

# GLOBAL EV OUTLOOK

Understanding the Electric Vehicle Landscape to 2020

April 2013





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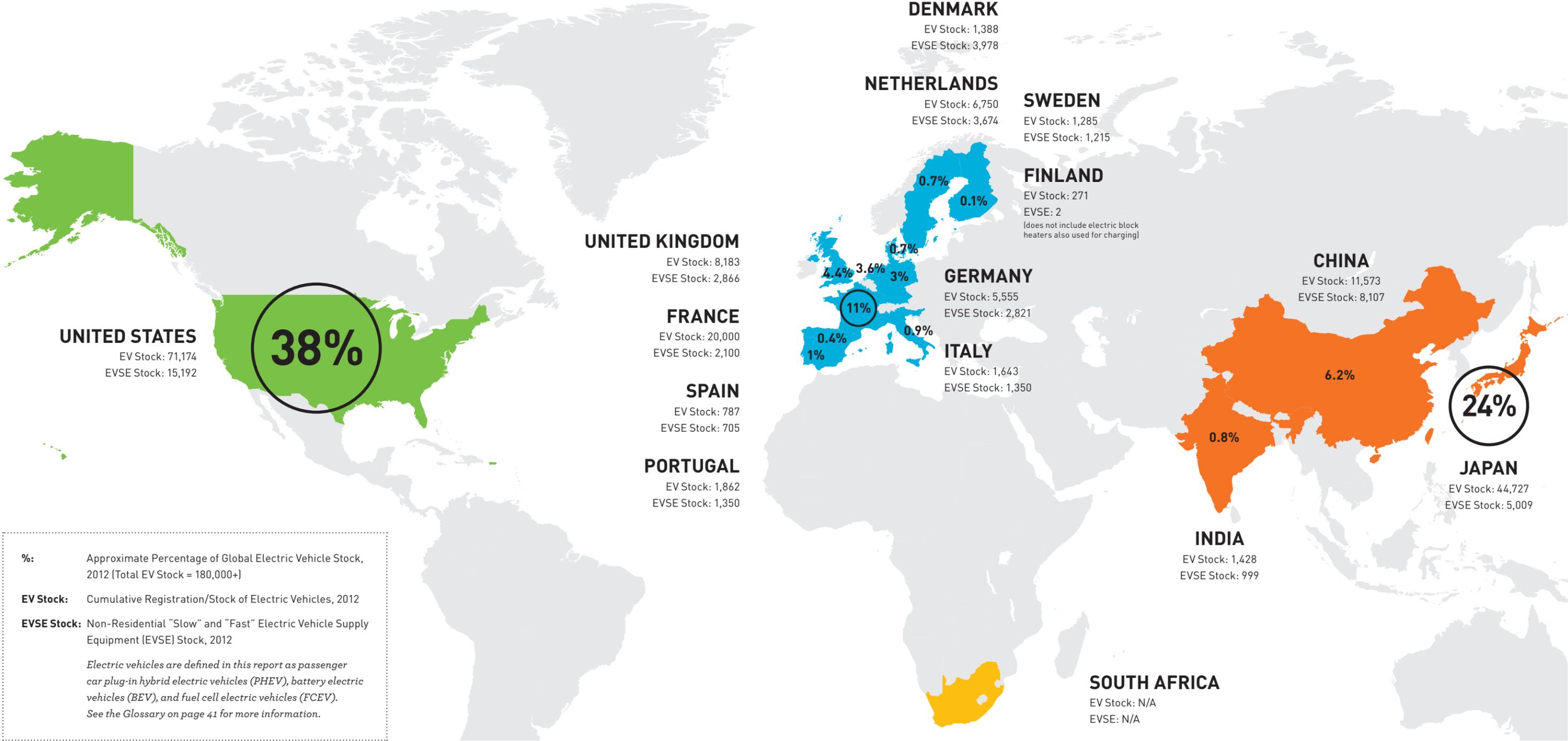
April 2013

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# ELECTRIC VEHICLES INITIATIVE (EVI)

EVI MEMBER COUNTRIES HELD OVER 90% OF WORLD ELECTRIC VEHICLE (EV) STOCK IN 2012

The Electric Vehicles Initiative (EVI) is a multi-government policy forum dedicated to accelerating the introduction and adoption of electric vehicles worldwide. EVI is one of several initiatives launched in 2010 under the Clean Energy Ministerial, a high-level dialogue among energy ministers from the world's major economies. EVI currently includes 15 member governments from Africa, Asia, Europe, and North America, as well as participation from the International Energy Agency (IEA).



**%:** Approximate Percentage of Global Electric Vehicle Stock, 2012 (Total EV Stock = 180,000+)

**EV Stock:** Cumulative Registration/Stock of Electric Vehicles, 2012

**EVSE Stock:** Non-Residential "Slow" and "Fast" Electric Vehicle Supply Equipment (EVSE) Stock, 2012

*Electric vehicles are defined in this report as passenger car plug-in hybrid electric vehicles (PHEV), battery electric vehicles (BEV), and fuel cell electric vehicles (FCEV). See the Glossary on page 41 for more information.*



Autolib Charging Station — Paris, France, December 2012

# Global EV Outlook

## Key Takeaways

The *Global EV Outlook* represents the collective effort of two years of primary data gathering and analysis from the Electric Vehicles Initiative's 15 member governments. Below are key takeaways and insights from this work.

### Global EV Stock

(through end of 2012)

represents 0.02% of total passenger cars

# 180,000+

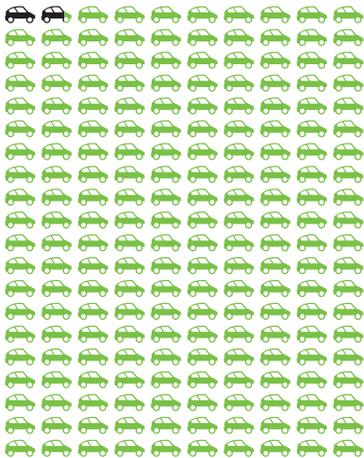
### EVI Goal

represents 2% of total passenger cars (projected)

# 20 million

on the road

# by 2020



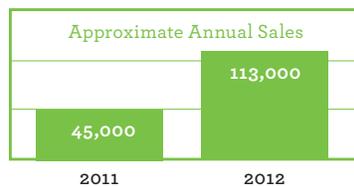
100,000 EVs

Global EV stock, end of 2012

### % of 2012 Global EV Stock in EVI Countries

# 90%+

### Global EV Sales More Than Doubled Between 2011 and 2012



### EVI Members

include

# 8 of the 10

largest vehicle markets in the world

# 63%

of the world's total vehicle demand

# 83%

of EV sales between now and 2020 (projected)

### Commitment is Strong

Through their actions and words, governments and industry have reaffirmed their commitment to vehicle electrification. Even more public-private coordination will be required to meet the 20 million by 2020 goal.



### RD&D is Paying Off

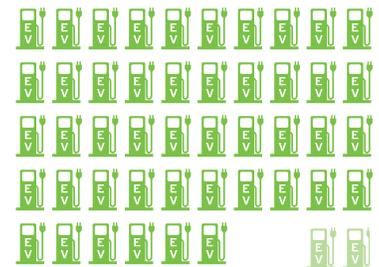
Research, development, and demonstration (RD&D) efforts are paying off with EVI governments providing over USD 8.7 billion in investment since 2008, helping to address one of the major hurdles to EV adoption by significantly reducing battery costs.



### EVSE Stock in EVI Countries

(approximate, through end of 2012)

represents non-residential charging points



46,000 slow 1,900 fast

### Moving Forward

EVI is facilitating the coordination and communication among key public and private stakeholders worldwide to address the challenges of vehicle electrification across the areas of technology, finance, market, and policy.

# INTRODUCTION & SCOPE

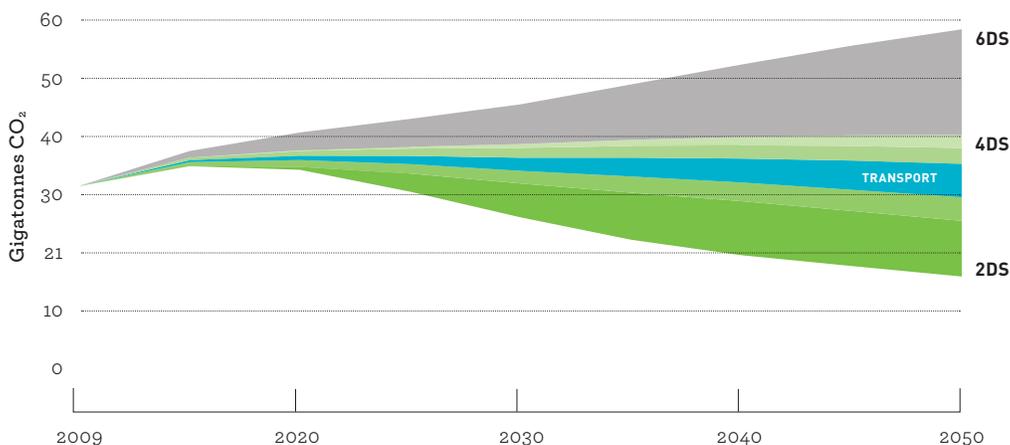
As countries seek to address future energy requirements in a rapidly growing and changing world, achieving sustainable transportation has emerged as a vital mission. Electric vehicles (EVs), in particular, represent one of the most promising pathways to increased energy security and reduced emissions of greenhouse gases and other pollutants.

*By helping to diversify the fuel mix*, EVs reduce dependence on petroleum and tap into a source of electricity that is often domestic and relatively inexpensive. Just as important, EVs have the potential to unlock innovation and create new advanced industries that spur job growth and enhance economic prosperity.

In the long-term, EVs are important to countries seeking to decarbonise the transport sector. **Figure 1** illustrates the key role of transport CO<sub>2</sub> reductions in the International Energy Agency's (IEA) "2DS" scenario (2°C Scenario), which describes a future energy system that would limit average global temperature increases to 2°C by 2050. In this scenario, the transport sector's potential share of overall CO<sub>2</sub> reductions would be 21% by 2050. In order to meet this share, three-fourths of all vehicle sales by 2050 would need to be plug-in electric of some type.

**Figure 1. Role of Transport in CO<sub>2</sub> Reduction (% = 2050 estimate)**

Source: IEA, ETP 2012. NOTE: Sector percentages represent cumulative contributions to emissions reductions relative to the 4DS (4°C Scenario, which is based on proposed policies).



## SECTORS

■ Power Generation <b>42%</b>	■ Buildings <b>12%</b>
■ Transport <b>21%</b>	■ Other Transformation <b>7%</b>
■ Industry <b>18%</b>	■ Additional Emissions <b>6DS (6°C Baseline Scenario)</b>

## IN THIS REPORT

// Presentation of primary data collected from EVI member governments on EV and related infrastructure deployment goals; policies, programmes, and incentives; deployment progress; and investment in research, development, and demonstration (RD&D); all of which informs an analysis of global market trends and progress in electric vehicle deployment and the implications for technology and policy.\*

// Identification of challenges to EV deployment as well as opportunities to address those challenges.

// An outline of areas of opportunity for governments and industry to accelerate adoption of electric vehicles: *Opportunity Matrix: Pathways to 2020.*

\*See also, IEA's "Tracking Clean Energy Progress," April 2013.

### THE THIRD AGE OF ELECTRIC VEHICLES

Electrified road transport has been around in some form for more than 100 years, although by the 1930s its use by light-duty passenger cars was displaced almost entirely by the petroleum-fueled internal combustion engine (ICE). EVs appeared on the market both in the early 1900s and briefly in the 1990s. In the last 10 years the world has again considered vehicle electrification in light of increasing and volatile oil prices, deteriorating urban air quality, and climate change. This renewed interest represents a “third age” of electric vehicles, starting with the mass-market introduction of EVs in 2010.<sup>1</sup>

(See *Timeline on page 23.*)

- A number of governments are now establishing clear deployment goals for EVs, which include PHEVs, BEVs, and FCEVs.
- Automobile manufacturers and consumers are also embracing this technological shift, driven in part by stricter fuel efficiency regulations and a desire to mitigate risks from oil price fluctuations.
- Robust rates of growth in sales in a number of major markets, new car models from a variety of manufacturers, and significant cost reductions in components such as batteries are helping to grow the nascent EV market.
- Innovative products and business models such as wireless charging, car sharing, and workplace charging are contributing to a new ecosystem that is further enabling electrification. Governments are assisting in this market transformation by providing sizable investments in research and development as well as consumer incentives.

While early sales of EVs have been strong, with over 180,000 passenger car EVs sold worldwide through 2012, they represent only 0.02% of the total passenger car stock at present. In order to meet ambitious deployment targets established by a number of countries, greater adoption rates will need to be achieved in the years up to 2020.

### THE ROLE OF THE ELECTRIC VEHICLES INITIATIVE

EVI seeks to facilitate the global deployment of at least 20 million passenger car EVs, including plug-in hybrid and fuel cell electric vehicles, by 2020. This goal is based in part on countries’ deployment targets and on other factors such as IEA scenarios. EVI will enable progress toward this goal by:

1. Encouraging the development of national deployment goals, as well as best practices and policies to achieve those goals;
2. Leading a network of cities to share experiences and lessons learned from early EV deployment in urban areas and regions;
3. Sharing information on public investment in RD&D programmes to ensure that the most crucial global gaps in vehicle technology development are being addressed;
4. Engaging private-sector stakeholders to better align expectations, discuss the respective roles of industry and government, and focus on the benefits of continued investment in EV technology innovation and EV procurement for fleets.

### REPORT SCOPE

Although the *Global EV Outlook* does not provide data or specific projections for every country that supports vehicle electrification, the progress and pathways of EVI countries represent a reliable bellwether for global EV readiness. EVI members include 8 of the 10 largest vehicle markets in the world, account for about 63% of the world’s total vehicle demand, and are projected to account for 83% of EV sales between now and 2020.<sup>2</sup> Moreover, many of EVI’s members rank high on researchers’ lists of top EV countries: 9 of the top 10 most developed markets in McKinsey & Company’s “electric vehicle index” are EVI members, as are 8 of the 10 top EV markets according to Pike Research.<sup>3</sup>

EVI is therefore assembling a unique and highly valuable global perspective of the burgeoning EV market while identifying important market trends and best practices.

# DATA & ANALYSIS

**EVI is uniquely positioned to track the initial years of mass-market deployment of EVs. The data presented in this section describe a rapidly growing market, but with a long way to go before achieving high rates of market penetration.**

## EV DEPLOYMENT TARGETS & PROGRESS

*EVI deployment targets* show that several countries have set EV sales and/or stock targets to signal their long-term commitment to vehicle electrification. Target-setting is by no means a prerequisite for, or determinant of, successful EV deployment, but it is useful for understanding the level of ambition and support from national policymakers.

Figures 2 and 3 show cumulative sales and stock targets for the 9 out of the 15 EVI members that have official targets\*. Together these targets add up to 5.9 million in sales and 20 million of stock by 2020. There are other countries outside of the EVI member group that have official targets, but the bulk of EV sales until 2020 will likely take place in EVI member countries, which can therefore be considered a useful benchmark for EV deployment in the near term.

National sales and stock targets are not meant to be forecasts, but they can be used for creating national roadmaps that outline steps to be taken to achieve the goals while also tracking progress.\*\*

### EV DEPLOYMENT PROGRESS

At the end of 2012, total worldwide electric vehicle stock numbered over 180,000, with over 90% of this stock in the EVI membership group [ Figure 4]. The largest non-EVI stock can be found in Norway, which numbers about 10,000.<sup>4</sup>

These figures only include passenger cars, and not buses, motorcycles or heavy-duty vehicles. In fact, China alone has almost 180 million fully electric two-wheelers, which far surpasses any other EV fleet.<sup>5</sup> Unless noted otherwise, EVs will refer to passenger cars throughout this report.

### CORRELATION BETWEEN SALES AND PRODUCT VARIETY

As Figure 5 shows, there has been an increase over the past two years of both cumulative EV sales and the number of vehicle models being offered. In 2010 there were 16 EV models on sale and around 20 in 2012. However, only 2-3 EV models on the market in 2010 were widely available to consumers, which increased in 2012 to about 6-8 EV models widely available to the general public in several countries. The numbers show a strong correlation between sales and product variety. This suggests that more EV models coming to market will result in more choices for the consumer, and could further increase sales.



Car2Go — Amsterdam, the Netherlands, November 2011

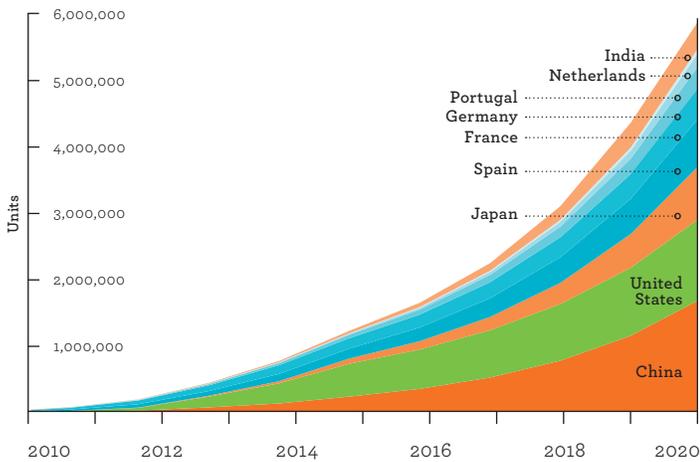
\*Some countries include vehicle types other than PHEVs and BEVs in their targets. Where possible, vehicle types were counted separately.

\*\*For more information, see IEA's "Technology Roadmap: Electric and Plug-in Hybrid Electric Vehicles," June 2011, and IEA's "Tracking Clean Energy Progress," April 2013.

## EV DEPLOYMENT TARGETS & PROGRESS [continued]

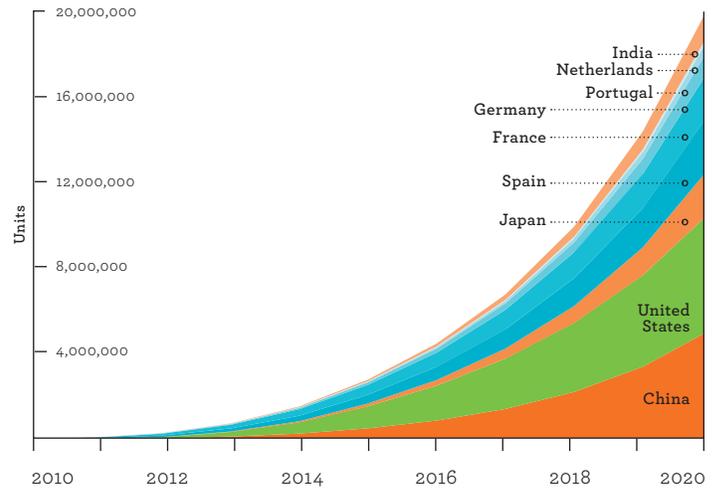
**Figure 2. EV Sales Targets [ select EVI members ]**

Source: EVI. Note: A 20% compound annual growth rate is assumed for countries without a specific sales target (i.e., only a stock target) or with targets that end before 2020.



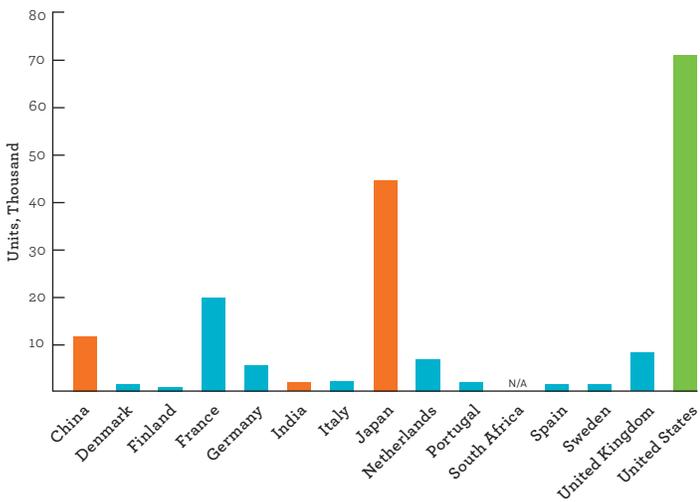
**Figure 3. EV Stock Targets [ select EVI members ]**

Source: EVI. Note: A 20% compound annual growth rate is assumed for countries without a specific stock target (i.e., only a sales target) or with targets that end before 2020.



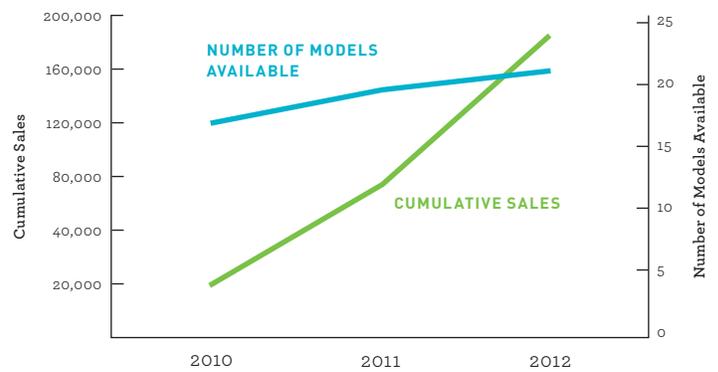
**Figure 4. EV Stock in EVI Countries, 2012**

Source: EVI.



**Figure 5. Global EV Model Diversity and Sales**

Source: MarkLines Database.



### CRUNCHING THE NUMBERS: SALES & STOCK TARGETS FOR 2020

The aggregated goal for all countries with known deployment targets is 7.2 million in EV sales and 24 million in EV stock. Of this goal, EVI countries account for cumulative sales of 5.9 million and stock of 20 million.

## EV DEPLOYMENT TARGETS & PROGRESS [continued]

### 2012 NOTABLE EV EVENTS

// World EV sales exceeded 100,000 units for the first time.

// *Motor Trend* magazine named the Tesla Model S its 2013 Car of the Year, marking the first time a non-petrol powered vehicle won the accolade.

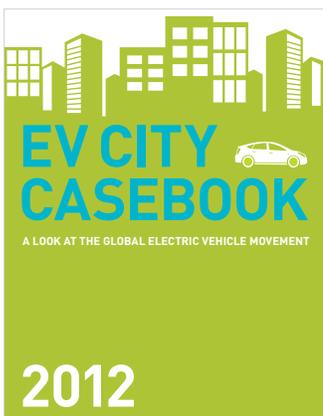


// Toyota launched its plug-in version of the Prius, which quickly outsold three other BEV models in 2012.

// The Chevrolet Volt ranked the highest in *Consumer Reports'* owner satisfaction survey for the second consecutive year.

// EVI and partner organisations published the *EV City Casebook*, a guide to EV deployment efforts worldwide, featuring 16 cities in 9 countries across 3 continents.

[bit.ly/EVCityCasebook](http://bit.ly/EVCityCasebook)



### DISTINCT GEOGRAPHIC DISTRIBUTION

2012 EVI data show a distinct geographic distribution for PHEV and BEV sales [Figures 6a, 6b].

- The largest share of the worldwide PHEV market is in the United States, due to the predominance of the Chevrolet Volt. Japan claims the second spot, largely due to increasing sales of the Toyota plug-in Prius.
- In the worldwide BEV market, Japan holds the largest share due to sales of the Nissan LEAF, followed by the United States, then China, due in part to the use of electric taxis in Shenzhen and Hangzhou. France is in the fourth spot, in part due to Bolloré's Bluecar, a part of the Paris EV car sharing scheme Autolib.
- The total number of FCEVs is very low due to a limited number of models on the market, limited infrastructure, and higher costs compared to a BEV or PHEV.

### MARKET SHARE

As shown in Figure 7, EV sales in Q1-Q3 2012 only reached 1% of total vehicle sales in Norway and Japan, but as EVs begin to penetrate the automotive market, the shares are likely to increase. In fact, in the last quarter of 2012 EV sales reached over 1% of total vehicle sales in both the Netherlands and the United States, furthering gains in market share. At the end of 2012, the highest sales shares of EVs were in Norway, Japan, Ireland, the Netherlands, and the United States. The main PHEV and BEV markets can be found in the 15 EVI countries with worldwide sales shares being about 96% and 89%, respectively.

Analysis of EVI data show that to reach the EVI goal of 5.9 million in annual sales of EVs in 2020, the 2011 EV market (approximately 45,000) would need to grow by 72% compounded each year until 2020. Meeting this target of course becomes more of a challenge each year, but as 2012 came to a close, total sales numbered approximately 113,000, a more than doubling of the market. While this one-year growth is ahead of the curve, it will be much more difficult to double sales in later years, e.g. between 2019 to 2020, than in the first year. Nevertheless, the result is that the market has doubled and the growth rate is ahead of both IEA's 2DS scenario and cumulative EVI sales/stock targets to date.

## EV DEPLOYMENT TARGETS & PROGRESS [continued]

Figure 6a. 2012 World PHEV Sales, by Country

Source: EVI, MarkLines Database.

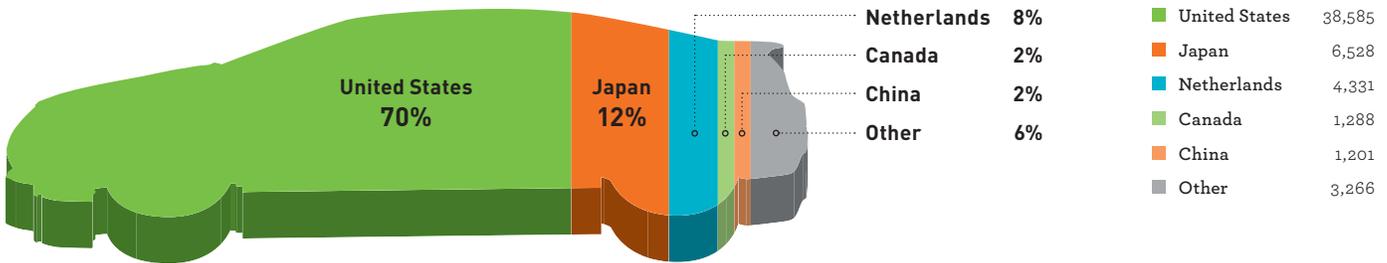


Figure 6b. 2012 World BEV Sales, by Country

Source: EVI, MarkLines Database.

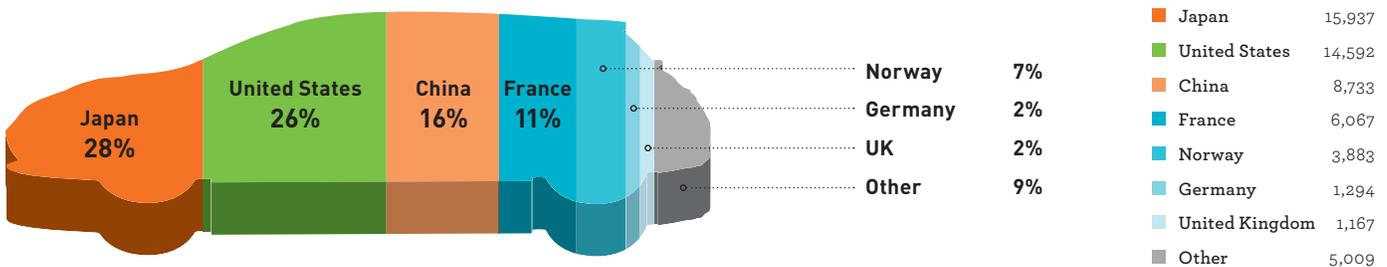
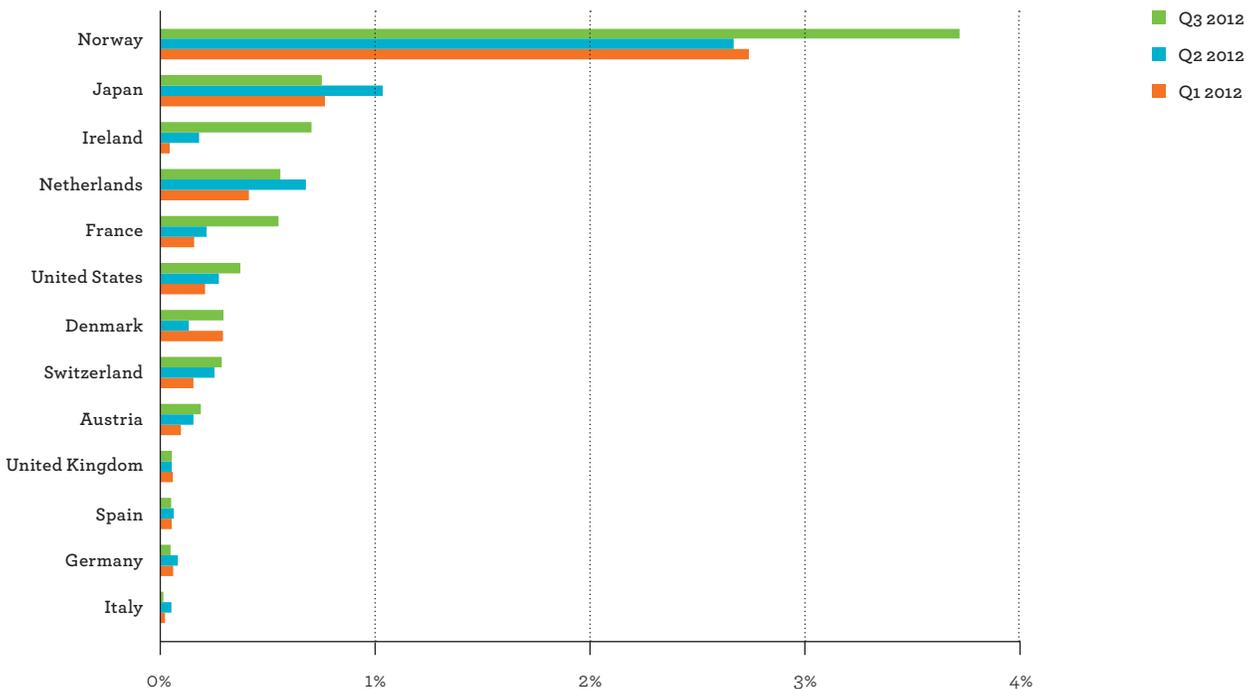


Figure 7. EV Uptake Comparison, Q1 -Q3 2012

[ EV sales as % of total passenger vehicle sales ]

Source: Bloomberg New Energy Finance. Note: Q3 sales data for China and some European countries was incomplete at time of publication.





**Mode d'emploi**  
Instructions

**1**

Retirez le couvercle de la borne et insérez sur le bouton de démarrage, par branchement, le câble de votre véhicule.

**2**

Placez votre carte CIRCUIT ÉLECTRIQUE sur le lecteur. Le statut de charge en cours de la borne s'affiche.

**3**

Lorsque la recharge est terminée, enrroulez le câble sur le crochet et branchez le pistolet sur la borne de recharge pour conclure la transaction.

When charging is finished, wrap the cable around the cable hanger and plug the connector back into the charging station to finish the transaction.

**e**  
Circuit  
électrique

ALIMENTÉ PAR  
HYDRO-QUÉBEC

État de tension

Power status

Prête pour la charge

Ready to charge

Véhicule connecté

Vehicle connected

Recharge en cours

Recharge in progress

Problème

Problem

Reprise

Resume

Pause

Pause

Problème d'utilisation  
de cette borne ?  
1 855 999-8378  
Service 24 heures

Problems using  
this charging station ?  
1 855 999-8378  
24-hour service



www.caa.ca



## EVSE DEPLOYMENT TARGETS & PROGRESS

### Electric Vehicle Supply Equipment (EVSE) deployment

is taking place across different locations – residential, office, fleet, retail, street, other – and by different modes of charging, which can be generally grouped into the categories of “slow” and “fast”. Definitions of slow and fast charging often vary by country and/or region. The definitions used in this report attempt to capture the range of charging times typically experienced.

By 2020, EVI countries have cumulative targets for approximately 2.4 million slow chargers and 6,000 fast chargers. Japan accounts for the bulk of this goal, with an official government target to deploy 2 million slow chargers and 5,000 fast charging points by 2020. As part of its nationwide demonstration project, the United States is targeting the deployment of over 22,000 chargers, including 350 fast chargers, by 2014. The Netherlands aims to have 20,000 slow chargers and 100 fast chargers by 2015.

### EVSE DEPLOYMENT BY SLOW AND FAST CHARGING POINTS

Figure 8 details the existing deployment of non-residential EVSE by slow and fast charging points, by country.

Figure 9 shows an increase over the past five years of both slow and fast chargers. EVSE deployment rose in 2010 as governments prepared the necessary infrastructure for impending EV market introduction in 2011. The EVI total at the end of 2012 for slow chargers was 47,462 and for fast chargers 1,907. However, this slow charger number does not include 1.5 million electric block heaters in Finland, which can also be used to charge electric vehicles. Additionally, the slow charger number is certainly an underestimate as almost no country keeps track of home installations of slow chargers. Unless otherwise noted, EVSE refers to non-residential charging points.\*

\*Where possible, EVSE locations were counted separately.

### SLOW CHARGING

The most common type of charging provides alternating current to the vehicle’s battery from an external charger. **Charging times can range from 4 to 12 hours for a full charge.**

### FAST CHARGING

Also known as “DC quick charging”, fast charging stations provide a direct current of electricity to the vehicle’s battery from an external charger. **Charging times can range from 0.5 to 2 hours for a full charge.**

Figure 8. Non-Residential EVSE Stock in EVI Countries by Slow/Fast, 2012

Source: EVI.

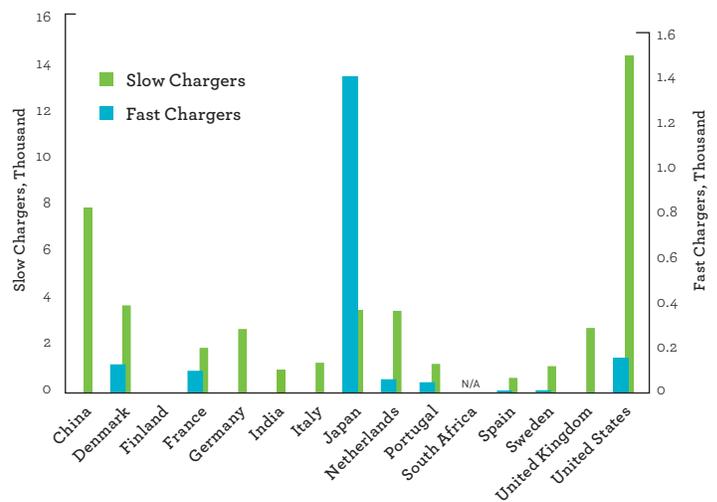
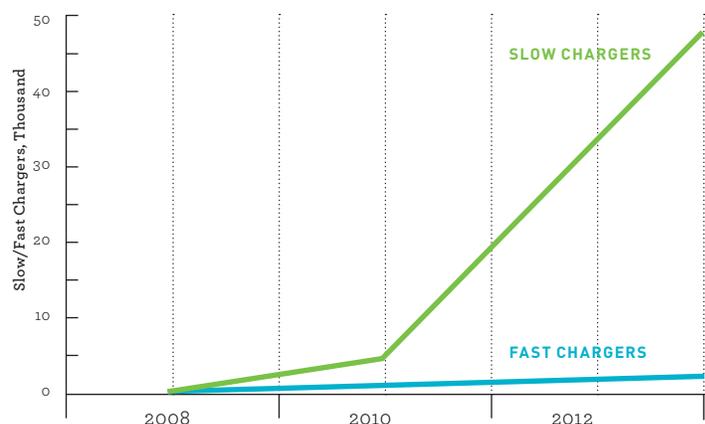


Figure 9. Non-Residential EVSE Growth in EVI Countries

Source: EVI.



## EVSE DEPLOYMENT TARGETS & PROGRESS [continued]

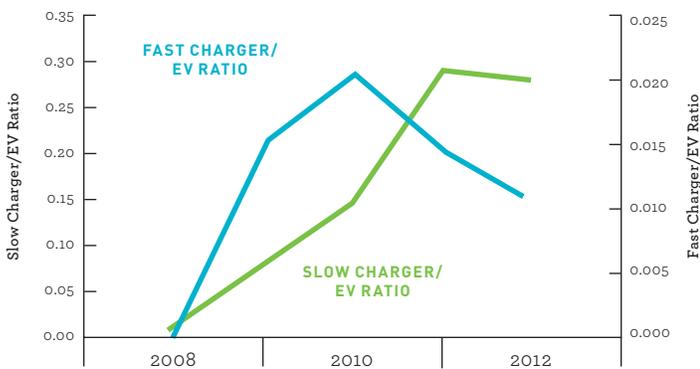
### EVSE TO EV RATIOS

The absolute number of chargers is not the sole driver of EV development, of course. More EVSE is not necessarily better. Figure 10 shows EVI ratios of EVSE/EV, which appear to be declining or stabilizing as vehicle deployment increases and countries take stock of their existing EVSE capabilities.

**Figure 10. Non-Residential EVSE/EV Ratio**

[EVI Countries]

Source: EVI.



Early estimates of adequate non-residential EVSE/EV ratios range from 0.08 to 0.3.<sup>6</sup> Figure 10 shows that EVI countries currently fall within this range for slow charging. While fast charging ratios are much lower, it is also possible that fast chargers are not as widely needed as previously thought. Preliminary research suggests, in fact, that a well-designed system would only need a few fast charging stations instead of blanketing a wide area. In one U.S. study, 100-200 fast charging locations were deemed sufficient for good initial geographic coverage for the majority of drivers in California.<sup>7</sup> Further research is needed to better understand the EVSE mix best suited to a given region's EV fleet. China, for example, is aiming for a 1.25 EVSE/EV ratio by 2020 for slow chargers, but is waiting for market developments to determine the best fast charger ratio.

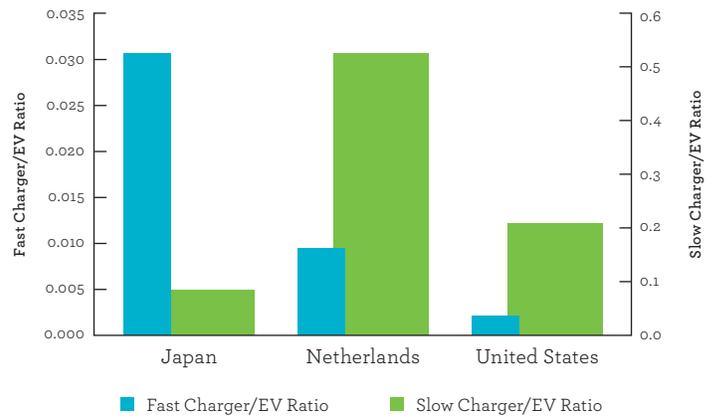
### DIFFERENT APPROACHES FOR DIFFERENT COUNTRIES

The three EVI members selected in Figure 11 show how countries are approaching non-residential EVSE deployment in very different ways. Japan has already installed 1,381 fast chargers, which is the highest amount for any country worldwide, but has placed less emphasis on slow chargers to date. In the United States, conversely, the emphasis appears to be on slow charging, perhaps due to more reliance on home charging and the prevalence of PHEVs. Finally, in the Netherlands a mix of slow and fast chargers is being employed, resulting in the most EVSE per capita worldwide. There is no one correct path, rather different EVSE networks based on local needs.

**Figure 11. Different EVSE Deployment Profiles, 2012**

[Select EVI Members]

Source: EVI.



EV Charging Point — Newcastle-upon-Tyne, United Kingdom, Autumn 2011

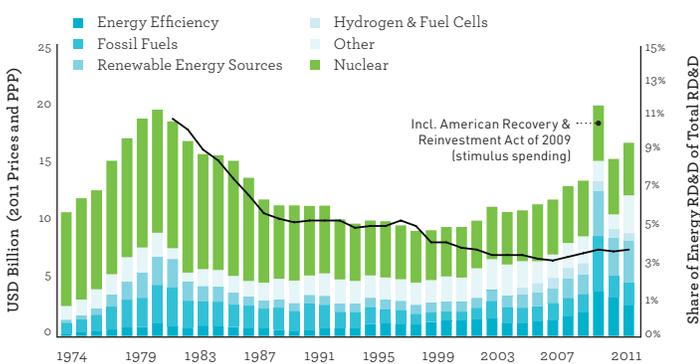
## RESEARCH, DEVELOPMENT & DEMONSTRATION (RD&D)

*Research, development & demonstration (RD&D)* are key activities for countries seeking to help technological innovation reach full market potential. The IEA tracks public sector energy RD&D among its 28 member countries. As seen in **Figure 12**, there is a decreasing relative share of global RD&D spending since tracking began in 1981, though an increasing trend in absolute figures since the mid-1990s.

There is a spike in funding in 2009 due to the U.S. economic stimulus, though several other countries, such as Germany and Japan, also increased RD&D in order to boost their automotive sectors and overall economies. The ripple effects of the 2009 stimulus spending will likely continue for some time, especially given the substantial investments made in battery research and development.

**Figure 12. Public Sector Energy RD&D in IEA Countries**

Source: IEA databases, 2012 cycle.



**Figure 13** details RD&D spending on electric vehicles by EVI countries from 2008-2012. Like overall energy RD&D, U.S. spending on EV RD&D spiked in 2009, with Japan and Germany showing similar jumps in 2010 and 2011. Encouragingly, public investment in RD&D after 2009 remained at a high level, which signals continuing commitment to EV innovation.

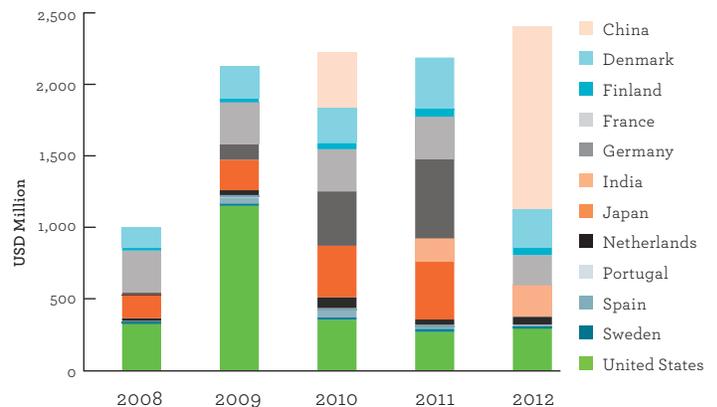
### INFRASTRUCTURE, FISCAL AND RD&D SPENDING

**Figure 14** shows cumulative spending by EVI countries in terms of fiscal expenditures (e.g. consumer incentives), infrastructure (e.g. EVSE), and RD&D. There is an emphasis on RD&D, which is logical considering the early market phase of EVs. Similarly, significant funding is directed to fiscal

spending including consumer incentives.\* These subsidies will come to an end eventually, but in the near term they are aiding EV market development and figure prominently in many vehicle electrification efforts worldwide. Infrastructure spending is relatively sparse, though this is perhaps due to the lower costs of deploying charging points than funding long-term research programmes, but also because the private sector and cities are focusing their financial support on infrastructure, suggesting that national governments have a larger role to play in RD&D and fiscal incentives.

**Figure 13. RD&D Spending by EVI Countries**

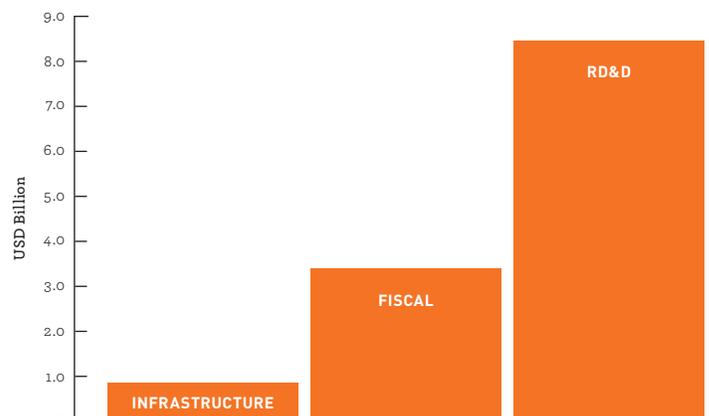
Source: EVI. Note: Missing countries indicate incomplete data.



**Figure 14. EV Spending by EVI Countries, 2008-2102**

[ by Category ]

Source: EVI.



\*Fiscal spending is defined here as financial support for vehicle purchases, such as consumer tax credits or rebates, but not including spending on infrastructure installations.

## RESEARCH, DEVELOPMENT & DEMONSTRATION (RD&D) [continued]

**Figure 15. Breakdown of RD&D Spending by EVI Countries 2008-2012 [by Category]**

Source: EVI.

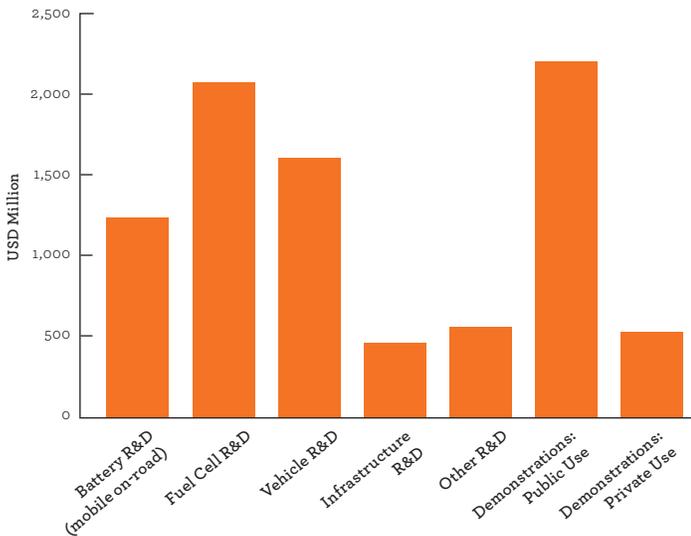


Figure 15 displays EVI support for RD&D by category, cumulatively for the 2008-2012 period. These numbers are likely an underestimate as they only count national-level support, and for some countries data were not available for all categories. There is relatively more focus on battery and fuel cell RD&D, which is a logical priority given that these components are still the largest cost of an EV. Demonstrations also received significant funding, reflecting the desire of governments to monitor and learn from initial vehicle and infrastructure deployment.

### BATTERY COSTS ARE FALLING

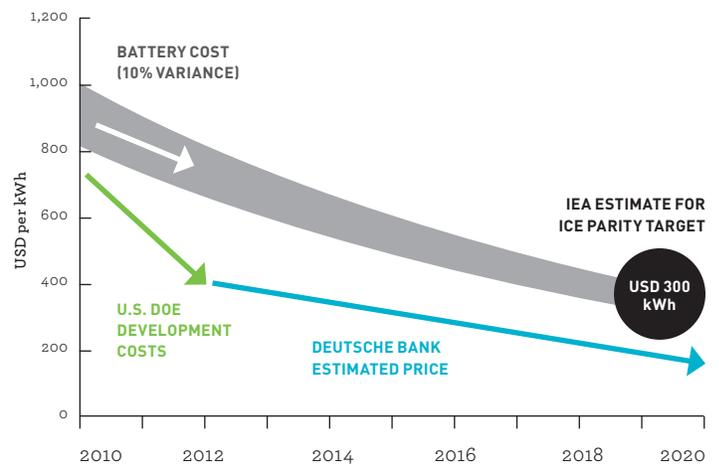
Battery costs are coming down at a rapid pace, more than halving in the past four years. According to the U.S. Department of Energy (U.S. DOE), battery costs based on development efforts have gone from USD 1,000 per kilowatt hour (kWh) in 2008 to USD 485/kWh of usable energy at the end of 2012.<sup>8</sup> These cost gains may take 3-4 years to be realised by industry, but the numbers give an indication as to what is possible in the near term.\* For potential costs in 2020, Figure 16 looks at the projected compound annual growth of the learning rate, which describes the reduction in cost of batteries through economies of scale. IEA estimates a learning rate of 9.5%,

which compares with Deutsche Bank's more conservative 7.5%, albeit at a lower starting cost point. As a point of comparison, laptop batteries developed at a rate of 15% in the 1997-2012 period.

The reduction in battery cost shows how targeted RD&D can aid the technological development and market deployment of electric vehicles. Battery costs are not just coming down in absolute terms, but in the near term battery costs may be less than half the cost of an EV. Beyond batteries there is an opportunity to diversify the RD&D scope for bringing down overall EV costs. Other opportunity areas include vehicle lightweighting, which can extend a vehicle's electric range. Advancements in electric-drive systems can also offer cost reductions through fully integrating motors and electronics, using wide bandgap semiconductors, and non-rare earth motors.

**Figure 16. Estimated Costs of EV Batteries through 2020**

Source: IEA, U.S. DOE, Deutsche Bank.



Volvo V60 — Brussels Motor Show, Belgium, January 2012

\*Costs do not include warranty costs or profit, and are based on a production volume of at least 100,000 batteries per year.

## MARKET TRENDS



*Trends suggest that PHEVs have more market momentum* than BEVs, perhaps reflecting consumers' desire to keep fuel flexibility for greater range; though with increased EVSE and consumer education it is conceivable that BEVs could similarly gain momentum.

Figure 17 compares sales since market introduction for two PHEVs, two BEVs, and the Toyota Prius hybrid electric

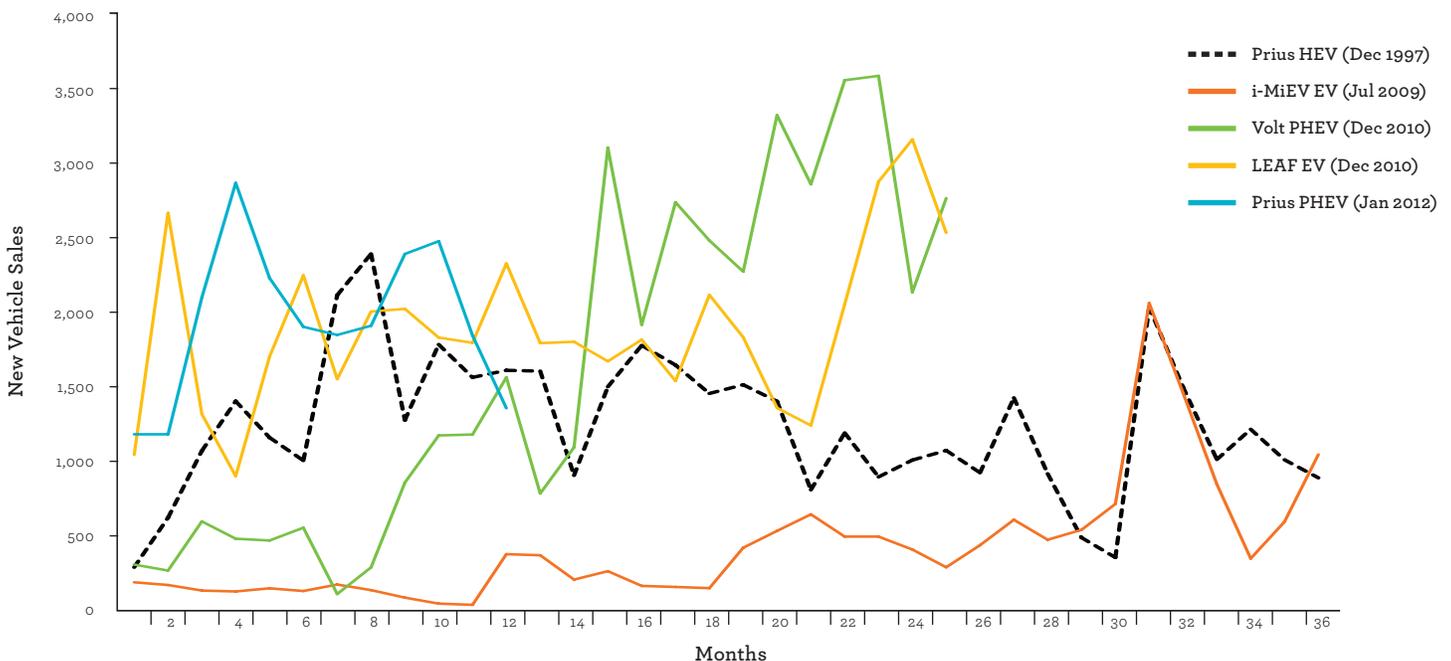
vehicle (HEV). Sales of three of the four EV models are currently above where the Prius HEV was at a corresponding point in time. Sales of the Chevrolet Volt increased in 2012, demonstrating consumer interest in the flexibility of a PHEV, whereas sales of battery electric models such as the Nissan LEAF and Mitsubishi i-MiEV have only recently been on the up-tick. Of course, comparing PHEVs and BEVs to the market development of an HEV is not a perfect “apples-to-apples” comparison (for example, does not take share of overall vehicle market into account, nor potential subsidy effects), but it nevertheless provides a useful understanding of how EVs are faring in terms of monthly sales and market development.

For this momentum to keep going, the market needs to traverse the so-called “valley of death” from a niche market to widespread adoption. Overall, sales numbers to date are considered lower-than-expected by some car manufacturers and market watchers, but in a weak car market during a recession, the doubling of sales between 2011 and 2012 can at least be considered progress for vehicle electrification.

**Figure 17. Sales Since Market Introduction**

(updated through December 2012).

Source: EVI, MarkLines Database, Nissan, Toyota, hybridcars.com. Note: Date indicates when model was first released. Different models were released at different times in various locations, but this graph is an attempt to approximate worldwide market deployment. All types of a model have been included, e.g. the Opel Ampera counts as sales under the Volt PHEV category.



## NATIONAL POLICY INITIATIVES

*EVI data show where mass EV deployment* is occurring.

A look at the policy support and market dynamics in those locations yields important insights into the level of global deployment efforts [ [Table 1](#) ].

In most cases, strong government support on both the demand and supply sides have contributed to rising market penetration. Well-designed financial incentives for consumers at the national and local levels are lowering upfront costs for EVs and EVSE, quickening sales and infrastructure deployment in a number of global markets. Such incentives are not only of benefit to early adopters, but give car manufacturers and other consumers confidence in market development.

A mix of non-financial incentives is also bearing fruit. EV access to restricted roadways is spurring uptake, especially in California, the United States' largest vehicle market. Utilities are demonstrating support through

time-of-use rates. Local governments are pursuing fleet acquisitions and partnering with the private sector on local mobility initiatives. Car sharing, for example, is proving a natural fit with EVs since it allows drivers to reap the benefits of electrified transport without having to face the higher upfront cost.

On the supply side, RD&D on batteries, fuel cells, and vehicle systems are having a positive impact on the market. Battery development costs have dropped significantly, thereby reducing the largest cost barrier to mass-market EV deployment.

Pilot cities are learning not only from their initial experiences, but also from each other. By doing so, cities seeking to transform local markets do not have to bear all the costs of a first-mover, but can learn from other early leaders. Policymakers are promoting inter-city and international forums to share feedback from early market introduction.



Smart Electric Drive Charging Station — Frankfurt, Germany, September 2011

Table 1. Current National Policy Initiatives

Source: EVI. Note: Some countries are missing, and some cells are empty, due to incomplete data. May not include regional or local government initiatives.

EVI MEMBERS	FINANCIAL	INFRASTRUCTURE	RD&D
China	Purchase subsidies for vehicles of up to RMB 60,000.	---	RMB 6.95 billion for demonstration projects.
Denmark	Exemption from registration and road taxes.	DKK 70 million for development of charging infrastructure.	Focus on integrating EVs into the smart grid.
Finland	EUR 5 million reserved for vehicles participating in national EV development programme, ending in 2013.	EUR 5 million reserved for infrastructure as part of the national EV development programme, ending in 2013.	---
France	EUR 450 million in rebates given to consumers buying efficient vehicles, with 90% of that amount from fees on inefficient vehicles. Remaining 10% (EUR 45M) is a direct subsidy.	EUR 50 million to cover 50% of EVSE cost (equipment and installation).	EUR 140 million budget with focus on vehicle RD&D.
Germany	Exemption from road taxes.	Four regions nominated as showcase regions for BEVs and PHEVs.	Financial support granted for R&D for electric drivetrains, creation and optimisation of value chain, information and communications technology (ICT), and battery research.
India	INR 100,000 or 20% of cost of vehicle, whichever is less. Reduced excise duties on BEV/PHEVs.	The National Mission for Electric Mobility will facilitate installation of charging infrastructure.	Building R&D capability through joint efforts across government, industry, and academia. Focus on battery cells and management systems.
Italy	EUR 1.5 million for consumer incentives, ending in 2014.	---	---
Japan	Support to pay for 1/2 of the price gap between EV and corresponding ICE vehicles, up to YEN 1 million per vehicle.	Support to pay for 1/2 of the price of EVSE (up to YEN 1.5 million per charger).	Major focus on infrastructure RD&D.
Netherlands	Tax reduction on vehicles amounting to 10-12% net of the investment.	400 charging points supported through incentives.	Focus on battery RD&D (30% of 2012 spending).
Spain	Incentives up to 25% of vehicle purchase price before taxes, up to EUR 6,000. Additional incentives of up to EUR 2,000 per EV/PHEV also possible.	Public incentives for a pilot demonstration project. Incentives for charging infrastructure in collaboration between the national government and regional administrations.	Five major RD&D programmes are operational with incentives for specific projects.
Sweden	EUR 4,500 for vehicles with emissions of less than 50 grams of CO <sub>2</sub> /km. EUR 20 million for 2012-2014 super car rebate.	No general support for charging points besides RD&D funding (EUR 1 million in 2012).	EUR 2.5 million for battery RD&D.
United Kingdom	---	GBP 37 million for thousands of charging points for residential, street, railway, and public sector locations. Available until 2015.	The UK Technology Strategy Board has identified 60 collaborative R&D projects for low-carbon vehicles.
United States	Up to USD 7,500 tax credit for vehicles, based on battery capacity. Phased out after 200,000 vehicles from qualified manufacturers.	A tax credit of 30% of the cost, not to exceed USD 30,000, for commercial EVSE installation; a tax credit of up to USD 1,000 for consumers who purchase qualified residential EVSE. USD 360 million for infrastructure demonstration projects.	2012 budget of USD 268 million for battery, fuel cell, vehicle systems and infrastructure R&D.

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# STRENGTHENING PUBLIC-PRIVATE ENGAGEMENT

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*The Electric Vehicles Initiative* is engaging in a robust public-private dialogue between its member governments and relevant electric vehicle stakeholders. It is part of a collaboration that will be important in accelerating the global scale-up of EVs. Much of the *Global EV Outlook* is informed by this dialogue and EVI will continue to absorb its key insights into future analyses.

## LONDON, APRIL 2012

At the 3rd Clean Energy Ministerial a high-level roundtable discussion was held between energy ministers and senior representatives from utilities, fleet operators, and car and battery manufacturers, among others.

Participants shared an optimistic outlook for the EV industry and committed to pursuing additional innovations, including wireless charging and the creation of a luxury EV market. Car manufacturers are responding by introducing and continually improving vehicles to take advantage of the growing market.

Participants discussed the benefits of EVs in commercial and government fleets, which can play a key role in scaling EV production and promoting mass adoption by showing that the technology works.

Participants also noted some challenges to EV deployment, including high costs and inadequate charging infrastructure. They agreed on the need for more R&D, targeted consumer incentives, increased public-private partnerships, and better coordination between transport and energy systems to ensure

electric mobility is clean and sustainable. Others stated that concerns about EV readiness are outdated — that the EV market is ready to expand aggressively, given proper consumer education and continued, robust government policies.

## STUTT GART, OCTOBER 2012

EVI convened a follow-up public-private roundtable in Stuttgart, Germany, between representatives from EVI member governments and major car manufacturers. Participants shared experiences and feedback from manufacturers' efforts to introduce EVs in global markets, as well as governments' efforts to realise EV goals through a variety of policies and programmes. Participants were encouraged by progress to date and reaffirmed their commitment to vehicle electrification. However, it was noted that patience will be required since significant market penetration will likely unfold over a number of years.

A major theme emerging from the roundtable was the need to align expectations between the various EV stakeholders, particularly governments and manufacturers. Common expectations about timescales should be aligned first, followed by coordination to implement market growth measures. These measures will benefit the market by signalling to consumers and investors that EV technology is viable today and will continue to transform the market in the future.

## NEW DELHI, APRIL 2013

EVI launched the *Global EV Outlook* at the 4th Clean Energy Ministerial in New Delhi, India, further strengthening the interaction between governments and relevant electric vehicle stakeholders.



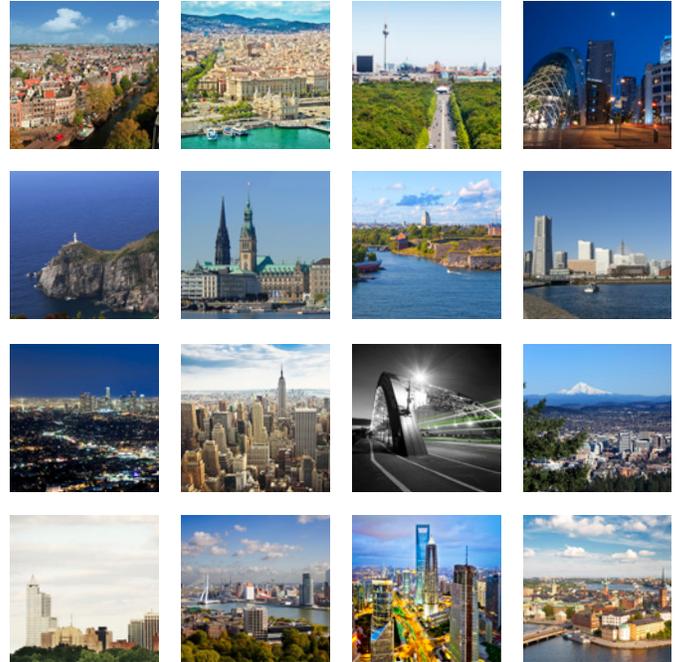
Electric  
Vehicles  
Initiative

## CITY AND REGIONAL EV DEPLOYMENT EFFORTS

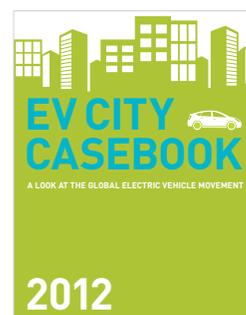
In May 2012, *EVI and partner organisations* published the *EV City Casebook*, detailing local EV deployment efforts in 16 cities and regions across nine countries and three continents. The 16 cities and regions together held about 30% of worldwide EV stock and represent the early leaders who are identifying challenges and best practices.

- The experiences of urban drivers and the pioneering policies of local governments are accelerating the transition to clean and sustainable mobility.
- Car sharing schemes (Berlin, Nagasaki, Brabantstad, Amsterdam) are giving urban citizens first-hand experience with driving an EV, which can then be used to make informed decisions about EV purchasing. Also, car sharing and EVs allow the two to be a demonstrable solution for innovative mobility, while lowering emissions, noise, and traffic.
- Fleets, including taxis (Amsterdam), buses (Los Angeles, Shanghai), freight (Berlin), and two-wheelers (Barcelona), are not just end-goals by themselves but also help propel the city's ability to electrify the rest of the passenger vehicle stock (Stockholm).
- Cities are “living labs” for EV deployment efforts and can offer early lessons to help other cities understand what is working, what is not working, and why.
- Incentives need to be contextualised to best fit the needs of a given city, including access to bus lanes (Portland), use of free parking (Amsterdam), and additional fiscal incentives (Kanagawa).
- Financial incentives have been effective in certain markets, though other motivators including priority access to parking have shown to be powerful incentives as well.
- Many cities are employing a mix of financial and non-financial consumer incentives to boost demand for vehicles and charging infrastructure. These include rebates or tax credits on EVs and EVSE, discounted tolls and parking fares, as well as preferential parking spaces, access to restricted highway lanes, and expedited permitting and installation of charging units.

- Several cities are leading by example and have already added EVs to municipal fleets and public transportation. They are placing charging spots at public buildings and, in some cases, offering discounted electricity rates for EV users through municipal-owned utilities.

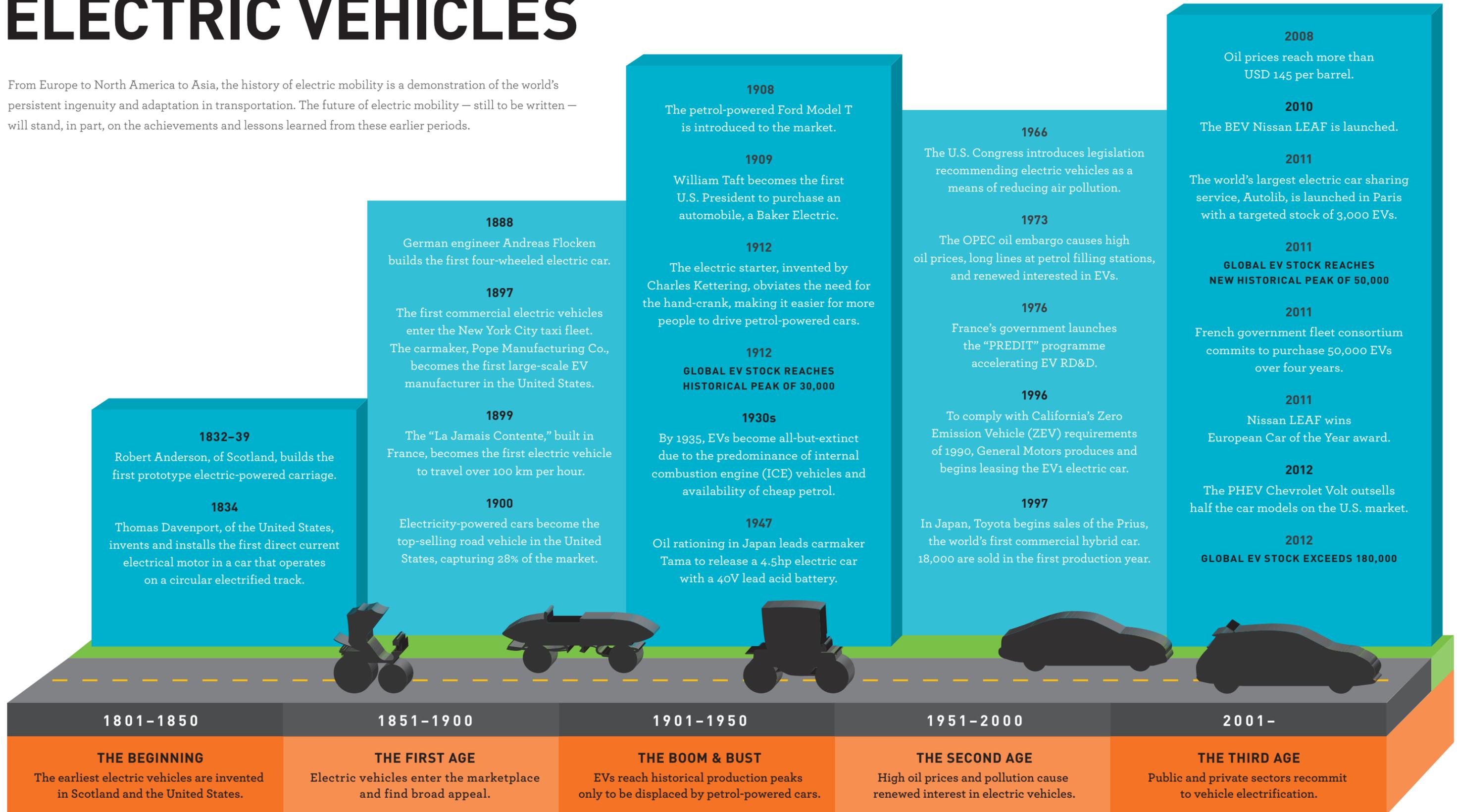


*Participating cities and regions: Amsterdam, Barcelona, Berlin, Brabantstad (the Netherlands), Goto Islands/Nagasaki, Hamburg, Helsinki, Kanagawa, Los Angeles, New York City, North East England, Portland, Research Triangle (North Carolina, United States), Rotterdam, Shanghai, Stockholm.*



# A BRIEF HISTORY OF ELECTRIC VEHICLES

From Europe to North America to Asia, the history of electric mobility is a demonstration of the world's persistent ingenuity and adaptation in transportation. The future of electric mobility — still to be written — will stand, in part, on the achievements and lessons learned from these earlier periods.



Sources: Curtis D. Anderson and Judy Anderson, *Electric and Hybrid Cars: A History*, McFarland and Company, 2012; burnanenergyjournal.com; pbs.org/now/shows/223/electric-car-timeline.



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# CHALLENGES & OPPORTUNITIES

Despite the advances that vehicle electrification has made in the past two years, there are still significant barriers that stand in the way of widespread adoption. Technological, financial, market, and policy challenges could hinder market transformation if not addressed through further RD&D investments, public-private collaboration, and innovative policy and business solutions. This section identifies the most pressing challenges to deployment and offers a number of opportunities that governments, in coordination with the private sector and the broader EV stakeholder community, can pursue to make a positive impact. While many EV challenges can be region-specific, those outlined below are some of the major issues facing both early market leaders and countries still contemplating initial approaches to electrification. For highlights, see the Opportunity Matrix on page 34.

## TECHNOLOGY

### COST

The most significant technological challenges currently facing electric-drive vehicles are the cost and performance of their components, particularly the battery. Price per usable kilowatt hour of a lithium-ion battery ranges between USD 500-650 and thus makes up a large portion of a vehicle's cost, depending on the size of the battery pack.<sup>9</sup> A Nissan LEAF, for example, has a 24 kWh battery that costs approximately USD 12,000, which represents about a third of the vehicle's retail price.<sup>10</sup> Similarly, Ford uses a battery that costs between USD 12,000-15,000 for its Focus Electric, an electric version of its petrol-powered Focus that itself sells for around USD 22,000.<sup>11</sup> PHEVs may be even more expensive due to the cost and complexity of dual powertrains. A Chevrolet Volt only uses a 16 kWh battery pack, but its purchase price is nearly USD 5,000 more than a LEAF, due in large part to its hybrid technology.

Most EVs will remain more expensive in the near term than their petrol vehicle equivalents even when combined with government purchase subsidies offered in many countries. Twelve EVI member governments offer some type of fiscal incentive at the national level for purchasing electric vehicles, usually in the form of tax credits or direct rebates. Many governments cap purchase subsidies at a certain amount of money or manufacturer sales volume, and some

are scheduled to expire soon. As government subsidies begin to phase out, the upfront purchase price will revert to higher levels unless substantial cost reductions are achieved.

### RANGE LIMITATIONS: REAL AND PERCEIVED

The sizable EV price premium perhaps would be acceptable to a large number of consumers if the vehicles offered more range or differentiated functionality than is currently on the market. With a usable range of about 100 kilometres (km), the 24 kWh battery-powered Nissan LEAF achieves about a fifth of the range of a comparable ICE vehicle. All-electric vehicles with larger battery packs, such as the 85 kWh Tesla Model S, may offer much greater range (480 km) but also come with significantly higher retail prices, which will likely deter most consumers. PHEVs eliminate range constraints, but many only offer about 15-65 km of electric-only range and thus may not fully deliver the benefits of electric drive (such as cheaper fuel and lower emissions) if driven predominantly in petrol-mode.

These range limitations appear to be holding back many potential customers. One survey of American consumers found that 75% of respondents considered range to be either a major disadvantage or somewhat of a disadvantage of EVs.<sup>12</sup> Another survey showed that consumers in the United States

## **TECHNOLOGY** [ continued ]

and France were the most sensitive to range.<sup>13</sup> Yet in the United States the average daily vehicle distance travelled per person is 46 km and average vehicle trip distance is 15 km.<sup>14</sup> Given the fact that U.S. average travel distances are the longest in the world, it is likely that most of today's electric vehicles have sufficient range for a majority of consumers worldwide. Nonetheless, as long as this gap remains between range expectations and actual average driving needs, negative perceptions about EV range and notions of range anxiety will persist.

### **SAFETY AND RELIABILITY**

Perceptions regarding the safety and reliability of EVs also remain an issue throughout the market. Fire-related incidents in China and the United States in 2011, for instance, attracted high-profile media attention.<sup>15</sup> While extensive testing and evaluation have demonstrated that EVs do not pose a greater risk of fire than petrol-powered vehicles, these incidents have brought extra scrutiny of EV safety.<sup>16</sup> (By comparison, there is usually little media reporting on the more than 250,000 ICE vehicle fires per year recorded in the United States.<sup>17</sup>)

Other reports of battery failures, recalls, and climate-related battery degradation have further raised doubts about EV technology.<sup>18</sup> Thus, the bar appears to be set quite high in the public mind in terms of EV safety and reliability, and remains an issue that needs to be addressed.

### **PROGRESS THROUGH RESEARCH AND DEVELOPMENT**

Recently, the cost of batteries has been steadily decreasing as a result of both public and private sector advances and will likely drop even further in the next five years due to pack design optimisation and cell count reduction, lower cost of cell materials, economies of scale, and improved manufacturing processes.

---

#### **OPPORTUNITY**

*Government funding for research can help achieve long-term cost-parity without the need for purchase subsidies.*

---

Sustained R&D investment by industry and governments is necessary to achieve some of the more consequential

cost and performance enhancements by 2020. Lithium-ion technology is still far from its theoretical energy density limit. Improvements in battery pack energy density, operating temperature range, and cycle life will all be important innovations that further reduce cost and increase range and battery life.

---

#### **OPPORTUNITY**

*International RD&D cooperation and coordination can help address common areas of need, spread costs, and accelerate technological breakthroughs.*

---

Increasing the usable range of EVs is necessary to address consumer anxiety and open the market to drivers who need longer range vehicles. This will require a significant increase in battery energy density, which could be achieved through longer-term research into next-generation battery chemistries, such as lithium-sulfur, zinc-air, and lithium-air.<sup>19</sup> More reliable manufacturing and further research into battery abuse tolerance will improve both actual and perceived reliability.

EVI member governments have already made substantial and consequential RD&D investments in the last five years, with USD 8.7 billion in collective spending since 2008. Many are committing to making further investments in the next five years. These research commitments represent an opportunity for government support to make significant impacts on the EV market so cost-parity can be achieved without purchase subsidies. Indeed, continued government RD&D can help provide the technology push needed to make meaningful leaps in innovation and help create a more sustainable market for EVs. International cooperation and coordination on RD&D can also help by filling gaps in the most pressing areas, sharing costs, and accelerating technological breakthroughs.

## FINANCE



*The immediate challenge of high purchase prices* exposes the need for different EV financing options than are widely available at present. Should cost reductions in batteries and vehicle systems not materialise quickly enough, attractive financing mechanisms may be needed to maintain sales growth, particularly as government purchase subsidies are phased out. Vehicle leasing is one potential pathway, and there is some evidence that competitive lease rates have already helped to bolster EV sales.<sup>20</sup>

### OPPORTUNITY

*Attractive vehicle financing can buoy sales, particularly as government purchase subsidies are phased out.*

However, leasing options may remain limited in emerging economies that do not yet have an established vehicle financing market, in which case there may be a need to identify other methods for financing EV purchases. (In China, for example, only 10% of total car buyers currently choose financing.<sup>21</sup>) Such options include leasing only the battery while purchasing the rest of the vehicle, or providing some guaranteed residual value for the vehicle or the battery at the end of its use. Renault offers battery leasing for its Zoe and Twizy models, as does Daimler for its Smart Fortwo. These models charge a monthly fee of about USD 100 to lease the battery and often come with replacement guarantees.<sup>22</sup>

### SUSTAINABLE INFRASTRUCTURE FINANCING

Perhaps the most urgent need in all EV markets is in financing charging infrastructure. When the mass-market introduction of electric vehicles began two years ago there was much debate about a so-called “chicken and egg” dilemma facing the nascent market: should EVSE be deployed first in order to spur EV sales, or does vehicle uptake need to occur before charging infrastructure takes shape? In 2013, the question is largely irrelevant. The reality is that EVs and EVSE are being deployed simultaneously in a mostly market-driven manner, with governments at the national, regional, and local levels contributing to infrastructure investment. EVI member governments alone have collectively made about USD 800 million in infrastructure spending already.

### OPPORTUNITY

*Identify and employ sustainable business models to best match charging infrastructure supply and demand, especially in public locations.*

### IDENTIFYING BUSINESS MODELS

The most salient issue going forward is to identify and employ sustainable business models to best match supply and demand for charging infrastructure, especially in public locations. That is, how will private EVSE investment increase as early government support declines? A number of financing schemes exist in the deployment of non-residential charging infrastructure. Pricing and operating models often depend on the ultimate owner of the EVSE and the cost recovery mechanisms available. Public and semi-public EVSE can be deployed by property owners, who pay the capital costs of purchasing and installing EVSE, then levy fees for its use – either by electricity consumed or by the length of time spent charging. Many retailers, restaurants, and other private businesses deploy publicly-accessible EVSE in such a manner, typically receiving payment directly at the charging station via credit card. In some instances, these businesses may offer free charging as a way of attracting customers.

## FINANCE [continued]

Other emerging business models involve third-party vendors that own and operate EVSE. These service providers can relieve property owners like retailers and small businesses from owning and operating the infrastructure, only requiring that they provide a location. EVSE service providers pay for installation, operation, and maintenance, and may use flat-rate monthly or annual subscriptions to a charging network (similar to payment schemes from mobile phone carriers) to recover the cost and earn profits. Utilities may also seek to deploy EVSE in their service territories as a way to increase revenue and better monitor daily loads.

It is unclear which of these business models are most viable. The cost of EVSE procurement and installation can be very high, ranging from USD 5,000-15,000; installation costs are higher when additional electrical work is required (such as panel upgrades or step-down transformers) or when trenching, boring, and pouring concrete foundation are needed. Additionally, there is no guarantee of a return on investment, especially when demand is uncertain. In areas where residential charging is predominant, public charging may only be used sparingly, thus decreasing revenue potential for EVSE providers. It is also unclear at present what price point the market is willing to bear for public EV charging. As the EV market develops, the private sector will have to experiment with varying business models and find the ones that account for local nuances and provide the most stable revenues.

## THE ROLE OF PUBLIC-PRIVATE COORDINATION

Whereas national governments have a unique role to play in supporting RD&D and offering fiscal incentives, private businesses can assume a larger role with regard to financing EVSE deployment. Meeting market demand for public charging through innovative business solutions is a necessity for the long-term viability of electrified transport. Of course, public investment can still assist in seeding new markets by catalysing initial EVSE deployment and encouraging private sector participation. Public-private cost-sharing for EVSE deployment can be particularly transformative in early markets.

### OPPORTUNITY

*Public-private cost-sharing can catalyse initial infrastructure deployment, while governments can provide clarity on how EVSE service providers will be regulated.*

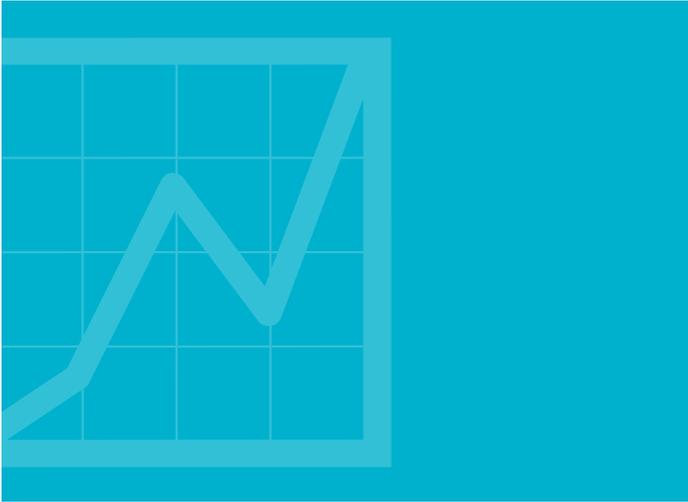
Governments can also provide more clarity to EVSE service providers on how they will be regulated. In some jurisdictions, only regulated utilities are allowed to sell electricity directly to consumers, which could diminish the business model of non-utility EVSE service providers. Such providers will need to establish some type of service fee instead of charging for electricity use. In any event, as much regulatory certainty as possible will help encourage more private investment.



Chevrolet Volt — Brussels Motor Show, Belgium, January 2012



Citroën C-Zero — Brussels Motor Show, Belgium, January 2012

 **MARKET**

**OPTIMISING EVSE DEPLOYMENT**

Not only do sustainable funding models for infrastructure provision need to be identified, but the scale and location in which infrastructure is deployed requires a smarter approach. Early attempts to cover cities with charging stations (much of them publicly-funded) in anticipation of large-scale EV uptake resulted in some instances of EVSE experiencing little or no customer utilisation.<sup>23</sup> In other instances, initial widespread deployment of EVSE did not lead to the expected jumpstart of EV sales.<sup>24</sup> Instead of solely maximising EVSE, it is better to optimise its deployment and integrate it properly with the broader electric vehicle ecosystem. This means deploying EVSE more intelligently outside the home.

---

**OPPORTUNITY**

*Optimise, rather than maximise, EVSE deployment.*

---

The appropriate number of public and semi-public EVSE required in a given area is difficult to know, of course, and will likely depend on a variety of region-specific variables such as EV penetration rates, consumer charging behaviour, and level of government support.

**INFORMATION AND DATA SHARING**

As a best practice, public EVSE deployment should be driven as much as possible by robust data on EV driver location and travel patterns, infrastructure utilisation, and charging

behaviour to ensure that equipment is placed in relevant locations and to avoid over-investment that may result in unused assets. Governments have a role in gathering and sharing such data, which can be collected through demonstration projects and other rigorous research initiatives. Examples of existing data-driven demonstration projects include the public-private “EV Project” in the United States, China’s “10 Cities with Thousands of Vehicles” programme, and the recently announced “European Electromobility Observatory” sponsored by the European Union.<sup>25</sup>

---

**OPPORTUNITY**

*Gathering and sharing data from demonstration projects and other research initiatives can help deploy infrastructure more intelligently.*

---

Private entities will also benefit from knowing the relative penetration rates of BEVs and PHEVs in a given geographic area in order to optimise public infrastructure provision. A city or region with relatively high PHEV ownership may require less publicly available charging, whereas high BEV regions may require more. As noted previously, EVI countries are exhibiting different EVSE deployment characteristics based on regional nuances: Japan’s abundance of public fast charging supports its relatively high uptake of BEVs, while the United States’ large number of PHEVs rely more on residential slow charging.

**WORKPLACE CHARGING**

Vehicles are parked more than 90% of the time, usually at home or work.<sup>26</sup> This fact represents an opportunity for EVSE to be deployed where cars are most often parked rather than where it is easiest to permit and construct charging equipment. Workplace charging, in particular, fills an important gap between residential and public infrastructure. It increases the number of charging opportunities and effectively doubles the commuting range of EVs. It also increases consumer exposure, acting as a “second showroom” where EV-driving employees can demonstrate and discuss the technology with interested co-workers. Employer-provided charging also serves as an attractive

 **MARKET** [continued]

employee benefit, enhances corporate sustainability efforts, and signals corporate leadership in adopting advanced technology. Employers should consider providing access to EVSE as a tangible employee benefit while interested employees should champion the idea and alert employers about their desire to charge at work.

---

**OPPORTUNITY**

*Employers should consider providing access to EVSE as an attractive employee benefit.*

---

Governments can help encourage workplace charging by connecting like-minded employers, sharing best practices, providing technical assistance, and leading by example through installation of their own workplace charging infrastructure.

**TOTAL COST OF OWNERSHIP**

Despite high initial purchase prices, electric vehicles offer some cost advantages, usually in the form of lower total cost of ownership (TCO) over the life of the vehicle, meaning the additional upfront purchase amount will likely be recovered over time. The TCO for an EV is usually less than that of an internal combustion engine vehicle primarily due to fuel savings, as well as lower service, maintenance, and repair costs, which may be as much as 30% cheaper than those of an ICE vehicle.<sup>27</sup>

---

**OPPORTUNITY**

*Lower total cost of ownership of EVs is an important benefit that should be made clear to consumers.*

---

Not only is electricity less expensive as a fuel than petrol but its price is more predictable, thereby insulating EV drivers from the price volatility inherent in global oil markets and bringing much greater certainty about a vehicle's operating costs. Some electric utilities even incentivise off-peak charging through time-of-use rates that are lower in the night time, which further reduces TCO for drivers using residential charging.

Of course, the “payback period” of an EV depends on other variables, like the life of the vehicle and its components, particularly the battery. Depending on such variables, the payback period for EVs can be anywhere from 6-8 years, which is longer than the 3-5 years a typical owner keeps a car.<sup>28</sup> In fact, early surveys of car buyers in China, Europe, and the United States show that most expect to recoup the initial price premium of an EV within three years.<sup>29</sup> In such cases drivers do not retain the vehicle long enough to realise the TCO benefits and so even a favourable TCO may not be compelling enough to consumers when making automobile purchases. Also, resale values of EVs are unknown at this point due to the early market, which makes EVs' actual TCO more uncertain than ICE vehicles' at the moment.

In some markets, moreover, government subsidisation of transport fuels can erode an EV's cost advantages, making them potentially less attractive on a TCO basis. Efforts to curtail or eliminate fuel subsidies will likely encourage greater EV adoption rates in those economies seeking sustainable transportation solutions.

**DRIVING ADOPTION THROUGH EDUCATION**

Greater consumer education and familiarisation with EV technology should help accelerate adoption. Some surveys reveal a high level of ignorance of the basic characteristics of electric cars or a misunderstanding of their current capabilities.<sup>30</sup> Public education campaigns that highlight the positive attributes and benefits of electric drive, such as cheap and convenient fuel, improved local air quality, and greater personal and national energy security, could get consumers interested enough to seriously consider purchasing an electric vehicle. Additionally, hands-on experiences with EVs introduce consumers to the technology by allowing them to “try before they buy”. Car sharing, in particular, provides a good opportunity for consumers to become familiar with driving an EV without having to make a large up-front purchase. Car sharing is already taking root in many American and European cities and has the potential to become a major market by 2020.

## MARKET [continued]

Addressing information asymmetries is a proper role for government and can complement existing private sector efforts. As part of public awareness, regulators can also include easy-to-understand labelling on vehicles to inform consumers of the fuel savings and TCO benefits of electric drive models on the market. Some EVI member governments are already taking these steps.\*

### OPPORTUNITY

*Consumer education campaigns and clear fuel economy labelling can alleviate information asymmetries.*

### STANDARDS HARMONISATION AND INTEROPERABILITY

The lack of harmonised standards and interoperability of charging systems is another market challenge. Common standards for charging couplers and communications protocols are crucial to market development, since they keep manufacturing costs low and provide seamless and predictable operation for EV drivers. Interoperable charging systems allow for charging at any EVSE regardless of operator or billing system. In Europe, standardisation and interoperability are of particular importance at present. European drivers should be sure they can drive from one country to another without encountering incompatible EVSE networks. Globally, fast charging systems currently face competing standards, one being the CHAdeMO protocol adopted by Japanese industry and the other being SAE International's Combined Charging System (CCS) adopted by U.S. and German car manufacturers.

In order to avoid a costly proliferation of parts and software, consistent standards should be developed through established standards development organisations such as the International Electrotechnical Commission (IEC) and the International Organisation for Standardisation (ISO). Other market-driven solutions may be needed to achieve as much compatibility as possible between existing standards. Government support for industry-led voluntary standards efforts is important, as is international collaboration on EV standards harmonisation. Many EVI

countries have begun to cooperate on standards already through multilateral and bilateral EV initiatives.<sup>31</sup>

### MODEL DIVERSITY

Another challenge at present is the limited diversity of vehicle models that offer different price points or differentiated functionality to suit customer needs. While the numerical supply of EVs now on the market may be adequate, not all customer segments are covered by the existing product offerings. Interviews with potential customers reveal a mismatch between consumer needs and preferences and the models currently on the market.<sup>32</sup> Compact and sub-compact EVs may not be adequate for a number of drivers, particularly in markets such as North America where cities and suburbs are less dense than in regions such as Europe. More options in range, styling, functionality, and other attributes could boost consumer interest.

The model years 2013 and 2014 will likely see the introduction of a variety of new EVs that may alleviate these constraints, but vehicle manufacturers should continue to increase consumer choice by providing viable alternatives to conventional cars. More EV sales will have the added benefit of driving down costs further through economies of scale.



BMW i8 Concept — Brussels Motor Show, Belgium, January 2012

\*See, for example, United States Environmental Protection Agency, [www.fueleconomy.gov](http://www.fueleconomy.gov).

## POLICY



*While some policies can have a beneficial impact* on EV deployment, a lack of policies or clear regulations can hamper widespread adoption of EVs in many countries.

### EVSE SIGNAGE

Signage for charging infrastructure is an often-overlooked area of need. Within many countries, standardised and widely deployed signage is lacking. In Europe, moreover, there is little consistency in signage across different countries, which may hinder cross-border travel and cause confusion among drivers. Providing consistent and abundant signage would enhance the convenience of refuelling for current EV drivers and highlight the availability of chargers for potential EV buyers. Signage offers added value for a relatively modest cost in that it is both functional and representational.

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#### OPPORTUNITY

*Consistent and abundant signage offers both functional and representational value.*

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There are generally two types of signage: way-finding, which directs drivers on roadways to the nearest charging station; and regulatory signage, which can either permit or prohibit certain vehicles in parking spaces. While many EVs now and in the future will employ telematics or GPS navigation systems to direct drivers to charging stations, physical signage will nonetheless remain important. Signage is particularly crucial for wayfinding in the last one hundred

metres to EVSE located in surface and structured garage parking. GPS-backed navigation systems cannot always pinpoint the location of EVSE in these areas. Another consideration is whether to distinguish between slow and fast charging on way-finding signage so drivers can more reliably meet their particular needs.

Uniform and effective regulatory signs are also important. These signs may allow EV parking regardless of charging status or restrict parking to EV charging only. Enforcement of regulatory signs usually requires local ordinances to be in place in order to penalise non-EVs that park in EV-restricted spaces. Governments at the supranational, national, and local levels can work to standardise signage, deploy it widely, and ensure enforcement.

### MULTI-UNIT DWELLINGS

While the convenience of home charging is one of the most attractive attributes of EVs, such convenience does not easily apply to drivers living in apartment buildings or other multi-unit dwellings (MUDs) that either lack garages or do not have the ability to install EVSE easily. Until this issue is addressed, demand for EVs (particularly BEVs) may remain low in dense urban areas.

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#### OPPORTUNITY

*Local governments can extend subsidies to MUDs or amend building codes and laws to mandate EVSE capability in all new construction.*

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57% percent of dwellings in Finland are MUDs, as are 45% in Spain.<sup>33</sup> Nearly 50% of China's population resides in urban areas, often living in large MUDs as opposed to single-family homes. In Chinese cities where high EV penetration is expected and encouraged, like Shanghai and Shenzhen, EV drivers are currently relying on limited workplace and public charging.<sup>34</sup> In one Chinese survey, drivers revealed that they were unable to use their cars on weekends because of a lack of home charging and closed workplaces.<sup>35</sup> In an attempt to alleviate these impediments, the city of Shenzhen is planning to place parking centres near high-rise buildings where owners can charge overnight.<sup>36</sup>

## **POLICY** [ continued ]

Older buildings may have physical and/or electrical restrictions that impede installation of EVSE. Differences between owner-occupied and tenant-occupied buildings can further complicate installation. Determining how electricity consumption is metered and billed is another significant consideration for MUDs. Also, some jurisdictions offering EVSE subsidies may not apply them to installations in MUDs (an issue Los Angeles is currently facing).<sup>37</sup> There is an opportunity for regional and local governments to extend subsidies to MUDs or amend building codes and laws to mandate EVSE capability (such as EV-ready wiring and conduits) in all new construction.

### **TAKING ADVANTAGE OF POLICY OPPORTUNITIES**

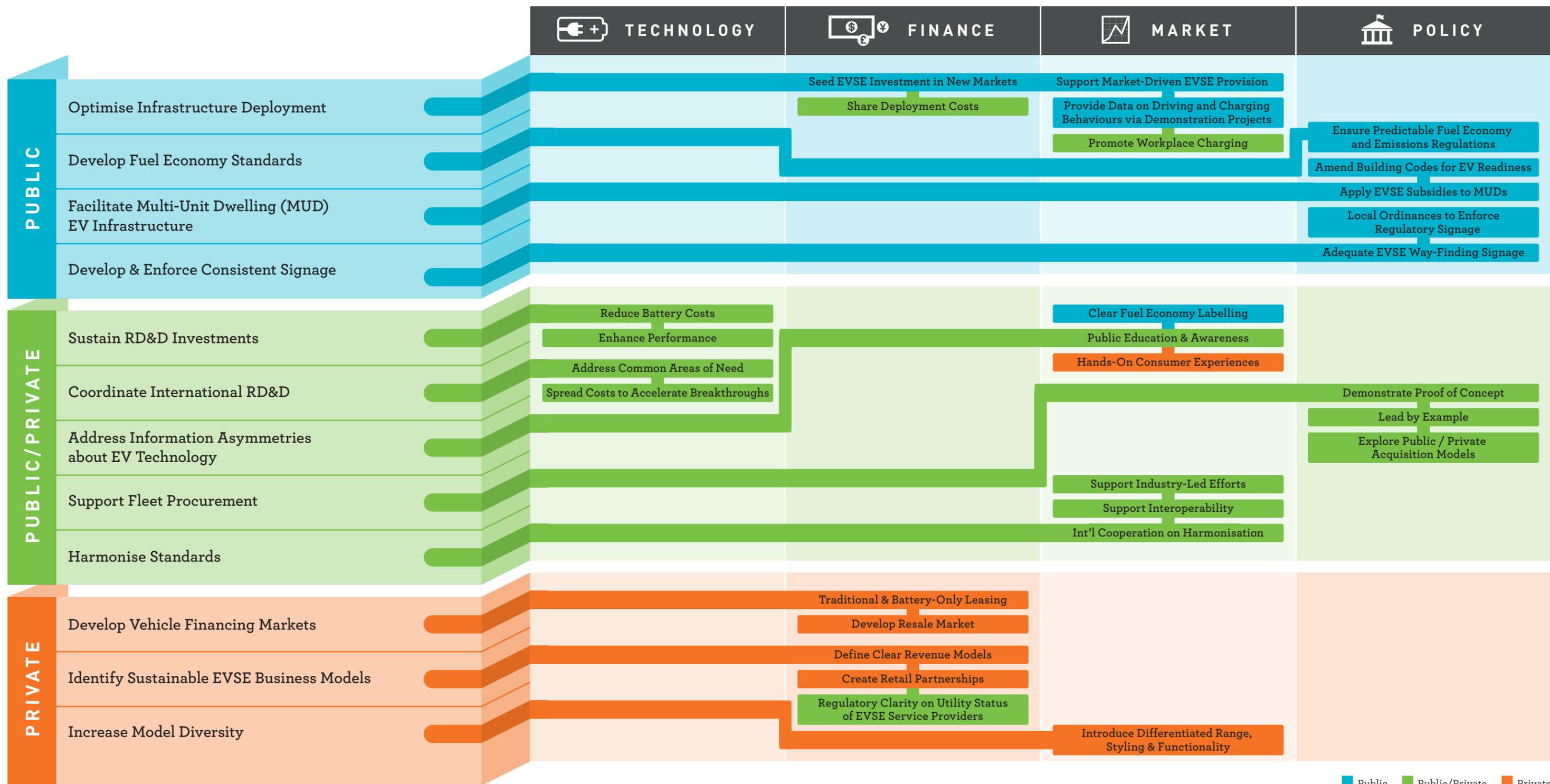
There are other significant policy opportunities to jumpstart the market that can be pursued by governments today.

Implementing stronger fuel economy regulations provides car manufacturers with incentives to invest in EV technology, among other fuel-efficient technologies, and helps increase product diversity. Furthermore, providing for transparent and predictable fuel economy regulations in the future will help manufacturers prepare to meet them. Governments at the national, regional, and local levels can more directly spur sales of EVs through large-scale fleet procurement. Examples include the French government's plan to coordinate the purchase of 50,000 EVs for 20 public and private entities, and the U.S. city of Indianapolis, which recently announced that all vehicles purchased for the non-police municipal fleet must be plug-in vehicles by 2025.<sup>38</sup> Such high-volume purchases can accelerate economies of scale, while allowing governments to lead by example and perhaps inspire other fleet operators to consider electrification.



# OPPORTUNITY MATRIX: PATHWAYS TO 2020

There are several actions that can help the world put at least 20 million electric vehicles on the road by 2020. Stakeholders will play different roles. Every action does not have to happen in every country, and no one country or sector can do everything on its own. The Electric Vehicles Initiative (EVI) will continue to facilitate coordination and communication to address the challenges of vehicle electrification, and align priorities among the key EV stakeholders worldwide. This Opportunity Matrix identifies which sectors are best suited to take the lead in the four areas of need: 1) technology, 2) finance, 3) market, and 4) policy. More importantly, it also identifies opportunities for the public and private sectors to work together.





# CONCLUSION

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**The electrification of the global vehicle fleet is undoubtedly a long-term ambition. EV market shares are still below 1% in most major markets, due in part to high upfront costs, real and perceived range limitations, and a lack of consumer education. At the same time, there has been considerable progress in the global market, which suggests a relatively positive outlook.**

The year 2012 was marked by some notable milestones in terms of sales, global RD&D efforts, and increased model diversity. Through their words and actions, governments and industry have reaffirmed their commitment to vehicle electrification. That commitment has resulted in a substantial reduction in battery cost, increased infrastructure deployment, fleet procurement, and a variety of innovative public-private partnerships.

Despite a long history of repeated obstacles and setbacks, electric mobility continues to advance toward a better state of art and a more durable market presence. Indeed, EVs continue to open up a variety of consumer segments not considered possible in the past. This is not to say that the road ahead will be easy, especially to meet countries' ambitious sustainability goals. Significant market penetration will likely unfold gradually over a number of years, thus requiring a healthy dose of patience for those anticipating a new era of clean transport. Transforming the way automobiles are powered and scaling the requisite infrastructure will not occur in a matter of months. The challenges facing vehicle electrification are complex and will therefore necessitate a broad and coordinated effort among all relevant stakeholders to address them.

Moreover, the electrification of the passenger fleet should be considered within the context of increasing urbanisation and population density. Today, half of the world's population lives in cities and the United Nations projects the proportion will be closer to 70% by 2050.<sup>39</sup> In order to avoid increased congestion and local air pollution, a broader mobility strategy is necessary. Improved and expanded public transit, enhanced pedestrian and bicycle access, and new "mobility services" should be components of such a strategy. EVs have a role to play in these smarter, more sustainable cities, and their technology has potential spillover benefits for a variety of industries. These effects could be both immediate and long-lasting, altering the world's energy, economic, and political dynamics.

Ultimately, a binary judgment of either the success or failure of electrification should not be applied at any one point in time. Rather, as the market continues to progress its development should be monitored, policy support assessed, and lessons applied. Tough questions should not be avoided; while insights gleaned should be used to employ broad-based and consequential solutions that will bring the world closer to the shared vision of sustainable transportation.



# GLOSSARY

**Battery Electric Vehicle (BEV):** An all-electric vehicle propelled by an electric motor powered by energy stored in an on-board battery.

**Electric Vehicle (EV):** A general term used to describe any car that uses a power source to drive an electric motor for propulsion.

**Electric Vehicle Supply Equipment (EVSE):** Delivers electrical energy from an electricity source to charge an EV's batteries. It communicates with the EV to ensure that an appropriate and safe flow of electricity is supplied. EVSE units are commonly referred to as "charging stations" or "charging points" and include the connectors, conductors, fittings and other associated equipment.

**Fast Charging:** Also known as "DC quick charging", fast charging stations provide a direct current of electricity to the vehicle's battery from an external charger. Charging times can range from 0.5 to 2 hours for a full charge.

**Fuel Cell Electric Vehicle (FCEV):** A vehicle that runs on a fuel cell that generates an electrical current by converting the chemical energy of a fuel, such as hydrogen, into electrical energy.

**Hybrid Electric Vehicle (HEV):** A vehicle that combines a conventional internal combustion engine (ICE) propulsion system with an electric propulsion system to achieve improvements in fuel economy.

**Internal Combustion Engine (ICE):** An engine in which the combustion of liquid fuel (such as petrol, diesel, or biofuels) or a gaseous fuel (such as compressed natural gas) and air occur at high temperature and pressure to generate mechanical power. It is the dominant power source for on-road vehicles today.

**Kilowatt (kW):** A unit of power equivalent to 1,000 watts, 1,000 joules per second or about 1.34 horsepower.

**Kilowatt Hour (kWh):** A unit of energy defined as the amount of energy released if work is done at a constant rate of 1 kW for one hour. The unit is typically used by an electricity company as the key metric for billing its customers.

**Plug-in Hybrid Electric Vehicle (PHEV):** A hybrid electric vehicle with a high-capacity rechargeable battery that is capable of using electricity as its primary propulsion source. The internal combustion engine typically assists in recharging the battery or serves as a back-up when the battery is depleted.

**Slow Charging:** The most common type of charging provides alternating current to the vehicle's battery from an external charger. Charging times can range from 4 to 12 hours for a full charge.

**Total Cost of Ownership (TCO):** The purchase price of a vehicle plus the costs of operation during the time period it is owned. Costs include depreciation costs, fuel costs, insurance, financing, maintenance, and taxes.

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# ACKNOWLEDGMENTS

Tali Trigg (IEA) and Paul Telleen (US) coordinated the production of this report with the assistance of the following individuals from EVI member governments:

Markku Antikainen (FI)	Mikko Koskue (FI)	Michael Rask (DK)
Hugo Brouwer (NL)	Juan Francisco Larrazábal Roche (ES)	Luis Carlos Reis (PT)
Mario Conte (IT)	Jean-Louis Legrand (FR)	Ambuj Sharma (IN)
Zhaoning Gu (CN)	Kenji Miura (JP)	Wolfram Spelten (DE)
Victor Hug (DK)	Sonja Munnix (NL)	Tomohisa Maruyama (JP)
Peter Kasche (SE)	Martin Palm (SE)	Maarten van Leeuwen (NL)
Martti Korkiakoski (FI)	Juan Luis Plá de la Rosa (ES)	Tim Ward (UK)

The following individuals at IEA provided data, ideas, input, and/or legal assistance for sections of this report:

Rachael Boyd	Annette Hardcastle	Lizzy Spong
Francois Cuenot	Didier Houssin	Kathleen Sullivan
Davide d'Ambrosio	Amb. Richard Jones	Cecilia Tam
Rebecca Gaghen	Hiroyuki Kaneko	Markus Wråke
Jean-Francois Gagné	Melissa C. Lott	

Many thanks are due to the Clean Energy Ministerial Secretariat at the U.S. Department of Energy. In addition, the IEA Implementing Agreement for Cooperation on Hybrid and Electric Vehicle Technologies and Programmes contributed comments and data. Kristin Abkemeier, David Beeton, David Howell, Tom Turrentine, and Martijn van Walwijk also provided helpful and substantive reviews of this report. Finally, a special thanks to Lew Fulton for his early work on the Electric Vehicles Initiative and his ongoing support.

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