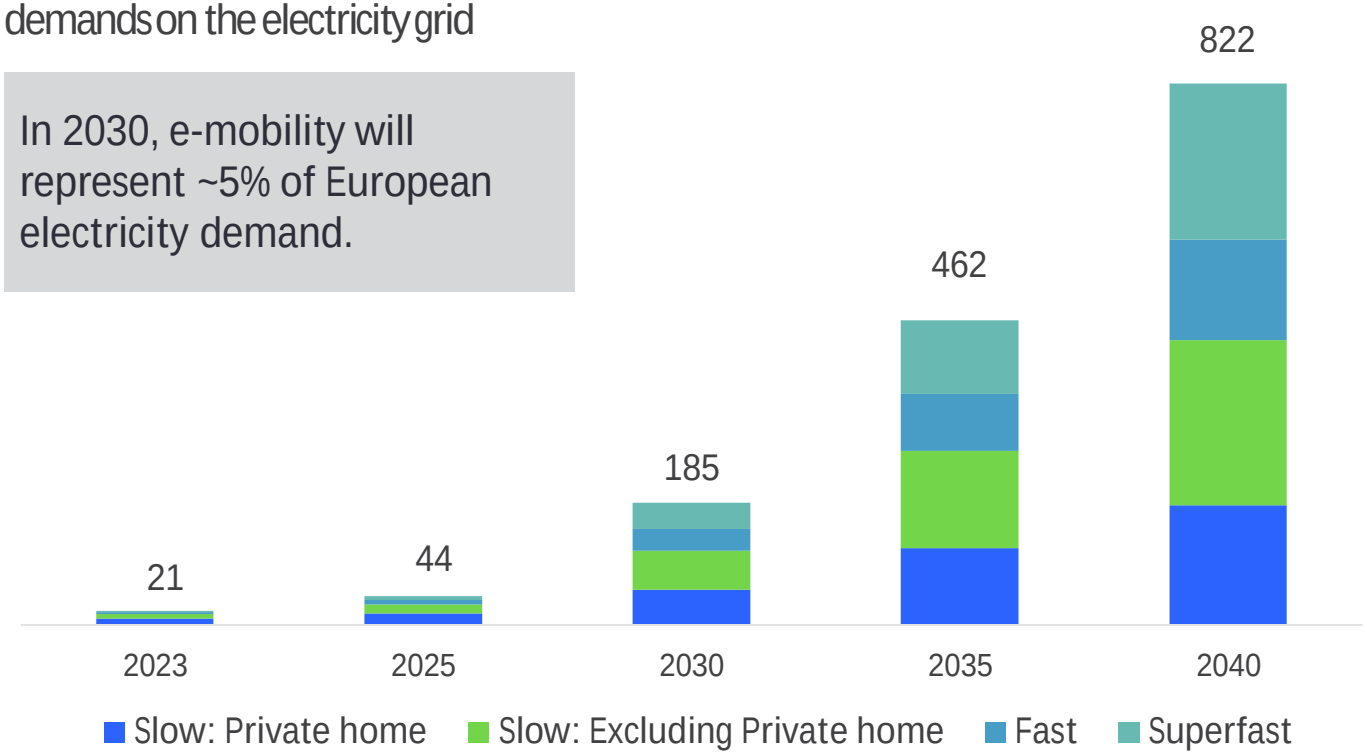
> “My prediction is that high-powered public charging infrastructure will remain under-utilised. A car is stationary for, on average, 22 hours. So let it charge while it’s sitting there. People will find that a much better convenience.
>
> Garrett Fitzgerald
> Senior Director of Electrification, Smart Electric Power Alliance (SEPA)

# 04 A smart grid

## European total electricity demand for EV charging, by charger type (TWh)

The more charging infrastructure we install, the greater the demands on the electricity grid

In 2030, e-mobility will represent ~5% of European electricity demand.




Source: EY analysis - EV Charging Infrastructure Forecast, February 2023

### Where EV electricity demand will come from

- EY identified the six most common charging use cases: residential (rural), residential (urban), workplace, fleet hub, overnight stay hub and highway corridor.
- EY analysts predict an 86% increase in peak load in multi-unit dwellings and a 90% increase on highway corridors, where rapid and high-powered chargers draw large amounts of electricity from the grid.
- Transformers, in most cases, will have to operate above their rated capacity.

# 04 A smart grid

## Pushing grid possibilities

For EVs to become a resource rather than a challenge to grid stability, we urgently need:

- Coordinated plans for grid expansion and enhancement
- Digital technologies for two-way communications and pricing between EVs and grids

Currently, optimised EV charging determines the cheapest time for EVs to charge. It is used to lessen the risk of overloading transformers or transmission lines and mitigates the costs of grid upgrades.

Coming up, as the next big thing in smart charging, is vehicle-to-everything (V2X) technology. It allows energy, stored within an EV battery, to be exported and used in the home, in other buildings, or even to balance the electricity grid. Vehicle-to-grid (V2G) technology allows the grid to push and pull energy to and from connected vehicles if energy demand threatens supply. A recent study by IRENA indicates that V2G can reduce grid reinforcements costs by 10%.[39] However, the technology is at a nascent stage, with around 78% of projects running on a trial basis.[40]

> “
>
> The technology is available. The next challenge, of course, is to change consumer behaviour and to remunerate flexibility, so that systems can be efficiently integrated.
>
> Urska Skrt
> Mobility Manager, World Business Council for Sustainable Development (WBCSD)

# 04 A smart grid

## Ways to increase EV hosting capacity on the grid

- Expedite grid connections with standardised and separate permitting processes, and encourage cooperation and collaboration between stakeholders.
- Develop grid forecasts for EV integration to estimate the impact of future additional loads.
- Improve the accuracy and reliability of data for EV forecasts.
- Create an EV/DSO coordination process, aimed at sharing knowledge and benchmarks.
- Explore V2G, V2X, bi-directional charging and other technologies that can deliver flexibility to the grid.
- Develop tariff structures and innovative promotional schemes to encourage consumers to charge at non-peak times (e.g., ToU tariffs) and mitigate the risk of overloading the grid.
- Consider how EV manufacturers can partner with utility companies to create custom electricity tariffs, which are bundled into the purchase of an EV.
- Develop a vision and technical requirements for LDV and HDV uptake.
- Adapt regulation so that DSOs can build their cases for future investment and resources around forecast load coming on to the grid.
- Increase rewards for EV participation in power markets as flexible resources.
- Support ambitious targets, set out in the Energy Performance of Buildings Directive, by installing pre-cabling in buildings to prepare them for charging points.

# 05 Digitalisation

## Create digital platforms and mobile applications to optimise EV charging for the customer

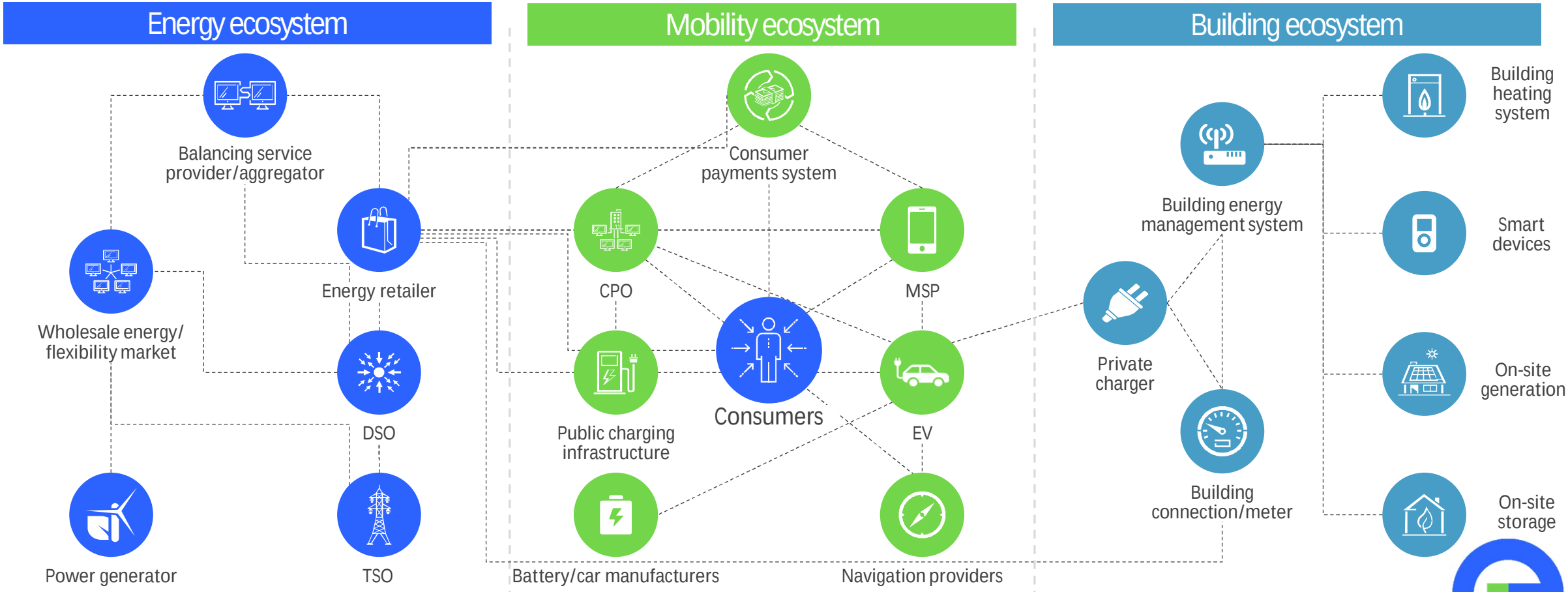
By the time millions of EVs hit the road over the next decade, the term “data highway” will take on a literal meaning. A complex EV ecosystem, interlinked by data flows, is emerging. Data is generated at primary nodes — in EVs, at public and private chargers and by CPOs — within the e-mobility ecosystem. This data connects with other ecosystems, such as energy, buildings and public and civil organisations, and becomes a single cohesive “ecosystem of ecosystems.”

Given this is a relatively nascent yet complex EV ecosystem, data management is emerging as a major challenge. It raises issues around data storage, ownership, usage and regulation.

> “From the outset, key players in the industry have tried to make EV charging as consumer friendly as possible. We support EV drivers and believe that payment should be easy and seamless. In the future, therefore, drivers will be able to use their EV as a means of authentication and payment (i.e., through Plug N Charge), making EV charging even simpler.
>
> Jayson Dong
> Senior Manager, Public Policy – EU, ChargePoint

Potential data flow

## The e-mobility ecosystem




Source: Adapted from CERRE energy data sharing the case of electric vehicle (ev) smart charging (cerre.eu), EY analysis

# 05 Digitalisation

## Digital turns data into insights

By mining and analysing the data generated by EVs and charging stations, it can be turned into valuable insights that inform wider industry needs. It can be used to:

- Assess infrastructure needs.
- Provide information on traffic density.
- Understand the capacity of the grid network.
- Assess suitability for renewable energy integration.
- Support identification of suitable locations for charging infrastructure.
- Develop additional services and hyper-personalised product offerings for customers.
- Explore and expand into non-core markets or to undertake joint initiatives with other ecosystem players.

Digitalisation is critical for interoperability too. It allows users to connect wirelessly, roam and pay to charge, in a safe and easy way, across different products or systems or locations.

In turn, this provides greater versatility and security from the charging experience, enhances customer confidence and helps to accelerate mass EV adoption.

# 05 Digitalisation

## Ways to make the e-mobility ecosystem interoperable

- Adopt and harmonise open protocols to support neutral interconnections between EVs, CPOs and e-mobility service providers (EMSPs), and to enable roaming and grid connection.
- Develop an open connected platform for data sharing, and create fair and transparent data access requirements.
- Make battery data available to CPOs and EMSPs to create better services for customers.
- Enable better customer choice and convenience with interconnections between car navigation systems and EMSP apps.
- Create a digital twin of the grid to model traffic density, grid network capacity and potential for renewable integration, and to identify suitable sites, land usage requirements and permits.
- Use data analytics and data science tools to develop services, applications and hyper-personalised product offerings.

# 05 Digitalisation

## New data for new business models

### Smart grid planning

Monitoring the grid to anticipate future use, design and investment needs.

### Intelligent third-party partnerships

Partner with retail and other businesses to offer destination charging and integrated services.

### Dynamic load management

Balance energy demand optimally across the charging network.

Using data to drive EV adoption

### Route planning

Plan journeys with EV charging in mind.

### Charging infrastructure planning

Plan and optimise site location to increase utilization and ROI.

### Apps for unified experience

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

Source: Adapted from Data and Mobility Intelligence Drive EV Adoption, https://otonomo.io/resource-category/white-papers/, EY analysis

06

# Skilled labour

## Equipping the next-generation workforce with e-mobility skills

The shift toward electric cars and trucks is creating economic opportunities along the auto-manufacturing value chain and in related industries, while disrupting legacy business models. But the transition is forecast to create more jobs than it displaces. In the US, a net gain of two million jobs would be realised in 2035 if all new car and truck sales were electric.[41] Similarly, if all EU fleet is fully electric, around 1.1 million permanent jobs would be created by 2050.[42]

The European battery industry needs 800,000 qualified workers by 2025. Meanwhile, utility staff are being poached by tech start-ups for their industry know-how, while staff close to retirement are opting to leave early.

To guarantee a talent pipeline, automakers are safeguarding jobs by re-skilling and providing opportunities to adapt to electric powertrains. Some are pledging to retain every worker on the road to creating an all-EV line-up. And to create tailored training pathways, many companies are teaming up with technology partners, universities, community colleges, industry experts and learning platforms.

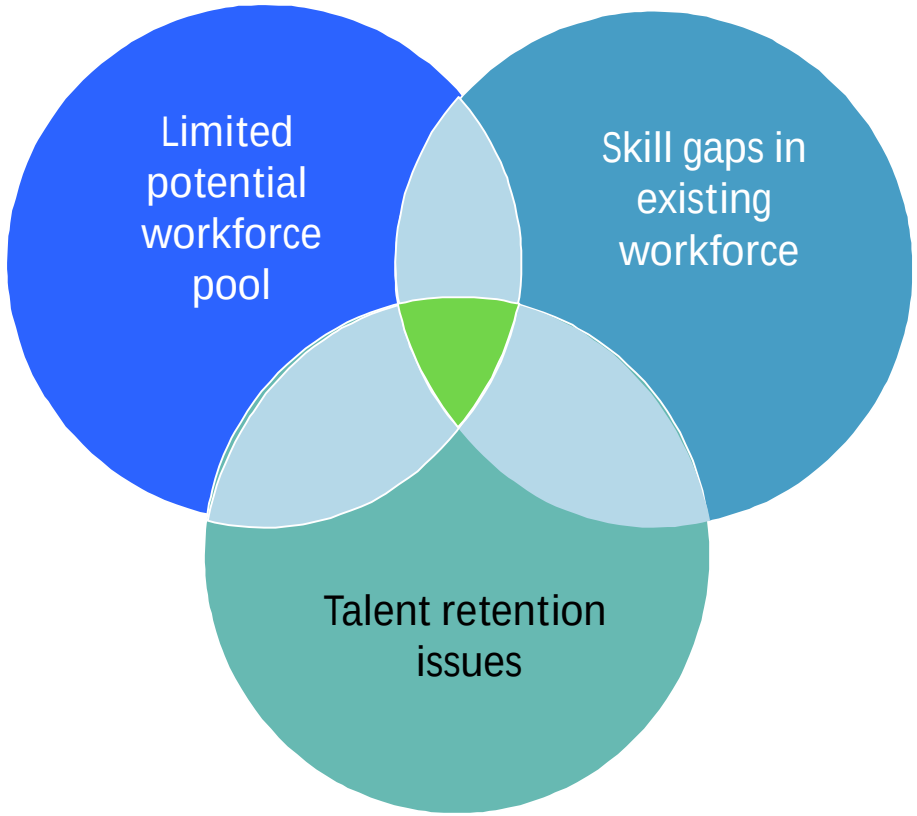
However, government must get behind education too. Investment in apprenticeships, retooling and retraining, as well as recognised qualifications, are fundamental to making this transition happen.

### Talent deficit in the global e-mobility ecosystem

- 90,000 qualified technicians will be needed in the UK EV industry by 2030.[43]
- 50,000 automotive workers must be upskilled if Australia is to meet its state and federal targets by 2030.[44]
- More than 150,000 jobs are to be created across the EV industry in the US by 2030.[45]
- 80% of engineer jobs are unfilled in the EV industry in India.[46]

# 06 Skilled labour

## Talent deficit in the global e-mobility ecosystem




Source: EY analysis

### Ways to make the workforce e-mobility-ready

- Implement organisational change management, putting humans at the centre. Where the logical and emotional journey is balanced, and people are supported along the way, transformation is more than twice as successful.
- Recruit knowledgeable and open-minded people in leadership and decision-making positions.
- Invest in upskilling the workforce to mitigate labour shortages and ensure the right capabilities to see through the e-mobility transformation.

# 06 Skilled labour

"

The energy transition demands new skills and capabilities. Some can be adapted from existing manpower; others will have to be developed. The transition to e-mobility will not be detrimental to jobs, but it will require a capability switch. There are shortages of skills associated with digital, payments, operations, maintenance (predictive or corrective) and manufacturing.

Gonçalo Castelo Branco
Head of E-mobility, EDP

# 03

# Getting to our destination

# Stakeholders collaborate

Milestones stretch out before us: 2035, the date at which sales of new ICE vehicles are banned; 2050, the year when medium- and heavy-duty vehicles are predicted to achieve net-zero carbon emissions.

Globally, the EV industry is heading towards 20% EV adoption. The next big milestone is to win over the next 60% of users, transitioning them from EV awareness to EV advocacy, and giving them reasons to be confident about e-mobility. Industry leaders who shared their views with us note that the conversation is moving on. From theorising about the magnitude of what's happening and how fast it's happening, the conversation is now all about the practicalities of making it happen at ground level. And that does not happen in silos, but when everyone pulls in the same direction and collaborates around problem solving:

- At a local level, cities are working with utilities and CPOs to inform policy decisions around electrification of passenger and commercial vehicle fleets to support decarbonisation.
- Automakers are listening to consumers and fleet operators and developing new EV models that meet their shifting preferences and priorities.

> “
> At the 30,000-foot level, everyone understands what's happening. But now we're at ground level, working out what kind of demands are going to be put on a specific point on a specific circuit. That is a monumental leap. We’re at the ‘nuts and bolts’ stage of making this transition work.
>
> Michelle Buffington
> Vehicle Program Specialist,
> California Air Resources Board

# Stakeholders collaborate (cont.)

- Regulators, utilities and CPOs are working together on challenges, such as how to get a charger to a multi-unit dwelling so that every resident who needs to charge can do so, or how much power and infrastructure is needed to support the charging demands of eHDVs.
- Automakers and utilities are putting in place educational programmes to address skill gaps.
- Utilities are working with investors to build and finance new renewable energy capacity.
- Automakers are partnering with technology providers to support EV drivers in finding fast-charging stations much more easily, enhance EV driver security or develop new solutions, such as usage-based insurance products, that could reduce insurance premiums for the customer.

> “When creating an industry from scratch, there will be people that will always have concerns and are uncomfortable with such significant change no matter what assurances are given. They’re potentially the last 20% of drivers who will switch. We’ve already convinced the first 20%, the first “movers”, who want to transition to e-mobility because they believe it’s important to their lives and what they stand for. Now we’ve got to convince the important 60% – the majority. And we do that by working hard to support their own awareness, understanding and decision-making.
>
> Dr Nina Skorupska
> Chief Executive, REA

# Critical role of utilities

In developing this study, industry leaders agree that two priorities — the ability to charge EVs and the ability to control EV consumption for load management purposes — are fundamental to maintaining the pace of the transition. Utilities have in-house electric engineering acumen, deep knowledge of electrical load on local distribution and transmission lines, and existing commercial power-supply relationships. Together, these capabilities will help them to address complex EV charging needs.

Though utilities are lynchpins in accelerating EV adoption, success hinges on five imperatives:

1. Develop a clear vision and overarching strategy: Utilities must align with internal and external stakeholders on the role they will play in shaping the new energy future. EV initiatives must not be siloed within or across organisations.
2. Connect customers better, faster and more cheaply: As EV adoption scales, infrastructure connections must be made proactively, digitally and seamlessly to support consumers and fleets with their electrification and net-zero ambitions. Delays and unexpected costs for grid connections will impact charging infrastructure rollouts.

# Critical role of utilities (cont.)

3. Engage with EV customers: Utilities must establish themselves as trusted advisers to customers, both before and after they buy an EV. From real-time decision-making tools on their websites, to incentivised V2X and managed-charging programmes, utilities can enable customers' EV transition in ways that support both the operational grid needs and the desired environmental, social and governance outcomes.
4. Build a robust ecosystem: Utilities must partner strategically with customers, automakers, CPOs, regulators and governments. They must collaborate with research organisations and with providers of data analytics and intelligent grid platforms. Strength and value will come from pooling knowledge and resolving challenges jointly as the energy and transportation industries converge.
5. Take advantage of funding now: Financial support is available to advance e-mobility and infrastructure rollout. Development and grant applications should be submitted now to pilot and scale programmes.

Supported by regulation and standards to support decarbonisation, the e-mobility transition is headed in the right direction. Now, as we shift the dial and the horizon becomes clearer, the conversation hones in on the details of what needs to happen, at grid level, to make the transition work functionally and equitably for all.

# Appendix

# Footnotes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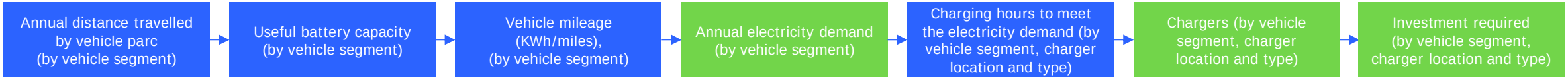
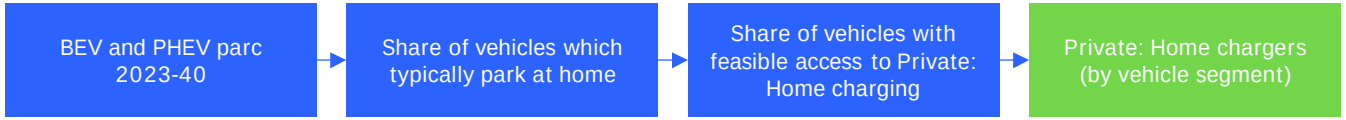
# EV charging infrastructure methodology

Forecasting for Private: Workplace, Public: On-the-go and Overnight, and Public: Destination segments is based on expected electricity demand at these locations, while accessibility and installation feasibility are key determinants of requirement for Private: home chargers

## Forecasting approach for Private: Workplace, Public: On-the-go and Overnight, and Public: Destination charging segments




## Forecasting approach for Private: Home charging segments




Source: EY analysis