



Global **EV** Outlook 2016

Beyond one million electric cars

INTERNATIONAL ENERGY AGENCY

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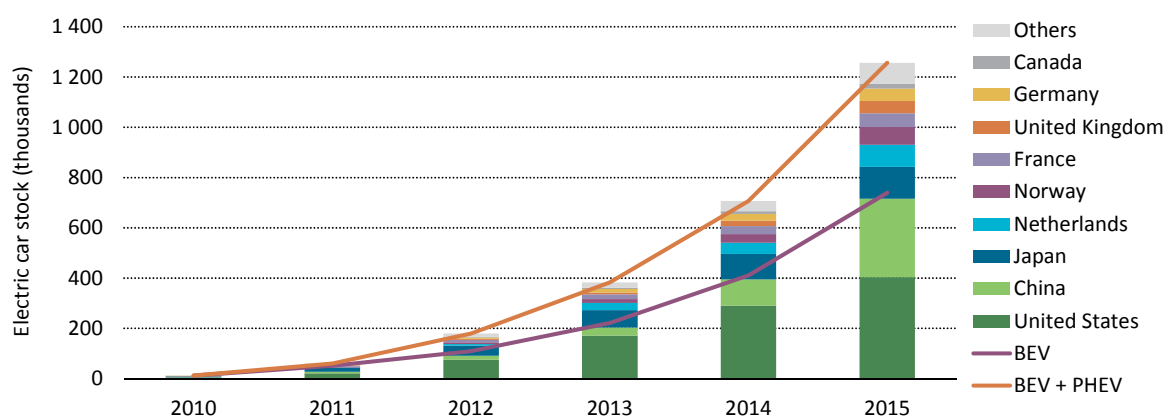
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Comments and questions on this report are welcome and should be addressed to transportInfo@iea.org.

Executive summary

The year 2015 saw the global threshold of 1 million electric cars¹ on the road exceeded, closing at 1.26 million. This is a symbolic achievement highlighting significant efforts deployed jointly by governments and industry over the past ten years. In 2014, only about half of today's electric car stock existed. In 2005, electric cars were still measured in hundreds.

Figure 1 • Evolution of the global electric car stock, 2010-15



Note: the EV stock shown here is primarily estimated on the basis of cumulative sales since 2005.

Sources: IEA analysis based on EVI country submissions, complemented by EAFO (2016), IHS Polk (2014), MarkLines (2016), ACEA (2016a), EEA (2015) and IA-HEV (2015).

Key point • The electric car stock has been growing since 2010, with a BEV uptake slightly ahead of PHEV uptake. 80% of the electric cars on road worldwide are located in the United States, China, Japan, the Netherlands and Norway.

Ambitious targets and policy support have lowered vehicle costs, extended vehicle range and reduced consumer barriers in a number of countries. The market shares of electric cars rose above 1% in seven countries in 2015: Norway, the Netherlands, Sweden, Denmark, France, China and the United Kingdom. Market shares reached 23% in Norway and nearly 10% in the Netherlands. China's booming electric car sales in 2015 made it the main market worldwide, before the United States, for the first time. China is also home to the strongest global deployment of e-scooters and electric buses.

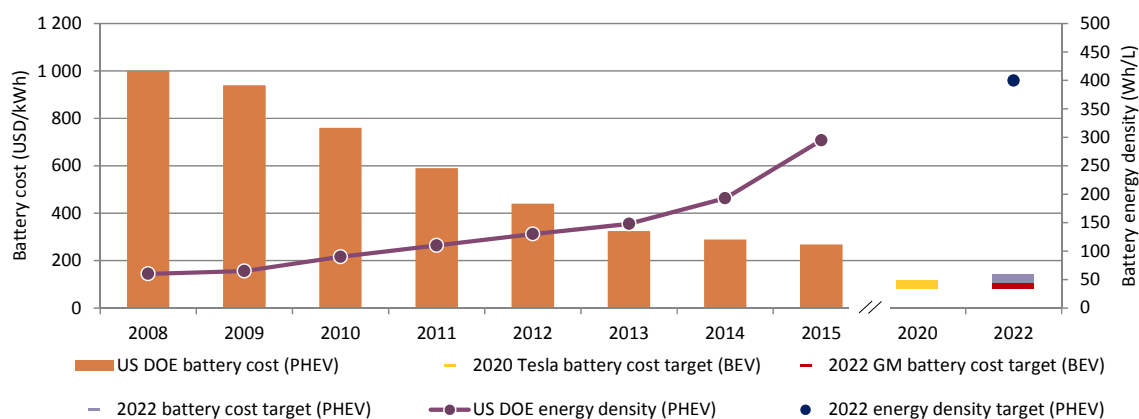
Substantial new implementation of electric vehicle supply equipment (EVSE) was also observed in 2015, on par with the growth of the global electric car stock. Public policies are encouraging publicly accessible charging development through direct investment and public-private partnerships. Such partnerships are occurring in urban areas and beyond, with charging networks aiming to enable long-distance travel on EVs even at the continental scale, as in the case of the European Union (EU).

Industry, governments and early adopters have succeeded in demonstrating that electric cars can deliver the practicality, sustainability, safety and affordability characteristics expected from them, but the EV market still requires policy support to achieve widespread adoption and deployment. Battery costs have been cut by a factor four since 2008 (Figure 2) and are set to

¹ Electric cars include battery electric, plug-in hybrid electric, and fuel-cell electric vehicles (BEVs, PHEVs, and FCEVs). The scope of this report, however, is limited to BEVs and PHEVs. References to electric cars and electric vehicles (EVs) used in this report shall be interpreted as references regarding exclusively these two categories. An extensive discussion on the status and prospects of FCEVs is available in the IEA Hydrogen and Fuel Cells Technology Roadmap (IEA, 2015a).

decrease further. In parallel, battery energy density needs to increase to enable longer ranges for lower prices. Technological progress and economies of scale are critical to move towards cost parity with conventional internal combustion engines (ICEs). Recent carmaker announcements suggesting EV ranges that will soon be exceeding 300 kilometres (km) give encouraging signals for the future.

Figure 2 • Evolution of battery energy density and cost



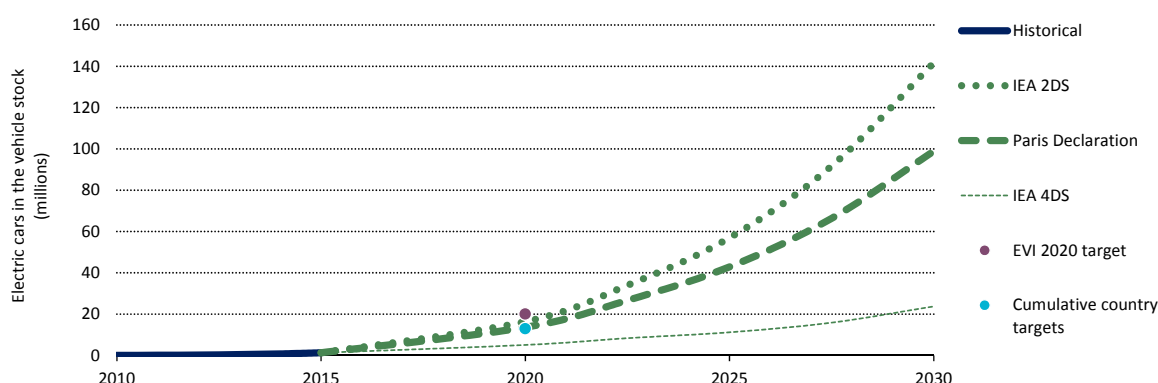
Notes: USD/kWh = United States dollars per kilowatt-hour; Wh/L = watt-hours per litre. PHEV battery cost and energy density data shown here are based on an observed industry-wide trend, include useful energy only, refer to battery packs and suppose an annual battery production of 100 000 units for each manufacturer.

Sources: US DOE (2015 and 2016) for PHEV battery cost and energy density estimates; EV Obsession (2015); and HybridCARS (2015).

Key point • The development of battery energy density and cost over the past decade gives encouraging signs on the possibility to meet targets defined by carmakers and the United States Department of Energy.

The electrification of road transport modes other than cars, namely 2-wheelers, buses and freight delivery vehicles, is currently ongoing in a few localised areas. With an estimated stock exceeding 200 million units, China is the global leader in the electric 2-wheelers market and almost the only relevant player globally, primarily because of the restriction on the use of conventional 2-wheelers in several cities to reduce local pollution. China is also leading the global deployment of electric bus fleets, with more than 170 000 buses already circulating today.

Figure 3 • Deployment scenarios for the stock of electric cars to 2030



Note: 2DS = 2°C Scenario; 4DS = 4°C Scenario.

Sources: IEA analysis based on IEA (2016), UNFCCC (2015b), the EVI 2020 target and the country targets assessment made in Table 3.

Key point • Reaching 2020 deployment targets for BEVs and PHEVs requires a sizeable growth of the electric car stock. Meeting 2030 decarbonisation and sustainability goals requires a major deployment of electric cars in the 2020s.

EVs of all types lie at the heart of future sustainable transport systems, alongside the optimisation of urban structures to reduce trip distances and shift mobility towards public transportation. The wide global deployment of EVs across all modes is necessary to meet sustainability targets. The EVI 20 by 20 target calls for an electric car fleet of 20 million by 2020 globally. The Paris Declaration on Electro-Mobility and Climate Change and Call to Action sets a global deployment target of 100 million electric cars and 400 million electric 2- and 3-wheelers in 2030. The IEA 2DS, describing an energy system consistent with an emissions trajectory giving a 50% chance of limiting average global temperature increase to 2°C, outlines an even more ambitious deployment pathway for electric cars by 2030 (150 million) (Figure 3). Meeting these targets implies substantial market growth to develop further the current 1.26 million electric car stock, as well as the swift deployment of electric 2-wheelers and buses beyond the Chinese market.

The climate change-related benefits of EVs can be fully harvested under the condition that their use is coupled with a decarbonised grid, an additional challenge for countries that are largely dependent on fossil fuels for power generation. Investment in EV roll-out can support this transition, e.g. increasing the opportunities available to integrate variable renewable energy. Early EV adoption also brings other immediate benefits (such as air quality improvements and reduced noise).

Introduction and scope

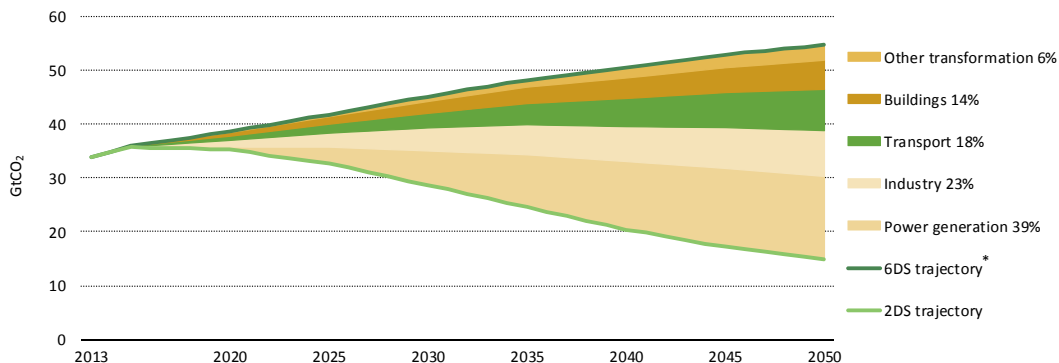
Introduction

The 21st Conference of the Parties (COP21) to the United Nations Framework Convention on Climate Change (UNFCCC) held in Paris in December 2015 reaffirmed the urgent need to strengthen, in the context of the transition to sustainable development and poverty eradication, the global response to the threat of climate change. The Paris Agreement, announced in December 2015, clearly set the objective to limit the global average temperature increase well below 2°C (UNFCCC, 2015a).

Meeting the objective set by the Paris Agreement can be achieved only provided that greenhouse gas (GHG) emissions from the energy system and non-energy sectors are reduced. The importance of mitigating emissions in the energy system is reflected in the 2DS of the IEA *Energy Technology Perspectives (ETP)* series (IEA, 2016a): the 2DS sets the target of cutting energy-related GHG emissions to roughly 15 gigatonnes (Gt) by 2050 (less than half of the 33 Gt emitted in 2013), and requires that they continue to fall thereafter (IEA, 2015c).

The transport sector accounts for about a quarter (23%) of global energy-related GHG emissions (IEA, 2015b). The ambitious GHG emissions reduction required to limit global warming to less than 2°C is unlikely to be achievable without a major contribution from the transport sector. The IEA 2DS indicates that the global transport sector must contribute about one-fifth of the total reduction of GHG emissions from energy use in 2050 (Figure 4).

Figure 4 • GHG emissions reductions by sector to 2050 on a 2DS trajectory versus a 6DS trajectory



* The IEA 6°C Scenario (6DS) is largely an extension of current trends and excludes the adoption of transformative policies of the energy system. By 2050, energy use almost doubles (compared with 2010) and total GHG emissions rise even more, leading to an average global temperature rise projected to be at least 6°C in the long term.

Note: GtCO₂ = gigatonnes of carbon dioxide.

Key point • Transport accounts for 18% of GHG emissions abatement in the 2DS (decarbonisation scenario) versus the 6DS (conservative projection based on the existing policy framework), by 2050.

EVs², primarily BEVs and PHEVs, are seen as a major contributor to the 2DS GHG emissions reduction goal in transport, as they increase energy efficiency and reduce carbon intensity of

² Electric cars include battery electric, plug-in hybrid electric, and fuel cell electric vehicles (BEVs, PHEVs, and FCEVs). The scope of this report, however, is limited to BEVs and PHEVs. References to electric cars and electric vehicles used in this report shall be interpreted as references regarding exclusively these two categories. An extensive discussion on the status and prospects of FCEVs is available in the IEA Hydrogen and Fuel Cells Technology Roadmap (IEA, 2015a).

transport energy carriers, while taking advantage of the reduction of GHG emissions in power generation and supporting the integration of variable renewable energy in the power generation mix.³ In a context of ever-growing urban populations, BEVs and PHEVs are also well equipped to reduce emissions of local pollutants in high-exposure areas and reduce noise levels. Key barriers to EV market penetration include battery costs and ranges, both areas where recent developments provide encouraging signs.

The 2DS of the IEA *ETP 2016* helps in understanding the importance of EVs and FCEVs for the achievement of increased sustainability in transport. In the IEA 2DS, their contribution in the light-duty vehicle (LDVs) stock exceeds 150 million (10% of the total) by 2030. Nearly 1 billion EVs, representing more than 40% of the total LDV stock, are in circulation in the 2DS by 2050. The stock of electric 2-wheelers exceeds 400 million in 2030 (40% of the global total). Two-wheelers become fully electrified by 2050 (IEA, 2016b).⁴

Today, EVs account for just a tiny fraction of the global vehicle stock (0.1% for cars) for all transport modes except 2-wheelers (electric 2-wheelers are about one-fifth of the global total). This is still not significant enough to impact the actual fuel consumption and GHG emissions from the transport sector as a whole. However, important signs of change emerged in the recent past. Countries such as Norway, the Netherlands and China witnessed an impressive growth of EV sales over the past five years and are now thriving EV markets for LDVs. The case of electric scooters in China, currently representing about 40% of the Chinese 2-wheeler stock (up from 1% in 2000), is also remarkable.

This development would not have been possible without policy support. Growing EV market shares are expected to progressively reduce technology costs in the forthcoming years, thereby making EVs an increasingly attractive option. Once electric cars are produced in large volumes, the cost differences between electric cars (both BEV and PHEV) and those using improved ICEs may fall below 10% of the total vehicle cost (IEA, 2016b), making them increasingly competitive. Some analysts even suggest that electric car costs may reach those of competing ICE vehicles within a decade (BNEF, 2016a). Electric scooters, costing less than 500 United States dollars (USD) in China, are already cost-competitive today.

The EVI

The EVI is a multi-government policy forum established in 2009 under the Clean Energy Ministerial (CEM), dedicated to accelerating the deployment of EVs worldwide with the goal of a global deployment of 20 million electric cars by 2020 (CEM, 2016).

The EVI counts today 16 member governments (Canada, China, France, Germany, India, Italy, Japan, Korea, the Netherlands, Norway, Portugal, South Africa, Spain, Sweden, the United Kingdom and the United States), representing most of the global EV stock and including the largest and most rapidly growing EV markets worldwide. China and the United States are co-chairs of the initiative, and the EVI secretariat is hosted by the IEA.

³ FCEVs also compete with BEVs and PHEVs as a decarbonisation solution. Other relevant solutions capable of contributing to several sustainability goals for the transport sector include the accelerated deployment of energy efficiency on all vehicles, avoiding transport activity (e.g. via application of integrated urban and transport planning), shifting mobility to energy-efficient transport modes (namely public transport), and the increased use of sustainable biofuels.

⁴ These values are also consistent with the Paris Declaration on Electro-Mobility and Climate Change, announced at COP21. The declaration targets more than 400 million electric 2-wheelers (up from more than 200 million today, nearly all in China) and more than 100 million EVs (up from 1 million today) by 2030.

Partnerships have been established with AVERE, GreenTech Malaysia, ICCT (hosting the secretariat of the International Zero-Emission Vehicle Alliance), the IEA Technology Collaboration Programme on Hybrid and Electric Vehicle Technologies and Programmes (IA-HEV), the International Renewable Energy Agency (IRENA), King Mongkut's University of Technology Thonburi (Thailand), the Lawrence Berkeley National Laboratory (LBNL), the United Nations Human Settlements Programme (UN Habitat), the United Nations Industrial Development Organization (UNIDO) and Urban Foresight.

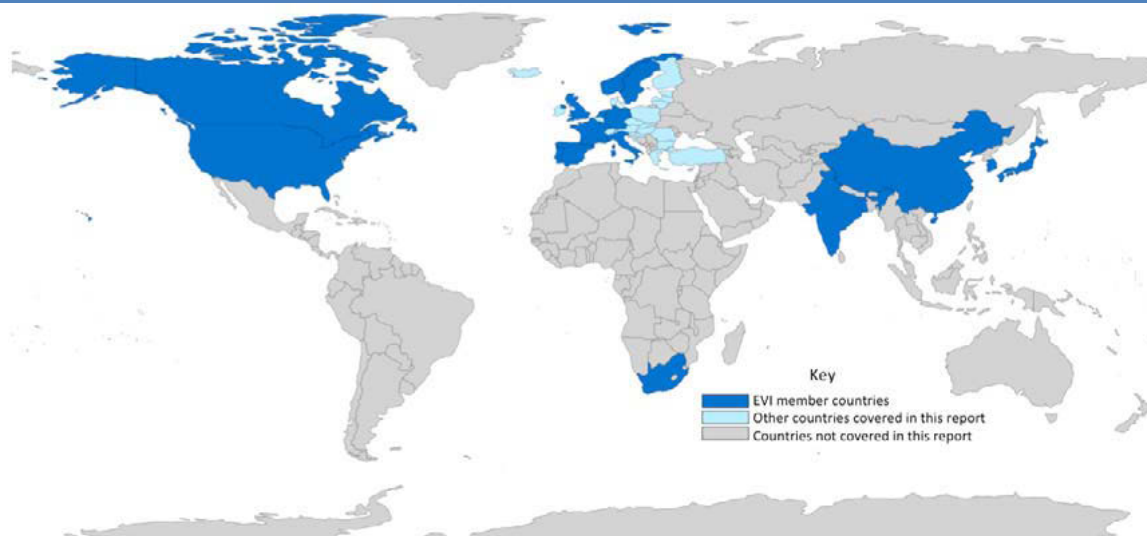
The EVI brings together representatives of its member governments and partners twice per year and acts as an effective platform for knowledge-sharing on policies and programmes that support EV deployment. To date, the EVI has developed analytical outputs that include earlier editions of the “Global EV outlook” (EVI, 2015a, 2013) and two editions of the EV city casebook (EVI, 2014, 2012), with a focus on initiatives taking place at the local administrative level. The EVI has also successfully engaged private-sector stakeholders in roundtables in Paris in 2010; in Stuttgart in 2012 and at COP21 in 2015 (EVI, 2015b) to discuss the roles of industry and government in the EV market as well as the opportunities and challenges ahead for EVs.

The EVI is now in the process of discussing the evolution of its nature towards a new phase of development (EVI 2.0). This builds on the increasing likelihood of a large-scale transition in transport based on higher EV uptake, and is driven by the commitment of its co-chairs. EVI 2.0 areas of focus include knowledge development and sharing (e.g. analytical reports, exchange of experiences in policy development, research activities and outreach), the development of tools facilitating EV deployment, training and peer-to-peer technical assistance, and consultation.

Scope of this report

This report aims to provide an update on recent developments in EV registrations (vehicle sales), EV stock estimates (mainly based on cumulative sales), and the availability and characteristics of EVSE. It also touches upon research aspects (e.g. the evolution of battery costs and energy density) and the profile of policy support in selected economies. The countries covered include EVI members and those included in the European Alternative Fuels Observatory (Figure 5).

Figure 5 • Country coverage of the “Global EV outlook 2016”



Note: This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries, and to the name of any territory, city or area.

Key point • The “Global EV outlook 2016” covers 40 countries and about 98% of the global electric car stock.

This report concerns mainly the electric car market, and does not cover other transport modes with the same detail. This focus on the car market is due to both its dynamism and the wider availability of data for this vehicle group. Information on cars is complemented by targeted details on 2-wheelers, low-speed electric vehicles (LSEVs) and buses, with a focus on cases that have had an impact on the indicators discussed and have implications for future market developments.

Data sources

The main sources of information used in this report include submissions from EVI members, statistics and indicators available from the European Alternative Fuels Observatory (EAFO, 2016) for European countries that are not members of the EVI (Figure 5),⁵ data extracted from commercial databases (IHS Polk, 2014; MarkLines, 2016) and information released by relevant stakeholders (ACEA, 2016a and 2016b; EEA, 2015).

EV deployment

This section reviews the latest developments in new registrations and the stock of EVs, looking primarily at electric cars and focusing on the developments that took place in 2015 as well as trends since 2010. Stock and sales figures are assessed against policy support schemes and country commitments on EV deployment for the 2020, 2025 or 2030 time horizons (depending on national settings), as well as for the EVI 20 by 20 target.

Electric cars

Market evolution

New registrations of electric cars (including both battery electric and plug-in hybrids) increased by 70% between 2014 and 2015, with over 550 000 vehicles being sold worldwide in 2015.

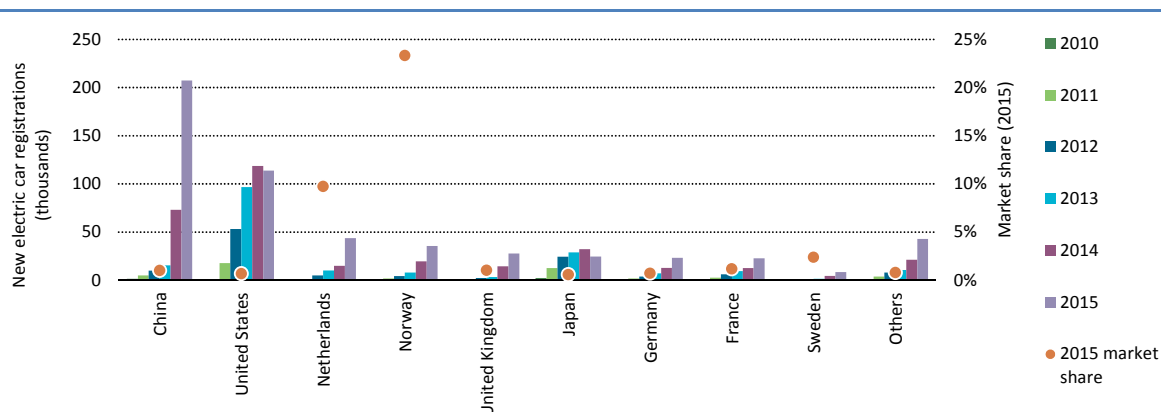
The United States was overtaken by China as the largest market for electric cars in 2015, with over 200 000 new registrations (Figure 6). Taken together, these two markets accounted for more than half of the global new electric car registrations in 2015.

The market share of electric cars in 2015 was close to 1% for China and 0.7% for the United States. New registrations of electric cars declined in the United States between 2014 and 2015, while they experienced a threefold growth in China.

In 2015, 90% of car sales took place in eight main electric car markets: China, the United States, the Netherlands, Norway, the United Kingdom, Japan, Germany and France. All of these markets except Japan and the United States experienced sustained growth between 2014 and 2015. Sales more than doubled in the Netherlands, where the market share of electric cars reached close to 10% (Figure 6), the highest in the European Union and the second-highest globally, after Norway (23%). The 2015 year-on-year sales growth for electric cars also exceeded 75% in France, Germany, Korea, Norway, Sweden, the United Kingdom and India.

⁵ Unless otherwise stated, the report covers Canada, China, Iceland, India, Japan, Korea, Norway, South Africa, Switzerland, Turkey, the United States and each of the member countries of the European Union (EU 28).

Figure 6 • EV sales and market share in a selection of countries and regions, 2015



Sources: IEA analysis based on EVI country submissions, complemented by EAFO (2016), IHS Polk (2014), MarkLines (2016), ACEA (2016a) and EEA (2015).

Key point • The two main electric car markets are China and the United States. Seven countries have reached over 1% EV market share in 2015 (Norway, the Netherlands, Sweden, Denmark, France, China and the United Kingdom).

Financial incentives and the availability of charging infrastructure emerged as factors that were positively correlated with the growth of electric vehicle market shares (Sierzchula et al, 2014 and Li et al., 2016). The Netherlands and Norway, the two markets with the highest market shares, implemented a range of measures favouring consumers that opt for electric cars. In the Netherlands, electric cars enjoy very significant reduction on registration and circulation taxes (see details in the following section), as well as privileged access to some portions of the transport network restricted for other cars. Norway provides strong incentives in the form of registration tax reductions and, for BEVs, the exemption from value-added tax (VAT), waivers on road tolls and ferries, and access to bus lanes.

Policy support

Thanks to much better efficiency, electric cars offer much lower running costs than comparable vehicles using ICEs: with current electricity and fuel taxation, a 100 km trip would cost about one-fourth to one-fifth of the cost of using a car powered by a conventional ICE in Europe, and roughly half in the United States. Over five years, this translates to fuel savings that exceed USD 3 000 in Europe, and about USD 2 000 in the United States, where higher mileages and vehicle sizes compensate for some of the fuel taxation gap with Europe.

Important barriers to greater adoption of electric cars over the past years include range limitations and vehicle costs, both of which can be attributed to the high cost of energy storage technologies. Additional barriers relate to the need to access recharging facilities, costs and other challenges associated with their installation, as well as the lack of awareness or confidence in the technology.

Benefits for local pollution reduction, energy diversification and climate change mitigation, as well as the encouraging signs observed in cost and performance developments in the recent past, are the main drivers of the deployment of a variety of policy support mechanisms supporting the market uptake of electric cars and attempting to overcome these barriers. This section provides an overview of these instruments (other support mechanisms, looking at EVSE, are discussed in the EVSE section of this report).

Box 1 aims to discuss some of the results achieved with "technology push" actions, focusing on direct research, development and demonstration (RD&D) support. The rest of the analysis will focus on "market pull" policies.

Box 1 • RD&D: Developments in battery cost and performance

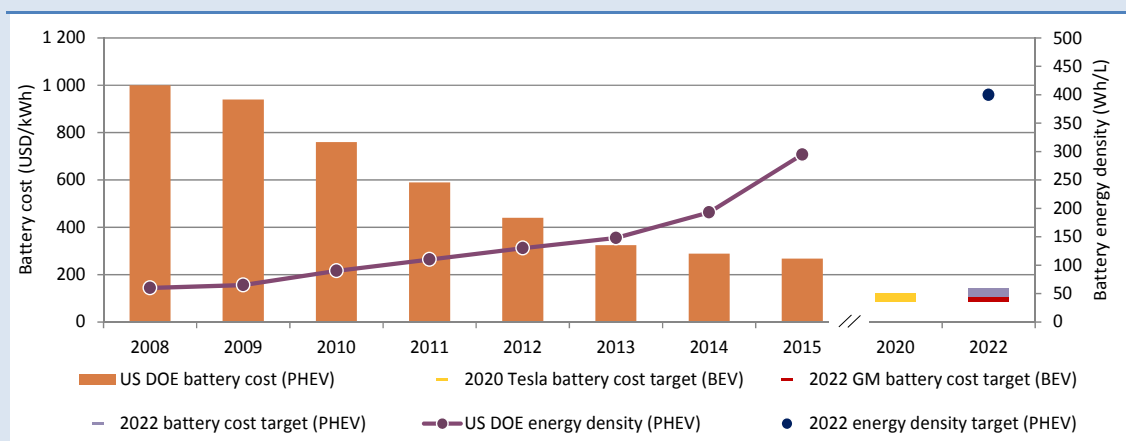
Technology learning, RD&D and mass production led to rapid cost declines and performance improvements in the past decade and hold the promise of continuing to progressively reduce technology costs in the near future.

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The figure below shows that PHEV battery cost estimates monitored by the US DOE fell from about USD 1 000/kWh in 2008 to USD 268/kWh in 2015, which represents a 73% reduction in seven years (US DOE, 2016). The US DOE set a target of USD 125/kWh by 2022 to achieve cost-competitiveness of PHEV batteries relative to vehicles using conventional engines in the United States (US DOE, 2015). Meeting this target implies an additional 58% cost decrease in the next seven years, corresponding to a 10.3% cost decrease every year between 2016 and 2022. This target seems realistic in regard to the improvements already achieved since 2008, although cost decreases have slowed down in the most recent years, with only a 7% drop between 2014 and 2015.

Some original equipment manufacturers announced even more ambitious cost estimates for BEVs: General Motors announced that battery costs for its 2016 Chevrolet Bolt had fallen to USD 145/kWh by October 2015, and that it hopes to reduce costs below the USD 100/kWh mark by 2022 (GM, 2015, EV Obsession, 2015). The electric car manufacturer Tesla aims to break the USD 100/kWh mark by 2020 (HybridCARS, 2015).

Evolution of battery energy density and cost



Note: PHEV battery cost and energy density data shown here are based on an observed industry-wide trend, include useful energy only, refer to battery packs and suppose an annual battery production of 100 000 units for each manufacturer.

Sources: US DOE (2015 and 2016); EV Obsession (2015); and HybridCARS (2015).

Key point • The development of battery energy density and cost over the past decade gives encouraging signs on the possibility to meet targets defined by carmakers and the United States Department of Energy.

Improvements in the energy density of batteries allowed a larger electric range of commercially available EVs, making significant progress to address range anxiety issues. In 2008, the energy density of PHEV batteries was at 60 Wh/L. In 2015, it attained 295 Wh/L, improving by almost 400% (US DOE, 2016). The 400 Wh/L target set by the US DOE to 2022 requires an additional 36% improvement to be achieved in the next seven years (US DOE, 2012).








Improvements in battery cost and energy density have led carmakers to announce EV ranges never heard of to date. As an example, in March 2016 Tesla launched orders for its new Model 3, committing to an electric drive range of nearly 350 km on a single charge by 2017, when the first vehicles are scheduled for delivery to customers (Tesla, 2016).

The analysis that follows looks at "market pull" policies, including:

- regulatory measures (e.g. tailpipe emissions regulations and fuel economy standards, sometimes including credits that favour electric cars, such as mechanisms that allow increased weight of EVs when accounting for corporate average fuel economy standards)
- financial levers (e.g. differentiated vehicle taxation, based on fuel economy or GHG emissions per kilometre and/or directly targeting electric cars)
- other instruments, such as waivers on parking fees and tolls, as well as waivers on access restrictions (e.g. bus or high-occupancy vehicle [HOV] lanes).

Table 1 • Summary of policy support mechanisms for EV uptake in place in selected countries in 2015

	EV purchase incentives				EV use and circulation incentives				Waivers on access restrictions			Tailpipe emissions standards		Market share of electric cars in 2015
	Rebates at registration/sale	Sales tax exemptions (excl. VAT)	VAT exemptions	Tax credits	Circulation tax exemptions	Waivers on fees (e.g. tolls, parking, ferries)	Electricity supply reductions/exemptions	Tax credits (company cars)	Access to bus lanes	Access to HOV lanes	Access to restricted traffic zones*	Fuel economy standards/regulations including elements	Road vehicles tailpipe pollutant emissions standards	
Canada													Tier 2	0.4%
China													China 5	1.0%
Denmark													Euro 6	2.2%
France													Euro 6	1.2%
Germany													Euro 6	0.7%
India													Bharat 3	0.1%
Italy													Euro 6	0.1%
Japan													JPN 2009	0.6%
Netherlands													Euro 6	9.7%
Norway													Euro 6	23.3%
Portugal													Euro 6	0.7%
South Korea													Kor 3	0.2%
Spain													Euro 6	0.2%
Sweden													Euro 6	2.4%
United Kingdom													Euro 6	1.0%
United States													Tier 2	0.7%

Legend:	
	No policy
	Targeted policy **
	Widespread policy***
	Nationwide policy
	General fuel economy standard, indirectly favouring EV deployment
	Euro 6
	Pollutant emissions standard in place in 2015

Notes: * Such as environmental/low emission zones.

** Policy implemented in certain geographical areas (e.g. specific states/regions/municipalities), affecting less than 50% of the country's inhabitants.

*** Policy implemented in certain geographical areas (e.g. specific states/regions/municipalities), affecting more than 50% of the country's inhabitants.

Key point • Tailpipe emissions regulations and EV purchase incentives are provided primarily at the national or State level, while measures facilitating the circulation of EVs tend to stem from local policies.

Table 1 shows that regulatory instruments such as fuel economy standards and incentives for purchasing EVs are almost systematically decided by the central government at a nationwide level, while circulation incentives and waivers to access restrictions (typically related to the road network) are more frequently adopted at the local level. This situation reflects the distribution of competences on taxation instruments (very often primarily coupled with state-level governments), the advantage of harmonised regulatory developments and the need to act at the local administrative level on issues related to the use of the road network.

The following sections briefly outline the characteristics of some of the policy instruments in Table 1.

Tailpipe emissions standards

The deployment of energy-efficient vehicles is encouraged by increasingly stringent fuel economy or tailpipe carbon dioxide (CO₂) emission standards, as well as stringent regulations on the emission of local pollutants. With zero tailpipe emissions and very good energy efficiency, EVs are well placed to benefit from these regulations. In order to deliver climate change benefits, EVs need to be delivering net GHG savings across the whole life cycle of the vehicle and fuel production and use. The use of electric cars results in net CO₂ savings only if vehicles are coupled with the electricity generated to charge the battery has a carbon intensity below 700 grammes of CO₂ per kilowatt-hour (g CO₂/kWh) (IEA, 2014), a challenge for countries that are largely dependent on coal for power generation.

All the countries listed in Table 1 have legislation in place to regulate the fuel economy and pollutant emissions of new vehicle registrations.

EV deployment is also favoured by specific features of the regulatory texts, such as the European super-credits, that allow increasing the weight of EVs in the evaluation of corporate average fuel economy standards. European countries, the United States and Canada apply such mechanisms (see column "Fuel economy standards/regulations including elements favouring EVs" in Table 1), even if super-credits may have a detrimental effect on the achievement of the overall fuel economy target (Archer, 2013).

EV purchase incentives

The comparative analysis of policy support schemes carried out for the United States by Jin, Searle and Lutsey (2014) suggests that purchase incentives are among the most relevant (in terms of financial support per vehicle) and the most effective instruments promoting electric car sales, even if further analysis is needed to better assess the impacts of non-fiscal, local and infrastructure actions.

The characteristics of purchase incentives are further explored in the list below, focusing primarily on countries with higher-than-average EV market shares.

- Electric cars in China enjoy an exemption from acquisition tax and from the excise tax, normally based on engine displacement and price (Mock and Yang, 2014). The value of the incentives was in the range of 35 000 Yuan renminbi (CNY) to CNY 60 000 (USD 6 000 to USD 10 000) to purchase electric cars (Lutsey, 2015). The analysis of Mock and Yang (2014) suggests that the lower-end estimate is best suited for PHEVs, while the higher incentive level is more likely to be applicable to BEVs.
- France began offering in 2013 purchase incentives of 6 300 euros (EUR) (USD 7 100) for BEVs (cars emitting less than 20 grammes of CO₂ per kilometre [g CO₂/km]) and EUR 1 000 (USD 1 100) for PHEVs (vehicles emitting between 20 g CO₂/km and 60 g CO₂/km) through its *bonus/malus* feebate scheme (MEEM, 2016a). Scrapping diesel vehicles allows a supplementary bonus of EUR 10 000 (USD 11 000) for BEVs and EUR 3 500 (USD 4 000) for PHEVs (MEEM, 2016b).
- Lutsey (2015) summarised Japanese incentives, indicating that subsidies are based on the price difference between an EV and a comparable gasoline car, with a maximum of 850 000 yen (about USD 7 800). Mock and Yang (2014) indicated that incentives amounted to EUR 3 000 to EUR 5 000 (USD 3 300 to USD 5 500) for typical BEVs and PHEVs.
- In the Netherlands, in 2016, cars emitting zero CO₂ at the tailpipe are exempt from paying registration tax. For other cars there is a differentiated taxation scheme with five levels of CO₂ emissions with progressively increasing taxation per g CO₂/km. PHEVs qualify for the first level (below 80 g CO₂/km) and pay EUR 6 per g CO₂/km. Diesels emitting more than 70 g CO₂/km

also pay EUR 86 per g CO₂/km (EVI, 2016a and Energielabel, 2016). This kind of structure provides significant benefits for both BEVs and PHEVs compared with vehicles powered by ICEs, with a steep growth for models having ICEs with emissions ratings above 106 g CO₂/km. The condition for exemption from the registration tax has become stricter since 2013, when it started to be fully coupled with CO₂ emission performances (Energielabel, 2016).

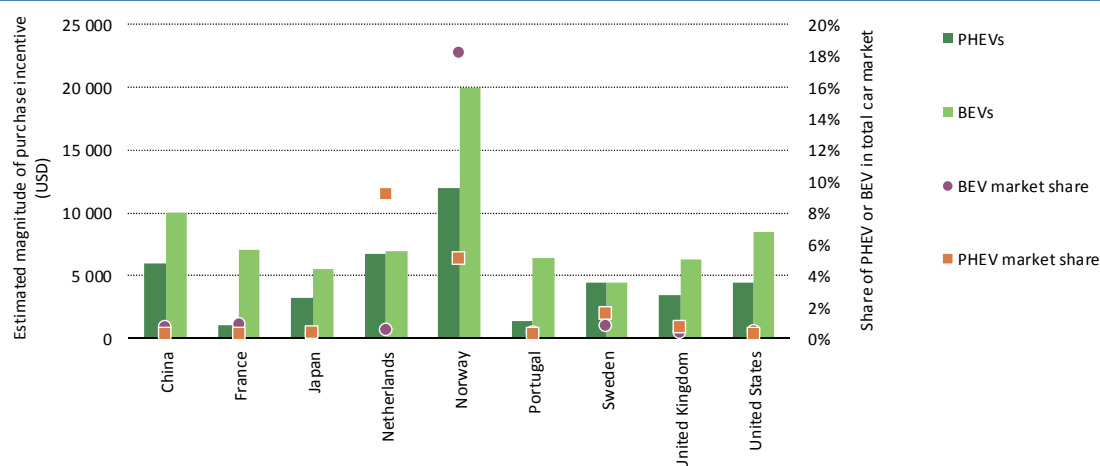
- In Norway, EVs are exempt from purchase taxes (about 100 000 kroner [NOK] – USD 12 000) (OECD, 2015). BEVs are also exempt from VAT (set to 25% of the vehicle price before tax). The VAT exemption does not apply to PHEVs (Mock and Yang, 2014).
- In Portugal, BEVs are exempt from vehicle registration (about EUR 1 250, or USD 1 400) and circulation taxes (Saldopositivo, 2014). Scrapping existing vehicles for a selection of BEVs also entitles buyers to a bonus of EUR 4 500 (USD 5 000) (Apambiente, 2016; IMT, 2016). PHEVs are not eligible for specific incentives.
- In Sweden, passenger vehicles with emissions levels lower than 50 g CO₂/km have been granted a 40 000 kronor (roughly EUR 4 000 or USD 4 400) rebate since 2011.
- In the United Kingdom, BEVs receive a purchase incentive up to 4 500 pounds (GBP) (USD 6 300) for cars and GBP 8 000 (USD 11 200) for light commercial vehicles; PHEVs below GBP 60 000 (USD 84 000) receive incentives equal to GBP 2 500 (USD 3 500) (GOV.UK, 2016a).
- In the United States, EVs enjoy tax credits capped at USD 7 500 at the national level. PHEV models with all-electric ranges (18 km to 40 km) receive credits of USD 2 500 to USD 4 000; BEV models and some PHEV models with relatively high all-electric range (e.g. Chevrolet Volt) receive the maximum USD 7 500 credit (Lutsey et al., 2015). States also apply purchase incentives (AFDC, 2016). For instance, California offers incentives of USD 2 500 for EVs and USD 5 000 for FCEVs (or more for low-income consumers); Colorado offers an income tax credit of up to USD 6 000; Connecticut offers up to USD 3 000 in rebates and Delaware up to USD 2 200. Jin, Searle and Lutsey (2014) estimated a range between USD 1 000 and USD 6 000 for BEV and PHEV purchase incentives at the state level, and an average value for the incentive offered to EV purchasers across the United States close to USD 1 000, both for BEVs and PHEVs.

Figure 7 provides a summary of the information above, showing estimates of indicative purchase incentives and market shares for BEVs and PHEVs in the total car market for the year 2015 (Box 2 aims at discussing the various BEV vs. PHEV success patterns that can be observed in a number of leading electric car markets). This can be compared with an estimated incremental cost of an electric car (BEV), assuming a 200 km range and a 34 kilowatt-hour (kWh) battery (whose cost is assumed to be USD 268/kWh⁶), of roughly USD 8 400 with respect to a car powered by a gasoline ICE.⁷ The incremental cost for a PHEV, based on the same engine and battery cost assumptions and a 40 km pure electric range, is USD 3 500.

⁶ This reflects the estimates of US DOE (2016), relative to PHEV battery packs. The value for BEVs could actually be lower if the chemistry in similar battery packs is calibrated to higher energy density rather than power density.

⁷ The estimated cost of a baseline gasoline ICE is USD 2 500, a value consistent with the estimate of Concawe, EUCAR and JRC (2008).

Figure 7 • Purchase incentives and market shares for BEVs and PHEVs, 2015



Note: estimates for the Netherlands are calculated as the difference between the tax paid by a BEV and a PHEV emitting 50 g CO₂/km and the average of the tax paid by a gasoline and a diesel car emitting 130 g CO₂/km. Incentives in Norway are based on an average electric car cost (before VAT) of USD 30 000.

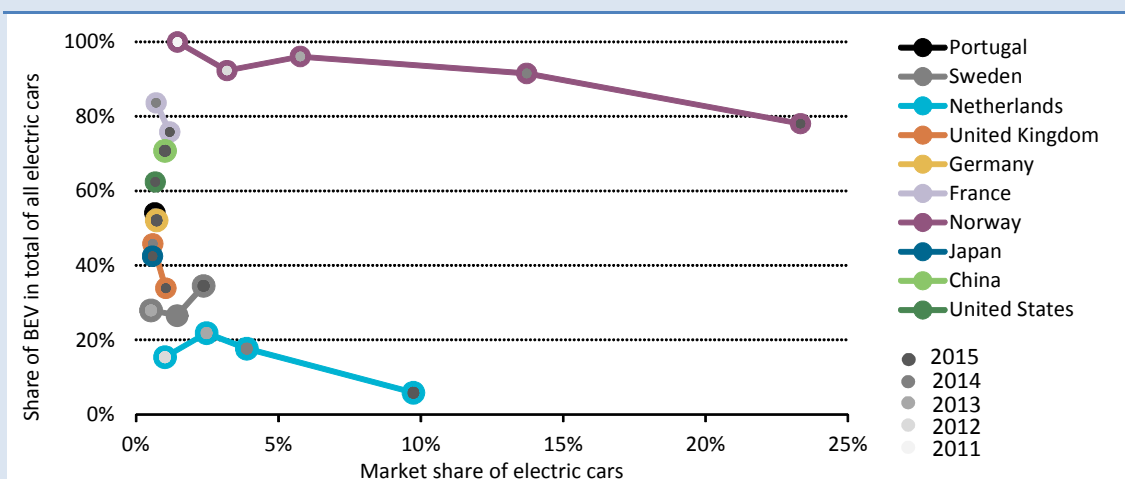
Key point • Policies deployed in different countries result in different purchase incentives and BEV over PHEV adoption patterns, with Norway's purchase incentives level standing out for both BEVs and PHEVs.

Box 2 • Electric car market characteristics: BEVs or PHEVs?

The figure below shows the evolution of BEV shares against total market shares of electric cars in countries where the share of electric cars exceeded 0.5% in 2015. When accounting for all the countries covered in this report, the BEV share was 59%, but the figure below demonstrates that the relevance of BEVs and PHEVs in different national EV market structures varies significantly.

- Most of the electric cars entering the Norwegian EV market are BEVs. This reflects the structure of Norwegian incentives, which tend to favour BEVs (largely exempt from registration taxes and VAT) over PHEVs (subject to significantly lower levels of tax exemptions) (Mock and Yang, 2014).
- The market distribution is significantly different in the Netherlands, the country with the second-largest electric car market share in 2015, as most of the newly registered electric cars were PHEVs. In the Netherlands, registration and circulation or ownership taxes are largely based on the specific CO₂ emissions of a vehicle per kilometre driven, with strong reductions below 82 g CO₂/km. Until 2015, BEVs and PHEVs were enjoying similar tax reductions on registration and circulation, even if rebates were more significant for BEVs (Mock and Yang, 2014; Munnix, 2015). In 2016, the rebates for circulation taxes for PHEVs were halved compared with BEVs (Energilabel, 2016). Consumer preferences were less affected by differentiations in incentives between PHEVs and BEVs in comparison with Norway, and resulted in a stronger market uptake of PHEVs, offering larger flexibility and lower acquisition costs.
- Sweden, the country with the third-largest EV market share in 2015, applies tax breaks that resulted in higher purchase incentives for PHEVs (Mock and Yang, 2014). The Swedish incentive scheme is closer to the Dutch profile than to the Norwegian one. As in the case of the Netherlands, this oriented the Swedish electric car market towards PHEVs, limiting the BEV share to roughly a third of all EVs sold in 2015.
- France and Portugal have policy support profiles that are significantly more favourable for BEVs than for PHEVs. This is consistent with a comparatively higher share of BEVs in their market. Comparatively higher PHEV shares in the United Kingdom are compatible with higher purchase incentives for PHEVs with respect to France and Portugal.

Evolution of BEV shares against total EV market shares in selected countries, 2010-15



Note: countries with EV market shares below 1% are shown only for the most recent year.

Key point: Customer preferences for electric cars in different markets have a varying degree of orientation towards BEVs or PHEVs. This is influenced by the characteristics of national policy support schemes.

EV use and circulation incentives⁸

Examples of countries exempting BEVs and PHEVs from circulation/ownership taxes are summarised in the list below.

- In China, EVs are exempted from circulation/ownership taxes.
- BEVs weighing less than 2 tonnes are exempted from annual circulation tax in Denmark.
- In France, BEVs and some PHEVs are exempted from annual taxation for company cars.
- In Germany, BEVs and PHEVs are exempt from circulation tax for a period of ten years from the date of their first registration.
- In the Netherlands, zero-emission cars are exempt from paying road taxes. In 2015, this also applied to PHEVs emitting less than 50 g CO₂/km. As of 2016, they are subject to charges that are only 50% of the road tax for a regular car.
- Japan has EV exemptions from annual tonnage tax and reductions for automobile tax.
- EVs are exempted from road taxes (based on CO₂ emissions) and part of company car taxes in Sweden.
- In the United Kingdom, the excise duties starting from the second year of purchase are based on the CO₂ emissions per kilometre ratings: BEVs and some PHEVs are exempt (this is also the case for the first year, due to purchase incentives). BEVs are also exempt from company car taxes.
- In the United States, states apply annual fees and provide exemptions for EVs.

Furthermore, in Wuhan, China, tolls on city roads, bridges and tunnels are waived from 2014 to 2016. In Denmark, municipalities can differentiate charging payments for parking lots up to 5 000 kroner (DKK) (USD 735) per year to give preferential treatment to EVs. In Germany, 2015 framework legislation allows municipalities to offer free or dedicated parking. Waivers of fees (e.g. tolls, parking, ferries) are widely available in Norway and are also applied by local

⁸ This section is based on a collection of information from EVI country submissions (EVI, 2016a to 2016e), Lutsey (2015), Mock and Yang (2014), IA-HEV (2015) and OECD (2015).

governments in Japan. In the United Kingdom, BEVs and PHEVs are eligible for a full waiver of the London Congestion Charge.

Electricity supply reductions/exemptions, leading to lower operational costs for EV users, exist in France, Japan, Norway, the United Kingdom, the United States, South Korea and Portugal. In Wuhan (China), new energy vehicles get free recharging in designated places from 2014 to 2016.

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In Denmark, companies that supply EV charging on a commercial basis can receive an electricity tax rebate that amounts to approximately DKK 1 (USD 0.15) per kWh.

Waivers on access restrictions

Examples of waivers of access restrictions provided to EVs include access to bus lanes in Ontario (until 2015) (OECD, 2015) and in Norway (Lutsey, 2015), as well as in some French cities (EVI, 2016c). In the United Kingdom, Nottingham, Bristol, Milton Keynes and London, as winners of the Go Ultra Low City Scheme, are entitled to give plug-in car owners extra local privileges, including access to bus lanes in city centres (GOV.UK, 2016b). The framework legislation introduced in 2015 in Germany also enables local administrations to allow EV access to bus lanes and other restricted areas (Mock and Yang, 2014). Waivers of access restrictions can also include access to HOV lanes and are implemented at the local level in Spain (BOE, 2015) and the United States (EVI, 2016d).

Over the past decades, China adopted policies restricting the availability of license plates in its major urban agglomerations. These "increment control" measures on motor vehicles consist primarily of lotteries and/or auctions issuing new license plates up to a certain annual quota. Cities listed in Table 2 implemented these policies. Between 2013 and 2014, they also introduced specific waivers for new energy vehicles.⁹ The city of Guiyang adopted policies restricting access to certain areas of the city for vehicles not having specific plates (issued via lottery systems and/or auctions).

Table 2 • Policies restricting availability of license plates in China and waivers for new energy vehicles

Cities	Since	Details	Waiver for new energy vehicles	Details
Beijing	2010	Lottery	2013	Quota exists, but odds are better for new energy vehicles
Guangzhou	2012	Lottery	2014	New energy vehicles allowed license plate
Guiyang	2011	Lottery	2015	New energy vehicles allowed license plate
Hangzhou	2014	Combined lottery and auction	2014	New energy vehicles allowed license plate
Shanghai	1994	Auction	2014	Quota on new energy vehicles allowed license plate
Shenzhen	2014	Combined lottery and auction	2014	Quota exists, but odds are better for new energy vehicles
Tianjin	2013	Combined lottery and auction	2014	New energy vehicles allowed license plate

Sources: Auto Home (2014), China Youth Daily (2014), Xinhua (2013), Xinhua (2011), Beijing Municipal Government (2010), Dongfang (2013), Colorful Guizhou (2015), MIIT (2009) and Jun (2015).

Key point • China tackles its pressing traffic and air pollution issues by restricting opportunities to own conventional ICE cars and favouring the adoption of electric models.

⁹ New energy vehicles include BEVs, PHEVs, FCEVs, vehicles using hydrogen and dimethyl ether as a fuel, and other vehicles with highly efficient energy storage devices. BEVs and PHEVs have been those with the most significant market uptake.

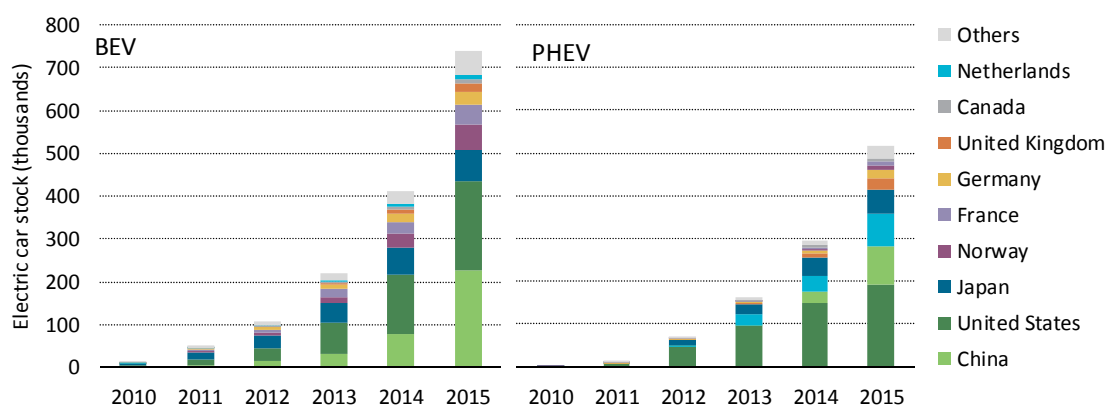
Vehicle stock

The electric car stock for the countries covered in this report reached 1.26 million in 2015, a value more than 100 times larger than the 2010 estimate, breaking for the first year the threshold of 1 million electric cars on the road (Figure 8).

In 2015, North America (mostly the United States) accounted for 34% of the electric car stock of the countries covered in this report (Figure 2). Close to one-third of the electric cars were located in Europe, where the Netherlands accounted for 23% of the total, Norway for 18%, and France, Germany and the United Kingdom for 13% to 14% each. Asia accounted for 36%: in 2015, one electric car out of four was in China, and one out of ten was in Japan.

The global electric car stock growth exceeded 77% in 2015 and 84% in 2014, slightly declining from the period 2011-13, when the number of electric cars more than doubled every year. In 2014 and 2015, the strongest increases took place in China, Korea, the United Kingdom, Sweden, Norway, the Netherlands and Germany.

Figure 8 • Evolution of the global electric car stock, 2010-15



Note: the EV stock shown here is primarily estimated on the basis of cumulative sales since 2005.

Sources: IEA analysis based on EVI country submissions, complemented by EAFO (2016), IHS Polk (2014), MarkLines (2016), ACEA (2016a) and EEA (2015).

Key point • The electric car stock has been growing since 2010, with a BEV uptake slightly ahead of PHEV uptake. 80% of the electric cars on road worldwide are located in the United States, China, Japan, the Netherlands and Norway.

Progress towards deployment targets

In spite of the current fast-evolving and promising uptake of new registrations, the global electric car stock in 2015 is still extremely low (0.1%) when compared with the total number of passenger cars on the road worldwide, close to 1 billion in 2015 (IEA, 2016b).

The EVI set a target of 20 million EVs on the road by 2020. Meeting this target would lead to a global market share of 1.7% by 2020 (IEA, 2016b).

Individual countries also engaged in setting ambitious targets for the years 2020 to 2025. Table 3 presents a review of the commitments made by individual countries and the assessment of the impacts they would have on vehicle sales and stock, where it can be seen that the cumulative target announced by 14 of the main electric car markets is coming close to 13 million electric cars on the road by 2020.

Countries whose electric car market share would exceed a two-digit average in the 2016-20 time frame include Austria, Denmark, France, the Netherlands, Portugal and the United Kingdom. Those whose average market share would be between 5% and 10% in 2016-20 include China,

Germany, Ireland, Japan and eight states in the United States that would account for about a quarter of the total new car sales nationwide (California, Connecticut, Maryland, Massachusetts, New York, Oregon, Rhode Island and Vermont) (CARB, 2014).

Nordic European countries have ambitions to move towards carbon neutrality by 2050: Denmark, Sweden and Norway have a full decarbonisation goal by mid-century. Finland targets an 80% reduction in GHG emissions and Iceland a 50-70% reduction (both relative to 1990 levels). Significant policy deployment favouring the electrification of transport has taken place to move towards these targets (as discussed in the policy section earlier and in the EVSE section below). Norway exceeded by far its target of 50 000 EVs on the road by 2015.

Maintaining the 2015 global growth rate of the electric car stock (78%) would lead to a stock exceeding the 2020 EVI target. Meeting the sum of all the targets set by individual countries, summarised in Table 3, would translate to a growth rate for the vehicle stock close to 60% per year from 2015 to 2020.

Table 3 • Electric car stock targets to 2020 based on country commitments

Countries with announced targets to 2020 or later	2015 EV stock (thousand vehicles)	2020 EV stock target (million vehicles)	EV share of all cars sold between 2016 and 2020	EV share in the total 2020 stock	Source
Austria	5.3	0.2	13%	4%	BMVIT, 2012
China*	312.3	4.6	6%	3%	State Council, 2012
Denmark	8.1	0.2	23%	9%	ICCT, 2011
France	54.3	2.0	20%	6%	MEEM, 2011
Germany	49.2	1.0	6%	2%	IA-HEV, 2015
India	6.0	0.3	2%	1%	LBNL, 2014
Ireland	2.0	0.1	8%	3%	SEAI, 2014
Japan	126.4	1.0	4%	2%	METI, 2016
Netherlands**	87.5	0.3	10%	4%	EVI, 2016a
Portugal	2.0	0.2	22%	5%	IA-HEV, 2015
South Korea	4.3	0.2	4%	1%	MOTIE, 2015
Spain	6.0	0.2	3%	1%	MIET, 2015
United Kingdom	49.7	1.6	14%	5%	EC, 2013 and CCC, 2013
United States***	101.0	1.2	6%	2%	IA-HEV, 2015
Total of all markets listed above	814.1	12.9	7%	3%	

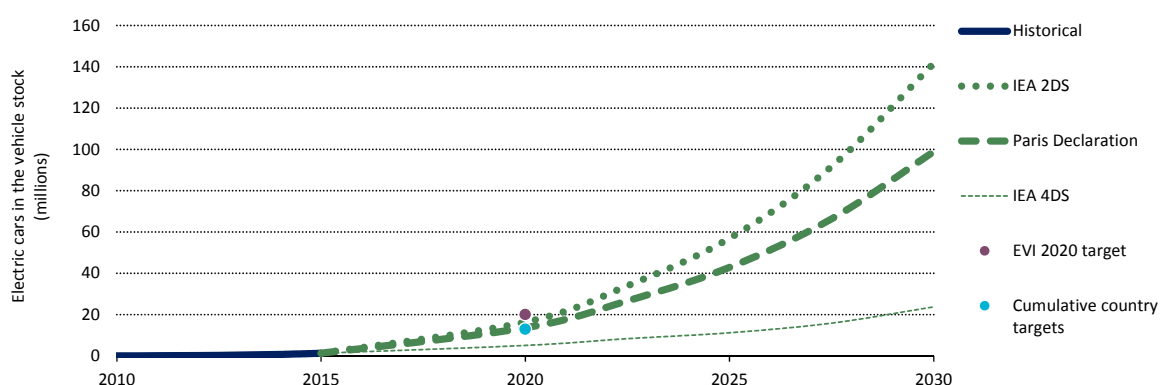
Notes: * This target includes 4.3 million cars and 0.3 million taxis and is part of an overall deployment target of 5 million cars, taxis, buses and special vehicles by 2020 (EVI, 2016b).
 ** Estimate based on a 10% market share target by 2020.
 *** Estimate based on the achievement of the 3.3 million EV target announced to 2025 in eight US states. All indicators in this table refer to the eight US states; market share and stock share are assumed to account for 25% of the total US car market and stock.

Key point • 14 countries have announced quantitative EV stock objectives, aspiring to bring 13 million EVs on the road by 2020.

The Paris Declaration on Electro-Mobility and Climate Change and Call to Action, developed in the framework of the Lima-Paris Action Agenda and announced at COP21, calls for the global deployment of 100 million electric cars by 2030 (UNFCCC, 2015b). The 2DS of the IEA *ETP 2016* sets a deployment target for electric cars exceeding the goal of the Paris Declaration: 140 million (10% of the total stock of passenger light-duty vehicles [PLDVs]) by 2030, and nearly 900 million (40% of the PLDV stock) by 2050. This translates to sales targets close to 20% by 2030 and 40% by 2040, with accelerated deployment in member economies

of the Organisation for Economic Co-operation and Development (OECD) and rapidly developing emerging economies (IEA, 2016a, 2016b).

Figure 9 • Deployment scenarios for the stock of electric cars to 2030



Sources: IEA analysis based on IEA (2016b), UNFCCC (2015b), the EVI 2020 target and the assessment made in Table 3.

Key point • Reaching 2020 deployment targets for BEVs and PHEVs requires a sizeable growth of the electric car stock. Meeting 2030 decarbonisation and sustainability goals requires a major deployment of electric cars in the 2020s.

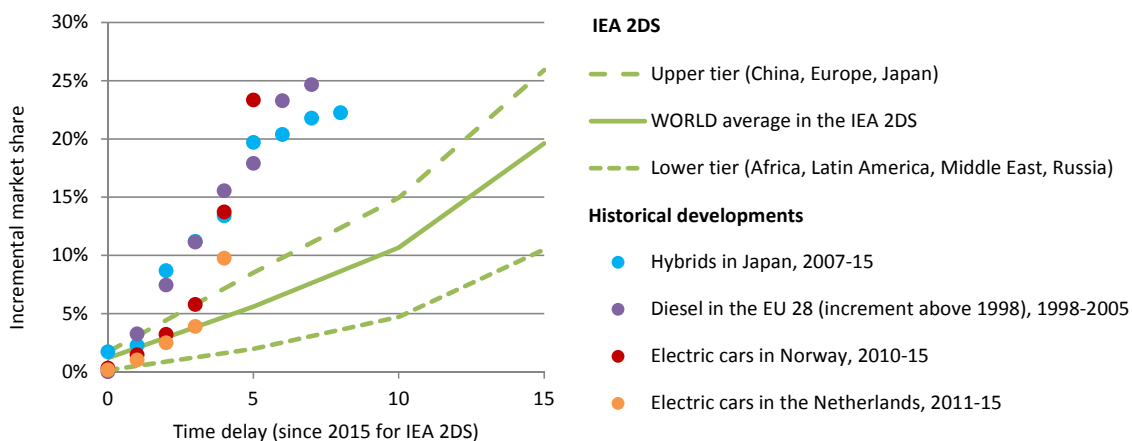
Meeting the 2030 target of the IEA 2DS implies that the global stock of electric cars should maintain annual growth rates above 25% by 2025 and in the range of 7% to 10% between 2030 and 2050. Meeting the targets of the Paris Declaration requires stock growth rates a factor 0.1 lower than those needed for the IEA 2DS until 2030.

The decline in the growth rates of the EV stocks suggested by these paths is consistent with the significant growth of investments needed to comply with increases in absolute production capacities once the EV market size keeps growing. This is also aligned with the diminishing returns resulting from technology learning per unit EV deployed once the volume of the EV stock grows. Long-term developments also depend on market dynamics due to different developments of vehicle stock and EV deployments across different global regions. Delays in the initial growth of EV deployments would require higher incremental rates for the vehicle stock at a later stage to meet the same mid- to long-term targets, lowering the likelihood of meeting the objectives and the associated GHG emissions mitigation targets.

Figure 10 attempts to compare the market shares needed for electric cars to meet the IEA 2DS targets with significant market transformations in powertrain technologies that took place in the recent past: the dieselisation of the European fleet between the late 1990s and the first decade of the new millennium, the hybridisation of the Japanese vehicle fleet in the last decade, and the growth of electric car penetration observed in the Netherlands and Norway over the past five years.

The penetration of electric cars needed to meet the IEA 2DS targets falls below the increments that characterized rapid market transformations that took place in the past two decades (Figure 10). This suggests that achieving 2DS goals is within reach, even when accounting for the additional barriers faced by EVs due to the deployment of recharging infrastructure, the challenges posed by long distance trips for BEVs and the higher projected cost differentials between BEVs and PHEVs with respect to those in place for diesels and hybrids in the past decade.

Figure 10 • Market penetration for electric cars needed to meet the IEA 2DS target compared with a selection of significant historical transformations in powertrain technologies



Sources: IEA analysis based on IEA (2016b), ACEA (2016b), Eurostat (2016), IHS Polk (2014) and MarkLines (2015).

Key point • The incremental market penetration of electric cars needed to meet the IEA 2DS targets falls below the increments that characterized other recent and rapid market transformations.

BEVs with 80 kilowatt (kW) power rating, 350 km range and batteries costing USD 100/kWh would cost EUR 3 600 (USD 4 000) more than a benchmark provided by advanced gasoline-powered ICEs.¹⁰ PHEVs with the same power rating, 40 km pure electric range and batteries costing USD 130/kWh would be EUR 1 700 (USD 1 900) more expensive than competing improved ICEs.

By comparison, a diesel engine was estimated to cost about EUR 1 700 more than a reference gasoline ICE in the period 2002 to 2010 (Concawe, EUCAR and JRC, 2008), and the cost differential for full hybrid vehicles was estimated at USD 2 800 to USD 3 400 (ORNL, 2007) in comparison with an ICE.

Box 3 • The case of LSEVs in China

LSEVs are low-speed (70 km per hour), short-range and small-size electric passenger vehicles, using basic battery (usually lead-acid) and electric motor technologies. LSEV sales experienced a considerable growth between 2012 and 2015, with more than 600 000 units sold in 2015 (Xinhua, 2016a). Estimates are for 1 million sales in 2016 (Xinhua, 2016a).

Some key reasons behind this remarkable development are their small size, cheap price and flexibility (e.g. they require low operation and maintenance expenses and can be driven without a licence).

Most LSEVs are currently used in small cities in China, and are expanding to larger cities. For example, Shandong is regarded as the first pilot province, because lots of small cities in Shandong have a high number of LSEVs and the production in Shandong amounted to 347 000 (Xinhua, 2016b). LSEVs are also becoming popular in larger cities such as Beijing and Shanghai (Wap, 2016).

¹⁰ Engine costs for gasoline powered ICEs with 80 kW power were estimated at USD 3 800. This accounts for incremental costs for systems improving fuel economy by 20-25% and abating tailpipe emissions to stringent regulated levels and is consistent with the assessment of Concawe, EUCAR and JRC (2008) for an advanced gasoline-powered ICE with a power rating of 77 kW.

LSEVs currently represent an energy-efficient alternative to conventional ICE cars. They also compete with modes with a better energy efficiency profile, such as public transport and 2-wheelers, and contribute to increased congestion of the road network. LSEVs' popularity and fast expansion also come with reliability and safety risks due to the scattered, small-scale nature of the LSEV manufacturing industry.

The lack of regulation for LSEV sales, the implications for increased road traffic, and the absence of a waste management chain to dispose of lead-acid batteries represent serious air and ground pollution threats. In order to regulate the LSEV market, the Chinese government is expected to issue standard-of-technology requirements for low-speed four-wheel EVs during the course of 2016 (Standardization Administration, 2016). The enforcement of this standard is expected to lead to a reorganisation of LSEV manufacturers, possibly reducing the number of players involved in this market to those best equipped to comply with the new legal framework. Projections for LSEV annual sales are about 2 million by 2020 (China Times, 2016).

Two-wheelers

New registrations and stock

Table 4 summarises the information submitted by EVI countries and partner institutions on new registrations and stock of electric 2-wheelers. Even if data in Table 4 are unlikely to be complete for all countries covered in this report, they are consistent with the assessment that China is by far the global leader in the adoption of electric 2-wheelers (IEA, 2016a, 2016b). The strong uptake of electric 2-wheelers in China was primarily spurred by policies banning the use of conventional motorcycles in Chinese cities.¹¹ In addition to the values shown in Table 4, electric 2-wheeler sales in 2015 have been estimated to reach 40 million in all world regions (primarily in China, but significant sales also took place in Japan and Europe) (Mason, Fulton and McDonald, 2015).

Table 4 • New registrations and stock of electric 2-wheelers: Submissions from EVI countries and partner institutions

Unit: thousand vehicles		2010	2011	2012	2013	2014	2015
New registrations	China	16 240	18 690	20 280	25 290	29 040	
	Netherlands			3.8	2.3	4.6	4.9
	Sweden					18.0	30.0
	Thailand	0.6	0.3	0.2	0.1	0.2	0.1
Stock	Netherlands		16.9	20.7	23.0	27.7	32.6
	Sweden				10.0	28.0	68.0

Note: the values regarding new registrations in China are estimated on the basis of the e-motorbike production data available from the China National Bureau of Statistics (EVI, 2016b). Due to data availability limitations, the country coverage in this table is not complete. The information shown here is not an exhaustive summary of the global electric 2-wheeler markets.

Key point • China is by far the major market for electric 2-wheelers, boosted by drastic conventional 2-wheeler bans in some urban areas.

Comparing the estimates on Chinese new registration data given in Table 4 (based on e-motorbike production data available from the China National Bureau of Statistics) with other

¹¹ In 2009, 13 major Chinese cities (Changzhou, Dalian, Foshan, Guangzhou, Harbin, Jinan, Ningbo, Suzhou, Taiyuan, Tangshan, Wuhan, Xi'an and Zhengzhou) had a full ban in place, and 16 had a partial ban (Beijing, Changchun, Changsha, Chengdu, Chongqing, Guiyang, Hangzhou, Kunming, Lanzhou, Nanjing, Qingdao, Shanghai, Shenyang, Shijiazhuang, Tianjin and Wuxi) (ADB, 2009).

sources suggests that these figures are subject to a wide variability. Such variability is possibly due to differences in classification and the lack of harmonised methodologies for the assessment of these data.

- New registrations reported in High Tech Lithium Ion (2012) for the year 2010 were estimated at 29.5 million electric 2-wheelers, more than 80% above the value provided in Table 4.
- Estimates from Qilu (2015) suggest that new registrations of electric 2-wheelers in 2014 reached 20.5 million, a value that is about one-third lower than the estimate in Table 4 and the estimate provided in China Market Research Web (2015) for the same year. Qilu (2015) also suggests that new registrations declined from 2013 to 2014, a trend contrary to that shown in Table 4.
- Discrepancies such as those highlighted here could also be due to information having a different market coverage and scope.
- Sina finance (2014) indicates a total number of new registrations for 2013 larger than 36.9 million, but states also that 25.3 million – a value aligned with the data of Table 4 – were produced by large factories.
- China Reports (2016) reports values of 35.5 million for the total 2014 amount of new registrations and 35 million for 2015, and states that manufacturers covered by statistics account for 29.3 million for 2014 and 30.0 million for 2015. These last figures are aligned with the estimates in Table 4.

The discrepancies discussed above for new registrations are also reflected in the assessment of the total stock of Chinese electric 2-wheelers, ranging between 198 million (China Reports, 2016) for 2015 to estimates above 200 million in 2014 (China Market Research Web, 2015; Eastern Daily, 2015; Huaxi News, 2015), and up to 230 million in 2014 (EVI, 2015a).

Despite these discrepancies, all of the reported data suggest that China is by far the world leader, by several orders of magnitude, and is likely to dominate the global electric 2-wheeler market for the near future.

Progress towards deployment targets

IEA analysis suggests that more than half of China's 2-wheeler stock is made up of electric 2-wheelers (223 million units) (IEA, 2016b). Given that China accounts for half of the global 2-wheeler stock, the global share of electric 2-wheelers is – today – around 25%.

The Paris Declaration on Electro-Mobility and Climate Change and Call to Action sets a global deployment target for electric 2- and 3-wheelers in 2030 exceeding 400 million units (UNFCCC, 2015b). This is consistent with the values indicated by the IEA 2DS (IEA, 2016b) and corresponds to annual sales exceeding 30% in 2020 and 70% in 2030 of global 2 and 3-wheelers sales (IEA, 2016b).

According to IEA scenarios, the Chinese 2-wheeler market is projected to account for roughly 40% of global sales in 2030 (IEA, 2016a, 2016b). Meeting the 70% targets indicated by the Paris Declaration would therefore require significant uptake of electric 2-wheelers beyond the Chinese market.

Electric buses

The 2015 global electric bus stock is estimated to be close to 173 000 vehicles, almost entirely located in China. Close to 150 000 of these are battery electric buses, running 100% on electricity. The electric bus stock grew nearly six fold between 2014 and 2015, demonstrating support for rapid public transport electrification from the Chinese government, which is driven by the urgent

need to limit air pollution levels in Chinese cities. By 2020, China plans to have over 200 000 electric buses on its roads, accompanied by a network of close to 4 000 charging stations dedicated to buses (EVI, 2016b).

In a few other countries, electric bus fleets exist at the level of a few tens of buses (100 in India, 94 in the Netherlands, 30 in Sweden and 21 in Japan, according to EVI data submissions), and are deployed as pilots and demonstration projects in a few major cities.

EVSE

This section provides an overview of EVSE infrastructure between 2010 and 2015 and the current status of policy support for EVSE deployment, and includes an assessment of future EVSE stock aligned with the ambition of EV deployment targets.

Recent developments

Figure 11 shows that the total number of EVSE outlets available in 2015 reached 1.45 million, up from 0.82 million in 2014 and only roughly 20 000 in 2010.¹² The share of publicly available EVSE outlets¹³ stabilised after 2013 to about 13% of the total. Publicly available EVSE outlets increased to 190 000 in 2015 from 110 000 in 2014 and 50 000 in 2013.

The growth of the publicly accessible charging infrastructure was comparable in 2015 (71%) to the growth of the global EV stock (78%). Publicly available slow and fast chargers experienced similar rates of growth in 2015: 73% for slow and 63% for fast. The average growth of the number of publicly available charging outlets indicates that both slow- and fast-charging outlets more than doubled on an annual basis in the past five years.

Fast chargers in China accounted for 44% of the total number of fast-charging outlets in 2015, down from 53% one year earlier (Figure 12). Fast-charging outlets in France experienced an increase more than fourfold in 2015. In the same year, the increase was more than threefold in Norway. In Canada, Germany, Japan, Sweden and the United Kingdom, fast chargers more than doubled. In 2015, year-on-year increases were weaker for publicly accessible slow chargers, except in China, Spain and France, where their growth outpaced the increase of fast-charging outlets.

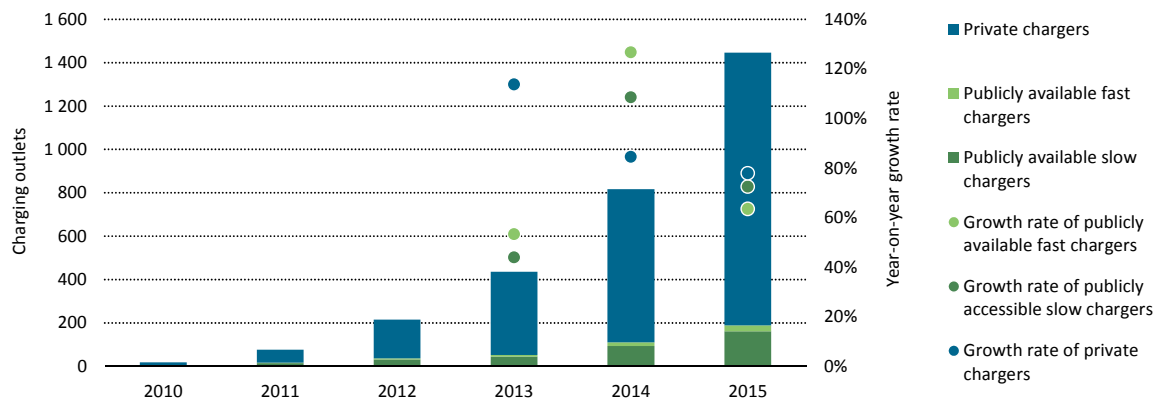
The key metric used to represent the link between vehicles and publicly accessible supply equipment in this section is the ratio of electric cars to public EVSE outlets.¹⁴ This choice was preferred to metrics such as public EVSE per unit land area, always low in countries with low population density, and public EVSE per capita, inherently low in countries with low vehicle ownership rates, e.g. because of comparatively low income levels or lower structural dependency on personal vehicles for urban and non-urban mobility.

¹² This estimate accounts for both private chargers, assumed to equal the number of EVs on the road, and publicly available chargers (derived from EVI submissions and EAFO, 2016).

¹³ Publicly available chargers discussed in this section include both slow and fast chargers. Slow chargers include alternating current (AC) level 1 (≤ 3.7 kW) and AC level 2 chargers (> 3.7 kW and ≤ 22 kW). Fast chargers include AC 43 kW chargers, direct current (DC) chargers, Tesla Superchargers and inductive chargers.

¹⁴ The choice to use electric cars rather than the sum of all EVs for the evaluation of this indicator is dictated by the need to focus primarily on vehicle classes that would be best positioned to use publicly accessible slow and fast chargers. Electric 2-wheelers would not be suitable for this purpose, and they often rely on conventional plugs for recharging, i.e. on outlets that are not included in the EVSE statistics tracked here. Electric buses are excluded because they would not be suitable for publicly available slow chargers. The data coverage for electric buses is also less complete than for electric cars.

Figure 11 • Global EVSE outlets, 2010-15

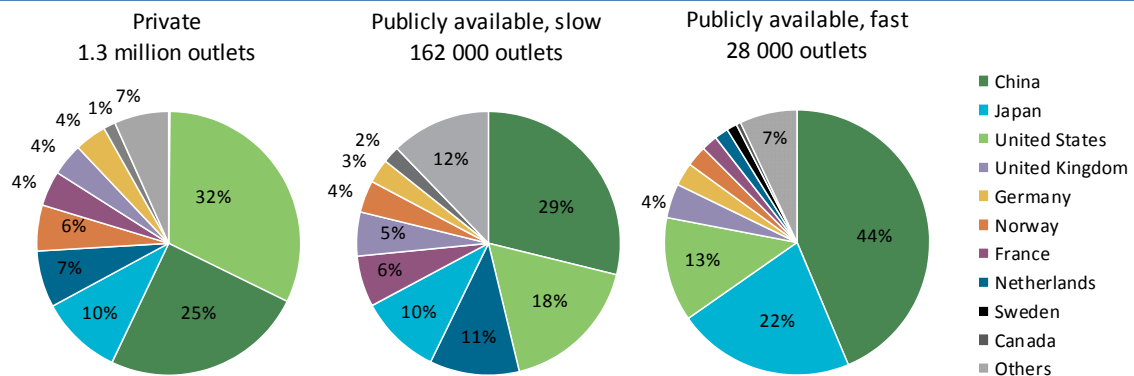


Note: Private chargers are estimated assuming that each EV is coupled with a private charger.

Sources: IEA analysis based on EVI country submissions, complemented by EAFO (2016).

Key point • Publicly accessible charging facilities have been following the growth trend of the electric car stock.

Figure 12 • Geographical distribution of the 2015 stock of EVSE outlets by charger type



Note: Private chargers are estimated assuming that each EV is coupled with a private charger.

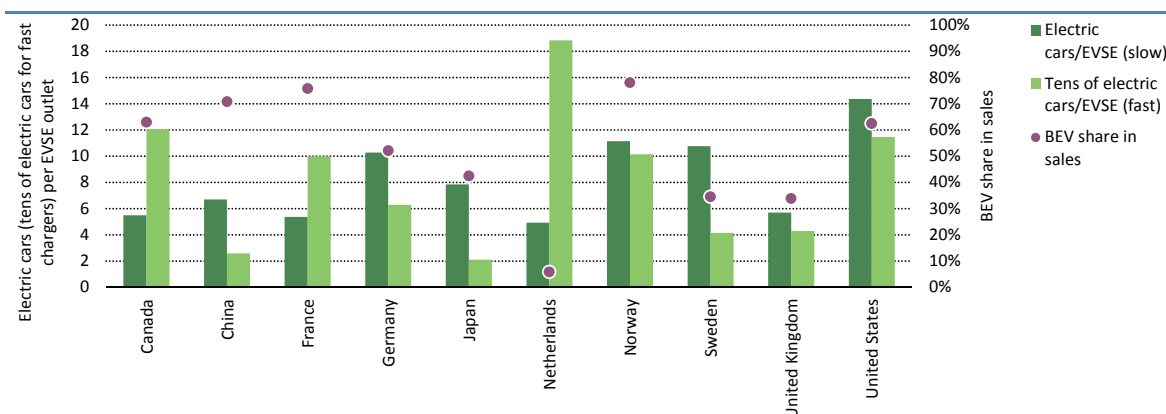
Sources: IEA analysis based on EVI country submissions, complemented by EAFO (2016).

Key point • Country profiles differ with respect to the development of EVSE infrastructure. China and Japan account for more than 65% of fast-charging outlets. The geographical distribution of publicly accessible slow chargers is closer to the distribution of electric cars and private charging outlets.

The total number of public EVSE outlets increased with the growth of the electric car stock, confirming observations of a positive relationship between the adoption of EVs and the deployment of publicly accessible charging infrastructure. Nevertheless, the nascent nature of EV markets and EVSE networks leads to high variability in the ratio of electric cars and public EVSE outlets, in the case of both slow and fast chargers.

Figure 13 provides a snapshot of this indicator in 2015 for a selection of countries with EV market shares falling above half of the global average. Out of all these markets, few (if any) could help identifying a ratio that could represent an optimal balance between vehicles and EVSE outlets: the Netherlands and Norway are the only cases with stock shares for electric cars above 1%, and Norway is the only market where this is the case also for BEVs only.

Notwithstanding the limited insights currently available on ideal or optimal EV/EVSE ratios, Figure 13 can help provide a broad indication of the differences in magnitude between slow and fast charger deployment rates.

Figure 13 • Electric cars/EVSE stock ratio for slow and fast publicly available chargers and share of BEVs in total electric car stock, 2015

Sources: IEA analysis based on EVI country submissions, complemented by EAFO (2016).

Key point • The ratio of electric cars per publicly available outlet is significantly larger for fast chargers than for slow chargers. The nascent nature of EV markets and EVSE networks leads to high variability in this ratio across countries, especially for fast chargers.

The selection of the largest electric car markets shown in Figure 13 indicates that the number of electric cars per publicly available EVSE outlet fell in the range of 5 to 15 vehicles for slow chargers, with a global average of 7.8 in 2015.

Globally, there are 45 electric cars (of which 27 are BEVs) per each publicly available fast-charging outlet. The magnitude of the EV/EVSE ratio for publicly available fast chargers is 5.8 times larger than for slow chargers on the global scale. The range of variability across countries is much wider for fast-charging infrastructure, and there are sizeable differences when this indicator is calculated only accounting for BEVs.

- In Japan and China, which accounted for more than three-quarters of the fast-charging outlets installed globally in 2015, a single fast-charging outlet was coupled with 21 EVs (in Japan) and 25 EVs (in China) (Japan had 12 and China had 19 for BEVs/fast EVSE outlets). These values fall in the low end of the range of the countries assessed in this report.
- The ratio of electric cars per fast-charging outlet is close to 40 in Sweden and the United Kingdom (14 in Sweden and 19 in the United Kingdom for BEVs/fast EVSE outlets), and 60 in Germany (39 for BEVs/fast EVSE outlets).
- The same indicator ranges between 100 and 130 (60 and 90 for BEVs/fast EVSE outlets) in Canada, France, Norway and the United States.
- In the Netherlands there were 188 electric cars (and 20 BEVs) per every fast charger outlet.

Possible explanations for this variability (besides the nascent nature of EV markets and EVSE networks) include:

- In Japan, early insights from the Tokyo Electric Power Company (TEPCO), based on the behaviour of users of electric cars among its employees and suggesting that the deployment of fast chargers helped overcome range anxiety (Anegawa, 2009), underpinned early deployment of fast chargers. Major Japanese companies are also founders of the CHAdeMO, the most widely deployed DC fast-charging protocol being proposed as global industry standard for fast charging (CHAdeMO, 2016).
- In the Netherlands, the low number of fast-charging outlets per electric car is due to the high shares of PHEVs: the ratio of BEVs per fast charger (20 BEVs/fast charger) is aligned with the lower values seen in other countries with shares of the electric car stock above half of the global average.

- In China, the large number of fast-charging outlets installed could also be consistent with the strong uptake of electric buses, with more than 140 000 new registrations in 2015 (EVI, 2016b). (For comparison, the Chinese electric car stock slightly exceeded 310 000 units in 2015) (Electrek, 2015, 2016).¹⁵

The rapid increase in the stock of fast chargers in 2015 also resulted in a decline of the ratio of EVs per fast charging point in Japan and China, as well as France, Germany, Norway, Sweden and the United Kingdom. This had significant downward impacts on the ratio of electric cars per fast-charging outlet in Germany, Sweden and the United Kingdom.

EVSE policy support

In order to incentivise further EV adoption, national and local governments must support the deployment of the charging infrastructure that is indispensable to EV drivers, whether at home, at work or at public locations. The main mechanisms deployed are classified in Table 5 as direct incentives by public authorities and institutions or as fiscal advantages (e.g. tax breaks for individuals or private entities for the installation of charging outlets).

Comparing Table 1 and Table 5 confirms the higher likelihood for EVSE policy support to take place at the local administrative level. This reflects the need for local action in cases where the policy implications have strong links with the road network.

Nearly all countries with an EV market share above 0.5% (in 2015, this was the case for China, Denmark, France, Germany, Japan, the Netherlands, Norway, Portugal, Sweden, the United Kingdom and the United States) provided either direct or fiscal incentives at the national level to install private charging outlets. The Danish government, for instance, offers a tax rebate on the installation of home chargers up to DKK 18 000 (USD 2 700) (EVI, 2016d), and the United Kingdom is supporting electric car home chargers by financing up to 75% or GBP 500 (USD 700) for the installation of a charging point (OLEV, 2016). Some countries (e.g. France) also require that all newly built residential buildings and workspaces include EV charging points (MEEM, 2012).

Some countries implemented national framework programmes enabling EVSE subsidy or fiscal credits to favour the deployment of publicly accessible EVSE. Examples of these instruments include:

- In the United States, a federal funding programme that contributed to 36 500 publicly accessible charging outlets in place in 2015 (Lutsey, 2015).
- In France, fiscal deductions for private operators investing in, maintaining or operating charging outlets in public spaces in at least two different regions, with the goal of having a national charging network (IA-HEV, 2015).
- In Denmark, a scheme administered by the Danish Energy Agency supports the deployment of new public charging stations.
- In Japan, a partnership with a retailer for the installation of 500 fast chargers and 650 standard chargers at its stores, providing two-thirds of the funding (OECD, 2015).

The support for publicly accessible EVSE is often developed with:

- initiatives at the city or region-level through local EV and EVSE support programmes (one example is the Go Ultra Low City Scheme in the United Kingdom [GOV.UK, 2016b])

¹⁵ This consideration hinges on the consideration that fast chargers for electric buses were included under publicly accessible outlets.

- public or private initiatives aiming to develop countrywide charging networks, in order to expand EV availability and adoption to a wider public, for non-metropolis dwellers or long-distance travellers (examples include the Ecotricity electric highway in the United Kingdom (Ecotricity, 2016) and Enova's requirement of two chargers per 50 km along the main road network in Norway (Enova, 2015)
- public or private initiatives aiming to develop office chargers (e.g. the "switched on @ work" initiative in the United Kingdom (Energy Saving Trust, 2016).

Table 5 • Summary of policy support mechanisms for EVSE deployment

	Direct investment		Fiscal advantages		Total EVSE stock per million inhabitants	Publicly accessible EVSE stock per million inhabitants
	Publicly accessible chargers	Private chargers	Publicly accessible chargers	Private chargers		
Canada					612	98
China					265	42
Denmark					1 732	309
France					970	159
Germany					664	67
India					5	0.3
Italy					129	29
Japan					1 171	174
Netherlands					6 280	1 084
Norway					15 143	1 372
Portugal					302	114
South Korea					113	26
Spain					161	35
Sweden					1 674	175
United Kingdom					933	155
United States					1 340	97

Legend:	
	No policy
	Targeted policy *
	Widespread policy**
	Nationwide policy

Notes: * Policy implemented in certain geographical areas (e.g. specific states/regions/municipalities), affecting less than 50% of the country's inhabitants.

** Policy implemented in certain geographical areas (e.g. specific states/regions/municipalities), affecting more than 50% of the country's inhabitants.

Key point • Countries with a high EVSE rate per capita have typically deployed attractive EVSE implementation incentives.

EVSE deployment targets

The following EVSE deployment targets for the 2020-30 decade have been set or are in the process of being set:

- In China, the 5 million EV deployment target (including 4.3 million cars, more than 0.3 million taxis, 0.2 million buses and 0.2 million special vehicles) is coupled with the EVSE deployment of 4.3 million private EVSE outlets and 0.5 million public chargers for cars. The EVSE deployment target also includes nearly 4 000 charging stations for buses, nearly 2 500 for taxis, 2 500 for special vehicles, about 2 400 city public charging stations, 0.5 million public charge points, and about 850 intercity quick-charge stations (EVI, 2016b).
- The EU Directive on the deployment of alternative fuels infrastructure (2014/94/EU) requires EU member countries to define electric charging point targets for 2020 by November 2016 (EC, 2014a). The text calls for a number (without suggesting a metric or a numerical indicator)

of publicly accessible points capable of ensuring that EVs can circulate at least in urban and suburban agglomerations (EC, 2015, 2014b). Targets should ideally foresee a minimum of one recharging point per ten electric vehicles (EC, 2014b). Earlier proposals of the European Commission included an EU-wide target of 800 000 publicly accessible chargers and a total of 8 million chargers by 2020 (EC, 2013).

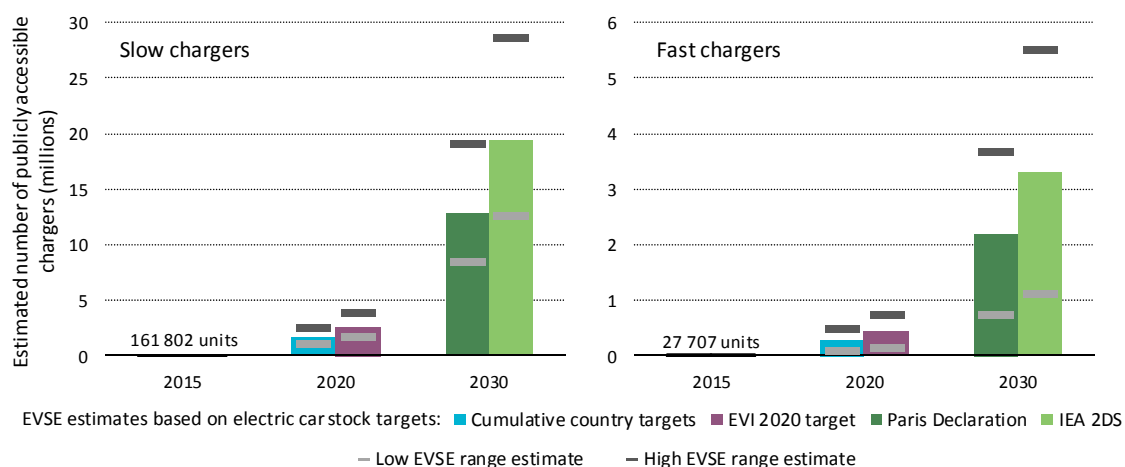
- France has the ambition to deploy, by 2030, 7 million charging outlets over the national territory (MEEM, 2016c).
- The National Electric Mobility Mission Plan 2020 for India suggests two scenarios for EV deployment to 2020: a “high gas/PHEV” scenario calling for the deployment of 175 000 charging points and a “high gas/PHEV/BEV” scenario calling for 227 000 charging points. Fast chargers represent about 10% of the total in both scenarios (MHIPE, 2013).
- The Japanese 2010 Next Generation Vehicle Plan (NGVP) was aiming at deploying 2 million standard chargers and 5 000 fast chargers across the country by 2020 (METI, 2010). The new roadmap for EVs released by the Japanese Ministry of Economy, Trade and Industry in 2016 is setting a new target of 1 million EVs in Japan by 2020 (METI, 2016), replacing the NGVP target of 15-20% EV sales by 2020. The EVSE deployment by 2020 may well align with the updated EV deployment target. This would lead to an estimate exceeding 1 million EVSE outlets by 2020.
- Korea is seeking to deploy 1 400 countrywide publicly accessible fast chargers, with the aim of making all parts of the country accessible with an electric vehicle (MOTIE, 2015).

Global EVSE deployment can be assessed on the basis of the deployment targets identified for EVs, assuming ranges of EV/EVSE average ratios (both for private and publicly accessible chargers) for future years that are anchored to the magnitudes of historical data. Given the high variability in the historical ratio of electric cars and public EVSE outlets, this assessment was carried out taking into account wide uncertainty margins, using three values of electric cars per EVSE outlet: the global average, the average of the three highest ratios for the countries shown in Figure 13 (i.e. countries with a stock share of electric cars above half of the global average), and the average of the three lowest ratios in the same country subset.

Figure 14 shows global EVSE deployment estimates generated with this methodology. In short, this would mean an estimated increase by more than a factor of 10 from 2015 to 2020, and by a factor of 100 by 2030.

- By 2020, publicly accessible slow chargers would have to increase to between 1.1 million units and 2.5 million units (with a central estimate at 1.7 million) to meet the cumulative electric car deployment targets derived from country commitments. Fast chargers would need to range between 0.1 million and 0.5 million to meet cumulative country targets (0.3 million in a central estimate, based on the global average of electric cars per fast charger ratio).
- EVSE deployment compatible with a 20 million EVI deployment target would need to be 50% larger.
- By 2030, publicly available slow chargers would need to range between 8.4 million and 19.1 million, with a central value of 12.9 million outlets, to meet the targets of the Paris Declaration on Electro-Mobility and Climate Change and Call to Action. Fast-charging outlets should grow to 0.8 million to 3.7 million, with a central estimate at 2.2 million.
- Values enabling the IEA 2DS deployment rates for electric cars to be attained would be 50% larger.

In short, this would mean an estimated increase for EVSE outlets by more than a factor of 10 from 2015 to 2020, and by a factor of 80 to 120 by 2030.

Figure 14 • EVSE deployment targets implied by deployment targets for electric cars, with electric car/EVSE ranges maintained constant at 2015 level

Note: a lower and a higher range of EV/EVSE ratios were considered, based on the average of the observed three lowest and three highest EV/EVSE ratios, respectively, among the countries listed in Figure 13.

Key point • Projections on EVSE outlets consistent with EV targets by 2020 and 2030 are more than a factor of 10 larger than 2015 estimates by 2020, and a factor of 80 to 120 by 2030.

Due to high power requirements during charging phases, the deployment of electric cars and EVSE infrastructure can have sizeable impacts on the load profile of the power generation system and the load distribution across the electricity network. The local nature of these effects suggests that they would be taking place at much lower penetration levels than those impacting the total energy demand. Electric car charging, in particular, can become a major flexibility source, but also major strain on system flexibility depending on charging patterns.

- Slow charging in residential garages and office parking lots has the potential to offer flexibility, primarily thanks to variable charging, i.e. the possibility to modulate charging time and power.¹⁶ With usual slow charger characteristics, analysis of charging profiles¹⁷ and the coincidence of power draw with peak system demand reveals that 125 thousand cars could be equivalent to 300 MW of flexibility – a medium size pump storage plant or a successful stationary demand side response program. Depending on the system and the concurrent deployment of other distributed energy resources, the value of such flexibility to mitigate the impact of EV deployment at low voltage grid levels might be moderate. At higher voltage levels, aggregating large numbers of EVs could emerge as a key flexibility resource for integration of high shares of variable renewables.
- Without adequate location and time signals in electricity pricing, fast charging could become a concern for distribution networks. At 43 kW to 200 kW, fast chargers are likely to require substantial reinforcements of the electricity grid. Their usage profile, centred on the need to minimize charging time, is also not compatible with the possibility to provide demand side response. Fast chargers are also likely to be underutilised at night, since they cannot be integrated into low voltage household networks. However, in contrast with slow chargers, fast charging stations can be proactively sized and sited during the planning stages by distribution system planners to minimise grid impacts. They

¹⁶ Feeding the grid from the vehicle requires specialised equipment allowing bi-directional charging and can be detrimental to battery life, making variable charging more feasible and appealing for EV owners.

¹⁷ With a 7 kW low voltage charger if the car parks for 6 hours, it can fill 24 kWh (70% of the total charge for a 34 kWh battery) by taking 4 kW on average, offering 3 kW flexibility.

can also be more readily monitored and controlled, and afford the possibility of implementing technical mitigating measures such as voltage control technology.

Guaranteeing the materialization of this flexibility requires adequate smart linkages between the car, the charger and the system operator or a demand aggregator, as well as the implementation of dynamic electricity pricing mechanisms. While there is no technical obstacle to this, the lack of standardisation, interoperability and regulatory frameworks for chargers and/or on-board information technology (IT) systems to enable this flexibility, may lock out the opportunity to take advantage of the benefits of smart charging. Weak price signals for individual consumers may also hamper the full exploitation of these benefits. The limited coordination in place between car manufacturers, network operators, regulators and consumers suggests that there is significant room for improvement in this field.

Conclusion

The electric car stock reached 1.26 million in 2015, 100 times more than in 2010. Substantial new EVSE implementation was also observed in 2015, on par with the growth of the global electric car stock.

New registrations of electric cars increased by 70% between 2014 and 2015, with over 550 000 vehicles being sold worldwide in 2015. The market shares of electric cars rose above 1% in seven countries: Norway, the Netherlands, Sweden, Denmark, France, China and the United Kingdom. Market shares reached 23% in Norway and nearly 10% in the Netherlands in 2015. China emerged as the main electric vehicle market: its booming electric car sales were larger in 2015 than in the United States. China is also home of the strongest global deployment of electric 2-wheelers and electric buses.

The wide global deployment of electric vehicles across all modes is necessary to meet sustainability targets. By displacing ICEs, EVs deliver immediate benefits for air quality in urban areas thanks to zero tailpipe emissions (in electric driving mode, for PHEVs), as well as reduced noise level, therefore increasing daily comfort for the city dweller. EVs are well positioned to diversify the energy mix in transport, the end-use sector showing the greatest dependence on oil. The efficiency of EVs is also well suited to deliver climate change-related benefits, but GHG emission savings can be maximized only once EVs are coupled with a low-carbon power generation mix. Investment in EV roll-out can support this transition, e.g. increasing the opportunities available to integrate variable renewable energy.

Meeting EV deployment targets set by the EVI for 2020, the Paris Declaration on Electro-Mobility and Climate Change and Call to Action for 2030 and the IEA 2DS requires substantial market growth and the swift deployment of electric cars across all market segments. Achieving sustainability goals also requires a large scale diffusion of electric 2-wheelers and buses beyond the Chinese market, as well as electrified road freight vehicles, starting from urban deliveries.

RD&D support, technology learning and economies of scale due to the increasing EV market uptake led to rapid cost declines and performance improvements in the past decade. They hold the promise to continue reducing progressively technology costs in the forthcoming years.

EV uptake will still require substantive policy support to accelerate the momentum that characterized EV deployment in the past five years. The complex interplay between differing policy support mechanisms, as well as the nascent nature of EV markets and EVSE networks make it challenging to identify an optimal way to encourage EV uptake. Financial incentives and the availability of charging infrastructure emerged as factors that were positively

correlated with the growth of electric vehicle market shares. The progressive tightening of fuel economy standards and pollutant emission regulations is also likely to stimulate EV deployment, given the good energy efficiency and pollutant emission abatement performances of EVs (especially BEVs).

EV policy support needs to account for effects on overall car travel, congestion, impacts on the quality of public transport services. Policy tools as waivers to access restrictions (e.g. access to bus lanes), for instance, could lose effectiveness and have reverse impacts on other strategies aiming at the promotion of sustainable mobility. They need to be conceived in a way that allows their progressive phase-out. Similarly, financial incentives need to be reduced once the consumer cost differential between EVs and ICE alternatives moves towards zero.

Electric car charging can provide means to improve the flexibility of the electricity distribution system (especially when using slow charging infrastructure), but can also become a major strain on system flexibility (especially with fast charging) if not properly managed through proper control of charging time and power. Guaranteeing the materialization of positive flexibility impacts requires adequate smart linkages between the car, the charger and the system operator or a demand aggregator. Policies need to address this issue, making sure that the opportunity to take advantage of the benefits of smart charging is properly seized.

In the longer term, the policy framework supporting the multiple benefits implied by a growing EV market uptake will need to evolve along with the technology and market maturity, and will need to take into account broader systems aspects, such as the potential impact of a reduction in national revenue raised from fossil fuel taxation.

Statistical annex

This section provides electric car and EVSE data time series for the 40 countries covered in the scope of this report, i.e. EVI members and those falling under the scope of activity of the European Alternative Fuels Observatory (Figure 5). These numbers were those used for the graphs and analysis carried out in the report.

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The main sources of information used in these statistical tables include submissions from EVI members, statistics and indicators available from the European Alternative Fuels Observatory (EAFO, 2016) for European countries that are not members of the EVI, data extracted from commercial databases (IHS Polk, 2014; MarkLines, 2016) and information released by relevant stakeholders (ACEA, 2016a; EEA, 2015).

Electric car stock

Table 6 • Electric car stock (BEV and PHEV) by country, 2005-15 (thousands)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Canada							0.52	2.60	5.71	10.78	18.45
China						1.43	6.50	16.40	31.74	104.91	312.29
France	0.01	0.01	0.01	0.01	0.11	0.30	2.93	9.25	18.88	31.50	54.29
Germany	0.02	0.02	0.02	0.09	0.10	0.25	2.34	6.13	13.25	26.03	49.22
India				0.37	0.53	0.88	1.33	2.76	3.13	4.02	6.02
Italy	0.53	0.53	0.53	0.60	0.60	0.64	0.76	1.42	2.47	3.99	6.13
Japan					1.08	3.52	16.14	40.58	69.46	101.74	126.40
Korea						0.06	0.34	0.85	1.45	1.52	4.33
Netherlands				0.01	0.15	0.27	1.14	6.26	28.67	43.76	87.53
Norway				0.25	0.39	0.79	2.80	7.21	15.42	35.21	70.82
Portugal						0.02	0.22	0.32	0.53	0.82	2.00
South Africa									0.03	0.05	0.29
Spain						0.07	0.65	1.20	2.21	3.66	5.95
Sweden		0.12	0.13	0.13	0.16	0.19	0.37	1.25	2.65	7.09	14.53
United Kingdom					0.19	0.29	1.37	3.78	7.28	21.86	49.67
United States	1.12	1.12	1.12	2.58	2.58	3.77	21.50	74.74	171.44	290.22	404.09
Others*							1.73	4.48	8.76	19.59	44.89
Total	1.67	1.78	1.79	4.04	5.89	12.48	60.65	179.23	383.09	706.77	1 256.90

* Austria, Belgium, Bulgaria, Croatia, Cyprus¹⁸, Czech Republic, Denmark, Estonia, Finland, Greece, Hungary, Iceland, Ireland, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Poland, Romania, Slovak Republic, Slovenia, Switzerland, Turkey.

¹⁸ 1. Footnote by Turkey: The information in this document with reference to “Cyprus” relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the “Cyprus issue”.

2. Footnote by all the European Union Member States of the OECD and the European Union: The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

Table 7 • Battery electric cars, stock by country, 2005-15 (thousands)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Canada							0.22	0.88	2.52	5.34	10.03
China						1.09	5.84	15.48	30.09	79.00	225.72
France	0.01	0.01	0.01	0.01	0.11	0.30	2.93	8.58	17.34	27.90	45.17
Germany	0.02	0.02	0.02	0.09	0.10	0.25	2.07	4.63	10.09	18.47	30.56
India				0.37	0.53	0.88	1.33	2.76	2.95	3.35	4.35
Italy	0.53	0.53	0.53	0.60	0.60	0.64	0.76	1.27	2.10	3.18	4.58
Japan					1.08	3.52	16.13	29.60	44.35	60.46	70.93
Korea						0.06	0.34	0.85	1.45	1.52	4.06
Netherlands				0.01	0.15	0.27	1.12	1.91	4.16	6.83	9.37
Norway				0.25	0.39	0.79	2.80	6.87	14.75	32.86	60.65
Portugal						0.02	0.22	0.28	0.45	0.65	1.28
South Africa									0.03	0.05	0.17
Spain						0.07	0.64	1.09	2.01	3.04	4.46
Sweden		0.12	0.13	0.13	0.16	0.19	0.37	0.60	1.01	2.17	4.77
United Kingdom					0.19	0.29	1.36	2.78	5.33	12.01	21.42
United States	1.12	1.12	1.12	2.58	2.58	3.77	13.52	28.17	75.86	139.28	210.33
Others*							1.68	3.52	7.02	14.99	31.98
Total	1.67	1.78	1.79	4.04	5.89	12.13	51.33	109.26	221.52	411.09	739.81

* Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Greece, Hungary, Iceland, Ireland, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Poland, Romania, Slovak Republic, Slovenia, Switzerland, Turkey.

Table 8 • Plug-in hybrid electric cars, stock by country, 2005-15 (thousands)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Canada							0.30	1.72	3.20	5.44	8.42
China						0.34	0.66	0.92	1.65	25.92	86.58
France							0.00	0.67	1.53	3.60	9.12
Germany							0.27	1.50	3.15	7.56	18.67
India									0.19	0.66	1.66
Italy							0.00	0.15	0.37	0.81	1.55
Japan							0.02	10.98	25.11	41.28	55.47
Korea											0.27
Netherlands							0.02	4.35	24.51	36.94	78.16
Norway						0.01	0.01	0.35	0.67	2.35	10.17
Portugal							0.00	0.03	0.08	0.18	0.72
South Africa											0.12
Spain							0.01	0.12	0.20	0.62	1.49
Sweden								0.65	1.64	4.92	9.76
United Kingdom							0.01	1.00	1.95	9.86	28.25
United States							7.98	46.57	95.58	150.94	193.77
Others*							0.05	0.96	1.75	4.60	12.91
Total						0.35	9.32	69.96	161.57	295.68	517.10

* Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Greece, Hungary, Iceland, Ireland, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Poland, Romania, Slovak Republic, Slovenia, Switzerland, Turkey.

Electric cars: New registrations

Table 9 • Battery electric cars, new registrations by country, 2005-15 (thousands)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Canada							0.22	0.62	1.64	2.83	4.38
China						1.09	4.75	9.64	14.61	48.91	146.72
France	0.01				0.10	0.18	2.63	5.66	8.76	10.56	17.27
Germany	0.02			0.07	0.02	0.14	1.83	2.56	5.46	8.38	12.08
India				0.37	0.16	0.35	0.45	1.43	0.19	0.41	1.00
Italy	0.53			0.08		0.04	0.12	0.51	0.84	1.08	1.40
Japan					1.08	2.44	12.61	13.47	14.76	16.11	10.47
Korea						0.06	0.28	0.64	0.67	1.26	2.54
Netherlands				0.01	0.03	0.12	0.86	0.79	2.25	2.66	2.54
Norway				0.24	0.15	0.39	2.01	4.07	7.88	18.11	27.79
Portugal						0.02	0.20	0.06	0.17	0.20	0.64
South Africa									0.03	0.01	0.12
Spain						0.07	0.57	0.44	0.92	1.04	1.42
Sweden							0.18	0.27	0.43	1.24	2.96
United Kingdom					0.19	0.10	1.07	1.42	2.55	6.68	9.42
United States	1.12			1.47		1.19	9.75	14.65	47.69	63.42	71.04
Others*							1.68	1.85	3.50	7.97	16.99
Total	1.67			2.24	1.72	6.21	39.19	58.06	112.36	190.84	328.77

* Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Greece, Hungary, Iceland, Ireland, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Poland, Romania, Slovak Republic, Slovenia, Switzerland, Turkey.

Table 10 • Plug-in hybrid electric cars, new registrations by country, 2005-15 (thousands)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Canada							0.30	1.40	1.48	2.24	2.58
China						0.34	0.32	0.26	0.73	24.27	60.66
France								0.67	0.86	2.07	5.52
Germany							0.27	1.23	1.66	4.40	11.11
India									0.19	0.48	1.00
Italy								0.15	0.22	0.45	0.74
Japan							0.02	10.97	14.12	16.18	14.19
Korea											0.27
Netherlands							0.02	4.33	8.08	12.43	41.23
Norway					0.01			0.34	0.32	1.68	7.82
Portugal								0.03	0.04	0.10	0.54
South Africa											0.12
Spain							0.01	0.11	0.09	0.42	0.87
Sweden								0.66	1.12	3.43	5.63
United Kingdom							0.01	0.99	0.96	7.90	18.39
United States							7.98	38.59	49.01	55.36	42.83
Others*							0.06	0.91	0.78	2.86	8.31
Total						0.35	8.97	60.63	79.65	134.25	221.80

* Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Greece, Hungary, Iceland, Ireland, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Poland, Romania, Slovak Republic, Slovenia, Switzerland, Turkey.

Electric cars: Market share

Table 11 • Electric cars (battery electric and plug-in hybrid), market share by country, 2005-15

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Canada							0.0%	0.1%	0.2%	0.3%	0.4%
China						0.0%	0.0%	0.1%	0.1%	0.4%	1.0%
France							0.1%	0.3%	0.5%	0.7%	1.2%
Germany							0.1%	0.1%	0.2%	0.4%	0.7%
India						0.0%	0.0%	0.1%	0.0%	0.0%	0.1%
Italy								0.0%	0.1%	0.1%	0.1%
Japan					0.0%	0.1%	0.4%	0.5%	0.6%	0.7%	0.6%
Korea							0.0%	0.1%	0.1%	0.1%	0.2%
Netherlands						0.0%	0.2%	1.0%	2.5%	3.9%	9.7%
Norway				0.2%	0.1%	0.3%	1.5%	3.2%	5.8%	13.7%	23.3%
Portugal							0.1%	0.1%	0.2%	0.2%	0.7%
South Africa											0.1%
Spain							0.1%	0.1%	0.1%	0.2%	0.2%
Sweden							0.1%	0.3%	0.5%	1.4%	2.4%
United Kingdom							0.1%	0.1%	0.2%	0.6%	1.0%
United States						0.0%	0.1%	0.4%	0.6%	0.7%	0.7%
Others*							0.0%	0.1%	0.1%	0.3%	0.7%
Total**				0.0%	0.0%	0.0%	0.1%	0.2%	0.3%	0.5%	0.9%

* Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Greece, Hungary, Iceland, Ireland, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Poland, Romania, Slovak Republic, Slovenia, Switzerland, Turkey.

** The total market share is calculated for all the countries covered above.

EVSE

The number of private chargers was estimated on the basis of one private charger per electric car. As a result, the data shown in Table 6 also represent the number of private chargers by country for the years 2005-15.

Table 12 • Publicly accessible slow charger stock by country, 2005-15 (number of units)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Canada							144	722	1 172	2 266	3 360
China										21 000	46 657
France						26	253	800	1 700	1 700	10 122
Germany						60	573	1 500	2 400	2 606	4 787
India						72	108	225	256	328	328
Italy						614	728	1 350	1 350	1 350	1 679
Japan										8 640	16 120
Korea						57	321	640	833	1 170	1 170
Netherlands						400	1 826	3 611	5 770	11 860	17 786
Norway						2 800	3 105	3 688	4 511	5 471	6 357
Portugal						88	1 080	1 128	1 154	1 172	1 192
South Africa											10
Spain						25	216	400	800	800	1 479
Sweden						76	146	500	1 000	1 070	1 350
United Kingdom						318	1 503	2 804	5 515	7 431	8 716
United States			333	339	373	482	3 903	11 695	14 990	20 115	28 150
Others*						1	49	2 190	3 525	6 810	12 539
Total			333	339	373	5 018	13 957	31 253	44 976	93 789	161 802

* Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Greece, Hungary, Iceland, Ireland, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Poland, Romania, Slovak Republic, Slovenia, Switzerland, Turkey.

Note: Slow chargers include AC level 1 (≤ 3.7 kW) and AC level 2 chargers (> 3.7 kW and ≤ 22 kW).

Table 13 • Publicly accessible fast charger stock by country, 2005-15 (number of units)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Canada								2	7	55	153
China						123	558	1 407	2 723	9 000	12 101
France							3	9	76	127	543
Germany						3	28	75	161	317	784
India											
Italy						2	2	4	6	10	70
Japan					95	312	801	1 381	1 794	2 877	5 990
Korea						6	33	85	59	60	100
Netherlands						4	15	63	114	262	465
Norway						6	23	58	87	200	698
Portugal							6	8	10	9	14
South Africa											
Spain						2	21	39	71	118	186
Sweden						1	1	5	70	135	350
United Kingdom						3	13	36	100	470	1 158
United States			42	42	47	60	489	1 464	1 877	2 518	3 524
Others*						3	25	241	320	790	1 571
Total			42	42	142	524	2 018	4 876	7 475	16 948	27 707

* Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Greece, Hungary, Iceland, Ireland, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Poland, Romania, Slovak Republic, Slovenia, Switzerland, Turkey.

Note: Fast chargers include AC 43 kW chargers, DC chargers, Tesla Superchargers and inductive chargers.

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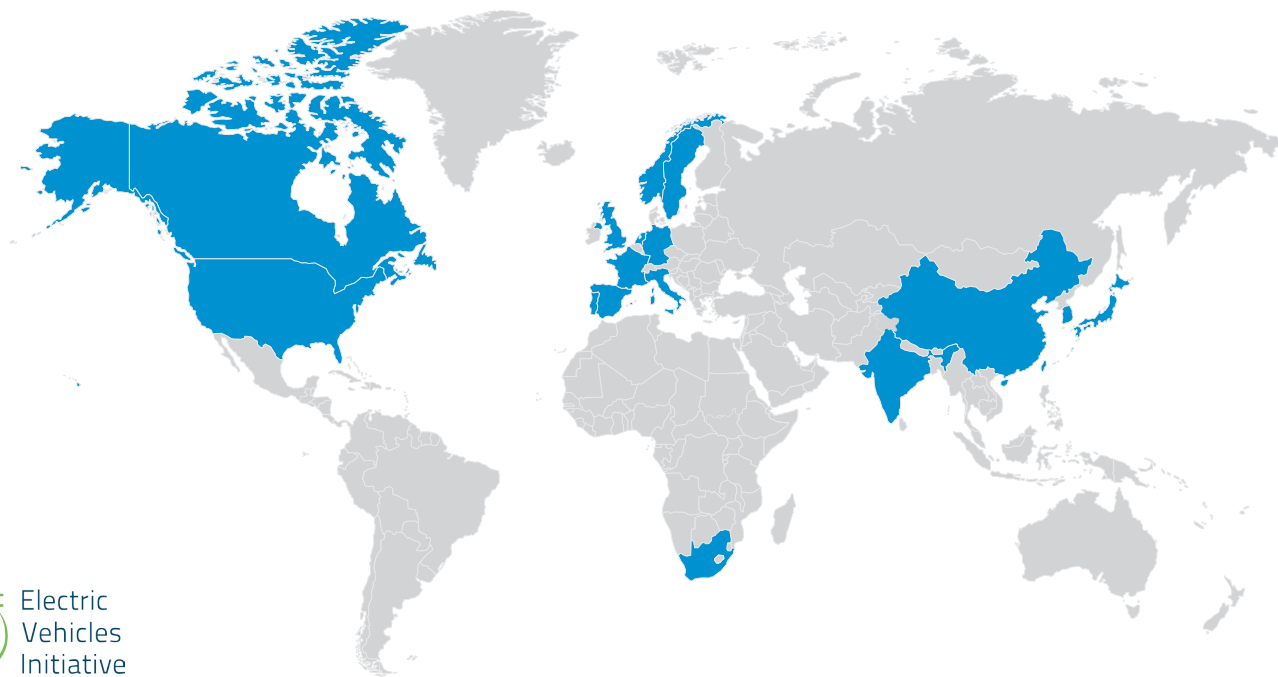
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Electric Vehicles Initiative

The EVI is a multi-government policy forum established in 2009 under the Clean Energy Ministerial, dedicated to accelerating the deployment of EVs worldwide with the goal of a global deployment of 20 million electric cars by 2020. It brings together representatives of its member governments and partners twice per year and acts as an effective platform for knowledge-sharing on policies and programmes that support EV deployment.

The EVI counts today 16 member governments (Canada, China, France, Germany, India, Italy, Japan, Korea, the Netherlands, Norway, Portugal, South Africa, Spain, Sweden, the United Kingdom and the United States), representing most of the global EV stock and including the largest and most rapidly growing EV markets worldwide. China and the United States are co-chairs of the initiative, and the EVI secretariat is hosted by the IEA.



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