A COMPARATIVE ANALYSIS OF ELECTRIC-DRIVE POLICY IN GERMANY AND CALIFORNIA

Coordinated by:

National Organisation Hydrogen and Fuel Cell Technology

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August 2015

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International Council on Clean Transportation

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Acknowledgements

This report is sponsored by the National Organisation for Hydrogen and Fuel Cell Technology (NOW GmbH). We thank Dr. Hanno Butsch and Dr. Klaus Bonhoff of NOW for their guidance throughout the project. We especially appreciate the oversight provided by the Steering Committee, including Dr. Hanno Butsch, Dr. Alberto Ayala of the California Air Resources Board, Dr. Alan Lloyd of the International Council on Clean Transportation, Heinrich Klingenberg of HySolutions, Lezlie Kimura-Szeto and Courtney Smith of the California Energy Commission, and Tyson Eckerle of the California Governor's Office of Business and Economic Development.

List of abbreviations

AC	Alternating current
ARVFTP	Alternative and Renewable Fuel and Vehicle Technology
BEV	Battery electric vehicle
CARB	California Air Resources Board
CaFCP	California Fuel Cell Partnership
CCS	Combined Charging System
CEC	California Energy Commission
CEP	Clean Energy Partnership
CPEV	California Plug-in Electric Vehicle Collaborative
CPUC	California Public Utilities Commission
DC	Direct current
eMO	Berlin Agency for Electromobility
EVSE	Electric vehicle supply equipment
HIA	Hydrogen Implementing Agreement
IEA	International Energy Agency
IPHE	International Partnership for Hydrogen and Fuel Cells in the Economy
FCH-JU	Fuel Cells and Hydrogen Joint Undertaking
FCV	Fuel cell vehicle
NEDC	New European Drive Cycle
NEW-IG	New Energy World Industry Grouping
NIP	Nationales Innovationsprogramm Wasserstoff- und Brennstoffzellentechnologie (National Innovation Program Hydrogen and Fuel Cell Technology)
NOW	National Organisation of Hydrogen and Fuel Cell Technology
NPE	Nationale Plattform Elektromobilität (National Electric Mobility Platform)
PEV	Plug-in electric vehicle (includes BEV and PHEV)
PEV	Plug-in Electric Vehicle Collaborative
PHEV	Plug-in electric hybrid vehicle
REEV	Range extended electric vehicle
SCAQMD	South Coast Air Quality Management District
VAT	Value-added tax
VKT	Vehicle kilometers traveled
ZEV	Zero emission vehicle (includes BEV, PHEV, FCV)

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Executive Summary

Governments around the world increasingly see electric-drive transportation as part of the long-term energy and climate solution, and also a major green technology economic growth area. Electric-drive technology, market development, and best-practice policies are still in the very early stages. Taking stock of what government actions are in place and which of these are working, is critical in understanding which policies might have the greatest effect in growing a sustainable electric-drive automobile market.

This assessment is focused on policies to promote electric-drive technology in California and Germany. California and Germany are, arguably, among the most important potential electric-drive automobile markets, based on these jurisdictions' broader policy influence, environmentally conscious consumers, and advanced technology uptake. Importantly, both of these governments have allocated substantial resources to push towards greater commercialization of electric-drive technologies – namely battery electric and hydrogen fuel cell electric vehicle technologies. The study is focused on hydrogen and electricity, due to the critical role of these technologies in transitioning to an ultra-low carbon transportation fleet over the long term.

This report compares and contrasts the electric-drive vehicle, electricity charging, and hydrogen refueling infrastructure policy landscape in California and Germany. The report's objectives are to assess the status of these two leading automobile markets' efforts to accelerate the transition toward an ultra-low carbon transport sector and identify the potential policy, infrastructure, and market environment barriers that precede future progress. This report includes a novel analysis of the California and Germany situations in accelerating the market for plug-in electric and hydrogen fuel cell vehicles and stakeholder interviews to identify and prioritize the most critical policy and market factors involved in the launch of these advanced technologies.

Figure ES-1 summarizes the findings regarding new electric-drive vehicle sales in 2014 and the approximate value of per-vehicle incentives that are available to prospective new car buyers. The figure shows how substantially larger incentives are available in California, due to national and state fiscal subsidies and in the substantial approximate value of preferential use of the carpool lane. The California incentives are valued at about $6,000 to $11,000 per vehicle. These compare to Germany's ownership and income taxation incentives that are valued at up to $600 to $2,400 per electric-drive vehicle. The report also assesses the importance of many other (non-fiscal) policies. Germany's and California's situations with respect to electric vehicle and infrastructure deployment, policy implementation, the usage and type of fiscal policies, and institutional organizations also differ to quite a degree based on this assessment. In total, new electric-drive vehicle registrations in California in 2014 were about 60,000, compared to about 13,000 in Germany.

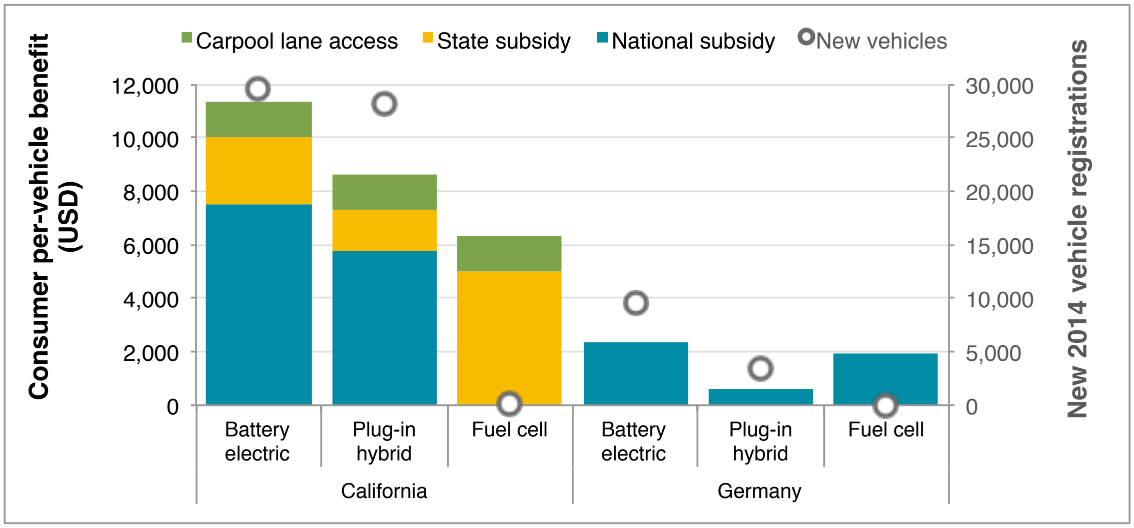


Figure ES-1. New vehicle registrations of electric drive vehicles and associated consumer incentives over six years for private cars and three years for company cars in California and Germany

This assessment points to a number of findings for Germany and California, as both jurisdictions look to accelerate the electric-drive market in the 2015-2025 timeframe. We draw the following five high-level recommendations for policy makers in Germany:

Vehicle policy. Regulatory policy that sets a clear long-term signal to manufacturers for deeper carbon emission reductions will be necessary to drive investment and deployment strategies to develop the market for electric-drive vehicles. One important element in this respect is mandatory CO_2 standards for new vehicles that are increasingly stringent over the long-term. While the EU's CO_2 standards through 2021 – according to the laboratory test procedure – are still slightly more stringent than the respective standards in the U.S. and California, Europe will need to put more emphasis on 'real-world' enforcement of these standards by introducing not only a new test procedure but also additional in-production and in-use conformity testing from independent bodies. Test cycle improvements that aid in-use compliance without proportional real-world CO_2 improvements delay the shift to more advanced technologies, including electric-drive. Furthermore, the EU – with Germany playing an important role in these discussions – will need to introduce CO_2 standards in 2025 that are at the lower end of the 68-78 g/km range suggested by the European Parliament in 2013, as well as 2030 standards that are in line with the long-term policy trajectories (*i.e.* around 50 g/km). This will help drive investment and deployment of more advanced combustion engines, hybrid-electric vehicles, and eventually a full electrification of the future vehicle fleet. Similarly, work in California toward 2026-2030 regulations that continue for at least 4% per year CO_2 reduction for new vehicles would greatly help in its transition toward an electric-drive fleet.

Although stringent, long-term vehicle CO_2 standards are necessary, they are insufficient by themselves in developing the early market for electric-drive vehicles without additional policy support. California's 2025 Zero Emission Vehicle requirements provide an unparalleled and strong investment signal in this respect. It is recommended that Germany consider a similar vehicle deployment requirement for manufacturers. Similar to the situation in the U.S., a ZEV-like policy could be implemented at state level (*i.e.* with Germany as the equivalent for California in the U.S.), complementing the EU-wide CO_2 standards, and helping to advance the German vehicle market into the lead market for battery and fuel-cell electric vehicles in the EU. As another alternative, the German government could consider making its continued public commitment to market development activities (like the showcase region projects), public incentive financing (e.g., rebates), or research and development funding contingent upon automaker's direct public pledges to increase electric-drive vehicle deployment at Zero Emission Vehicle-like levels (e.g., 10% of new vehicle sales in 2021-2022; 15% or greater by 2025). Stronger policies like this would likely be necessary to help achieve the German government's targets of 1 million electric drive vehicles by 2020 and 6 million by 2030. Making such policies technology-independent would best allow for companies to determine whether to deploy and help develop the market for plug-in hybrid electric, battery electric, or fuel cell electric vehicles.

Industry and economic assessments of the effects of an increasing electrification are outside the scope of this study. Yet, other studies point to the fact that in a scenario where Germany becomes a lead market for battery and fuel-cell electric vehicle production, this will help securing and creating jobs and economic growth in the vehicle manufacturing industry (ELAB, 2012; ECF, 2013). In contrast to California, where there is relatively limited vehicle manufacturing, Germany's policies are key to not only drive the *demand* for electric vehicles but to lead in helping spur the *supply* for innovative electric-drive technologies. This provides another reason why electric vehicle deployment requirements should also be considered for Germany.

Public and private financing. CO_2 standards and ZEV-like vehicle deployment requirements need to be complemented by financial signals to guide the transition of consumers, infrastructure, and utilities toward an electric drive future. On the consumer side, our analysis shows that financial incentives for electric vehicles are substantially higher in California than in Germany. While consumers and vehicle manufacturers alike would certainly welcome purchase subsidies for electric vehicles, it is questionable whether this would be a sustainable avenue for a major market like Germany to incentivize the uptake of electric vehicles. Instead, it is recommended to adapt the vehicle taxation scheme in Germany to be in line with the policy objectives for reducing vehicle emissions and increasing the number of electric vehicles on the roads. It is recommended that such fiscal policies promote plug-in hybrid electric, battery electric, and fuel cell electric vehicles to suit the automaker-specific technology strategies and the relative consumer advantages of each.

New financing and incentive policies could also be directly linked to vehicle technology in both Germany and California. A fee-bate scheme, taxing high-CO_2 emitting vehicles while providing a fiscal incentive to low-CO_2 emitting and particularly electric vehicles, is considered the best-practice option in this respect. Such a system would leverage the effect of vehicle CO_2 standards and ZEV-like deployment requirements and would help vehicle manufacturers to meet their respective targets, while at the same time ensuring revenue-neutrality for the German government, *i.e.* not resulting in any increased spending as would be the case for purchase subsidies. Such a program could also be important in California to create a long-term funding mechanism beyond 2020. In this context it is important to not only adapt the taxation scheme for private vehicles but also for company cars, as these account for the majority of new combustion and especially electric vehicle registrations.

On the infrastructure side, five to ten-year commitments to public and private financing for electricity charging and hydrogen refueling infrastructure enable improved automaker and infrastructure provider deployment decisions. Considering the differing growth of plug-in and hydrogen vehicles in the market, strategic planning with input on automakers' expected rollout strategies (e.g., at least 5 years forward), would ideally be a key input for the expansion of charging and hydrogen refueling infrastructure over time.

Consumer engagement. Wide-ranging consumer awareness, education, and outreach regarding electric vehicles and their benefits that will be critical in growing the early market. California consumers are exposed to a comprehensive and streamlined system of state and local incentives, charging infrastructure support, utility customer engagement, outreach events, and local informational tools. In comparison, the corresponding set of electric vehicle promotion actions in Germany appears to be more fragmented into many parallel pilot and incentive programs at regional and local level, with the risk of confusing customers who are considering purchasing an electric vehicle. To engage early electric-drive consumers, it is recommended that Germany introduces **nationwide** fiscal (see point above on public funding) and non-fiscal incentives and awareness programs that draw from its own pilot program experience, as well as California's framework for comprehensive electric vehicle promotion. Plug-in electric and hydrogen fuel cell vehicle types have substantially different consumer questions, and the two technologies are at different stages with respect to their wider market development. We recommend that California and Germany continue to have separate programs devoted to helping overcome consumer understanding, awareness, and education issues for the two major technology types. Such activities could be led by prominent government-industry partnerships, with the associated consumer research undertaken by leading universities.

Stakeholder partnerships. Public-private partnerships are critical to align stakeholders' interests, assist and lead consumer and dealer outreach and awareness activities, as well as ensure that infrastructure investments and public expenditures are well prioritized. Both California (e.g., with the Plug-in Electric Vehicle Collaborative, and the California Fuel Cell Partnership) and Germany (e.g., with the Clean Energy Partnership and the SLAM project) have shown strong commitment to building such collaborative institutions. It is recommended to continue and extend these types of stakeholder partnerships in the future. Partnerships like these might be especially important in connecting the critical vehicle manufacturer, charging infrastructure provider, national and state government, local planning organization, and citizen group stakeholders to navigate broader issues in electromobility. The types of questions which are not yet well understood are how best to link early vehicle market development to public and company charging infrastructure, consumer awareness activities, public transit, car-sharing programs, and urban biking and walking

International cooperation. Moving from this early phase in the development of an electric-drive market and moving from early adopters to a mainstream market will require global cooperation to accelerate learning on consumer, financing, and policy best-practices. California and Germany would gain from continued technical and policy exchanges with each other and with other leading electric-drive jurisdictions globally, in the years ahead. It is therefore recommended that the two jurisdictions increase their joint collaboration through government ministries that are actively engaged on topics like vehicle technology, market data, incentives, infrastructure, and financing. It is also recommended that both jurisdictions foster international cooperation with the formation of, and increasing recruitment for, a global zero-emission vehicle fleet alliance that includes active participation from all leading electric vehicle markets.

The results from this assessment are broader than California and Germany. The readiness of these two markets for a transition to electric-drive is critical to the success in the US and Europe. Further, the potential for electric-drive commercialization success, potentially toward deep transportation carbon cuts for long-term climate stabilization, will require similar electric vehicle readiness actions and policy learning around the world. The success of electric vehicles in any one market will almost surely require that there is great success in electric vehicle deployment in many markets simultaneously. Commercial success throughout Europe, Asia, and the Americas would greatly increase innovation and economies of scale, and result in technology improvements and cost reductions. As a result, global policymaker cooperation, coordinated action and market signals, as well as continued re-assessment of best practices, will be key.

I. Introduction

Governments around the world seek to lead in developing advanced automotive technologies, especially electric-drive technologies for plug-in electric and hydrogen fuel cell vehicles. Growth in electric-drive technology offers the prospect for industrial leadership for countries that are major centers of automobile research, development, and manufacturing. In addition, electric-drive technology is a critical part of a country's long-term prospects for dramatically reducing petroleum use, greenhouse gas emissions, and local air pollution. As a result, most major countries are exploring the most relevant and effective policies, financing, and promotional activities to enable a transition to electric-drive vehicle fleets to greatly reduce the fleets' energy and emission impacts.

China, Europe, Japan, and the US are leading in early electric-drive vehicle market development. Figure 1 summarizes the electric vehicle sales across the major automobile markets. As shown, global annual electric vehicle sales approximately reached 100,000 in 2012, 200,000 in 2013, and 300,000 in 2014. As indicated in Figure 1 below, the electric vehicle sales growth in the United States was greater in 2012 and 2013, and sales growth in China and Europe were greater in 2014. Within Europe, the leading markets by sales volume are France, Germany, the Netherlands, Norway, and the United Kingdom. California accounted for half of the approximately 119,000 electric vehicle sales in the US in 2014. These regions differ in their electric vehicle promotion actions, policy incentives, and charging infrastructure.

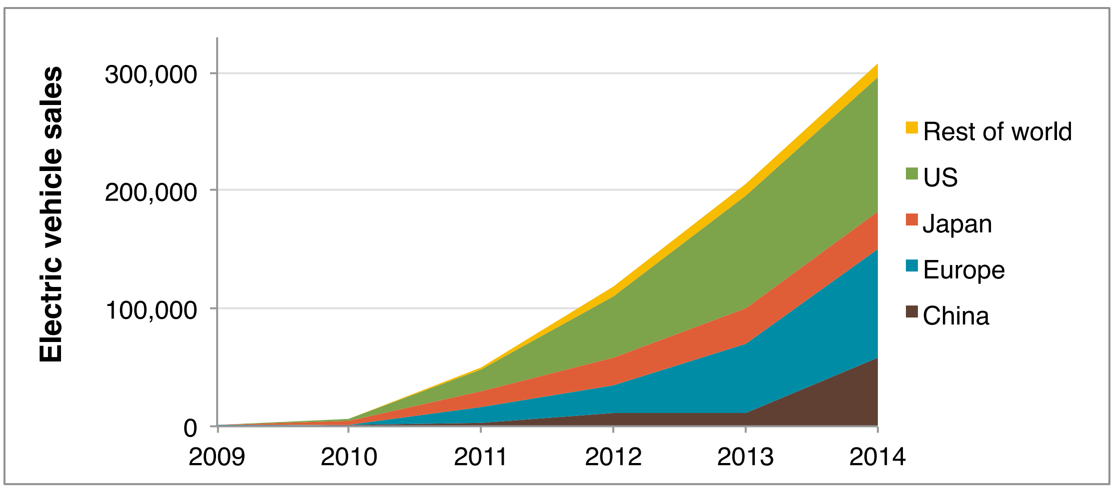


Figure 1. Annual global electric vehicle sales

California and Germany are two of the most important vehicle markets in the world. This is not only due to these markets' sizes, but also due to the critical role these regions play in setting policies that have effects beyond their own jurisdiction – namely California in preceding national US policy and Germany working together with other member states in setting policies for the European Union. Importantly, California and Germany have unique concentrations of advanced technology development by leading and start-up companies, have a strong and environmentally aware consumer base for the purchase of advanced technology, and have political leaders that have expressed a clear desire to become global leaders in accelerating the transition to an ultra-low carbon electric-drive transport sector.

Table 1 provides basic background information to put these two critical vehicle markets into context. The data shows that Germany is about twice as large as California in terms of population, overall economic activity, and vehicle sales, as well as more than twice as densely populated as California. In 2014, the market share for hybrid electric, plug-in hybrid electric, and battery electric vehicles sold in California was approximately eight times larger than in Germany. Meanwhile, hydrogen fuel cell vehicle deployment has been in the hundreds of vehicles for early demonstration and early market analysis purposes in both markets.

Table 1. Summary of Germany and California size, market, vehicles

	Germany	California
Population (in million)	81	38
Size (in km^2)	357,021	423,970
Gross domestic/State Product (in trillion USD)	3.3	2.2
Passenger vehicle sales (in million)	3.0	1.7
Passenger vehicle population (in million)	59	27.7
Number of retail fueling stations	~14,000	~10,000
Passenger new vehicle market share:		
--- Electric vehicles	0.3%	1.5%
--- Plug-in hybrid electric vehicles	0.1%	1.6%
--- Hybrid electric vehicles	0.7%	6.4%

Sources: US Census, 2014; Wikipedia, 2014a,b; FHWA, 2014; CNCDA, 2014; CEC, 2014a; ICCT, 2014

As both of these regions attempt to overcome the barriers to large-scale adoption of alternative fuel vehicles, there are important policy differences that greatly influence these vehicle technology trends. The three main electric vehicle types – (1) battery electric vehicles, BEVs; (2) plug-in hybrid electric vehicles, PHEVs; and (3) hydrogen fuel cell electric vehicles, FCEVs – are each in early market development phases. Various plug-in electric vehicle types have a clear “head start” in terms of basic factors like the number of models introduced by every major auto company, the total vehicles sold, and the widespread availability of electricity as a fuel. Fuel cell vehicles are in the midst of their commercial launches, with Hyundai, Toyota, and Honda each having 2014-2016 launches, and others following, and hydrogen as a transportation fuel is not yet widely available. In this early time in the launch of electric-drive, there are key questions about what the most important infrastructure, institutional, financing, and policy prerequisites are for commercial success of the new advanced technologies. Similarly, there are questions concerning which business models and corporate visions of automobile manufacturers will best accelerate the transformation towards widespread electrification of transportation.

The overarching intent of this report is to assess global best practices to accelerate the market for advanced electric-drive vehicle technology. The more specific objective is to comprehensively compare and contrast the electric-drive vehicle and infrastructure policy landscape in California and Germany to inform policy actions in the 2015-2020 timeframe. The work includes a novel comparative analysis of the two markets, their status in accelerating the transition toward an ultra-low carbon transport sector, and the identification of gaps that precede future progress. The work also includes industry and government stakeholder interviews to help prioritize actions for California's and Germany's policy and planning related to the deployment of electric-drive technology.

Due to the multi-faceted nature of the electric-drive vehicle deployment, this study compares and contrasts the approaches that are being taken by California and Germany along vehicle, infrastructure, and institutional dimensions. This report is outlined as follows. Subsequent to this introduction, Section II reports on electric vehicle policies, Section III reports on electric vehicle infrastructure policy, and Section IV reports on electric vehicle institutional and public-private initiatives. Section V reports on the results from an expert stakeholder questionnaire about the key obstacles and most effective policies to promote electric vehicles. Finally, Section VI summarizes the results and offers several final policy conclusions.

II. Electric-drive vehicle policy

This section focuses on policies and other government actions that are related directly to electric-drive vehicles in Germany and California. The promotion of electric-drive vehicle sales and use is generally seen as a critical focus area in advancing the transition to an electric-vehicle fleet. Covered within this section are regulatory policies for vehicle manufacturers, vehicle purchasing incentives for consumers, programs to promote purchasing in vehicle fleets, and complementary non-fiscal vehicle incentives. Within each area, we summarize the action in California and Germany. We note that in many cases, the Californian and German policies are subject to national US and European Union policies, respectively, so those overarching policies are included. In the final subsection we provide a condensed summary of actions in the two markets.

Vehicle regulations

Electric-drive requirements. Among the regulations that pertain to electric-drive vehicles, there are new vehicle carbon dioxide (CO_2) emission requirements, technology-specific regulatory incentives within the CO_2 regulations, and there are direct electric vehicle requirements. California uniquely has direct electric vehicle requirements. California's Zero Emission Vehicle program was established in 1990 and has gone through numerous amendments. Its last major amendment in 2012, in light of major commercial product offerings by most major automobile manufacturers, substantially restructured and extended the program requirements through 2025.

The new ZEV program was adopted as a package with the California greenhouse gas emission regulations to acknowledge that the carbon dioxide (CO_2) regulations would not sufficiently address the need for the greater volumes of electric-drive vehicles needed to meet California's long-term climate goals. While deployment of electric-drive vehicles can help a manufacturer comply with CO_2 limits, the principal objective of the California ZEV program is to be transformative and technology forcing, with a clear goal towards zero tailpipe emissions. Through 2014, the new vehicle fleet as a whole was substantially ahead of schedule in complying with the ZEV program requirements. Over 3% of California's 2014 light-duty vehicle sales were plug-in electric vehicles, whereas the California Air Resources Board projects that the fleet would only need this level of electric vehicle deployment in 2018 or a later timeframe.

Figure 2 summarizes the estimated light-duty vehicle sales and sales share in California from a projection of industry ZEV compliance through model year 2025 (Based on CARB, 2011). The ZEV program is designed to be flexible in allowing various forms of electric-drive vehicle technologies, including BEVs, PHEVs, and FCEVs. The figure shows the California Air Resources Board regulatory assessment of average fleet-wide compliance, whereas various companies will have strategies that are more focused on one of two of the various electric-drive technology types. As shown, an expected compliance scenario has approximately 9% PHEV sales share, 4% BEV, and 2% FCEV sales share in 2025. The associated cumulative sales amount to over 1.6 million BEVs, PHEVs, and FCEVs in California through 2025. Note that ZEV program compliance could occur with greater or lesser shares of the three main technologies; for example, if there were no FCVs, the PHEV and ZEV shares would be significantly higher. The ZEV provisions grant credits to vehicles according to their estimated electric driving range on prescribed testing cycles. For example, a 50 mile (80 km) PHEV receives 1.0 credit, a 100 mile (161 km) BEV receives 1.5 credits, and a 300 mile (483 km) FCEV receives 4.0 credits. PHEVs with electric vehicle ranges from 10-40 miles (16-64 km) can accrue 0.4-0.9 ZEV credits in the ZEV program. The electric range is generally based on the Urban Dynamometer Driving Schedule (or "city") test cycle, but there are other conditions that impact on the allowable vehicle credits. The program allows credit trading between companies, and non-compliance is subject to a $5,000 fine per ZEV credit. Some companies purchase credits from other companies to reduce their requirements or accrue regulatory credits for use in future model years. The auto company Tesla has perhaps gained most from such credits, reportedly selling regulatory credits for a total exceeding $500 million (Hirsch, 2015).

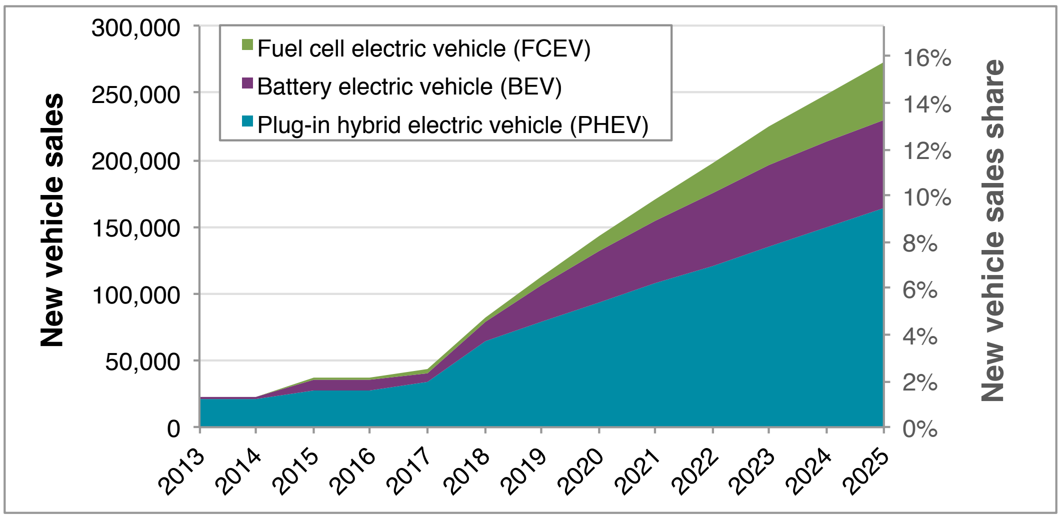


Figure 2. Estimated new vehicle sales and sales share of electric-drive vehicles by model year to meet California Zero Emission Vehicle program

Figure 3 summarizes 2013 data on new vehicle registrations in California, the US, Germany, and the EU. These recent data on California vehicle registrations suggests that the electric-drive vehicle sales numbers are similar to the CARB (2011) ZEV program projections from above, but different in several ways. The total 2013 new plug-in electric vehicles sales were approximately 42,000 – including 22,000 BEVs and 20,000 PHEVs. The 2014 sales were approximately 58,000 – including about 30,000 BEVs and 28,000 PHEVs. These recent electric vehicle sales are greater than the original rulemaking estimates, especially for BEVs. For FCVs, as of a June 2014 CARB report, total FCV registrations are at 125, and automobile manufacturers project that there will be 6,650 FCVs by the end of 2017 and 18,500 by the end of 2020 (CARB, 2014b). Also, the figure shows how the California market represents approximately 40% of overall US electric vehicle sales.

Despite its larger vehicle market, considerably less electric-drive passenger vehicles were registered in Germany than in California during 2013. Germany's total 7,300 electric-drive vehicle registrations consisted of about 6,300 BEVs and 1,000 PHEVs in 2013. In 2014, Germany's total 13,000 electric-drive vehicle registrations consisted of about 9,600 BEVs and 3,500 PHEVs. Germany's electric vehicle sales increased by approximately 80% from 2013 to 2014 (see Figure 3).

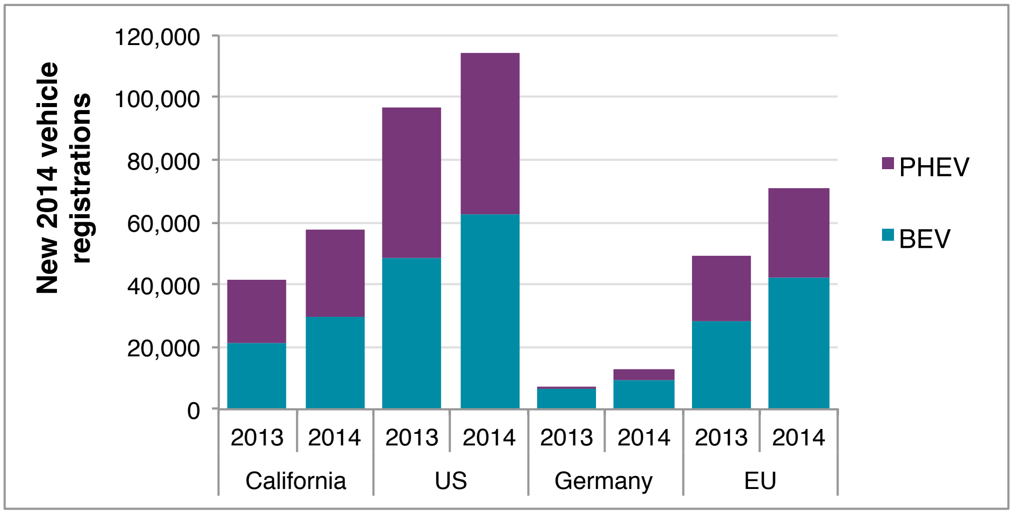


Figure 3. New 2013-2014 electric vehicle registrations in California, US, Germany, EU

In the context of electric vehicle sales in Europe, Germany accounted for roughly 22 percent of all passenger vehicle registrations and had a 14 percent share of the Europe's electric-drive vehicles in 2014. These figures place Germany fourth in Europe in terms of EV registrations (behind Norway, the United Kingdom, and the Netherlands), but lower in terms of market share (see Figure 4).

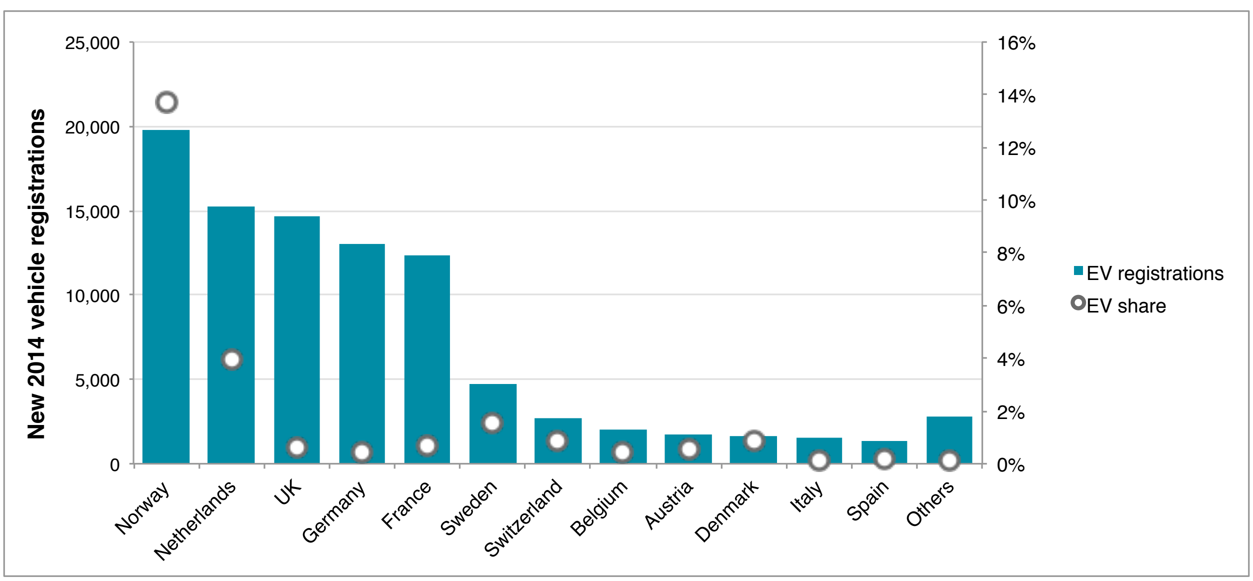


Figure 4. 2014 registrations and market shares of electric vehicles in Europe

The California ZEV program is unique. Neither Germany nor any other region or country yet has adopted such prescriptive electric-drive vehicle sales requirements. The California ZEV program is a command-and-control policy that puts a binding and legal requirement on vehicle manufacturers to produce and sell ZEVs in California. Other US states (e.g., New York, Oregon) have adopted the same California requirements, increasing the total ZEV deployment requirement in the US.

Although direct requirements like California's ZEV program are not found elsewhere, many governments have national non-binding targets for sales and cumulative electric vehicle deployment within given timeframes. The German government first developed a strategy for electric-drive vehicles in its national development plan for electric mobility (*Nationaler Entwicklungsplan Elektromobilität der Bundesregierung*) in 2009. The development plan aims to make Germany the market leader in electric mobility by promoting research and development of electric powertrains, energy storage in particular, as well as charging infrastructure. The strategy works toward the mass market adoption of electric-drive vehicles: a key objective is to increase the number of electric-drive vehicles to one million by 2020 (Federal Ministry of Education and Research, 2009), which is equivalent to 2 percent of the current fleet (KBA, 2015). The development plan targets apply to battery electric vehicles, plug-in hybrid electric vehicles (depending on range and application), and battery electric vehicles with range extenders. The US set a goal of one million electric vehicles by 2015 and other countries have set similar goals (See IEA, 2013).

CO_2 regulations. The EU and US regulations that require increasingly lower new vehicle CO_2 emissions also provide a strong policy push for the deployment of all low-CO_2 technologies, including electric-drive. The regulations require each automaker to deploy greater numbers of low-CO_2 vehicles in future years to meet lower fleet-average CO_2. Figure 5 illustrates the average reduction in CO_2 emission required in Europe and in the US, with the US standards approximately converted to the New European Drive Cycle (NEDC) (ICCT, 2014a). More precisely, the regulations allow each manufacturer to achieve varying levels of CO_2 standards, depending on their own sales fleet's vehicle weight (in EU) or vehicle footprint (in the US). The exact CO_2 emission rate for a given company, or within a given US state or EU member state, may be higher or lower than depicted, depending on the vehicle sales mix. For example, the EU average CO_2 emissions in 2012 were 134 gCO_2/km, compared to Germany at 143 gCO_2/km (ICCT, 2014b). Practically, these regulations translate to average vehicles in Germany and California, reducing their CO_2 emissions by 2-4% per year, as new technologies (i.e., more advanced gasoline and diesel efficiency, hybrids, electric-drive) displace older conventional technology.

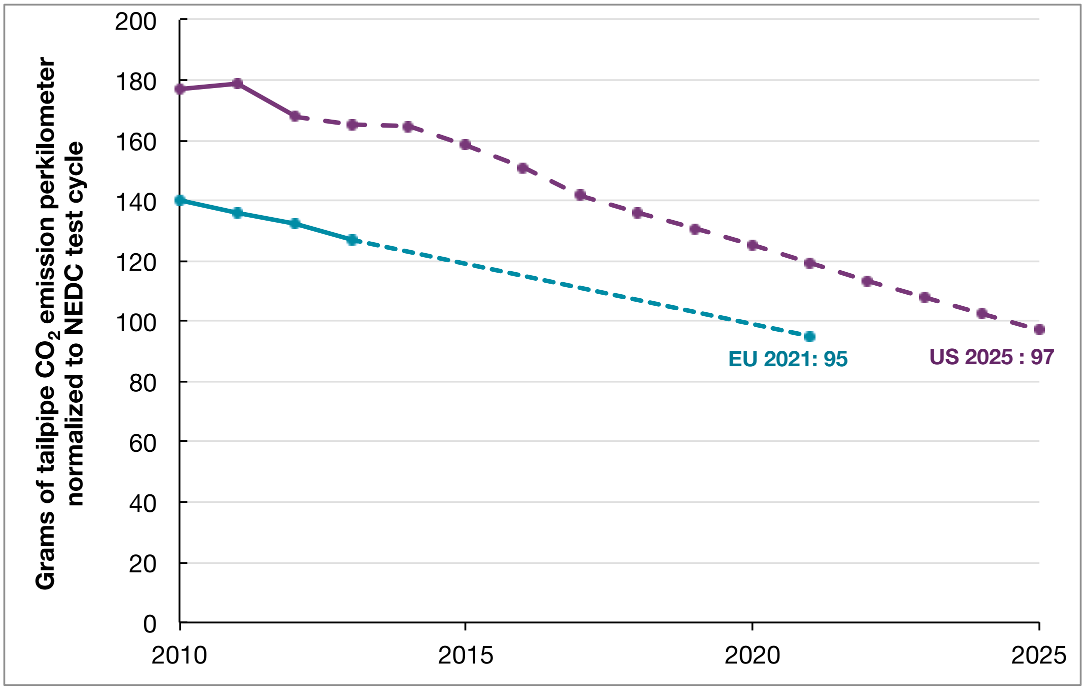


Figure 5. Average CO_2 reduction for passenger cars from regulations in the US and Europe (ICCT, 2014)

Although the CO_2 requirements do indeed provide a strong motivation for electric-drive, it is widely acknowledged that the prevailing standards (i.e., 95 g/km by 2020 in EU, and 97 g/km for passenger cars by 2025 in the US) are not sufficient to drive large-scale commercialization of electric vehicles. There are dozens of diesel and gasoline vehicle models that already achieve very low-CO_2 emissions and would comply with the 2020 regulation emission levels (US EPA, 2013; ICCT, 2014b). Diverse technical studies indicate that advanced gasoline and diesel engines, transmission, and road-load technologies can increasingly be deployed to help the entire new vehicle fleet comply with the adopted 2020-2025 CO_2 standards with minimal use of electric-drive technology (see US EPA, 2012; Ricardo, 2011; Meszler et al, 2014; Meszler et al, 2012). In practice, different manufacturers will make use of different product strategies to meet their individual CO_2 emission fleet targets. For example, it is to be expected that premium brands will tend to introduce more electric-drive vehicles, given the co-benefits in terms of drivability that help to market these vehicles particularly in the premium vehicle segment. For the lower vehicle segments, at least in the short term, a stronger focus on conventional combustion engine technologies is expected. The US regulatory analysis projects that the most cost-effective industry technology pathways to comply with the GHG standards through 2025 are dominated by advanced gasoline and diesel technologies, with only 2% BEVs, 0% PHEVs, and 0% FCEVs (US EPA, 2012).

Incentives within CO_2 regulations. Acknowledging that the CO_2 regulations do not necessarily push electric-drive technology into the fleet, the US and European CO_2 regulations each include additional incentives to promote electric-drive vehicles. The two primary regulatory electric-drive vehicle incentives that are utilized are (1) to account for electric-drive carbon emissions as 0 g CO_2/km and (2) to count each of these vehicles as more than one vehicle in the regulations, using “super credits” or “multipliers.” These incentives do indeed make the deployment of electric-drive vehicles compelling from a regulatory perspective, although with some risk of eroded regulatory CO_2-reduction benefits if used over the long-term as the electric-drive vehicles increase (Lutsey and Sperling, 2012).

Both the US-California and EU-Germany regulations utilize such incentives within their CO_2 regulations. Key details about the two areas' regulatory incentives for electric drive vehicles are summarized in Table 2. The US GHG regulation includes 0 gCO_2/km accounting and multipliers for the various electric-drive vehicle types, with some variation according to vehicle technology types and over given model years. Specifically for model years 2012 through 2021, BEVs and FCEVs are granted 0 g/km for 2012-2021, and PHEVs are granted 0 g/km for the estimated fraction of time they are driven on electricity (based on "utility factor" from SAE 2841 testing procedures). As an example of PHEV accounting, a PHEV with a range-depleted 40 mile (64 km) electric range and a utility factor of 0.65 would receive a certification value that is weighted as 65% at 0 g/km and 35% as the CO_2 value of the vehicle when its electric charge is depleted and the vehicle functions as a hybrid.

Table 2. Availability of electric-drive vehicle incentives in California and Germany within vehicle CO_2 regulations

Technology	Incentive	US	EU [a]
Battery electric vehicle	0 g/km	• 0 g/km 2012-2021 • 0 g/km 2022-2025 [b]	• 0 g/km
	Multiplier	• 2.0 in 2017-2019 • 1.75 in 2020 • 1.5 in 2021	• 3.5 in 2012-2013 • 2.5 in 2014 • 1.5 in 2015 • 2.0 in 2020 • 1.67 in 2021 • 1.33 in 2022
Plug-in-hybrid electric vehicle	0 g/km	• 0 g/km for 2012-2021 for estimated electric driving [c] • 0 g/km 2022-2025 for estimated electric driving [b,c]	• 0 g/km for estimated electric driving [d]
	Multiplier	• 1.6 in 2017-2019 • 1.45 in 2020 • 1.3 in 2021	If tailpipe CO_2 emissions ≤ 50g/km: • 3.5 in 2012-2013 • 2.5 in 2014 • 1.5 in 2015 • 2.0 in 2020 • 1.67 in 2021 • 1.33 in 2022
Fuel cell electric vehicle	0 g/km	• 0 g/km 2012-2021 • 0 g/km 2022-2025 [b]	• 0 g/km
	Multiplier	• 2.0 in 2017-2019 • 1.75 in 2020 • 1.5 in 2021	• 3.5 in 2012-2013 • 2.5 in 2014 • 1.5 in 2015 • 2.0 in 2020 • 1.67 in 2021 • 1.33 in 2022

[a] *Based on Regulation (EC) 443/2009 and (EC) 333/2014; multipliers for 2020-2022 timeframe for each manufacturer have an equivalent cap of 7.5 gCO_2/km*

[b] *This incentive for 2022-2025 applies for up to 200,000 BEV/PHEV/FCEV, or up to 600,000 BEV/PHEV/FCEV for manufacturers that sell over 300,000 BEV/PHEV/FCEV in 2019-2021, after which upstream electricity-related emissions are included*

[c] *Based on SAE 2841 procedures for approximating average fraction of driving from grid electricity*

[d] *Based on European/UNECE procedures for approximating average fraction of driving from grid electricity*

As a further incentive in the US regulations, automakers can also utilize 0 g/km accounting beyond 2021, for up to 200,000 total PHEV, BEV, and FCEV (or up to 600,000 total PHEV, BEV, and FCEV if the automaker sells over 300,000 electric-drive vehicles from 2019-2021). In addition, the US regulations allow a multiplier of 2.0 in 2017 for BEV and FCEV technology, and this phases down to 1.5 in 2021. The PHEV multiplier phases down from 1.6 in 2017 to 1.3 in 2021. The electric vehicle multipliers are no longer available from 2022 on in the US regulations; after the above regulatory incentives, from 2022 on, the regulatory accounting for electric vehicles would include the average upstream greenhouse gas emissions from fuel production and electric power plant operation. In addition, because battery electric vehicles are without after-treatment pollution control systems, they have the benefit of bypassing compliance with on-board diagnostics (OBD) requirements.

Within the EU's 130 g/km 2015 and 95 g/km 2020 passenger vehicle standards, multipliers are used as regulatory incentives for ultra-low carbon vehicles, defined as vehicles with less than 50 g/km. The multiplier for ultra-low carbon vehicles was set at 3.5 in 2012 and will be phased out by 2016 (see Table 2). With respect to the 2020 target of 95 g /km, a second round of multipliers will be applied. These multipliers will be reduced from two in 2020 to one in 2023 according to (EC) 333/2014. Between 2020 and 2022, the total impact of multipliers will be limited to 7.5 g/km for each manufacturer. Within the European-type approval process, based on the New European Driving Cycle, 0 g/km accounting is used for BEVs and FCVs but not for PHEVs. Emissions from PHEVs are determined by an electric drive portion, equivalent to 0 g CO_2/km, and a portion of driving with minimum state of charge (a depleted battery). The ratio of electric drive to conventional drive in the calculation of aggregate emissions is determined by the vehicle's electric range (see section 3.4 of United Nations Economic Commission for Europe, 2005). While 0 g/km accounting does not apply to PHEVs, they may still qualify as ultra-low carbon vehicles as long as they emit 50 g CO_2/km or less.

Vehicle purchasing subsidies and fiscal incentives

National electric vehicle purchasing subsidies and fiscal incentives. Internationally, direct subsidies and various forms of tax incentives are being utilized by many national governments to promote the sales of electric-drive vehicles. The variation in national fiscal incentives across countries is having some early effect on driving electric vehicle sales (Mock and Yang, 2014). Prospective purchasers (and leasers) of electric vehicles in California can receive incentives from federal US and California incentive programs. In the federal US program, plug-in electric vehicles with a minimum of 5 kilowatt-hour (kWh) battery capacity are eligible for $2,500 per vehicle, scaling up at $417 per kWh to a maximum of $7,500 per vehicle of 16 kWh or greater. Generally this means that plug-in hybrid electric vehicle models with all-electric ranges from 18-40 km (11-25 mi) receive approximately $2,500-4,000; this includes popular Toyota, Ford, and Honda plug-in hybrid models. Based on the battery capacity requirements, essentially all BEV models and some PHEV models with relatively high all-electric range (e.g., Chevrolet Volt) receive the maximum $7,500 credit. These tax credits are applicable for 200,000 total BEV and PHEV vehicles per manufacturer, and the incentives are phased out for the year following the manufacturers' 200,000th BEV/PHEV sold (See IRS, 2014).

While Germany offers no purchasing subsidies on a national level, the federal government offers two dedicated fiscal incentives for the purchase of electric-drive vehicles. First, BEVs and FCVs registered before 2016 are exempted from road tax for ten years after registration, while vehicles registered between 2016 and 2020 are exempted for five years (Federal Ministry of Justice and Consumer Protection, n.d. a) and PHEVs are not exempted. The savings from the road tax exemption is contingent on vehicle characteristics. German road tax on private passenger vehicles is composed of a CO_2-based component (€2 for each gram CO_2 above 95 g/km) and an engine displacement component (€9.50 per 100 cm^3 for diesel vehicles and €2 per 100 cm^3 for gasoline vehicles).

Table 3 summarizes the financial impact of the road tax exemption for a number of vehicles registered in 2015. The financial incentive is equal to the undiscounted savings resulting from the road tax exemption when comparing an electric-drive vehicle with a comparable diesel car. It should be noted that, even under generous assumptions, the road tax exemption is offset by the higher value-added tax (VAT) of electric-drive vehicles, which are typically more expensive than conventional counterparts. In Figure 6, savings from the road tax exemptions were calculated as the discounted savings (6 percent discount rate), over a six-year time horizon, which is representative of average holding periods in Germany. Comparing electric-drive vehicles with diesel vehicles may inflate the savings since diesel vehicles incur higher road taxes than gasoline vehicles. Comparing a VW Golf 1.6 TDI with the e-Golf reveals that the road tax exemption amounts to €865 in discounted savings over a six year timeframe. However, the VAT is €1,529 higher for a VW e-Golf than for the comparable diesel type.

Figure 6 delineates acquisition costs and ownership taxes of diesel vehicles and juxtaposes them with comparable electric-drive vehicles. The figure indicates that the tax exemption of electric-drive vehicles typically pales in comparison with the higher acquisition costs of electric-drive vehicles. The Volvo V60 plug-in hybrid is not exempted from the ownership tax on private vehicles as PHEVs are not included in the regulation.

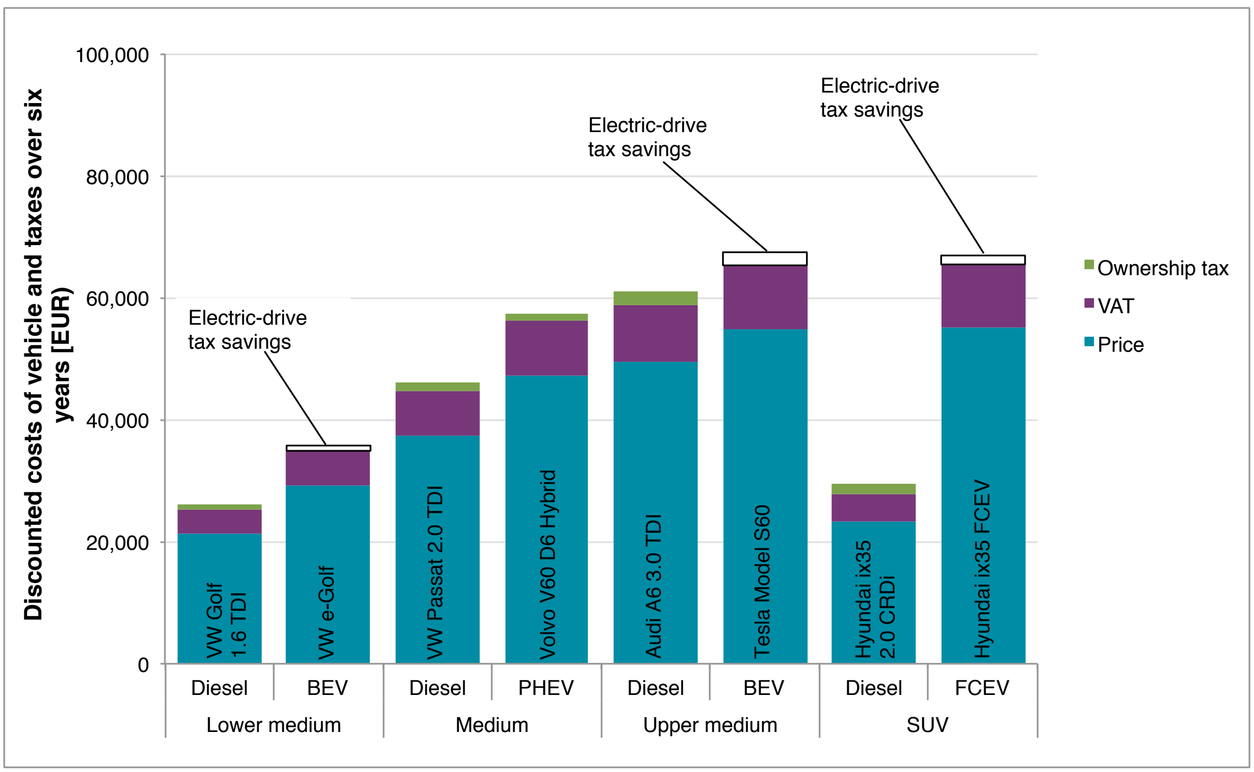


Figure 6. German tax incentives for private cars comparing conventional and electric-drive vehicles registered in 2014 in different vehicle segments

In addition to this ownership tax exemption, a second fiscal incentive applies to electric-drive company cars. Germany levies income tax on the benefits arising from the private usage of company cars. One method of determining the taxable income is to add one percent of the vehicle's list price to the monthly personal income (ACEA, 2014). Since 2013, the list price can be reduced by €500 for each kWh of electric energy storage included in the vehicle for the calculation of the taxable income. This tax deduction is reduced by €50 each year after 2013. The total reduction of the vehicle's list price is limited: the maximum allowable tax deduction was set at €10,000 in 2013 and the limit is lowered by €500 each year thereafter (Federal Ministry of Justice and Consumer Protection, n.d. b). Over a three-year timeframe, the tax deduction reduces discounted income taxes for a VW e-Golf from €3,560 to €2,641, thereby making the income taxes comparable to a diesel Golf with similar performance (see Figure 7 and Table 3 for a number of comparisons). While this scheme currently only applies to BEVs and PHEVs, it is likely to be extended to FCVs.

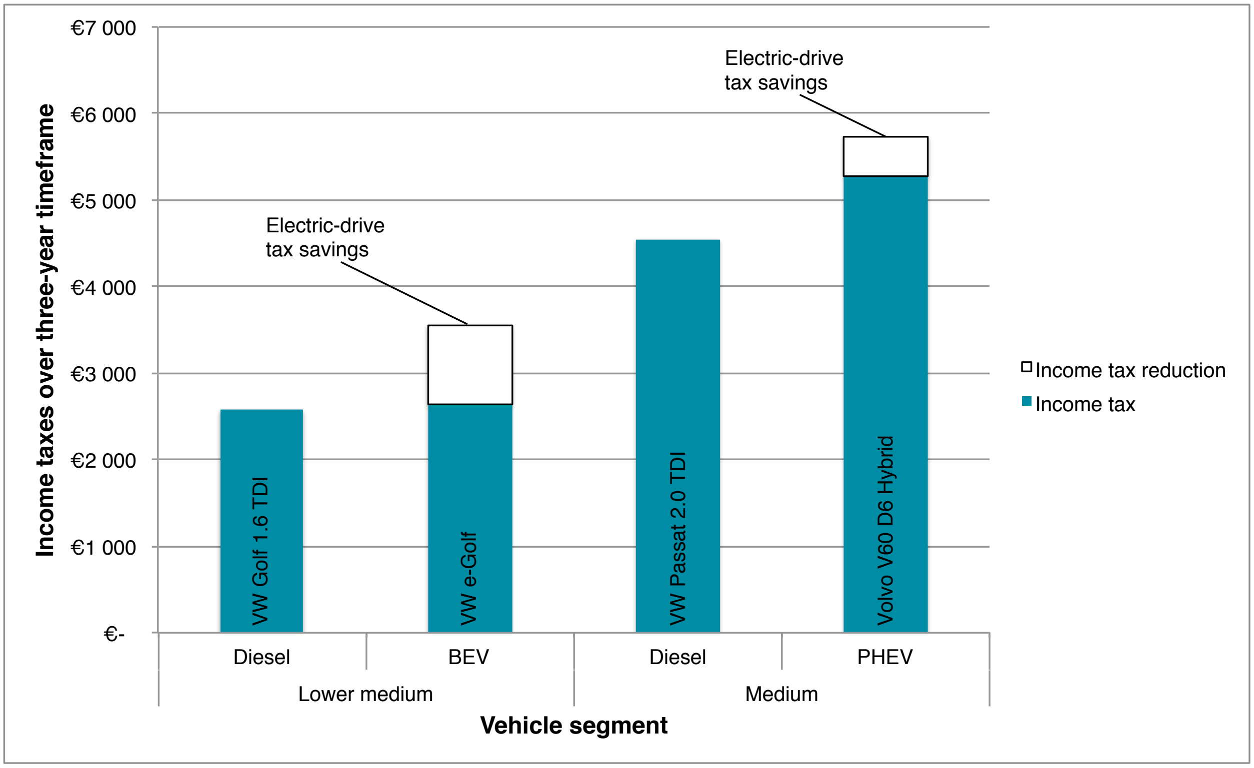


Figure 7. German income taxes on private use of company cars for conventional and electric-drive vehicles registered in 2014

The federal government of Germany also offers low-interest loans for the acquisition of electric vehicles through the government-owned development bank KfW. Under the KfW's Environmental Protection Program ("KfW-Umweltprogramm"), companies can apply for a loan for hybrid or hydrogen-powered passenger cars with CO_2 emissions below 50 g/km or with an electric range of more than 40 km (KfW, a). Companies may also apply for a loan from the KfW for light commercial vehicles that fulfill the Euro 6 emission standard and do not exceed a reference mass of 2,840 kg. The loan can amount to the full list price of the vehicle. While the conditions of loans are contingent on the loan duration, company size, and other parameters, the interest rate can be as low as one percent (KfW, 2015b).

Table 3 summarizes the impact of the tax deduction for a number of vehicles registered in 2014. The fiscal incentive is equal to the discounted savings resulting from the tax deduction over six years for private cars and three years for company cars. Some key takeaways include that the exemption from private ownership taxes often typically is not sufficient to offset the increased VAT leveraged on electric-drive vehicles. Moreover, private owners of low-carbon vehicles face increased total costs of ownership of approximately €5,000 to €8,000 (including the exemption from ownership taxes) when compared to a conventional vehicles (Wietschel, Plötz, Kühn, & Gnann, 2013 as cited by Mahler & Runkel, 2015). For company cars, the tax deduction is in some cases sufficient to ensure that income taxes for conventional and electric-drive vehicles are equal.

Table 3. Comparison diesel and electric-drive vehicles, and associated national fiscal incentives for electric-drive vehicles registered in 2015 in Germany

Segment	Diesel vehicle	Electric-drive vehicle	Fiscal incentive for electric-drive vehicle[a,b]
Lower medium segment BEV	•Model: VW Golf •Engine: 81 kW, 1,598 cm^3 •Emissions: 102 g CO_2/km •Price: €25,325 •VAT: €4,043 •Road tax: €166/year •Income tax: €912/year	•Model: VW e-Golf •Engine: 85 kW, 0 cm^3 •Emissions: 0 g CO_2/km •Price: €34,900 •VAT: €5,572 •Road tax: €0/year •Income tax: €914/year	•Ownership tax exemption (private and company cars): €865 •Income tax reduction (company cars): €919
Medium segment PHEV	•Model: VW Passat Variant •Wngine: 176 kW, 1,968 cm^3 •Emissions: 140 g CO_2/km •Price: €44,625 •VAT: €7,125 •Road tax: €280/year •Income tax: €1,607/year	•Model: Volvo V60 D6 hybrid •Engine: 206 kW, 2,400 cm^3 •Emissions: 48 g CO_2/km •Price: €56,200 •VAT: €8,973 •Road tax: €228/year •Income tax: €1,842/year	•Ownership tax exemption (private and company cars): €0 •Income tax reduction (company cars): €920
Upper medium segment BEV	•Model: Audi A6 3.0 TDI •Engine: 235 kW,: 2,967 cm^3 •Emissions: 159 g CO2/km •Price: €58,900 •VAT: €9,404 •Road tax: €413/year •Income tax: € 2,120/year	•Model: Tesla Model S60 •Engine: 225 kW, 0 cm^3 •Emissions: 0 g CO_2/km •Price: €65,300 •VAT: €12,407 •Road tax: €0/year •Income tax: €2,009/year	•Ownership tax exemption (private and company cars): €2,153 •Income tax reduction (company cars): €505
SUV segment FCV	•Model: Hyundai ix35 2WD •Engine: 100 kW, 1,995 cm^3 •Emissions: 141 g CO_2/km •Price: €27,890 •VAT: €4,453 •Road tax: €282/year •Income tax: €1,004 /year	•Model: Hyundai ix35 FCEV •Engine: 100 kW, 0 cm^3 •Emissions: 0 g CO_2/km •Price: €77,350 •VAT: €12,300 •Road tax: €0/year •Income tax: unknown	•Ownership tax exemption (private and company cars): €1,470 •Income tax reduction (company cars): unknown

[a] *Private cars: savings from the road tax exemption are calculated as the discounted savings (six percent discount rate) over six years of vehicle ownership when comparing an electric-drive vehicle with a comparable diesel vehicle .*

[b] *Company cars: the fiscal incentive was calculated as the discounted savings (six percent discount rate) from tax deductibles for electric-drive vehicles for three years of vehicle ownership. The income tax rate was set equal to 30%.*

State and regional-level electric vehicle purchasing subsidies and fiscal incentives. Electric vehicle purchasing and leasing incentives in California and Germany are summarized in Table 4. California offers additional fiscal incentives for the purchase and lease of electric-drive vehicles. The California Air Resources Board administers California's Clean Vehicle Rebate Project (CVRP), and the rebates per vehicle that vary by technology type have shifted somewhat over time. In 2014, the rebates were $2,500 per BEV, $1,500 per PHEV, and $5,000 per FCV (CCSE, 2014). Over 2009-2013, the program has distributed over $60 million for more than 27,000 vehicles, for an average of approximately $2,200 per vehicle (CCSE, 2014). Legislation in 2014 extended the program's funding through 2023, with the goal of helping put one million electric-drive vehicles on California's roads (CLI, 2014). To expand the access and use of the electric vehicle rebates, California has modified the eligibility requirements and increased financing support for lower-income and disadvantaged consumers (CARB, 2015b). In addition, some regional governments annually offer additional incentives for electric vehicle purchasing. For example, the San Joaquin Valley offers $3,000 for BEV and FCV purchases, and $2,000 for PHEV purchases (SJVAPCD, 2014). The total effect of the federal California state rebates is illustrated in Figure 8. As shown, the rebates reduce the price differences between the plug-in electric vehicle models and their conventional gasoline counterparts. This figure does not reflect the electric vehicles' average fuel savings of other policy incentives described below.

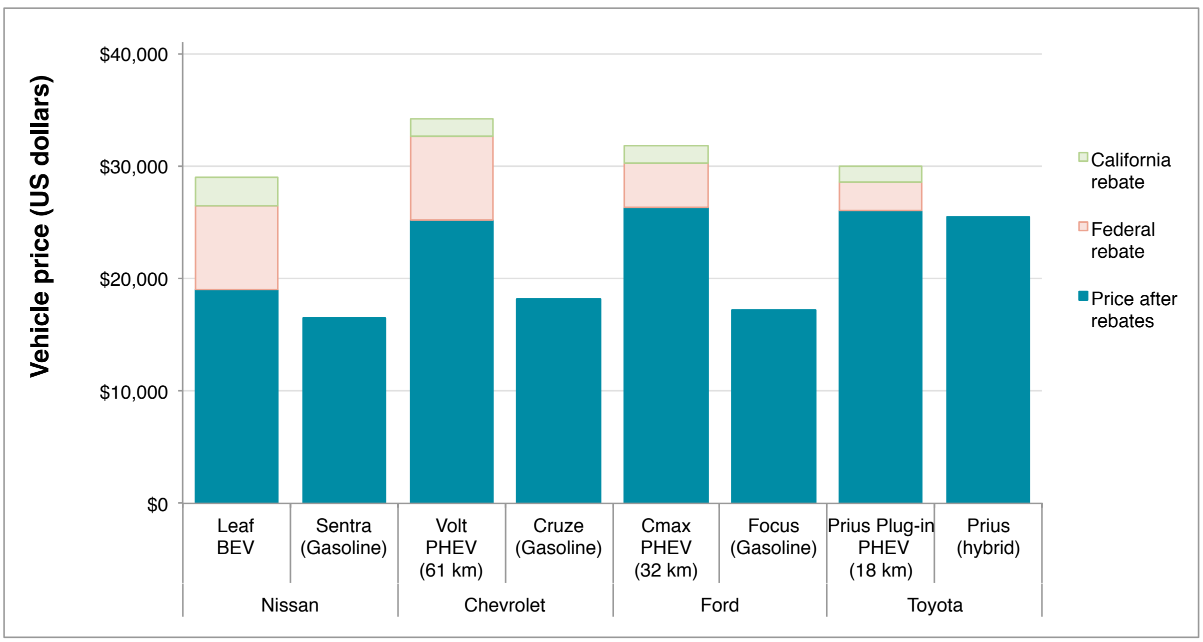


Figure 8. US and California tax incentives for pairs of model year 2015 conventional and electric-drive vehicles

Few German states and regions have introduced fiscal incentives for electric-drive vehicles. For example, the Hamburg Chamber of Commerce offers discounts on the list price of electric-drive vehicles to its member organizations. By partnering with car manufacturers and charging infrastructure and by bringing together potential buyers, the initiative can reduce the list price by up to 23 percent (Handelskammer Hamburg, 2015). Project partners include Daimler, Mitsubishi, Nissan, Renault, and Volkswagen, among others. Similarly, the chambers of commerce in the cities of Frankfurt and Wiesbaden, with €1M funding from the state of Hesse, offer purchasing subsidies to local craft enterprises for up to 200 BEVs, PHEVs, and range extended electric vehicles (REEVs). The level of subsidy is contingent on the list price of the vehicle and ranges from €4,000 for vehicles with a list price lower than €20,000 up to €6,000 for vehicles with a price exceeding €30,000 (State Government of Hesse, n.d.). The city of Munich is discussing direct purchasing subsidies for electric vehicles. According to one proposal, companies may apply for a €2,500 subsidy for electric-drive passenger vehicles and a €4,000 subsidy when purchasing an electric-drive delivery van or taxicab. This subsidy would be part of a €30M promotional program (Völklein, 2015). Lastly, a number of regional utility providers offer subsidies for electric-drive vehicles. For example, a number of regional utilities ("Kommunalwerke") in North Rhine-Westphalia offer purchasing incentives for electric vehicles ranging from €500 to €1,500 (EnergieAgentur NRW, 2015). Similar incentives can be found throughout Germany, albeit at a city or communal level. Due to large amount of regional utilities and their complex ownership structures, it proves difficult to discern to what extent these incentives can be considered government funding.

Table 4. Electric-drive vehicle fiscal incentives in California and Germany

	Action	California	Germany
Federal	Incentive by technology	• BEV/PHEV incentives based on battery capacity from $2,500 (5 kWh) to $7,500 (16+ kWh) per vehicle	• Private vehicles: five or ten year road tax exemption for BEVs and FCVs[a] • Company vehicles: reduced taxable income for private use of company vehicles[b] • Company vehicles: low interest loans for EVs offered by the government-owned development bank KfW
	Duration of incentive program	• Tax credit applicable for up to 200,000 total BEV/PHEV vehicles per manufacturer • Incentives phased out for year following 200,000 BEVs/PHEVs sold	• Private vehicles: up to and including 2020 • Company vehicles: gradual reduction of tax deductible up to 2023
State	Incentive by technology	• BEV rebate of $2,500 • PHEV rebate of $1,500 • FCV rebate of $5,000	• Hamburg: up to 23% reduction of list price through the Hamburg Chamber of Commerce
	Duration of incentive program	• Funding extend through 2023, with goal of supporting total of 1 million vehicles	
	Vehicle fee exemptions	• BEV exempt from annual emissions testing	• BEVs exempt from emission component of the general inspection
Regional	Incentive by technology	• San Joaquin Valley: BEV, FCV $3,000, PHEV $2,000 rebate	• Frankfurt and Wiesbaden: €4,000 - €6,000 subsidy for BEVs, PHEVs, REEVs in craft enterprises • Munich: €2,500 for electric-drive passenger vehicles and €4,000 for taxicabs and vans • Multiple regions: typically between €500 and €1,500 offered by regional utilities

[a] *Kraftfahrzeugsteuergesetz §3d*
[b] *Einkommensteuergesetz §6*

Non-fiscal vehicle incentives

A number of non-fiscal vehicle incentives are increasingly being utilized to increase the attractiveness of electric vehicles. In particular, access to high-occupancy vehicle (HOV) or "carpool" lanes, exemptions on annual fees, and access to preferential or free parking are utilized in many areas. These measures provide non-fiscal benefits in terms of time saving and can reduce costs for highway tolls and parking fees, and they also increase the visibility of electric vehicles to those consumers who are unaware of the new technology. In a large and heterogeneous market, various types of these non-fiscal measures can also have a strong effect on some consumers' vehicle purchasing decisions.

California has a number of such policy actions. California is among ten states to offer HOV access to single-occupant electric-drive vehicles. The use of HOV lanes by electric vehicles is restricted and controlled by the distribution of stickers (or decals, or license plates in other states) that are displayed on the outside of the vehicle. Through Dec 2013, California had issued over 41,000 White (for BEVs and FCVs) and 28,000 Green (for PHEVs) clean air vehicle stickers that grant access to over 2,200 km of California HOV lanes for single occupancy drivers (Caltrans, 2014). California extended its cap on Green stickers to 70,000 vehicles (CARB, 2014). Most of the HOV lanes are around the major metropolitan areas of Los Angeles and the San Francisco Bay area; as a result, the stickers significantly save time for consumers during congested peak travel times. Several anecdotal stories suggest that stickers add up to $1,200-$4,000 to the value of such used vehicles, versus comparable vehicles without the stickers, when the stickers are scarce (Blanco, 2009; Woodyard, 2007). Jin et al (2014) analyzed the value of carpool lane access for electric vehicles in California as being $1,300.

In addition to access to carpool lane access, there are several smaller incentives for electric vehicles owners in California. California does not offer state-wide parking preferences, but free parking is offered by many different communities, including Berkeley, Hermosa Beach, Manhattan Beach, Laguna Beach, Pasadena, Sacramento, San Jose, and Santa Monica. Some of these cities utilize the same state HOV access Clean Air decal to assist in monitoring and enforcement of the parking incentive. In addition, two California state agencies – the Department of General Services (DGS) and the California Department of Transportation – are required to provide alternative fuel vehicle parking spots at public lots and park-and-ride (i.e., near rail transit) facilities (CLI, 2012). The usage of designated electric vehicle parking spots is regulated and enforced with the use of zero-emission vehicle decals, administered by the California Department of Motor Vehicles (DMV, 2014). In addition, because BEVs are exempt from undergoing vehicle inspections, as mentioned above, BEV owners benefit from saved time from being exempt from periodic vehicle testing.

Germany currently does not offer non-fiscal electric vehicle incentives on a national level. However, the government passed the federal electric mobility law ("Elektromobilitätsgesetz") which authorizes regional governments to grant privileges to vehicles with emissions of 50 g CO_2/km or less and an electric range of more than 30 km. These vehicles are to receive a special label and may be granted access to bus lanes, preferential or free parking, and access to restricted traffic zones (Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, 2014a). As the electric mobility regulation comes into effect in the spring of 2015, regional governments had yet to grant privileges to electric-drive vehicles outside of pilot projects as at summer 2015. The electric mobility regulation is set to expire by mid-2030. Lastly, electric vehicles are subject to general vehicle inspections but are exempted from the emission measurements, resulting in lower inspection costs (in the order of €20 per year).

Non-fiscal incentives that are applicable to electric vehicle owners in California and Germany are summarized in Table 5. As shown, California offers a number of non-fiscal incentives, including HOV lane access and exemption from annual emissions inspections as well as preferential parking in a number of cities. In contrast, Germany solely relies on regional governments to grant privileges to low carbon vehicles once the federal electric mobility regulation comes into effect.

Table 5. Non-fiscal electric-drive vehicle incentives in California and Germany

	California	Germany
Carpool and bus lane access	• BEV/FCV White sticker access through January 1, 2019 (unlimited) • PHEV Green sticker access through January 1, 2019 (limited to 70,000)	• Regional governments may grant access to bus lanes[a]
Preferential parking	• Designated parking and free metered parking for electric vehicle in many cities (e.g., Berkeley, Hermosa Beach, Manhattan Beach, Laguna Beach, Pasadena, Sacramento, San Jose, Santa Monica) • State agencies provide alternative fuel vehicle parking spots at public lots and near transit facilities	• Regional governments may implement preferential and/or free parking[a]
Labeling of electric vehicles	•	• Electric vehicles to be labeled on license plates[a]
Access to restricted traffic areas	•	• Regional governments may grant access to restricted traffic areas[a]

[a] *Electric Mobility Law*

Complementary vehicle promotion activities

A number of additional programs in California and Germany are being implemented to further increase awareness and educate new prospective buyers of electric-drive vehicles. Vehicle procurement activities by government agencies serve to increase early volume of electric vehicles sales, help agencies reduce their fuel expenditures, and assist in achieving broader state goals for technology advancement and climate change mitigation. Early vehicle procurement programs also help increase the visibility of these vehicles, increase exposure to the new advanced technologies, but do so in a manner that is closely controlled and monitored by a fleet with centralized monitoring, maintenance, refueling, and management in organizations fleet with known driving characteristics.

California has several electric vehicle promotion policies that pertain to government vehicle fleets. By a 2012 Executive Order, California's state government vehicle fleet is set to increase its zero-emission vehicle purchasing to at least 10% of light-duty vehicle fleet purchases by 2015, and at least 25% by 2020, with exemptions for special health and public welfare vehicle types (Office of the Governor, 2012). Furthermore, beginning in 2014, DGS has provided reduced parking fees by up to 55% for state government employee BEV, PHEV, and FCV drivers in their parking lots (DGS, 2014). Local government agencies have annual additional procurement policies for electric vehicle purchasing. For example, the Bay Area Air Quality Management District's plug-in electric vehicle rebate program helps public agencies acquire with vouchers of $2,500 for BEVs and $1,000 for PHEVs; the program runs through 2014 or until $90,000 has been expended (BA AQMD, 2014).

The German government has also implemented a program to incentivize the procurement of low-carbon vehicles for government fleets: the limits on expenditures for government vehicle purchases have been raised for electric-drive vehicles compared to conventional powertrains. For vehicles below 70 kW of engine power, electric-drive vehicles may cost up to €23,500 while conventional vehicles are budgeted for up to €15,500. For vehicles between 70 and 150 kW, these limits are raised to €33,500 for electric-drive vehicles compared to €28,900 for conventional powertrains (Federal Government of Germany, 2014a). These incentives are to ensure that low-carbon vehicles, defined as vehicles with less than 50 g CO_2/km, make up ten percent of the new additions to the government fleets in accordance with the government's non-binding targets outlined in the electric mobility program ("Regierungsprogramm Elektromobilität") (Federal Ministry for Education and Research, 2011).

As identified in the 2013 ZEV Action Plan, California has numerous outreach, education, and consumer awareness activities that are led by various agencies to help promote electric-drive vehicles (Office of the Governor, 2013). Among the activities, the Department of Motor Vehicles (DMV) is tasked with distributing educational materials on electric vehicles at vehicle registration. Participation in outreach and awareness events (e.g., Clean Cities, National Plug-in Day) is coordinated by CARB. CARB and the Governor's office are active in promoting private electric vehicle use in car-sharing and rental fleets. In particular the Greenhouse Gas Reduction Fund Investment Plan, as part of Senate Bill 1275, is directed to include "Car-sharing programs that serve disadvantaged communities and utilize zero-emission and near-zero-emission vehicles" (CLI, 2014). The funding for these and other programs is from California's cap-and-trade program, which aims to ensure electric mobility needs are eventually broadly met for the full fleet. The California Public Utilities Commission (CPUC) is responsible for presenting information regarding plug-in electric vehicle electricity usage compared to conventional gasoline and diesel for same amount of travel.

Germany primarily relies on two programs to raise public awareness of electric vehicles. First, the Electromobility Model Regions is a funding program by the federal government that supports cross-sector development of electric mobility in Germany. One key objective of the Electromobility Model Regions funding program is gauging user acceptance of low-carbon transportation and raising consumer awareness (Tenkhoff, Braune, & Wilhelm, 2012). Second, since 2013, four showcase regions (see section IV for a description) also include education and promotion activities. Both Electromobility Model Regions and Showcase Region projects rely on government-industry collaborations as most projects are implemented and partly funded by private businesses. Examples include an online portal on electric mobility developed in the showcase region Baden-Württemberg and an educational event in Lower Saxony that aims to introduce concepts of electric mobility to the German youth.

In the states of Berlin and Brandenburg, funding from the Federal Environment Ministry is used to subsidize leasing rates of electric-drive vehicles. The project, termed *InitiativE BB*, is coordinated by the Berlin Agency for Electromobility (eMO) and aims to introduce 500 electric-drive vehicles in the region by the end of 2016 in order to increase the visibility of electric vehicles and to provide research on electric mobility (Berlin Agency for Electromobility, 2015a). To achieve this target, the project covers 45 percent of the costs arising from the electrification of the vehicle, i.e. the additional cost of a BEV or PHEV compared to a conventional passenger vehicle. Similarly, the project *InitiativE-BW* aims to introduce 300 electric drive vehicles in

Baden-Württemberg by the end of 2016 (InitiativE-BW, 2015). While a comprehensive review of all projects related to raising public awareness proves difficult due to the large number of projects, additional examples are provided in section IV.

The US, California, and Germany engage in a number of international activities to leverage learning, promote greater economies of scale, and foster increased electric-drive vehicle deployment. Many engagements are bilateral, for example, a Memorandum of Understanding for collaboration between California Plug-in Electric Vehicle Collaborative and the Netherlands Coast-to-Coast e-Mobility connection programs (PEVC, 2013). A number of regular electric-vehicle workshops, study tours, and fact-finding missions, among, for example, California, US, Germany, United Kingdom, and China delegations, involve sharing experiences regarding vehicle technology, vehicle policy, and consumer research. Germany and California also jointly work on the advancement of hydrogen vehicle technologies through the alliance between the German Clean Energy Partnership (CEP) and the California Fuel Cell Partnership (CaFCP) (CEP, 2009). The CEP and CaFCP are described in section III. In addition, Germany is a partner in the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE), an initiative promoting international collaboration on hydrogen and fuel cell research and development, standards, and knowledge exchange (IPHE, 2015).

For multi-lateral international meetings, there are two groups that are affiliated with the International Energy Agency. First, the Hybrid and Electric Vehicle Implementing Agreement convenes 18 countries to share and collaborate on electric vehicle experiences (See IEA, 2014). Germany and the US are members and contribute to many of the working groups. In addition, the Clean Energy Ministerial Electric Vehicle Initiative further engages countries that are working on the question of how best to develop the early electric vehicle market (CEM, 2014). California is not formally engaged in either group.

Table 6 summarizes a variety of actions by the Californian and German governments that aim to support and complement the various electric vehicle promotion policies with government procurement, consumer awareness, and international experience learning. As shown in the table, California and Germany have set similar targets for shares of electric-drive vehicles in government fleets. With regards to consumer awareness, both Germany and California employ a wide array of programs to educate the general public about electric mobility. Germany's consumer awareness activities involve a myriad of private business partners through its showcase projects. Lastly, international collaboration between California, the US, and Germany leverages network effects and economies of scale in the deployment of electric-drive vehicles.

Table 6. Complementary electric-drive vehicle promotion activities in California and Germany

	California	Germany
Government fleet promotion	• State: 10% of 2015; 25% of 2020 government fleet vehicle purchases are electric-drive (exemptions for non-light-duty, special vehicle types) • State: reduced parking fees for government • Bay Area: $2,500 BEV and $1,000 PHEV procurement voucher for public agency vehicle purchasing	• National level: increased expenditure limits for electric-drive vehicles (€8,000 increase for vehicles under 70 kW and €4,600 for vehicles between 70 and 150 kW) • National level: non-binding target of 10% of new government vehicles below 50 g CO_2/km[a]
Consumer awareness activity	• Education materials at vehicle registration • Outreach and awareness events (e.g., Clean Cities, National Plug-in Day) • Promote private electric vehicle use in car-sharing and rental fleet	• Consumer outreach activities incorporated in the Electromobility Regions and four Showcase Regions, including promotion distribution, leasing, and car-sharing of electric vehicles • Clean Energy Partnership
International learning	• Bilateral collaboration (MOUs, workshops, study tours, delegation visits with China, Netherlands, Germany, UK, etc) • Alliance between Germany's Clean Energy Partnership and the California Fuel Cell Partnership	• Bilateral collaboration (MOUs, workshops, study tours, delegation visits with China, Netherlands, Germany, UK, etc) • Participation in IEA Hybrid and Electric Vehicle Implementing Agreement • Participation in Clean Energy Ministerial Electric Vehicle Initiative • Participation in the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE) • Alliance between Germany's Clean Energy Partnership and the California Fuel Cell Partnership

[a] *"Regierungsprogramm Elektromobilität"*

Summary of Germany and California electric-drive vehicle actions

As described above, Germany and California are each implementing many different policies to accelerate the early electric drive market. Table 7 summarizes the above-discussed electric vehicle promotion actions in Germany and California. As shown, there are many similarities and differences between the jurisdictions' approaches to using regulatory, fiscal incentives, non-fiscal incentives, and various complementary actions. California generally provides stronger fiscal incentives than Germany and non-fiscal incentives have yet to be developed in Germany. This difference in policies is reflected in the market shares of electric-drive vehicles, where Germany sees a substantially lower share of BEVs and PHEVs. In the absence of strong incentives for consumers, the German government also puts greater emphasis on collaboration with private businesses, as evidenced by the involvement of the private sector in Germany's model and showcase regions (see Section IV for a closer inspection of government-industry partnerships).

Table 7. Summary of electric-drive vehicle actions in California and Germany

Area	Action	California	Germany
Vehicle manufacturer	Direct regulatory requirements for electric vehicles	• Zero Emission Vehicle program requiring approximately 15% BEV/PHEV/FCEV sales in 2025 • Typical per-vehicle credits: FCV 4.0; BEV 1.5; PHEV 0.8	• None
	CO_2 light-duty vehicle emission reduction requirements	• Regulated reduction for new passenger cars to 97gCO_2/km fleet average in 2025	• Regulated reduction for new vehicles to 95 gCO_2/km fleet average in 2020/21
	Incentives for electric vehicles in CO_2 regulation accounting	• BEV/FCEV 0 g/km 2012-2021 • PHEV 0 g/km for e-VKT 2012-2021 • Multiplier of 1.5-2.0 is applied for 2017-2021 BEVs and FCEVs • Multiplier of 1.3-1.6 is applied for 2017-2021 PHEVs	• Multiplier of 1.5 is applied for vehicles below 50 g CO_2/km for 2015, phased out by 2016 • Multiplier of 2 is applied in 2020, reduced by 1/3 each year thereafter
Consumer incentives	Vehicle purchasing tax incentive	• BEV/PHEV $2,500-7,500 (US) • BEV/PHEV $1,500-2,500 (Calif.) • FCV $5,000 (Calif.)	• Private vehicles: road tax exemption for 5/10 years • Company vehicles: reduction of taxable income from private use
	Access to high-occupancy vehicle lane	• BEV/FCV through 2018 (unlimited) • PHEV through 2018 (70,000 limit) • 2,200 km of HOV lanes	• Regional governments may grant access to bus lanes
	Preferential/free parking access	• Many cities (e.g., Sacramento, San Jose, Los Angeles area)	• Regional governments may grant preferential/free parking
Complementary vehicle programs	Fleet placement programs	• State: 10% of 2015; 25% of 2020 government fleet vehicle purchases are electric-drive • Reduced parking fees for electric drive in state parking lots • Local vouchers	• Non-binding target of 10% of new vehicles in government fleet below 50 g/km • Increased allowable spending for electric-drive vehicles
	Consumer awareness activity	• Education materials at vehicle registration • Outreach and awareness events (e.g., Clean Cities, National Plug-in Day) • Promote private electric vehicle use in car-sharing and rental fleet	• Distribution, leasing, renting, and car-sharing of electric vehicles under the model and showcase regions
	International policy collaboration	• Bilateral collaborations (China, Netherlands, United Kingdom) • Alliance between CEP and CaFCP	• Participation in IEA Hybrid and Electric Vehicle Implementing Agreement • Participation in Clean Energy Ministerial Electric Vehicle Initiative • IPHE • Alliance between CEP and CaFCP

** eVKT = estimate percent of electric vehicle kilometers traveled (about 40% for 30-km PHEV, 64% for 65-km PHEV per SAE) ….*

Some of the more pronounced differences between Germany and California are in their vehicle regulation and consumer incentives. Both jurisdictions use regulatory requirements to push all low-carbon technologies into the fleet; however, Germany (and the European Union) does not have long-term 2025 requirements or specific electric-drive legally-binding requirements for vehicle manufacturers, like those in California. In addition, the applicable consumer incentives in the two regions to promote the purchase of electric vehicles are summarized in Figure 9. As shown, the incentives that electric vehicle consumers had access to in 2014 in California, including state and national subsidies in carpool lane access (included over a first owner's three-year ownership), were equivalent to $6,000 to over $11,000 per vehicle. A comparison with German tax incentives proves difficult as non-fiscal incentives have yet to be implemented and fiscal incentives are contingent on the vehicle's technical characteristics. The best-case (i.e., highest possible) incentives in Germany are shown in the figure, taking into account vehicle ownership and income tax incentives. For comparison, the savings from road tax exemption were calculated for the C-segment BEV, the D-segment PHEV, and the J-segment FCV, based on the examples vehicles from Table 3 above, and assuming a 5% discount rate for future year benefits for three years of ownership. No federal non-fiscal incentives were identified and quantified for electric vehicles in Germany. The comparison of incentives in California and Germany demonstrates that California offers higher fiscal subsidies for purchasing BEVs and PHEVs. Moreover, outside of model and showcase regions, fiscal and non-fiscal incentives have yet to be developed on state or regional levels.

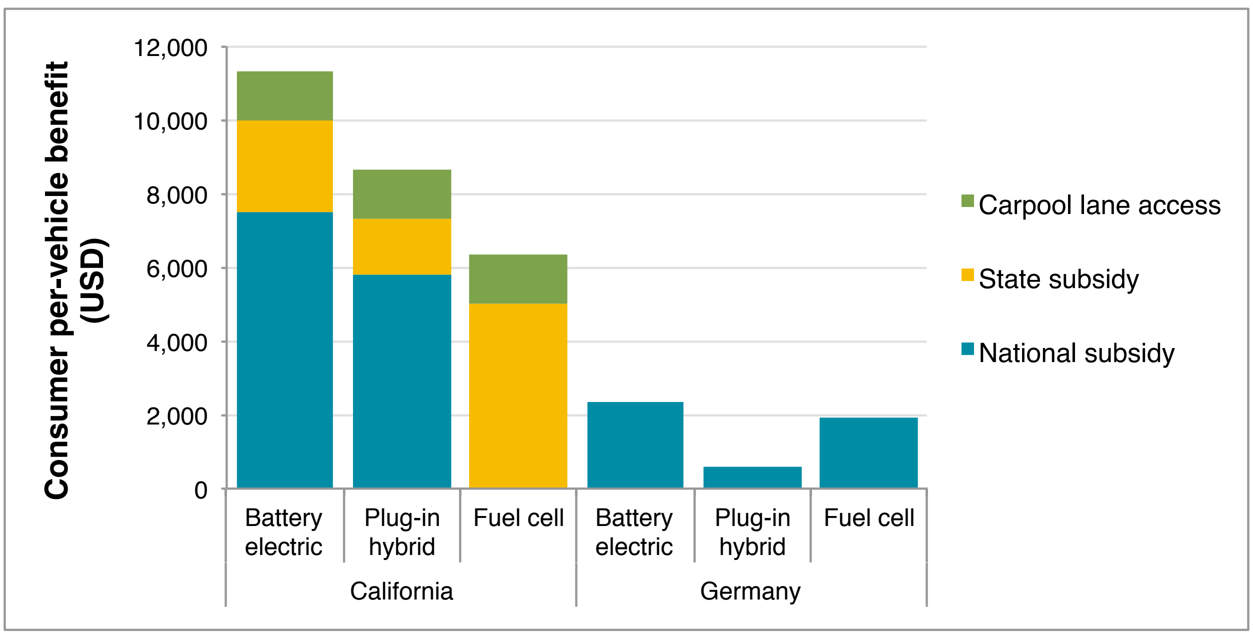


Figure 9. Consumer incentives for electric-drive vehicles in California and Germany over six years for private cars and three years for company cars

III. Electric-drive fueling infrastructure

This section focuses on policies and other government actions that are related directly to electric-drive recharging and refueling infrastructure in Germany and California. Regulations, requirements, financing, and incentives to ensure the installation of electric charging and hydrogen fueling infrastructure are all critical in the long-term transition toward an electric-drive fleet. Covered within this section are quantification and description of the existing and planned infrastructure, infrastructure related policy and regulations, and initiatives to help finance electric-drive infrastructure. Within each area, we summarize the measures in California and Germany. In the final subsection we provide a condensed summary of actions in the two markets.

Fueling stations

Electric Charging Stations. In March of 2012, Governor Brown issued Executive Order B-16-2012, directing state agencies to establish a set of goals for ZEV deployment in California, including infrastructure development. The 2013 *ZEV Action Plan*, conducted by the Governor's Interagency Working Group on Zero-Emission Vehicles (2013) describes these goals and defines the role of several state agencies in carrying out the necessary actions to achieve sufficient infrastructure to support widespread ZEV sales and use, up to 1 million ZEVs by 2020. The ZEV Action Plan does not include a numeric goal for charging stations, but does include strategies to both incentivize and lower barriers to the construction of more charge points by communities and private investors. Guidance for the deployment of EV charging infrastructure is provided in a National Renewable Energy Laboratory (NREL) report recently completed for the California Energy Commission (CEC), and emphasizes the importance of infrastructure in homes, workplaces, and multiunit dwellings in addition to public charge points (Melaina and Helwig, 2014). NREL estimates that by 2018, there will be a need for over 17,000 more Level 2 charge points, and up to 40,000 if drivers depend heavily on public chargers rather than charge primarily at home (Smith and Orenberg, 2015).

California Assembly Bill 118 (Nunez, 2007) created the Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP), which was subsequently authorized in 2008 to use funds from vehicle licensing fees to, among other things, develop and deploy alternative fuels. The California Energy Commission has awarded nearly $40 million in ARFVTP funding for electric vehicle charging stations in California. Due in part to these investments, California possesses the largest network of nonresidential charging stations in the United States, accounting for about one out of every four public charging points. As of March 2015, the ARFVT program has issued grants to fund over 9,300 electric vehicle-charging points; over 6,600 of these have been installed and an additional 2,700 are planned (Smith and Orenberg, 2015).

Construction of charging stations in residences and those provided by private business and municipal governments may be eligible for state or federal grants. All new state-funded PEV charging stations in California must be open to the public and accessible to electric-vehicle drivers, and they have restrictions on their use of fees and membership access (CLI, 2013). A legal settlement between NRG Energy Inc. and the state requires NRG to construct 200 public fast-charging stations and the infrastructure for 10,000 plug-in units, overseen by the California Public Utilities Commission (CPUC, 2012). CPUC rulemaking R.13-11-007, adopted in December 2014, permits investor-owned utilities to construct electric vehicle charging infrastructure within their service territories, subject to the approval of the CPUC. The three major utilities have proposed projects for over 60,000 charging stations at commercial, public, and residential locations (Smith and Orenberg, 2015).

The German government's joint council on electric mobility, Nationale Plattform Elektromobilität (NPE), predicts that approximately 1.2 million AC charging points as well as 7,100 DC outlets will be required by 2020 (NPE, 2014). However, only 5 percent are projected to be installed in public spaces such as curbside and other public parking lots. 85 percent of all charging points, or roughly one million points in absolute terms, are planned to be located in private areas such as residences and private businesses. The remaining ten percent of outlets are expected to be installed in semi-public areas, including parking garages and highway rest stops. Currently, approximately 2,400 AC charging stations with 4,800 charging points as well as 100 DC charging points are available in Germany (NPE, 2014).

Due to the fragmented nature of different public, private, and public-private projects at different political and geographical levels (for example, federal, state, regional, showcase region), it proves difficult to provide detailed estimates for planned expansions of charging infrastructure. However, a number of private and public-private partnerships have been identified. These projects include:

- A partnership of diverse German and international businesses has developed a charging station concept termed ChargeLounge. With funding from the state of Baden-Württemberg and IKEA, among others, the partnership is planning to install 600 DC charging stations with 2,000 outlets across Germany, Austria, and Switzerland by 2020 (ChargeLounge, 2015).

- Electromobility Model Regions have implemented a wide range of charging infrastructure projects. These projects are discussed in section IV.

- The public-private partnership SLAM (Schnellladenetz für Achsen und Metropolen), backed by BMW, Daimler, Porsche, VW, and the energy utility EnBW, plans to install 400 DC charging outlets by 2017 (Federal Ministry of Economic Affairs and Energy, 2014).

- Autobahn Tank & Rast GmbH, an organization operating highway rest stops in Germany, introduced DC charging stations at 50 of its rest stops and plans to rollout DC charging stations to all of its 400 rest stops by 2017 (Dpa, 2014). It is unclear to what extent this project will receive funding from the German government.

- Tesla Motors, Inc. currently operates 29 superchargers in Germany, with more charging stations planned or under construction.

- All Showcase Regions have introduced projects on charging infrastructure. For example, the Showcase Region Berlin-Brandenburg is testing DC charging points in a pilot study and 1,600 AC charging points are under construction (eMO, 2015b).

Figure 10 summarizes the state of electric vehicle charging infrastructure in California and Germany at the end of 2014. The station types in the figure include Level 1 (generally 120 volt, less than 2 kW), Level 2 (generally 3-20 kW), and direct current fast charging (generally 40-90 kW). As of October of 2014, there are over 2,200 electric stations with about 8,000 electric outlets or charge points in California, with additional units in planning stages (US DOE, 2014). This compares with 2,400 public electric charging stations and 4,800 outlets in Germany.

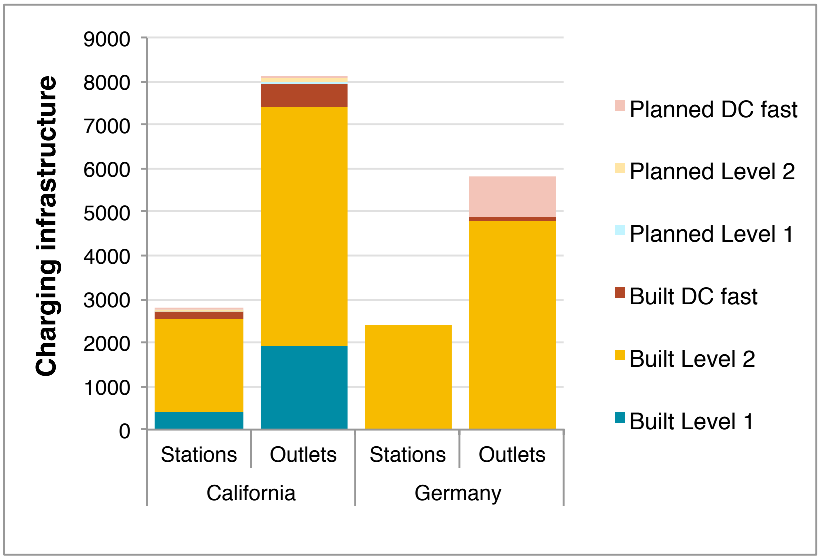


Figure 10. Built and planned electric vehicle charging infrastructure in California and Germany

Hydrogen Stations. The ZEV Action Plan specifies that the CEC, with support from CARB, will create the early network of hydrogen stations to provide a foundation for fuel cell vehicle commercialization, with a goal of 100 for full commercial launch (CARB, 2014b). With the passing of Assembly Bill 8 in 2013, the ARFVT program is directed to dedicate up to $20 million (or 20% of available ARFVT program funds) to develop the initial infrastructure network of 100 stations. Through the ARFVT program, the CEC has provided funding to install or upgrade 49 publicly available stations capable of light-duty vehicle refueling. These stations are being added to the 9 existing stations funded by CARB under the Hydrogen Highway program. In the 2015-2017 timeframe, the California network of hydrogen stations is projected to include between 51-54 stations.

Refueling FCVs is currently possible at 16 hydrogen fuel stations in Germany. In order to enable first stages of commercialization of hydrogen vehicles, the National Innovation Program Hydrogen and Fuel Cell Technology (NIP) is pursuing the goal to provide hydrogen at 50 locations by the end of 2015 through the Clean Energy Partnership (see Section IV) (NOW, 2014). In addition, the H_2 Mobility initiative aims to increase the number of hydrogen fueling stations to 100 by 2017 and 400 by 2023 (Daimler, 2014; NOW, 2013). The H_2 Mobility initiative is a consortium of industry stakeholders, including vehicles manufacturers, fuel suppliers, and other industry partners while NOW acts as the interface with the German federal government.

Figure 11 summarizes the status, in late 2014, for planned hydrogen fueling infrastructure in California and Germany. As shown, California has 20 operating hydrogen stations, 11 public and 9 private (from US DOE, 2014), has committed funding for the planned construction of 100 hydrogen fueling facilities in the 2020 timeframe. Due to the comparatively high volume of planned hydrogen fueling stations from government-industry partnerships, Germany compares favorably with California in terms hydrogen infrastructure.

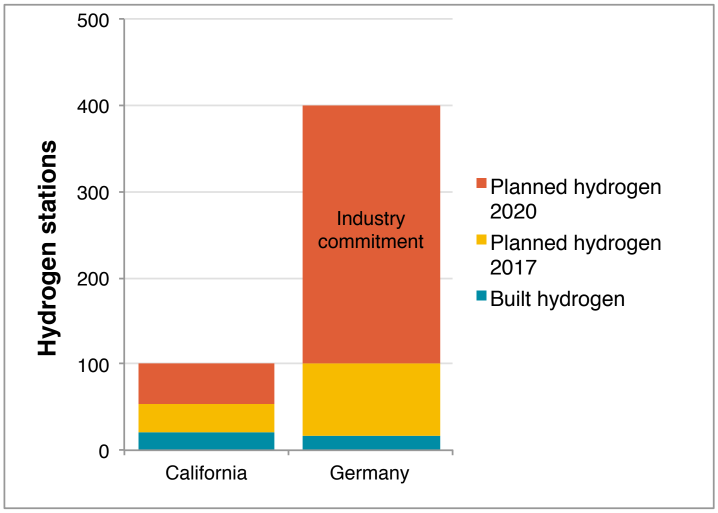


Figure 11. Built and planned hydrogen refueling facilities in California and Germany

As summarized in Table 8, both California and Germany have significant built and planned infrastructure for charging electric vehicles and refueling hydrogen for fuel cell vehicles. California and Germany have comparable numbers of charging stations while California has a substantially higher number of charging points. With respect to hydrogen infrastructure, both regions are beginning to roll out fueling stations. In addition to the 20 built stations in California and 16 stations in Germany, both regions are planning a several-fold increase in the number of fueling stations.

Table 8: Fueling Infrastructure

Technology	Status	California	Germany
Electricity Recharging	Built (2015)	• 2,108 public stations (6,774 total outlets) [a] • 6,602 state-subsidized charging stations (residential, commercial, workplace, and DC fast) [b]	• 2,400 public stations (4,800 total outlets) [c] • 100 DC outlets [c]
	Under Construction	• 2,767 planned or under construction through projects funded by CEC • At least 10,200 total stations to be built by NRG • Over 60,000 charging points proposed by investor-owned utilities	• Unknown
	Planned through 2020		• At least 900 DC stations to be built by private and public-private entities
Hydrogen Refueling	Built (2015)	• 9 public stations [b]	• 16 stations
	Under Construction	• 43 additional stations funded, and additional funding to upgrade stations, resulting in 51-54 through the 2015-2017 timeframe [b]	• 34 stations (planned or under construction) to be constructed by the end of 2015
	Planned through 2020	• 100-station target (minimum to support commercial market), funded through AB118	• ~100 by 2017 and 400 by 2020 (H_2 mobility)

[a] *US Department of Energy (2015).*
[b] *Smith and Orenberg (2015)).*
[c] *Nationale Platform Elektromobilität (2014).*

Alternative stations planning

Electric Charging Stations. The ZEV Action Plan specifies an initial focus on developing infrastructure in metro areas, then progressing to the creation of interregional corridors. As shown in Figure 12, current infrastructure is centered around the metropolitan areas of Sacramento, the San Francisco Bay Area, Los Angeles, and San Diego, with some additional stations along major highways and in destination locations (Lake Tahoe, Palm Springs).

The ZEV Action Plan charges the CEC with developing a statewide infrastructure plan and aligning strategies across regional plans. The CEC released an initial solicitation for PEV regional readiness planning in 2011. Ten regional planning areas were funded, covering 40 counties and all major metropolitan areas of the state (CEC 2014d). All of these plans have been completed. Six of the 10 regions also received funds to streamline the permitting, installation, and inspection for EVSE, and establish best practices for "PEV-ready" building through the PEV Readiness Project, funded by the U.S. Department of Energy (DOE), (SCAQMD 2013). As a result, several organizations have developed guidelines for siting, permitting, outreach and other considerations (ABAG et al., 2011; PEVC, 2012a; PEVC, 2012b; Advanced Energy, 2014). The Readiness Project involved the creation of a community readiness toolkit synthesizing existing planning guidelines, six new regional infrastructure plans, the creation and convening of a statewide coordinating council, and a series of workshops to disseminate information among local stakeholders. In support of this planning, the project also commissioned the California Center for Sustainable Energy to conduct a survey of California PEV drivers to determine vehicle usage and charging habits (SCAQMD, 2013).

The CEC released its Statewide Plug-In Electric Vehicle Infrastructure Assessment in May of 2014 (Melaina and Helwig, 2014). The Assessment describes a range of infrastructure expansion scenarios that could provide support for 1 million PEVs by 2020, and makes recommendations for Electric Vehicle Service Equipment (EVSE) siting and future policy. The Office of Planning and Research produced a complementary Community Readiness Guidebook and PEV Access Guidelines (OPR 2013a, 2013b). The CEC, the office of the Governor, and the Strategic Growth Council continue to provide ongoing support, financial and other, to ZEV planning. The CEC encourages all public EVSE and hydrogen stations to be reported to the National Renewable Energy Laboratory's Alternative Fuels Data Center Database, which serves to help drivers find available stations and planners locate new stations (See US DOE, 2014).

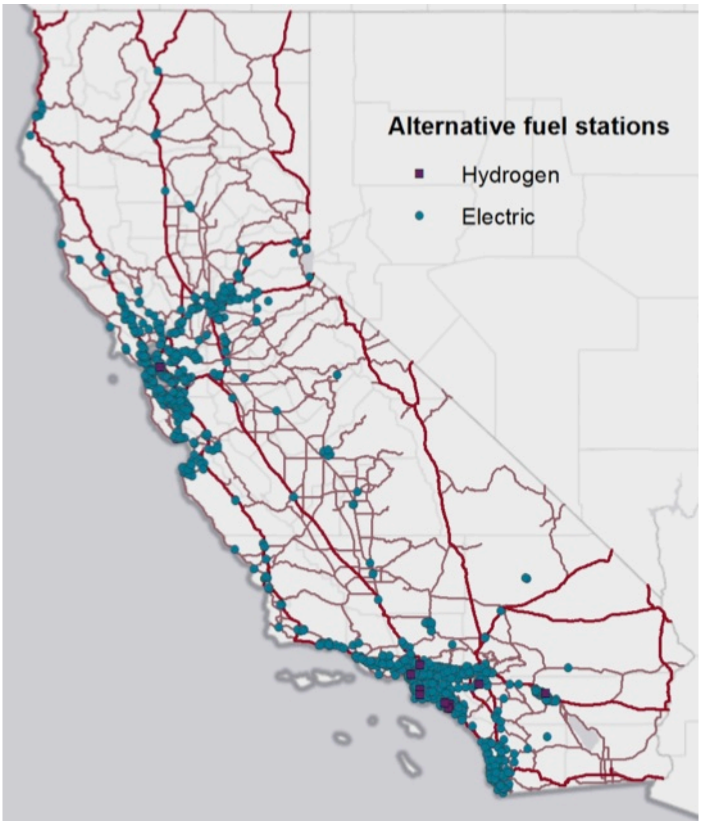


Figure 12. Network of public alternative fuel stations currently in operation (US DOE 2014a)

As Germany primarily relies on communes and industrial actors for the planning and construction of charging infrastructure, planning of the infrastructure is generally not conducted by federal agencies. The national development plan for electric mobility ("Nationaler Entwicklungsplan Elektromobilität") indicates that most of the charging infrastructure in Germany will be located in private spaces, particularly around places of residence and work, but offers no guidance on the geographical spread of charging points. Similarly, the NPE observes that most charging points are located in metropolitan areas and in model and showcase regions but does not offer prescriptive guidelines for geographic planning of charging infrastructure. As the planning is devolved to communes, NOW offers a guidance document ("Praxisleitfaden – Elektromobilität in Deutschland") for the local planning of charging infrastructure and outlines best practice examples (NOW, 2011). Other planning documents include technical guidance (National Platform Electric Mobility, 2013), state or region-specific literature (for example, see HafenCity Hamburg, n.d.), and guidance documents for communes (Federal Ministry of Transport and Digital Infrastructure, 2015).

Hydrogen Stations. California Fuel Cell Partnership (CaFCP), a public-private organization including CARB, CEC, and hydrogen-interested industry groups in the energy and auto manufacturing sectors, has been instrumental in the planning of hydrogen infrastructure. The group produced an action plan in 2009 that recommends placing initial infrastructure in early-adopter communities (CaFCP, 2009). The CaFCP, with support from National Fuel Cell Research Center (NFCRC) and Energy Independence Now (EIN), produced a more detailed roadmap in 2012 that defines how to place stations in "pre-commercial clusters" where early adopters live, work, and travel. CaFCP members have recommended that stations be built in five geographic clusters where initial adoption of fuel cell vehicles is likely to be highest:

Berkeley, the southern San Francisco Bay Area, Santa Monica and western Los Angeles, Torrance and nearby coastal communities, and Irvine and southern Orange County. Additional "connector" and "destination" stations, in cities like Sacramento, Long Beach, Santa Barbara, and San Diego would connect the clusters into a regional network (CaFCP, 2014). In the most recent ARFVT program hydrogen fueling infrastructure funding opportunity, funded stations were required to be located more than 6 minutes away from an existing or planned station (CEC, 2014c) to promote increased geographic spread of the stations. To further support planning efforts, Assembly Bill 8, passed in Sept. 2013, requires CARB to survey fuel cell vehicle automakers and determine the projected number of sales for the next three years, and assess the state's hydrogen fueling infrastructure. The first annual report was issued in June of 2014 (CARB, 2014).

Support and planning for hydrogen infrastructure in California looks beyond light-duty vehicles and considers the role of hydrogen for heavy-duty transit and freight vehicles. A recent draft of CARB's sustainable freight plan highlights the role of hydrogen fuel in cutting emissions from the heavy-duty sector (CARB, 2015a). ARFVTP provided a $3 million grant to Alameda-Contra Costa Transit District (AC Transit) to develop a transit-only hydrogen refueling station (Smith and Orenberg 2015).

In Germany, NOW plays a central role in the coordination of hydrogen infrastructure as it coordinates projects of the NIP and is involved in the H_2 Mobility Initiative. The Clean Energy Partnership, overseen by NOW, plans to construct the first 50 hydrogen stations around metropolitan regions and along main motorways (see Figure 13) (Bonhoff et al., 2012; NOW, 2014). This implies that a majority of stations will be constructed in Berlin, Hamburg, Stuttgart, Munich, and clusters of urban areas in North Rhine-Westphalia and connecting motorways. These connecting motorways generally coincide with the Trans-European Transport Networks (TEN-T) corridors, which are vital passages in the EU's infrastructure and receive special attention in terms of planning and funding. In addition, the H_2 Mobility Initiative intends to ensure that spacing of hydrogen fueling stations does not exceed 90 km along main highways and that at least ten fueling stations are available in each metropolitan area. In addition, the H_2 Mobility Initiative aims to extend hydrogen infrastructure in rural areas (Total, 2013).

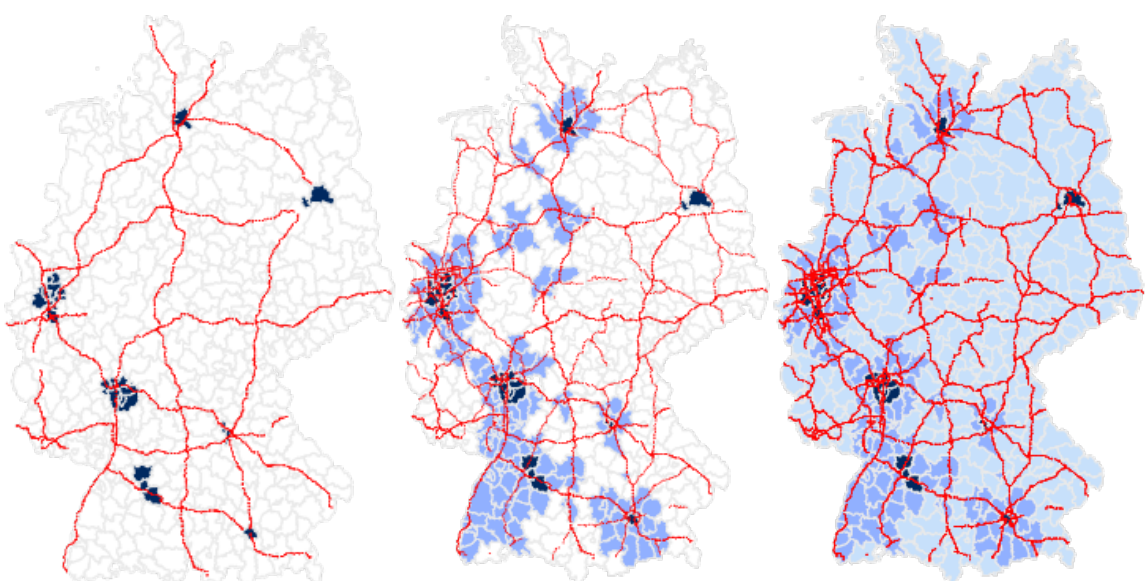


Figure 13. 2015, 2020, and 2030 scenarios for hydrogen fueling stations and coverage in Germany (source: NOW)

Table 9: Infrastructure planning and distribution

Technology	Status	California	Germany
Electricity Recharging	Coordinating parties	• CEC (state-level) • CCSE (state-level) • Governor's Office of Planning and Research • PEV Collaborative (statewide industry/public partnership) • Regional Air Quality Management Districts • Municipal governments	• NPE (federal level) • Communal governments (regional level) • NOW for Electromobility Model Regions • Regional coordination centers in Electromobility Model Regions
	Planning documents	• Ten regional infrastructure plans • PEV usage and charging survey • ZEV readiness guidelines for city-level and private stakeholders	• "Praxisleitfaden – Elektromobilität in Deutschland"[a] • "Technischer Leitfaden Ladeinfrastruktur"[b] • regional guidance documents such as the "Praxisleitfaden Elektromobilität" for Hamburg[c] • "Starterset Elektromobilität" – guidance on electric mobility for communes[d]
	Development Pattern	• Initially, 70-90% of charging residential • Prioritize urban areas and workplace charging first, then shift funding to interregional corridors • Long-term goal to complete West Coast Green Highway, system of fast chargers	• 85% in residential and commercial settings • Focus on urban areas and main motorways (TEN-T corridors)
Hydrogen Refueling	Coordinating parties	• CaFPC (CARB, CEC, industry, non-profits) • CEC • NFCRC (academic) • EIN (non-profit) • Municipal utilities and planning groups	• NOW
	Planning documents	• California Road Map (CaFCP 2012)	• 50 Hydrogen Refueling Stations in Germany paper[e] • "Genehmigungsleitfaden für Wasserstoff-Stationen" [f]
	Development Pattern	• Begin in clusters in Los Angeles and San Francisco area • 100 strategically located stations could support commercial launch	• Clusters in metropolitan areas and along main motorways (TEN-T corridors) • Gradual expansion into rural areas

[a] *NOW, 2011*
[b] *National Platform Electric Mobility, 2013*
[c] *HafenCity Hamburg, n.d.*
[d] *Federal Ministry of Transport and Digital Infrastructure, n.d.*
[e] *Bonhoff, Herbert, & Butsch (2012).*
[f] *NOW, n.d.*

Alternative fuel station funding

The majority of action by the state of California in creating ZEV fueling facilities has been through grants issued from the CEC through the ARFVT program. From 2009-2014, ARFVTP grants provided over $550 million for alternative or renewable fuels. Of this, $38.3 million was awarded to projects devoted to electric charging infrastructure and $85.3 million for hydrogen fueling infrastructure. These grants have funded the installation of 9,369 electric charging stations and 48 new or upgraded hydrogen stations (Smith and Orenberg, 2015). As discussed above, the passage of 2013 State Assembly Bill 8 substantially increases the funding for hydrogen infrastructure, requiring that the CEC allocate $20 million annually from the ARFVT fund (not to exceed 20% of available ARFVTP funding) until there are at least 100 publically available hydrogen-fueling stations.

Electric Charging Stations. In addition to ARFVT-funded projects, the CPUC reached a settlement with NRG Energy Inc. requiring NRG to devote $100 million to public charging infrastructure in California. In projects run completely by the state, the Department of General Services (DGS) has installed 24 electric charging stations at five state facilities in the Sacramento Area, and will continue to coordinate installation of charging equipment at state-owned buildings and parking structures (DGS, 2013). The Federal Aviation Administration may also provide funding in the future for airport charging infrastructure through their Zero Emissions Airport Vehicle and Infrastructure Pilot Program. To further facilitate the installation of new electric charging infrastructure, CEC and the California State Treasurer's office began a financing initiative called the Electric Vehicle Charging Station Financing Program that provides coverage for lenders on loan defaults and rebates for borrowers (CPCFA, 2015).

In Germany, low-interest loans from the KfW Environmental Protection Program (see section II) also apply to investments in charging infrastructure and hydrogen fueling stations (KfW, a). In addition to these loans, funding for charging infrastructure was made available through numerous projects in the Electromobility Model Regions and Showcase Regions. As these projects build on public-private partnerships, the activities in Model and Showcase Regions are discussed in section IV. Lastly, EU's TEN-T program is investing over €4 million funding in 155 fast charging stations along main motorways in northern Europe, of which 67 charging stations will be constructed in Germany (Innovation and Networks Executive Agency, 2014a). Similar project under the TEN-T program will also contribute to charging infrastructure in Germany (see Innovation and Networks Executive Agency 2014b and 2014c) and typically combine EU and national funding.

Hydrogen Stations. The nine public hydrogen stations in operation as of June 2014 were built with funding from the CEC, ARB, the US Department of Energy, the South Coast Air Quality Management District, and the AC Transit (Smith and Orenberg 2015). Through ARFVTP, the CEC has provided funding for the construction of 43 new stations and five station upgrades, contributing over $80 million for these projects. The private companies that receive ARFVTP grants and carry out construction may contribute to the cost of construction; in the grants awarded in 2014 through PON-13-607, the solicitation specified that grants would cover 70-85% of the construction cost (up to a set funding cap), with greater contributions for stations with earlier completion dates (CEC, 2013b).

In addition to the low-interest loans from the KfW Environmental Protection Program (see section II), the Clean Energy Partnership (CEP) of the National Innovation Program for Hydrogen and Fuel Cell Technology is providing funding for hydrogen refueling infrastructure. As the CEP combines funding from private and public sources, the funding is discussed in section IV. A number of German states have introduced funding programs revolving around hydrogen and fuel cell technologies, including fueling infrastructure for vehicles. Since 2008, North Rhine-Westphalia provided approximately €50 million in funding for the "NRW Hydrogen HyWay" program (Ministry for Climate Protection, Environment, Agriculture, Conservation and Consumer Protection of the State of North Rhine-Westphalia, n.d.). Among other demonstration, research and development activities, this funding was used to construct a hydrogen refueling station in Düsseldorf. Similarly, the state of Baden-Württemberg provided €4 million in funding between 2012 and 2015 for the demonstration and research projects related to hydrogen infrastructure (Ministry of the Environment, Climate Protection and the Energy Sector Baden-Württemberg, n.d.). Funding at the EU level, specifically from the private-public partnership Fuel Cells and Hydrogen Joint Undertaking, is discussed in Section IV.

Mandates and incentives for investors and fuel providers

Electric Charging. Under the Alternative Fuel Infrastructure Tax Credit, valid from 2006-2013 and now expired, electric fueling equipment was eligible for a federal tax credit of 30% of the cost, not to exceed $30,000 (DOE 2014d). The state does not currently offer tax incentives or impose a mandate to construct charging equipment, but the California Green Building Code includes voluntary measures that can be taken during building construction or renovation, including requiring wiring for future electric vehicle charging and minimum parking requirements. The City of Los Angeles has adopted such requirements, mandating that new multi-user dwellings be equipped with at least one charging station. In the ZEV Action Plan, the California Department of Housing and Community Development (HCD) agrees to consider imposing a requirement for PEV charging spots in multi-unit building parking in the 2013-2015 timeframe. To date, no state law requires the installation of residential chargers, but the California civil code prohibits homeowner associations or other common interest development groups from installing a charger (CLI, 2012b), and requires that apartment owners allow tenants to install charging stations (CLI, 2014b). To facilitate the development of residential or commercial charging stations, the CEC is required to maintain a website containing specific links to local electric utilities, basic charging circuit requirements, and other information that property owners may need to plan and complete installation (CLI, 2010). The Bay Area Air Quality Management District (BAAQMD), a regional group, has offered funding for up to 3,000 residents to install level 2 home chargers (BAAQMD, 2012) and grants to fund construction of DC fast charge stations in the Bay Area. The offered funding, which expired in June 2014, provided a base award of $10,000 and bonus awards up to an additional $10,000 for early completion (US DOE, 2014e).

In addition, the California Governor's office pledged to consider expanding incentives, programs, and technical assistance to companies that install workplace PEV chargers. The state has funded at least 417 workplace charging points (210 installed, 207 planned) through ARFVTP (Smith and Orenberg, 2015). A variety of educational resources, including case studies and decision guides, are provided by the California PEV Collaborative, which includes representatives from several state agencies (including CARB, CEC, and CPUC), automobile and energy industries, and other nonprofit organizations. In the case studies for workplace charging provided by the PEV Collaborative, the majority of companies covered the entire cost of charger installation in their operational budget. A third received some support or tax credits from the federal government; none received funding from the state.

The nonprofit CALSTART began the Employer EV Initiative (EEVI) with support by BAAQMD, SCAQMD, US DOE and the California PEV Collaborative, and have engaged with a variety of California employers. This initiative now has over 80 participants (EEVI, 2014). The EEVI has included employer surveys to identify key barriers for workplace charging and produced a best practices guidance document (E.g., see Calstart, 2013; PEVC 2013b). In addition, there is a similar major national US DOE program, the “EV Everywhere Workplace Challenge,” that provides technical assistance, informational resources and recognition to companies that install workplace chargers. The program has created partnerships with 22 companies with charging locations in California and two local government offices, and has designated several Californian organizations—PEVC, CALSTART, and Plug In America—as ambassadors for the program (US DOE, 2014b).

The California Low Carbon Fuel Standard (LCFS) recognizes electricity and hydrogen as low-carbon fuels, assigning it one of lowest carbon intensity scores compared to various petroleum, biofuel, and natural gas fuel pathways. Electricity providers have the option to generate LCFS credits to offset their own LCFS debits or sell to regulated entities. Electricity is granted a 3.0 energy efficiency ratio that adjusts for the on-vehicle usage of the energy being approximately 3-times greater energy-per-delivered-unit of fuel on a plug-in electric vehicle than on a conventional vehicle. Compared to a conventional gasoline carbon intensity of 96 gram carbon dioxide equivalent per megajoule (gCO_2e/MJ) of fuel, electricity use in plug-in electric vehicles offers a 57-64% carbon reduction, compared to approximately 0-30% for most biofuel and fossil fuel pathways (CARB, 2009). Under the LCFS, with potential carbon permit prices of $100-200 per tonne CO_2e, and for carbon intensities of 20-50 gCO_2e/MJ, the charging of each BEV could represent $200-500 per year of BEV use; PHEVs with an electric range of 40 miles could be worth up to $300 per year (Yang, 2013). This study points out the value of BEVs and PHEVs under low-carbon fuel standards. Such value could directly support charging infrastructure, as well as provide an incentive for prospective plug-in electric vehicle consumers.

Hydrogen. The federal Hydrogen Fuel Infrastructure Tax Credit, in place since 2006, allows fueling station owners a tax credit of up to 30% of infrastructure cost, not to exceed $30,000 (DOE 2014c). The federal government also provided a hydrogen fuel excise tax credit, now expired (US DOE, 2014d) and the subject of efforts for reinstatement. The state does not mandate construction of hydrogen infrastructure. Some precedent for the mandatory provision of alternative fuels at existing infrastructure in California is provided by CARB’s Clean Fuels Outlet (CFO) regulation, originally passed in 2000. A proposed amendment to the CFO would have required fuel providers to supply hydrogen at a fraction of their locations if 20,000 or more vehicles were certified in California to use that fuel. However, proposed CFO regulatory requirements for hydrogen have been cancelled for now; instead the adoption of 2013 Assembly Bill 8 provided public funding support for hydrogen infrastructure for the first 100 stations.

Similar to plug-in electric vehicles, California’s LCFS recognizes hydrogen as a low-carbon fuel, assigning it one of lowest carbon intensity scores compared to various petroleum, biofuel, and natural gas fuel pathways. Hydrogen fuel providers have the option to generate LCFS credits to offset their own LCFS debits or sell to regulated entities. Hydrogen is granted a 2.3 energy efficiency ratio that adjusts for the on-vehicle usage of the energy being approximately 2.3-times greater energy-per-delivered-unit-of-fuel on a FCV than on a conventional vehicle. Compared to a conventional gasoline carbon intensity of 96 gCO_2e/MJ of fuel, hydrogen use in FCVs offers a 35-66% carbon reduction, compared to approximately 0-30% for most biofuel and fossil fuel pathways (CARB, 2009).

California Senate Bill 1505 requires that, on a statewide basis, at least 33.3% of the hydrogen produced for, or dispensed by, fueling stations that receive state funds be made from eligible renewable energy resources (CLI 2006). It is anticipated that the hydrogen stations that have been funded by ARFVTP will surpass this requirement, with a network-wide average renewable content of 38% (Smith and Orenberg 2015).

Carbon cap-and-trade systems. Carbon trading schemes also can create value for the deployment of low-carbon fuels. As of 2015, transportation fuels are included in California's cap-and-trade system. The system had its first credit auction in February 2015 and the average price was approximately $12 per ton CO_2 (Doan, 2015), which is the minimum price in California's system. This is approximately equivalent to $0.10-0.12 per gallon ($0.03 per liter) of gasoline or diesel fuel. Based on approximately 150 million tons CO_2 emissions from on-road transportation fuel use per year, this could amount to over $1.5 billion in annual revenue and an additional investment signal to California fuel providers to deploy electricity and other alternatives. Transportation fuels are not included in the European Emission Trading Scheme.

Codes, standards, specifications

Electric Charging. The state of California has not yet issued a directive to adhere to a specific charging standard. The ZEV Action plan recognizes both CHAdeMO certification and SAE certification and suggests the development of standards to support dual-compatibility. The state promotes adherence to the most up-to-date standards, and has issued grants through the ARFVT program to upgrade 795 legacy chargers to the new SAE-J1772 standard. The office of the Governor and the CEC are responsible for encouraging interoperability standards for charging stations (Governor's Interagency Working Group on Zero-Emission Vehicles, 2013). In a workshop on interoperability, stakeholders indicated that the state should support but not mandate a unified charging standard, and that agencies should require a basic open protocol with allowances for proprietary technologies (Melaina and Helwig, 2014). At the federal level, the US DOE coordinates efforts to develop codes and standards for ZEV infrastructure. They provide a directory of current codes and standards at the Alternative Fuels Data Center (US DOE, 2014).

The California state building codes do not currently include standards for charging infrastructure, but the California Green Building Standards Code (CALGreen) includes voluntary provisions for residential EV charging that have been adopted by some local authorities (HCD, 2013). The ZEV Guidebook issued by the OPR recommends actions that include permit streamlining, model codes and standards, parking and zoning policies, and signage. Permits for charging equipment installation are created and granted by cities; the PEV Collaborative and US DOE both provide templates for EVSE permits to guide city standards. The California Building Standards Commission is required to adopt mandatory building standards for the installation of charging infrastructure at multi-family dwellings and nonresidential parking in the next set of building codes, effective January 1, 2017 (CLI, 2013b).

The German NPE recognizes that the harmonization of charging and payment standards is key to the uptake of electric-drive vehicles (National Platform Electric Mobility, 2014). To this end, the NPE endorses the Combined Charging System (CCS) as the international standard for AC and DC charging of electric vehicles. This position is reflected by the EU in the Directive 2014/94/EU on the deployment of alternative fuels infrastructure. As the CCS is technically compatible with the SAE J1772 standard, Germany is pursuing the development of a unified charging standard through the Transatlantic Trade and Investment Partnership and has made progress with SAE J2847 and J2931 standards as well as the ISO 15118 norm (National Platform Electric Mobility, 2014). In addition, the German government is also working with China and Japan to progress towards an international electric vehicle charging standard.

With respect to payment systems, a number of different payment platforms have been introduced in Germany in the course of showcase projects and other pilot projects. While cross-platform systems have been developed and enable users to employ different charging services, a process termed *roaming*, the German government sees no need for intervention in the market forces that are expected to lead to more interoperable payment systems (National Platform Electric Mobility, 2014). Lastly, both the German government and the EU directive 2014/94/EU encourage bi-directional charging or smart grid functionality of electric vehicles.

Hydrogen. California's ZEV Action Plan directs the CEC to require SAE standards for all state-funded hydrogen stations. The CEC distributed $20.6 million through the ARFVT program and inter-agency agreements for certifying hydrogen dispensing equipment for retail hydrogen fueling stations and establishing specifications for hydrogen and biodiesel fuels (CEC 2013). The CEC provided $4 million to the California Department of Food and Agriculture (CDFA) Division of Measurement Standards to develop retail fueling standards, protocols, and regulations that will allow hydrogen to be sold on a retail per-kilogram-hydrogen basis (Smith and McKinney, 2013). This process is now complete, with the Hydrogen Research and Fueling Facility at Cal State Los Angeles becoming the first hydrogen fuel dispenser to pass the CDFA-designed type evaluation and receive commercial certification (CDFA 2015).

Regarding the safe use of hydrogen for transportation and stationary applications, California began by enforcing a limited set of standards on the construction of hydrogen operating stations in Building Code 333 (CBSC, 2010). In July 2014, California became the first state to adopt and approve the 2011 edition of the National Fire Protection Association (NFPA) book, *NFPA 2: Hydrogen Technologies Code* (See NFPA, 2011), into California Building and Fire Code (CAL FIRE 2014), with NFPA 2 regulations effective for statewide application in July, 2015.

The National Renewable Energy Laboratory published a Regulations, Codes, and Standards (RCS) Template (see Rivkin et al., 2012) to inform on state rulemaking, providing templates for potential permitting, listing station requirements under the California fire code and California Environmental Quality Regulation. The Governor's Office of Business and Economic Development (GO-Biz) is actively developing a Hydrogen Station Permit Guidebook, expected to be available in the summer of 2015 (GO-Biz 2013).

Due to the exploratory character of the first hydrogen fueling stations constructed in Germany, the fueling stations generally lacked unified technological standards (Fraunhofer Institute for Solar Energy Systems, 2013). In contrast to these proprietary solutions, the EU directive on deployment of alternative fuels infrastructure (2014/94/EU) introduced unified requirements for hydrogen infrastructure (European Parliament, 2014). The directive stipulates that connectors for motor vehicles should comply with the ISO 17268 standard. The directive sets further requirements on hydrogen refueling stations, which are to comply with ISO/TS 20100. A standard for hydrogen fuel quality (ISO 14782-2) is also prescribed in the directive.

Summary of Germany and California electric-drive infrastructure actions

Table 10 summarizes major California and Germany electric-drive infrastructure actions. As shown, California and Germany each have numerous actions and funding to support the development of electric-drive infrastructure.

Table 10. Policies for ZEV Infrastructure Development

		California	Germany
Federal	Regulation	• None	• EU: 2014/94/EU • Germany: high level strategy defined in “Mobilitäts- und Kraftstoffstrategie”
	Funding & incentives	• Tax credit for hydrogen infrastructure, 30% not to exceed $30,000; Hydrogen fuel excise tax credit (expired) • Tax credit for electric charging stations of 30% not to exceed $30,000 (expired)	• €9 million in federal funding for DC charging stations (SLAM project) • €Federal funding for hydrogen stations (NIP) • Electromobility Model Regions • Electromobility Showcase Program • EU: FCH-JU and TEN-T • KfW low interest loans
	Voluntary	• DOE EV Everywhere Workplace Challenge	•
State	Regulation	• Low Carbon Fuel Standard, performance standard to promote all low-carbon fuels and create market signal to deploy electricity, hydrogen	• None
	Market-based CO_2 system	• Fuels in CO_2 trading system generating $1.5 billion annually and sending market signal to fuel providers	• None
	Funding & incentives	• ARFVTP Grants of $20 million annually for hydrogen infrastructure from 2014 on; funding for electric infrastructure varies, $15 million is allocated during FY 2014-2015 • Information resources	• NRW Hydrogen HyWay in North Rhine-Westphalia • H2 BW in Baden-Württemberg
	Codes and standards	• State Fire Marshal adopted NREL 2 standards for hydrogen stations, effective July 2015 • CALGreen voluntary standards for residential charging infrastructure • DOE and PEVC templates for city EV codes • GO-Biz developing hydrogen station permitting guidebook	• None
	Voluntary	• CALSTART Employer EV Initiative	• Only within showcase region (charge@work in Badem-Württemberg)
Regional	Regulation	• PEV Ready Building Requirements (Los Angeles) • Common interest developments may not prohibit charger installation	• None
	Incentive	• BAAQMD grants to fund construction of DC fast charge stations in Bay Area • BAAQMD grants for up to 3,000 residents to install Level 2 EVSE	• None

IV. Electric-drive institutional and public-private initiatives

This section focuses on institutional initiatives and public-private partnerships related to promoting electric-drive vehicles in Germany and California. The section investigates institutional, public-private partnerships, financing, and other complementary approaches to help advance the transition toward a fleet with an increasing amount of electric-drive vehicles – recognizing the inherent difficulties in aligning government, business, and consumer goals for vehicles and infrastructure. Within each area, we summarize the actions in California and Germany. In the final subsection we provide a condensed summary of actions in the two markets.

Government-industry partnerships

Electric Vehicles. Although they do not have regulatory authority, public-private partner groups play a critical role in conducting research, building technical capacity, coordinating the implementation of policies, and providing public outreach. The California PEV Collaborative (PEVC) brings together government, industry, and other stakeholders. PEVC sponsors industry meetings, provides outreach and produces and disseminates research. The PEVC played a key role in the California PEV Readiness Project, funded by US DOE and managed by the South Coast Air Quality Management District. PEVC created an EV toolkit for policymakers, including regional and state infrastructure planning guidelines, and makes all of these resources available online (SCAQMD, 2013). The Electric Vehicle Infrastructure Training Program (EVITP) is a national program that brings together over 30 industry partners in vehicle manufacturing, EVSE manufacturing and utilities to provide training for electricians in PEV charging station infrastructure. The State of California Employment Training Panel (ETP) awarded EVITP $750,000 to train an additional 1,100 electricians in the state (PEVC, 2012c). Also acting at the national level, the EV Project is managed by the private company ECOtality and is funded by both the US DOE and partner organizations, which include Nissan and Chevrolet, city and state governments, utility providers, and several major retailers (Macy's, Sears, Ikea). The EV Project facilitates the construction of chargers in major cities across the US, funding the installation of over 8,000 residential chargers nationwide and gathering information on EV charging and driving behavior (ECOtality, 2013). The EV Project has also provided funds for 3,750 commercial chargers, and was instrumental in several Californian workplace-charging projects (PEVC, 2013b).

Government agencies are also collaborating with non-profit and industry groups to carry out specific goals stated in the ZEV Action Plan. In one case, CARB pledged to impose ZEV reporting requirements detailing the number of ZEVs sold by location and projected sales to assist local and regional agencies in planning. CPUC is also responsible to provide utilities with information on where PEV chargers are installed. General Motors and Nissan agreed to assist with this effort, and will notify California utility companies when a PEV is purchased unless the customer specifically asks the automaker not to. CARB partnered with the non-profit Center for Sustainable Energy (CSE) to administer the Clean Vehicle Rebate Program; CSE also produces annual PEV owner surveys. Private industry groups carry out most of the ARFVT-funded infrastructure development projects, in many cases sharing costs with the CEC.

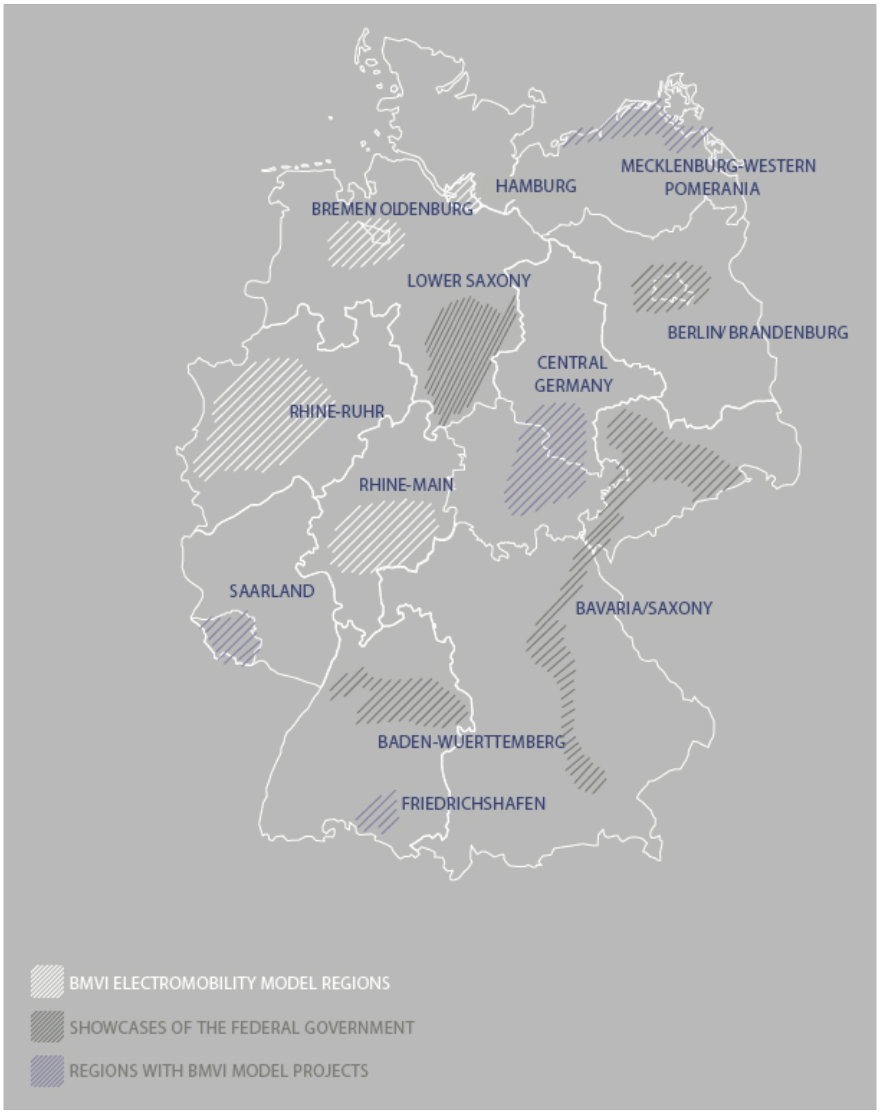


Figure 14. Public-private partnerships in Electromobility Model Regions and Showcase Regions (Source: NOW).

The German government predominantly employs model and showcase regions (see Figure 14) to promote alternative fuel vehicles and to develop suitable business and infrastructure models. The Electromobility Model Regions is a funding program of the Federal Ministry of Transport and Digital Infrastructure that supports collaboration between the public and private sector on the topic of electric mobility. The model regions, as well as a number of cross-regional projects, combine funding from the ministry (€~140 million between 2011 and 2014) with industry expertise and funding. The projects focus on making electric mobility suitable for everyday use (Tenkhoff, Braune, Wilhelm, 2012; NOW, 2015). In addition, scientific research on the topics of fleet management, safety, infrastructure, vehicle innovation, transport planning, regulative law, and user perspectives are conducted at the supra-regional level. Industry partners in the Electromobility Model Regions include prominent actors from diverse sectors, including Daimler AG, Deutsche Bahn AG, E.ON AG, Siemens AG, among many others. The role of Electromobility Model Regions in the development of charging infrastructure is examined in the subsection on electric charging and hydrogen infrastructure financing.

The four Showcase Regions for Electric Mobility bring together four federal ministries with a combined funding of €~180 and a wide range of industrial and research organizations with a combined funding of €~120 million between 2012 and 2016. The four ministries are the Federal Ministry for Economic Affairs and Energy (BMWi); the Federal Ministry of Transport and Digital Infrastructure (BMVI); the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB); and the Federal Ministry of Education and Research (BMBF). This funding flows into approximately 90 projects, in turn consisting of 334 activities, which investigate technical and societal barriers to the uptake of electric mobility (Showcase Regions Electric Mobility, 2013). A significant portion of these projects promotes electric vehicles in the commercial sector. For example, specialized professional training for auto mechanics is offered in all showcase regions. From a manufacturing perspective, BMW displays its production facilities for its electric-drive i Series as part of the showcase Bavaria-Saxony to demonstrate changes in the vehicle value chain to visitors.

The federal government of Germany places special emphasis on research in its funding programs. Due to the expansive number of projects and topics, a comprehensive review of all government-industry research activities transcends the scope of this paper, but research topics include energy storage, charging infrastructure, information and communication technology, business models, legal issues, urban and modal development, environmental effects, transportation management, and education, among others. The NPE has identified a need for €360 million per year in federal funding to ensure that Germany can meet its target of becoming a leading market for electric mobility (NPE, 2014). Some examples include testing of smart charging in Baden-Württemberg and Lower Saxony, optimization of payment services for charging infrastructure between Munich and Leipzig, and the introduction of 158 electric vehicles across 80 communes in Lower Saxony. In addition to promoting electric vehicles and charging infrastructure, technical issues, such as lithium-ion battery recycling, are also being investigated through government-industry partnerships. Lastly, another important example of public-private partnerships is the SLAM project, where prominent businesses (including Daimler, BMW, and VW, among others) collaborate to construct 400 DC charging outlets in metropolitan areas and along main motorways by 2017.

Hydrogen. Public-private collaboration is widely viewed as a key component to help bring hydrogen fuel cell technology through its nascent stage in California. The CaFCP has brought together market research, industry targets, and policy goals to produce a roadmap for fuel cell vehicles in California; this roadmap helped to form many of the fuel cell goals stated in the California ZEV Action plan. In addition, the CaFCP has offered training to about 2,000 emergency responder professionals about hydrogen basics and safety. As with electric charging stations, private industry groups carry out most of ARFVT-funded hydrogen infrastructure development. At the federal level, the DOE launched H2USA in 2013 to bring together automakers and hydrogen fuel providers to promote the commercialization of hydrogen technology, and the state of California joined the partnership in April 2014 (CARB, 2014e).

As with battery electric vehicles, public-private partnerships play a prominent role in the advent of fuel cell vehicles in Germany. Somewhat analogous to the showcase region program, the National Innovation Program Hydrogen and Fuel Cell Technology (NIP) offers a platform for collaborative work and funding for hydrogen technologies. The NIP is funded by the Federal Ministry of Economic Affairs and Energy as well as industrial organizations, which respectively will provide €700 million funding between 2007 and 2016 (Federal Ministry of Transportation and Digital Infrastructure, 2014). The Federal Ministries for the Environment and the Federal

Ministry of Education and Research and the Federal Ministry for Economic Affairs and Energy also support the NIP. As part of this platform, one program area, namely *Transport and Hydrogen Infrastructure,* is of particular relevance for the comparison of electric mobility in Germany and California.

With funding from the NIP, the Clean Energy Partnership (CEP) promotes hydrogen vehicles and infrastructure. The CEP is an initiative consisting of car manufacturers (for example, Daimler, BMW, Ford, and others), energy utilities, and public transportation companies, among others. The partnership is also supported by the states of Berlin, Hamburg, Baden-Württemberg, Hesse, and North Rhine-Westphalia (Clean Energy Partnership, 2015 a). With respect to the promotion of hydrogen vehicles, the CEP focuses on the demonstration, technical improvement, and standardization of fuel cell vehicles and hydrogen infrastructure. The partnership also aims to demonstrate the potential of fuel cell vehicles and had introduced a fleet of 120 vehicles by 2013. On the EU-level, the Fuel Cells and Hydrogen Joint Undertaking (FCH JU) and the New Energy World Industry Grouping (NEW-IG) are government-industry partnerships that support research and development and the market introduction of fuel cell technologies (FCH JU, 2014; NEW-IG, 2014). The partnerships are collaborations between the European Commission, industry actors represented by the NEW Industry Grouping, and the research organizations represented by the Research Grouping N.ERGHY.

Table 11 (for California) and Table 12 (for Germany) summarize a number of prominent government-industry partnerships that are working to promote various aspects of electric-drive vehicle and infrastructure deployment.

Table 11: Major Government-Industry Partnerships in California

	California / United States	
Plug-In Electric Vehicles	California Plug-In Electric Vehicle Collaborative (PEVC)	• Government: CARB, CEC, CPUC, Office of the Governor, others; regional air quality districts • Industry: nine automobile manufacturers, private utility companies • Other: Non-profits including ALA, ICCT, and others.
	Electric Vehicle Infrastructure Training Program (EVITP)	• Government: DOE, State of California Employment Training Panel (ETP) • Industry: IBEW, NECA, vehicle manufacturers, utility companies
	The EV Project	• Government: DOE • Industry: Chevrolet, Nissan, retailers (IKEA, etc.)
Fuel Cell Vehicles	California Fuel Cell Partnership (CaFCP)*, formed 1999	• Government: CARB, CEC • Industry: Ballard Power Systems, Daimler Chrysler, Ford Motor Company, BP, Shell Hydrogen, ChevronTexaco, Air Products and Chemicals, Inc., Air Liquide, Linde, Hydrogencis, Powertech Labs, others.
	H2USA, formed 2013	• Government: DOE • Industry: American Gas Association, Association of Global Automakers, Hyundai, ITM Power, Mercedes-Benz, Nissan, Proton OnSite, Toyota • Other: CaFCP, Electric Drive Transportation Association, Fuel Cell and Energy Association, Massachusetts Hydrogen Coalition

Table 12: Major Government-Industry Partnerships Germany

	Germany / European Union	
Electric Vehicles	Showcase Regions for Electric Mobility	• Government: four federal ministries, six states • Industry: prominent industrial actors, SMEs • Other: research organizations
	Electromobility Model Regions	• Government: Federal Ministry of Transport and Digital Infrastructure • Industry: Deutsche Post DHL, Daimler, BMW, Bosch, Deutsche Bahn, among others • Other: numerous research organizations
	SLAM	• Government: Federal Ministry for Economic Affairs and Energy • Industry: BMW Group, Daimler, Volkswagen, etc. • Other: research organizations
Fuel Cell Vehicles	NIP	• Government: funding from Federal Ministry of Economic Affairs and Energy, support from Federal Ministry of Education and Research and Federal Ministry of Environment • Industry (CEP): BMW, Daimler, EnBW, Ford, GM/Opel, Honda, Hyundai, Linde, Shell, Siemens, Total, Toyota, Vattenfall, Volkswagen, among others • Other: research organizations
	FCH JU & NEW-IG (EU-level)	• Government: European Commission • Industry: NEW-IG, including companies such as Daimler, Siemens, Vattenfall, among others • Other: 58 research organizations that are part of N.ERGHY

Consumer education and awareness

Consumer awareness, education, and outreach regarding electric-drive vehicles and their benefits are a key part of governments' ability to help grow the early market. Outreach activities in California range from a wealth of high-quality online information on ZEV availability, to public demonstration of ZEVs, as well as outreach regarding fuel saving benefits and available incentives, to the integration of ZEV signage throughout the state. In addition, electric vehicle consumers throughout California are exposed to electric vehicles due to publicity from state and local departments regarding their many electric vehicle promotion activities, like fleet purchasing and local electric vehicle readiness plans (e.g., on new public charging or fueling facilities or EV-ready buildings). Based on an analysis of the 25 most-populous metropolitan areas in the US, California consumers are exposed to one of the more comprehensive systems of state and local incentives, charging infrastructure support, utility customer engagement, awareness and outreach events, and local informational tools (see Lutsey, 2014, 2015a, 2015b; Jin et al, 2014). Due to all of the varied electric vehicle promotional activities and their publicity and website information, important information is provided to prospective ZEV consumers from many different perspectives at many different times.

Many of these California electric vehicle consumer engagement activities are captured in Table 13. Regional groups and public-private partner groups play a large role in ZEV outreach. In 2011, Bay Area Climate Collaborative created the "Ready, Set, Charge!" campaign, which produced a guideline document and led workshops to educate the public. The Community Readiness Guidebook and a series of guides to prepare communities to support PEV were also distributed to local stakeholders like city planners, building officials, and local government through a series of workshops. 95% of those attending workshops stated intent to share this knowledge. These guides are all made available online, and CaFCP, the PEV collaborative, and a number of other ZEV-centered organizations provide a user-friendly website with easy-to-find educational guides. The US DOE funded the creation driveclean.ca.gov, a consumer guide to cleaner vehicle models (including both conventional and alternative fuel), and provides data on all electric charging stations and hydrogen fueling stations available through their Alternative Fuels Data Center. CaFCP has conducted more than 125 outreach activities reaching about 14,000 people in 2012-2013, and won a Merit Award for its social media “Go” campaign. The organization participates in numerous consumer awareness events, hosts test drives, and presents educational exhibits at conferences and expos across the state.

Germany’s consumer education and awareness activities generally fall within the Showcase Regions for Electric Mobility projects. It should therefore be noted that these activities mostly apply to regional or state-wide audiences in contrast to national outreach programs. Regional activities include business outreach, youth education programs and information campaigns, among others. Examples of different outreach activities are listed by type of activity in Table 13.

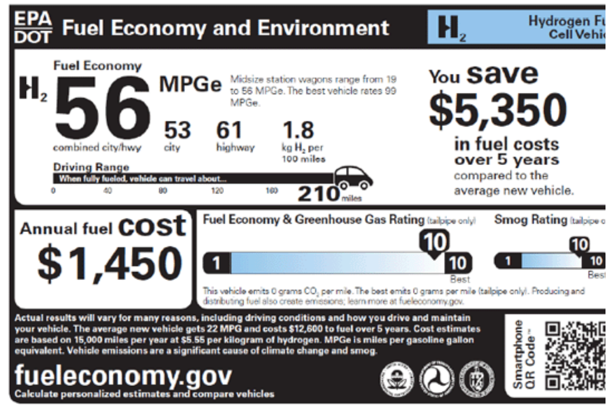
Table 13: Consumer outreach to promote electric-drive in California and Germany

	California	Germany
Online Resources and Social Media	• PEV Collaborative's eight communications guides (PEV) • ZEV Community readiness guidebook • US DOE Alternative Fuels Data Center • CaFCP "Go" Campaign	• "Online Schaufenster Elektromobilität": online showcase of the Baden-Württemberg • "Ingolstadt – Intelligentes Laden": Interactive resources for finding charging stations
Workshops	• CEC PEV infrastructure workshop • Six workshops by CEC on funding hydrogen infrastructure between 2012-2013	• A number of workshop in the Showcase Regions for Electric Mobility • NIP General Assembly • Symposia on Electromobility Model Regions
Events	• Clean Cities • National Plug-in Day • Ride'n'Drive events by CaFPC	• "Akademische Bildungsinitiative zur Elektromobilität Bayern-Sachsen": educational events in topics related to electric mobility • All showcase regions have electric mobility centers which present the projects to the general public • "Roadshow Elektromobilität": demonstration of electric mobility by the Federal Ministry of Transport and Digital Infrastructure
Employer and Business Owner Outreach	• US DOE handbook for fleet managers • PEV Collaborative's Employer EV Initiative, guide to installing workplace charging	• InitiativE BB and InitiativE-BW • Multiple projects in Model and Showcase Regions
Signage and Labeling	• Caltrans standardized allowable signage for PEV/H stations in Traffic Operations Policy Directive 13-01 • California Manual on Uniform Traffic Control Devices: instructions for use and placement of signs	• Labeling of EVs – Electric Mobility Regulation
Awards and Recognitions	• CalEPA created prize for excellence in enabling hydrogen stations in Governor's Environment and Energy Leadership Awards • Points for LEED certification earned through installing EV chargers, providing preferred parking for EVs.	• F-Cell Award: award for innovation in fuel cell technology by the state Baden-Württemberg • eCarTec Award: award for furthering electric mobility by the state of Baveria
Youth Education and Professional Development	• Extensive funding of University of California (e.g., UC-Davis) research to advance understanding of electric vehicle consumer research and train future leaders	• "Jugend denkt Zukunft": collaboration between schools and industry relative to electric mobility • "IdeenExpo – junge Generation begeistern": event which presents electric mobility to youth • Educational material by NOW/HZwei • ETUDE: education and professional training program of the NIP

California automobiles have fuel efficiency labels to assist consumers' decision making. These labels are required by federal fuel economy labeling requirements. California, in 2008, had required its own Environmental Performance label for model year 2009 and later vehicles, but the California labels were abandoned in order exclusively utilize the federal labels. The federal US consumer fuel economy labels underwent major changes in 2011, effective for 2013 and later model years – including accommodating electric-drive and other alternative fuel vehicle models (US EPA and NHTSA, 2011). The labels are displayed alongside the vehicle specifications and vehicle price on all new vehicle models that displayed for sale at dealerships in the US.

Figure 15 illustrates selected consumer fuel economy labels for new vehicles of various technology types, including BEV, FCEV, various PHEV types, and a gasoline vehicle. As shown, electric-drive vehicles each have their test cycle energy efficiency converted to miles-per-gallon-gasoline equivalent (MPGe). For BEV and PHEV this includes converting electric kilowatt-hours to gasoline with a 33.7 kWh per gallon of gasoline conversion factor. For hydrogen, a kilogram of hydrogen is approximately equal in energy content to a gallon of gasoline. For PHEVs, the MPGe includes a weighting according to the estimated electricity and gasoline usage according to particular test procedures and the associated electric range. Note that all US label MPGe values include an adjustment from the laboratory regulatory testing that generally reduces the miles-per-energy-consumed by 20-30%. Also shown, the labels inform consumers that all electric-drive vehicles result in very low annual fuel costs ($500 to $1,450 per year), have very large fuel savings (from $5,350 to $9,000 over 5 year ownership) compared to average new vehicles, and have the highest possible fuel economy and greenhouse gas emission ratings (i.e., 10 out of 10). As shown, the labels also explicitly show the all-electric range of the vehicle models; for example, the BEV BMW i3 has an electric range of 81 mi (130 km), compared to the PHEV Chevrolet Volt electric range of 38 mi (61 km) and the PHEV Toyota Prius plug-in equivalent electric range of 11 mi (18 km).

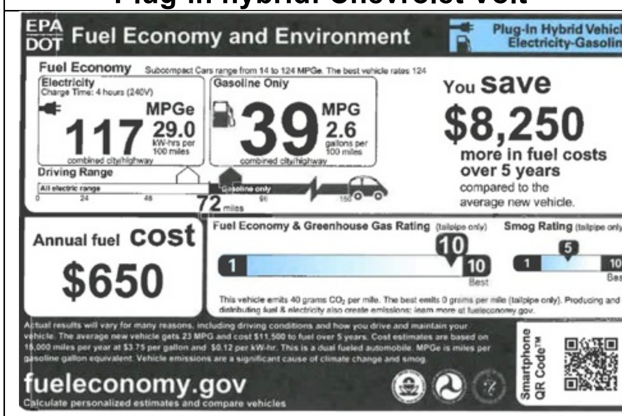
Battery Electric Vehicle: BMW i3



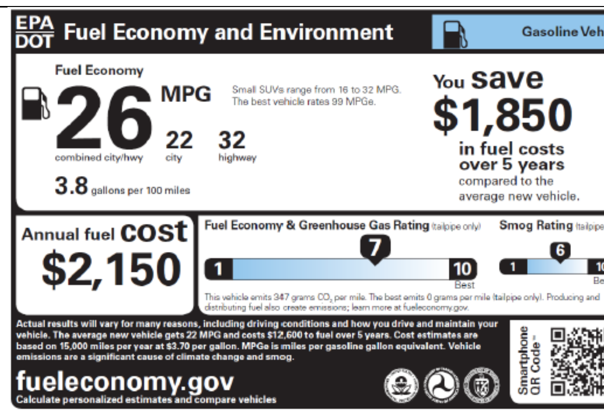
Fuel cell vehicle (E.g., Honda FCX Clarity)

Plug-in hybrid: Chevrolet Volt

Plug-in hybrid: Toyota Prius Plug-in



Plug-in hybrid: BMW i3 (range extender)



Typical gasoline compact car

Figure 15. Selected consumer fuel economy labels for new vehicles

In addition, as part of the ZEV Action Plan, the CEC, with support of CARB, supports expanded education at auto dealerships regarding ZEVs (Governor's Interagency Working Group on Zero-emission Vehicles, 2013).

Within the EU, information about fuel consumption and CO_2 emissions must be provided for new vehicles. Directives 1999/94/EC and 2003/73/EC set requirements for the information and location in which it is to be displayed: the label must include information on fuel economy and

CO_2 emissions and the label must be attached to all new cars or displayed nearby. Each member state may develop its own label that meets these requirements. The German label provides a grading of CO_2 efficiency (from A+ to G) akin to the energy efficiency label for consumer appliances (see Figure **16**). This efficiency grade presents the vehicle's CO_2 emissions, as determined by the combined value from the NEDC, but relative to the vehicle's mass (Deutsche Energie-Agentur, n.d.). It is thereby possible that a high-CO_2 emitting vehicle and a low-CO_2 emitting vehicle are labeled with the same efficiency grade. Due to 0 g/km accounting for BEVs and FCEVs, these technologies receive the highest grade in the fuel consumption label. The label also – significantly less prominently than on the US label – displays fuel costs for an annual mileage of 20,000 km, but does not display savings in fuel costs from selecting an energy-efficient or electric-drive vehicle.

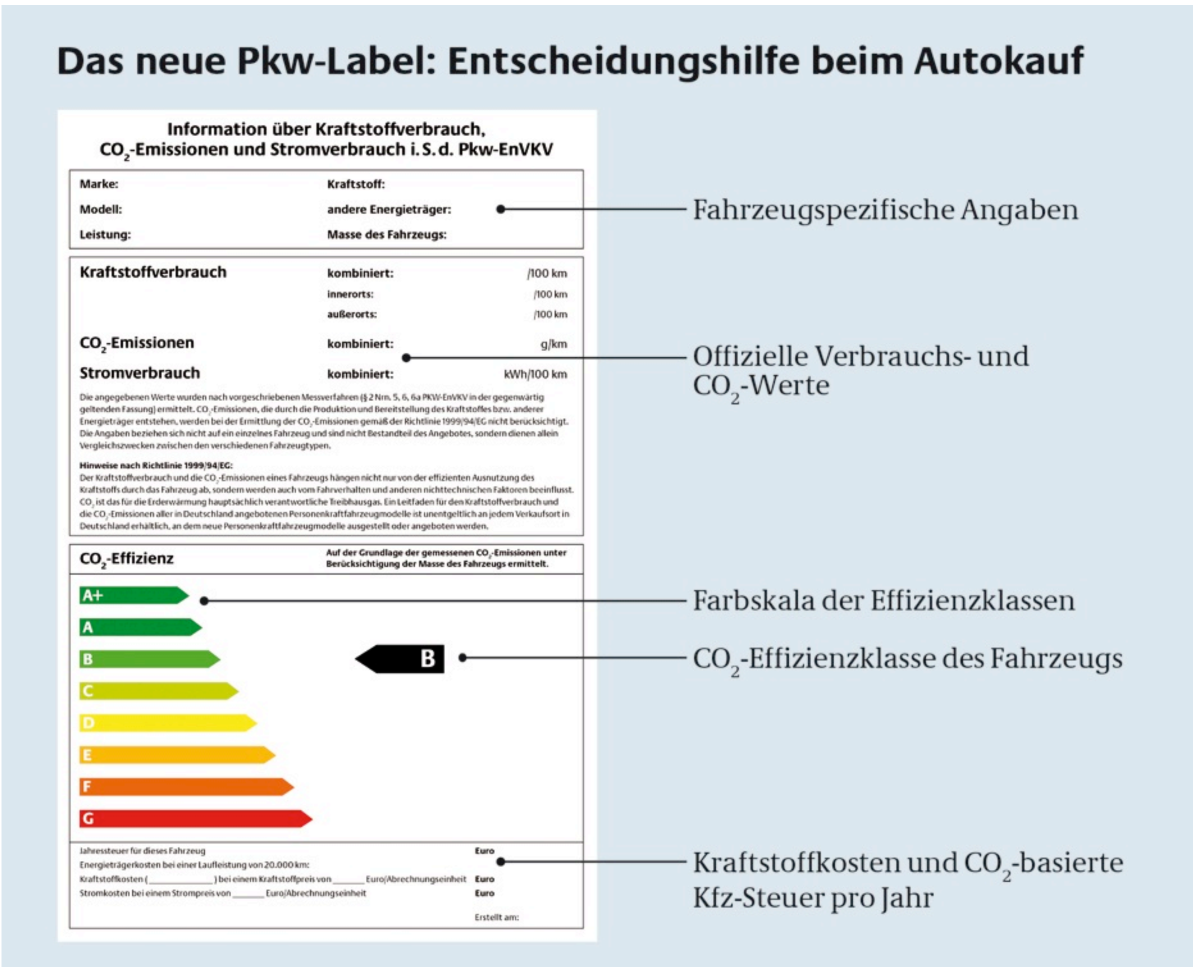


Figure 16**. German fuel consumption and CO_2 emission label for new vehicles (source: Federal Government of Germany, n.d.)**

Electric charging and hydrogen refueling infrastructure financing

In California, a large pool of funds is made available through the ARFVT program, as discussed above in Section III. From 2009-2014, ARFVTP grants provided over $550 million for alternative or renewable fuels. Of this, $38.3 million was awarded to projects devoted to electric charging infrastructure and $85.3 million for hydrogen fueling infrastructure. The ARFVT program was created in 2007 and was originally planned to operate through 2015. Funding for the program has been extended to 2024 by State Assembly Bill 8 (Perea, Statutes of 2013). Further funding for hydrogen infrastructure is guaranteed by the 2013 State Assembly Bill 8, which requires that the ARFVT annually fund $20M to hydrogen infrastructure until there are at least 100 publically available hydrogen-fueling stations. At the federal level, the DOE provides funding for infrastructure; the EV Project has provided financial assistance for workplace charging infrastructure and other charger projects, and the Transportation Electrification project, part of the American Reinvestment and Recovery Act, provided partial financing for vehicle charging in the Sacramento Municipal Utility District (CEC 2013).

Although the state has used a direct funding mechanism for current and planned hydrogen stations, the CaFCP roadmap describes an alternative “cash-flow support” approach, in which investors pay for and finance station development but receive incentive payments starting when the station begins operations and lasting until cash flow is positive (projected to be 3-5 years) or until financing is paid off (within 10 years). The analysis presented in that study finds that both approaches would require essentially the same level of funding – approximately $65M – and a hybrid between the two approaches may be required to complete the 68-station network (CaFCP 2012).

ARVFT will offer grants to cover a large portion of infrastructure construction cost, but companies will match grant funds with their own. Table 14 provides several examples for both hydrogen and electric charging infrastructure (it is not a comprehensive account). Currently, as shown in these examples, the state will bear a larger share of the cost for hydrogen infrastructure – in one funding solicitation, CEC offered to fund up to 85% of project cost if rapid construction goals were met – while for electric chargers, the grantee will bear an equal or larger share.

Table 14: Cost-sharing in California government-funded infrastructure projects

Fuel type, company, stations	Funding	
Hydrogen	**State Grant**	**Private Funds**
Air Products and Chemicals, Inc. (six new stations, two upgrades)	$11.2M	$4.6M
Linde, Inc. (two new stations)	$3.4M	$1.1M
Electric Charging	**State Grant**	**Private/Regional Funds**
Association of Bay Area Governments	$1.5M	$2.7M
Coulomb Technologies (1,300 charging stations)	$3.4M	$3.7M
Electric Transportation Engineering Corporation (1,738 charging stations)	$8M	$9.1M
Southern California Regional Collaborative	$840k	$542k

The national rollout of charging stations in Germany is heavily reliant on private businesses and government-industry partnerships. However, in future addendums to the recently passed electric mobility law, the federal government expects to develop a funding program for charging infrastructure, most likely based on low interest loans to private entities (Federal Government of Germany, 2014b). To date, public-private partnerships in the Model Regions and Showcase Regions have been instrumental in providing first charging points for German consumers. For example, Living Lab BWe mobil, the showcase project for Baden-Württemberg, will provide funding for 1,000 charging points. Similarly, the SLAM project uses federal and private funds to finance the construction of 400 DC charging outlets in metropolitan areas and along main motorways by 2017. A detailed list of infrastructure investments from the Electromobility Model Regions is shown in Table 15.

Table 15. Infrastructure investments in the Electromobility Model Regions

Region	Project	Private Funding[a]	Public Funding[a]
Multiple regions	Crome - Deutsch Französischer Flottentest	€3.7M	€3M
Berlin-Potsdam	Berlin Elektromobil 2.0 (BeMobility 2.0)	€3.9M	€5.4M
Bremen/Oldenburg	PMC - EWE-Flottenversuche Elektromobilität	€1M	€1M
Bremen/Oldenburg	PMC-H2O e-mobile	€0.2M	€0.3M
Bremen/Oldenburg	UI ELMO	€4.2M	€4.8M
Hamburg	hh = more	€2.4M	€2.2M
Hamburg	Hamburg - Wirtschaft am Strom	€12.8M	€10M
Munich	Drive e-Charged	€3.1M	€2.7M
Munich	eFlott	€4.4M	€4.4M
Rhine-Main	e-Car-Fleet	€1.3M	€1.3M
Rhine-Main	EMIO - Offenbach	€1.6M	€1.3M
Rhine-Main	eMOMA	€2M	€2.4M
Rhine-Main	FREE	€1.6M	€2.6M
Rhine-Main	Leben im Westen	€0.5M	€0.5M
Rhine-Main	Mainova	€0.5M	€0.4M
Rhine-Main	NEMO	€0.2M	€0.2M
Rhine-Ruhr	CologneE -mobil	€7M	€7.4M
Rhine-Ruhr	ColognE-Mobil II	€5.9M	€7.5M
Rhine-Ruhr	E-Carflex Business	€1.4M	€2.2M
Rhine-Ruhr	ELMO	€1.2M	€1.5M
Rhine-Ruhr	E-mobil NRW	€1M	€1.4M
Rhine-Ruhr	E-Mobilität im Pendelverkehr	€3.5M	€4M
Rhine-Ruhr	Langstrecken-Elektromobilität	€0.5M	€1.1M
Rhine-Ruhr	metropol-E	€2.8M	€4M
Rhine-Ruhr	RuhrautoE	€0.6M	€1.1M
Saxony	SaxMobility	€1M	€1.7M
Saxony	SaxMobility II	€2.8M	€3.8M
Stuttgart	Elektromobile Stadt	€0.3M	€0.8M
Stuttgart	Elektromobilität vernetzt nachhaltig	€0.1M	€1.1M
Stuttgart	EMIS - Elektromobilität im Stauferland	€1.3M	€1.9M
Other	BodenseeEmobil	€2.8M	€3.6M
Other	e-Mobil Saar	€1.6M	€3.1M
Other	EMOTIF	€0.4M	€0.7M
Other	Mitteldeutschland: Grüne Mobilitätskette	€1.8M	€2.4M

[a] *Most projects combine infrastructure investments with other research areas. The estimates of private and public funding refer to the total project financing. Source: NOW*

For hydrogen infrastructure, the Clean Energy Partnership (CEP) is a key actor in the financing of fueling. The funding from both industry and government amounts to €40 million. As with electric charging stations, private investments are also likely to play a significant role in the construction of hydrogen stations. While the costs have yet to be determined, the industry consortium H_2 Mobility will require substantial funding from German businesses. On the EU level, €7 million of funding from the Fuel Cells and Hydrogen Joint Undertaking (FCH-JU) flow into the SWARM demonstration project, which involves the construction of hydrogen refueling stations in the Weser-Ems region of Germany (FCH-JU, 2015). Further €10.6 million are provided by private organizations.

Table 16: Cost-sharing in Germany government-funded infrastructure projects

	Germany	
Hydrogen	**State Grant**	**Private Funds**
Clean Energy Partnership	$53.2M	$53.2M
Electric Charging	**State Grant**	**Private/Regional Funds**
SLAM	~$11.6M	~$5.6M
ChargeLounge	~$200k	Unknown
Model and Showcase Regions	Unknown	Unknown

Fuel provider vehicle promotion, decarbonization actions

Electric Charging. There are more than 50 electric utilities in California and each has its own rate structure. The State Alternative Fuels plan directs CPUC to encourage preferential rates for electricity used as a transportation fuel (CARB and CEC, 2007). Under Rulemaking 09-08-008, CPUC issued two major decisions. The first, designed to encourage competition, stated that businesses that sell PEV charging services would not be defined as utilities and thus not directly regulated by the CPUC. The second decision was to provide direction to investor-owned utilities in rate design, the provision of sub-meters to track PEV energy use, and other issues. The California ZEV Action Plan emphasizes the continued role of the CPUC and CEC in electricity pricing, directing the agencies to develop electricity tariffs for public transit fleets and the freight sector to encourage electrification, promote efficient utilization of grid resources and allow for the recovery of capital, and directing the CPUC to continue its effort to revise utility time-of-use rates for PEVs based on PEV charging data and other customer data.

Many California utility companies offer services with tiered rates depending on the time of day to help manage grid load. Through the rates themselves and in the rate information provided to consumers, utilities encourage EV owners to charge during low electricity load periods. In 2012 across the five largest California utilities, charging rates ranged from $0.09-$0.15 per kWh during off peak hours, and $0.17-$0.26 during on peak (daytime) hours (CCSE 2012). Several utility providers offer additional rate discounts for EV charging during off-peak hours, detailed in Table 15. Many utility companies provide information about tiered time-of-use rates for EV owners on their websites (for example, SDGE, 2014; PGE, 2014) and Southern California Edison also provides an advice line to advise EV owners how to charge to minimize costs (SCE, 2014). A 2012 survey found that 70% of respondents who owned PEVs knew about tiered time-of-use rates, with significant variation across customers of different utility providers (CCSE, 2012).

Table 17: Time-of-day discounts from California utility providers

Utility	Description	Amount
Los Angeles Department of Water and Power	Discounted per kWh rate to charge PEVs during off-peak hours	2.5 cents per kWh
Pacific Gas and Electric	Discounted per kWh rate to charge PEVs	Variable, depending on time of use
Sacramento Municipal Utility District	Discounted per kWh rate to charge PEVs during off-peak hours; monthly service charge waived for PEV charging rate	2.43 cents per kWh winter, 2.71 cents per kWh summer
Southern California Edison	Discounted per kWh rate available for EV charging	7.825 cents per kWh for charging PHEVs and BEVs during off-peak hours
San Diego Gas and Electric	Lowest time-of-use rates during super off-peak hours for EV charging.	0.145 cents per kWh

California also has a Renewable Portfolio Standard (RPS) that increasingly requires a higher percentage of renewable electric power generation over time. The California RPS moves the average electricity generation from to 20% renewable in 2010 and to 33% in 2020 (CPUC, 2014). At his second inaugural address in 2015, Governor Brown announced a plan to increase the RPS to 50% in 2030, to be introduced in the senate as Senate Bill 350: Golden State Standards 50-50-50 (CalNewsroom 2015, California Climate Leadership 2015). In addition, the ZEV Action Plan also directs the CPUC to explore green power programs that encourage utilities to offer voluntary green power purchasing programs targeted at PEV customers. CPUC also works to ensure owners of distributed generation systems (e.g. rooftop solar PV) can size their load with future ZEV ownership in mind, and is exploring the possibility of pairing incentives for distributed gen systems with ZEV usage.

While German utilities generally do not offer similar tiered rates, the German Energy Management Act ("Energiewirtschaftsgesetz") includes a provision on the reduction of electric transmission costs for *controllable consumer installations* in §14a (Federal Ministry of Justice and Consumer Protection, 2005). *Controllable* here refers to electrical appliances with separate metering and whole power consumption can be controlled remotely. As long as chargers for electric-drive vehicles have these capabilities, electric transmission costs could be reduced by means of future regulations.

Hydrogen fueling. In the US, the Environmental and Energy Standards for Hydrogen Production, SB 1505, requires that state-funded hydrogen stations must produce 33% from eligible renewable energy resources; this requirement will be in effect for all hydrogen stations once annual throughput reaches 3,500 metric tons. The state has funded a number of solar-powered hydrogen generation stations. The Orange County Sanitation District in California is the host of the world's first tri-generation (heat, hydrogen, and power) facility, which demonstrates production of renewable bio-hydrogen at a wastewater facility. The project was developed as a partnership between the U.S. DOE, CARB, OCSD and private industry.

In Germany, the strategy for mobility and fuels ("Mobilitäts- und Kraftstoffstrategie der Bundesregierung") of the Federal Ministry of Transport and Digital Infrastructure (2013) anticipates that hydrogen will play an important role in the decarbonization of the transport sector and highlights its potential to combat intermittency issues of renewable energy sources. In terms of practical implementation of this strategy, the Clean Energy Partnership produces 50 percent of its hydrogen fuel from renewable resources (NOW, 2015), defined as hydrogen derived from biomass or electrolysis with electricity from renewable energy sources (Clean Energy Partnership, 2015 b).

Long-term climate and energy planning

The California ZEV action plan fits within a number of overarching state and national plans to reduce petroleum consumption, GHG emissions, and conventional pollutants. Several major state policies are outlined in Table 16. We note that, although these high-level policies are more aspirational and relatively unspecific for electric-drive, these actions are routinely cited as the motivation for more specific regulatory, infrastructure, and financing actions discussed above. Electrification of transportation – for all modes, not just passenger cars – is a deeply rooted policy in every clean air and low carbon action in California. California's economy-wide climate legislation, Assembly Bill 32 (AB 32) of 2006, gives the state its authority to implement many new policies and includes overall emission reduction goals to achieve 1990 emission levels by 2020 and 80% below 1990 emissions by 2050. In April of 2015, Governor Brown issued an executive order setting a midterm target of 40% below 1990 levels by 2030 (Office of the Governor, 2015). The recent update to the AB 32 Scoping Plan clearly reiterates the state's resolve to shift toward an increasingly electric vehicle fleet, including electric-drive commercial medium and heavy-duty vehicles (CARB, 2014c). The overarching transportation fuel policy, the Low Carbon Fuel Standard, which was mentioned above, similarly is committed to helping incentivize electrification; electric utilities are accruing credits (CARB, 2014d), and CARB is considering ways to promote electrification more, within the policy. Finally, California also gets increased motivation for electric-drive vehicles from the federal US Clean Air Act. The Clean Air Act directs all US states to implement policies to achieve compliance with ambient air quality standards. California, due to its particular air quality situation for NOx, is still seeking to reduce NOx emissions from all sources by over 80% from 2015 levels in the 2023 timeframe.

The European Union has stipulated a number of GHG mitigation targets in the context of preventing climate change and reducing reliance on fossil fuel imports. The 20-20-20 targets set three objectives for 2020: a 20 percent reduction in EU GHG emissions compared to a 1990 baseline; increasing the share of renewable energy sources to 20 percent of the EU energy mix; and improving the EU's energy efficiency by 20 percent (European Commission, 2014). By 2030, GHG emissions are to be reduced by 40 percent compared to a 1990 baseline. The German government has stipulated more ambitious targets and aims to reduce GHG emissions by 40 percent by 2020 (Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, 2014b). Table 18 provides a broad overview of German and EU climate and energy targets for the transport sector and the entire jurisdictions.

For the EU transport sector, Directive 2009/28/EC is of particular interest. Directive 2009/28/EC, the Renewable Energy Directive, mandates that 20 percent of all energy consumed in the EU comes from renewable sources by 2020 with differentiated targets for individual member states. The directive further stipulates that every member state should ensure that 10 percent of energy consumption in the transport sector is derived from renewable energy sources. In addition to biofuels, electricity from renewable energy sources used in the transportation sector counts toward this target. The use of renewable electricity in transportation is incentivized by applying a multiplier of 2.5 in the calculation of the share of renewable energy sources in each member states' transport sector (Council of the European Union, 2009). A proposal for amendment of the Renewable Energy Directive suggests raising the multiplier to five for road transport (Council of the European Union, 2014). Hydrogen fuel derived from renewable energy sources also counts toward the transport sector target. Lastly, the European Commission's roadmap to a single European transport area states that a 60 percent reduction of EU transport sector emissions (compared to a 1990 baseline) will be required by 2050 to meet the EU target of reducing overall GHG emissions by 80 to 95 percent by 2050 (European Commission, 2011).

Table 18. Overview of German and EU climate and energy targets

Target	Region	Sector	2020	2030	2040	2050
Reduction of GHG emissions	EU[a, b]	All	20-30% (1990 baseline)	40% (1990 baseline)		80-95% (1990 baseline)
	EU[c]	Transport		20% (2008 baseline)		>60% (1990 baseline)
	Germany[d, e]	All	40% (1990 baseline)	55% (1990 baseline)	70% (1990 baseline)	80-95% (1990 baseline)
Reduction of energy consumption	EU[b]	All	20% (1990 baseline)	27% (BAU baseline)		
	Germany[d, e]	Transport	10% (2005 baseline)			40% (2005 baseline)
Share of renewable energy	EU[f]	All	20% (share of gross final energy consumption)	27% (share of gross final energy consumption)		
	EU[f]	Transport	10% (share of gross final energy consumption of all modes)			
	Germany[d, e]	All	18% (share of gross final energy consumption)	30%	45%	60%

Based on German Energy Agency (2012)

[a] *European Commission (2011b).*
[b] *European Parliament (2009).*
[c] *European Commission (2011a).*
[d] *Federal Government of Germany (2010)*
[e] *Federal Ministry for Economic Affairs and Energy (2012).*
[f] *Council of the European Union (2009).*
[g] *European Council (2014)*

Table 19: Climate and Energy Targets

Policy	California	Germany/EU
Overall economy-wide CO_2 goals	• **Assembly Bill 32 of 2006** • Reduce overall GHG emissions to 1990 levels by 2020 • Reduce overall GHG emissions to 80% below 1990 levels by 2050 • Transportation fuels to be included in the overall state cap in 2015 • Scoping Plan updates and indicates expanded and new policies • **Executive order (2015)** • Reduce overall GHG emissions to 40% below 1990 levels by 2030	• Reduce overall GHG emissions to 40 percent below 1990 levels by 2020 • EU and Germany: 80-95 percent reduction of GHG emissions by 2050 compared to 1990 baseline
Overall transportation alternative fuel and energy goals	• **Low Carbon Fuel Standard** • Require 10% reduction in carbon intensity of transportation fuels in California by 2020 • Provisions encourage electric-drive, including utility generation for plug-in electric vehicle electricity use	• **Directive 2009/28/EC (EU)** • Ten percent of energy consumption in transport sector must be renewable by 2020 • **Directive 2009/30/EC (EU)** • 10% reduction of GHGs per unit of energy in transport sector by 2020 compared to 2010 baseline • **Energiekonzept der Bundesregierung (Germany)** • 10% reduction of energy use in transport sector by 2020 and 40% reduction by 2050 compared to 2005 baseline

V. Stakeholder questionnaire and interviews

As part of this comparative study of California and Germany, we also sought to capture leading stakeholders' perspectives on the current situation in the US and Germany with respect to the development of the market for electric-drive vehicles. Collection of the stakeholders perspectives involved an online survey that was distributed to approximately 200 experts that actively work on various aspects of vehicle technology, vehicle policy, electric charging infrastructure, hydrogen fuel, consumer research, and other areas related to electric-drive vehicles.

The survey was conducted via the online survey tool SurveyMonkey during March and April of 2015. The survey involved a combination of Likert-type (strongly agree, agree, etc) questions, ordering of priorities (first, second, third), quantitative ordering of priorities (allocation of "chips"), and opportunities for free-form comments and elaborated responses. The survey was generally completed within 15 minutes. Survey respondents were assured in advance that their responses would remain strictly confidential.

In response to the survey solicitation, 96 respondents from Germany and the US completed the survey, representing approximately a forty percent response rate. Among the correspondents were numerous individuals from automobile manufacturing companies, electric power utilities, other electric power providers, hydrogen providers, national energy research laboratories, state and national policymakers, non-profit organizations, and research organizations. The group largely consists of high-level representatives within the organizations, generally having over 10 years experience in the area and having significant leadership over key appropriation, research, deployment, marketing, and policy decisions at their respective organizations. In total, 57 completed surveys from Germany-based respondents and 39 completed surveys from US-based respondents were received.

Survey results on electric-drive vehicle obstacles

The following three figures present survey results related to the obstacles for electric-drive vehicles. Three successive questions were asked to assess which factors were significant obstacles for PHEV, BEV, and FCV technology. The respondents were specifically prompted to provide their expert judgment about the obstacles, rather than assess public opinion on the issue. In each case, a list of options was offered and an "other" category was offered for survey respondents to name additional potential obstacles. In each case, the survey results are summarized from Germany-based and US-based stakeholders to help assess any potential differences in two the regions.

Figure 17 summarizes the survey results related to whether survey respondents believe that the various factors are significant obstacles to PHEVs in Germany and the US. The results are ordered according to whether more of the respondents, on average, agreed or disagreed about the obstacle being significant ("Strongly agree" was weighted as +2, "Agree" +1, "Neither" 0, "Disagree" -1, "Strongly disagree" -2). As shown in the figure, there are similarities among which items rose to the top as the most significant obstacles. In particular, vehicle price, vehicle resale, charging payment systems, vehicle choice, and workplace charging were all among the top-seven PHEV obstacles in both regions. Several factors stand out as having clear differences in how the stakeholders in the US and Germany rated their significance. For example, respondents from Germany indicated that government incentives and total cost of ownership are of greater significance, whereas US respondents rated consumer awareness and all-electric range higher. Neither German nor US respondents regarded vehicle safety, battery safety, or vehicle performance as significant obstacles.

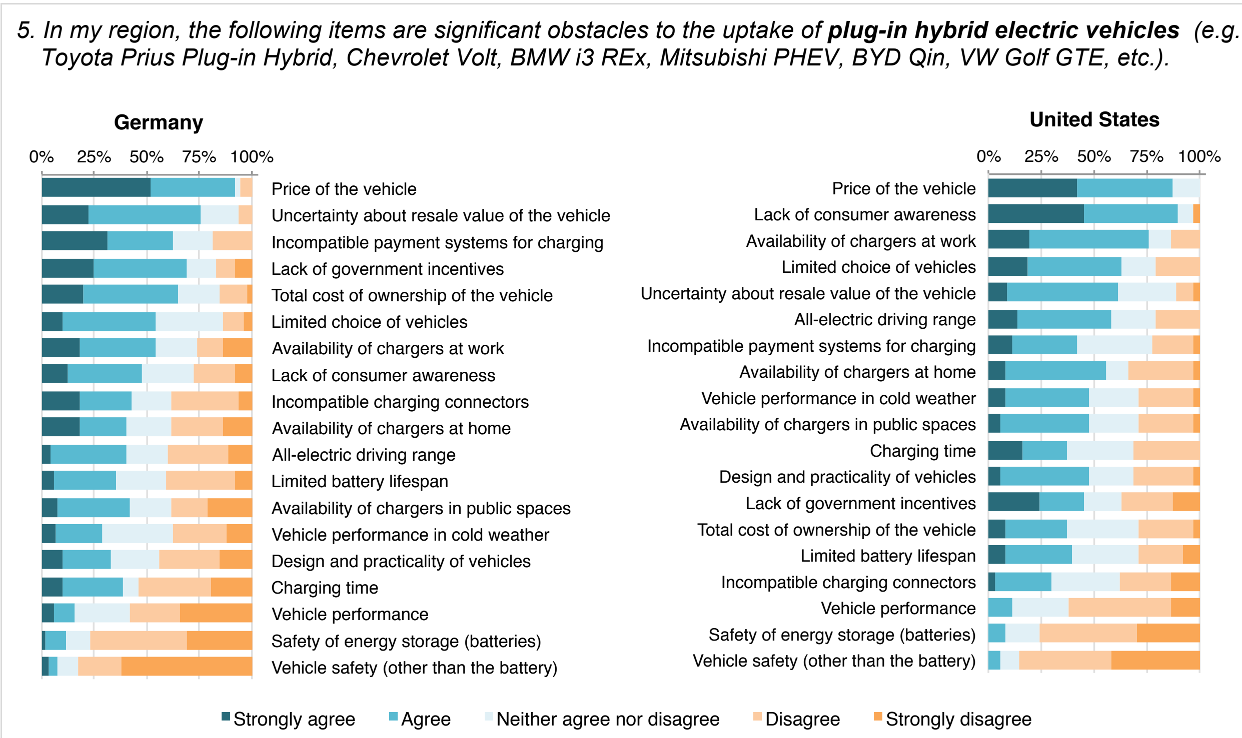


Figure 17. Ranked obstacles for uptake of plug-in hybrid electric vehicles from survey responses in Germany and the United States

Figure 18 summarizes the survey results related to whether survey respondents believe that the various factors are significant obstacles to BEVs in Germany and the US. As above, the results are ordered according to whether more of the respondents tended to agree or disagree about the obstacle being significant. As shown in the figure, there are similarities among which items were rated as the most significant obstacles. In particular, vehicle price, vehicle range, vehicle resale, and charging time were all rated among the top-seven BEV obstacles in both regions. Several factors stand out as having clear differences in how stakeholders in the the US and Germany rated them. For example, respondents from Germany indicated that charging payment systems, government incentives, and total cost of ownership are of greater significance, whereas US respondents rated consumer awareness and workplace charging higher. Neither German nor US respondents regarded vehicle safety, battery safety, or vehicle performance as significant obstacles.

*6. In my region, the following items are significant obstacles to the uptake of **battery electric vehicles** (e.g. Nissan Leaf, Renault Zoe, Tesla Model S, etc.).*

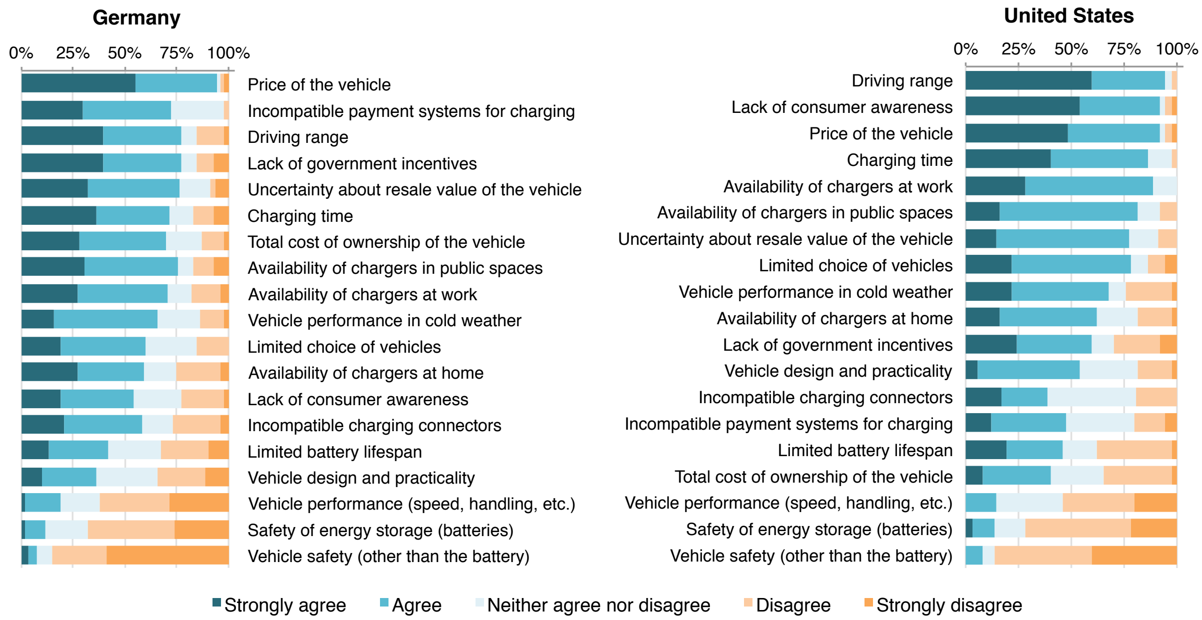


Figure 18. Ranked obstacles for uptake of battery electric vehicles from survey responses in Germany and the United States

Figure 19 summarizes the survey results related to whether survey respondents believe that the various factors are significant obstacles to FCVs in Germany and the US. As above, the results are ordered according to whether more of the respondents tended to agree or disagree about the obstacle being significant. As compared to BEVs and PHEVs, there are far more similarities among which items were rated as the most and least significant FCV obstacles for respondents in Germany and the US. In particular, vehicle price, availability of hydrogen fueling, limited vehicle choice, and total cost of ownership were among the foremost obstacles in both regions. Relative to above for plug-in vehicles, there were not factors that stand out as having clear differences in how stakeholders in the US and Germany rated them for FCVs. Neither German nor US respondents tended to regard driving range, fueling time, vehicle safety, vehicle performance, or fueling standards as particularly significant obstacles for FCVs.

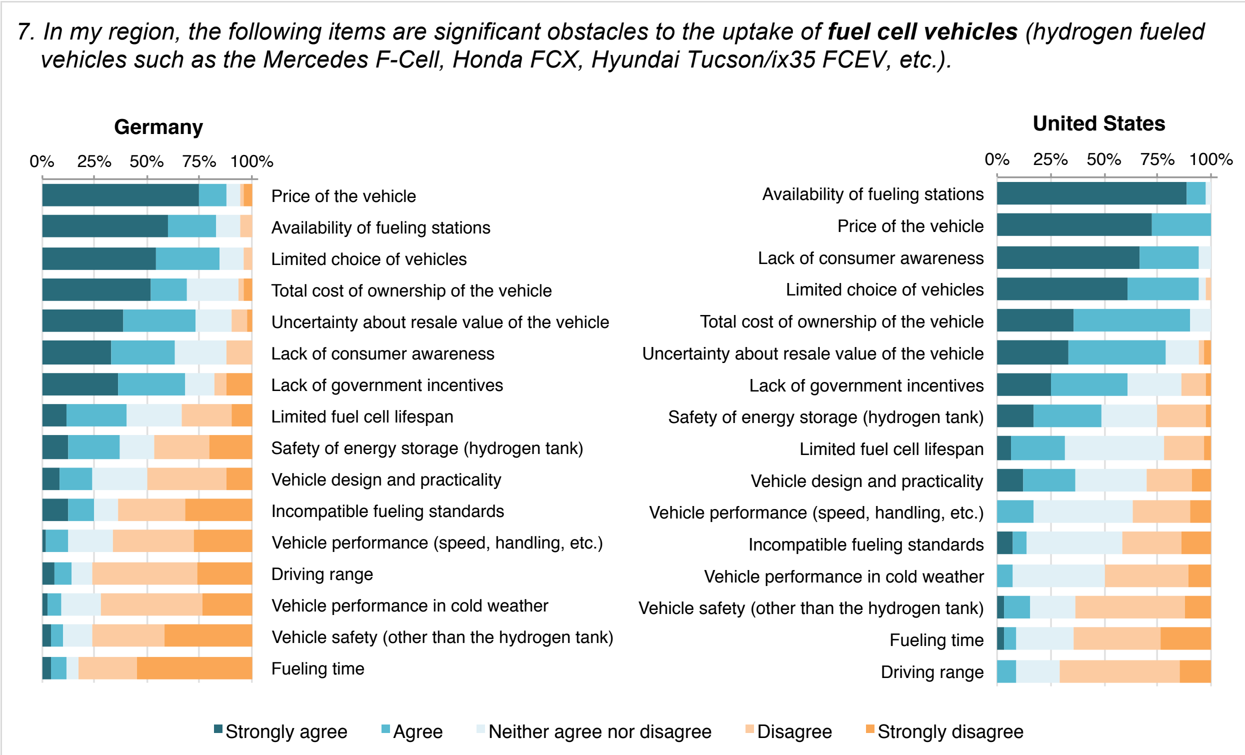


Figure 19. Ranked obstacles for uptake of fuel cell vehicles from survey responses in Germany and the United States

Survey results on most effective electric-drive vehicle actions

Following the questions about the obstacles to the electric-drive technologies, the survey respondents were asked about which incentives they considered to be most effective at promoting electric-drive vehicles. As above, the survey asked the questions for each of the three vehicle categories. In this case, to encourage survey respondents to prioritize the relative importance of each action, they were allowed to select only the top three most effective incentives. The results below order the findings according to the total amount of top-three selections each action received in the surveys. Associated with the survey questions about which incentives were most effective, the various incentives were defined as follows –

- Purchasing subsidies: a direct fiscal subsidy reducing the price of electric-drive vehicles
- Emission or fuel economy standards: CO_2 emission targets for new vehicles (e.g. 130 g CO_2/km target for 2015 in the EU, 34.1 mpg by 2016 in the US)
- Tax incentives: reduction of registration or ownership taxes for electric-drive vehicles
- Direct regulation: policies that require a specified number or percentage of electric-drive vehicles among new cars (e.g. California's ZEV Program)
- Preferential electric-drive access: access to low-emission zones, carpool lanes, bus lanes, or preferential parking
- Consumer education: public campaigns to promote consumer awareness
- Subsidized charging rates and equipment: subsidized electricity rates for charging electric vehicles, support for home charging equipment

- Charging infrastructure investments: investment in constructing public charging and/or fueling stations
- Research and development: public investment in research of battery and/or fuel cell technologies
- Consumer behavior research: research to understand key constraints of electric-drive vehicles

Figure 20 summarizes survey responses regarding survey respondents' views on the most effective incentives for PHEVs. As shown in the figure, purchasing subsidies were overwhelmingly seen as the most effective, getting the most first and the most total top-3 selections from the respondents in both Germany and the US. One key difference between the US and German responses is that emissions (and efficiency) standards are viewed as more effective in Germany than in the US. As introduced above, the more stringent EU CO_2 standards could be a partial reason for this difference. Many German and US respondents viewed direct regulation (e.g., the California ZEV program) as among the more effective incentives. Preferential electric-drive access (e.g., carpool lane and parking access) is seen as one of the more important incentives for PHEVs in the US.

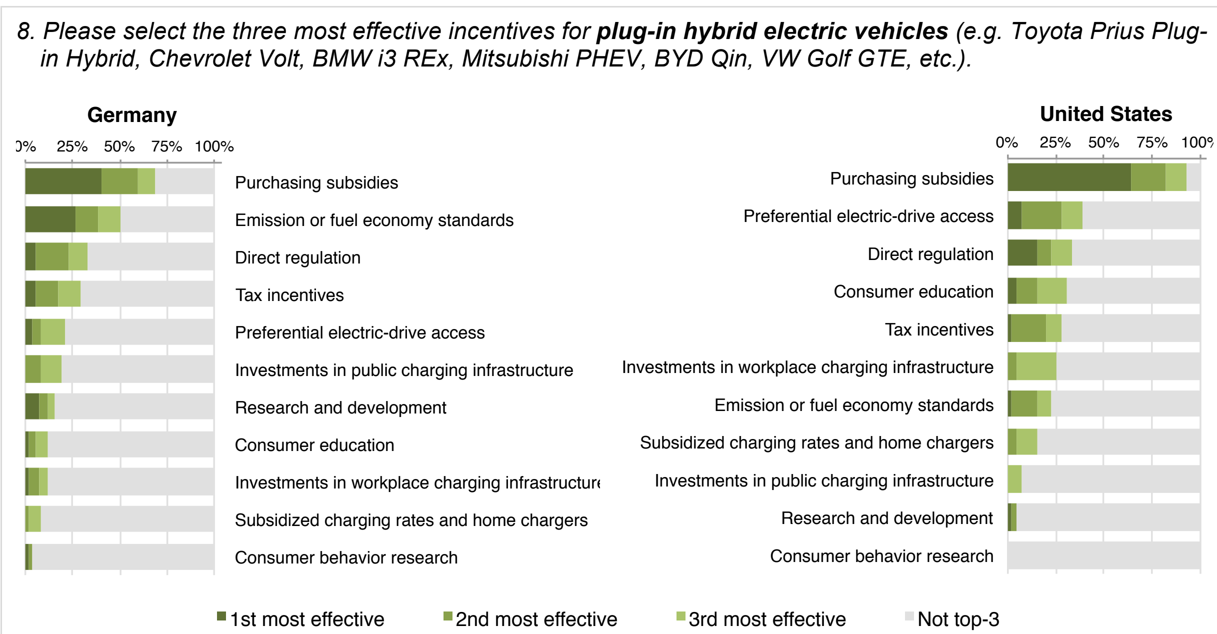


Figure 20. Ranked most effective incentives for uptake of plug-in hybrid electric vehicles from survey responses in Germany and the United States

Figure **21** summarizes survey responses regarding survey respondents' views on the most effective incentives for BEVs. As shown in the figure, and similar to PHEVs above, vehicle purchasing subsidies were overwhelmingly seen as the most effective, getting the most first and the most total top-3 selections from the respondents in both Germany and the US. Direct regulation, as in the California ZEV program, is see as highly effective in the US, second only to vehicle purchasing subsidies. As with PHEVs, the survey responses indicate that emissions (and efficiency) standards are viewed as more effective incentives for BEVs in Germany than in the US. Preferential electric-drive access (e.g., in carpool lanes, city parking) is seen as one of the more important incentives for BEVs in the US. Other tax incentives were also seen as relatively effective in both the US and Germany.

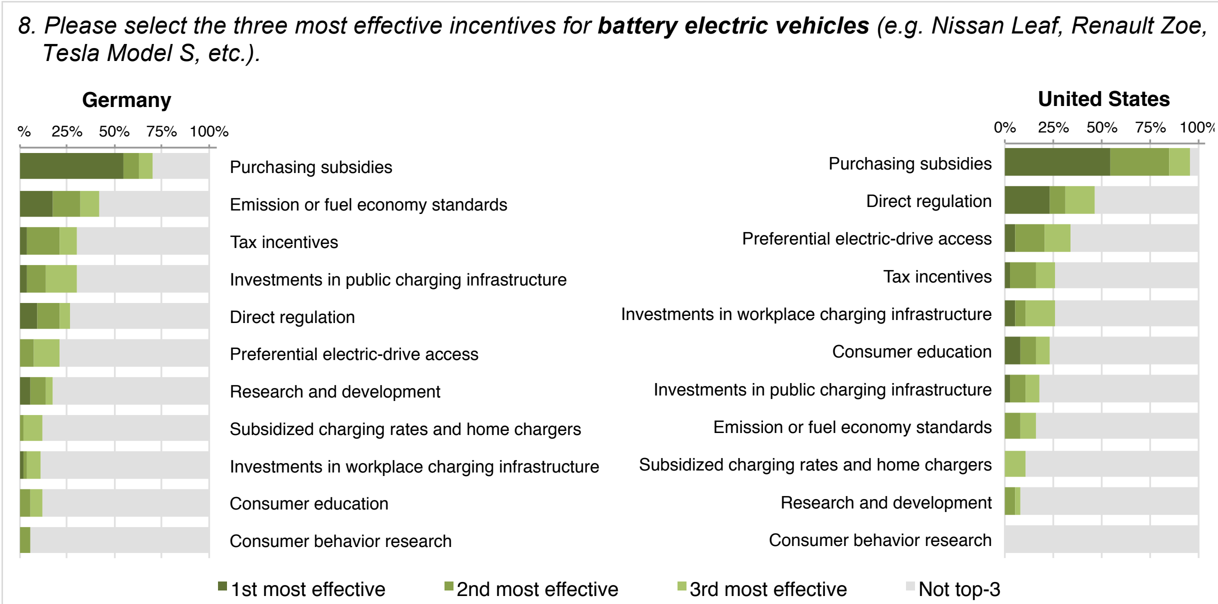


Figure 21**. Ranked most effective incentives for uptake of battery electric vehicles from survey responses in Germany and the United States**

Figure 22 summarizes survey responses regarding survey respondents' views on the most effective incentives for FCVs. Similar to PHEVs and BEVs above, vehicle purchasing subsidies were seen as the most effective, getting the most total top-3 selections from the respondents in both Germany and the US. A major distinction in these results for FCVs compared to those above for BEVs, is that many of the survey respondents in Germany and US found investment in public hydrogen fueling infrastructure to be among the most effective incentives. German respondents found emissions (and efficiency) standards as more effective, and US respondents rated direct regulation and consumer education more highly.

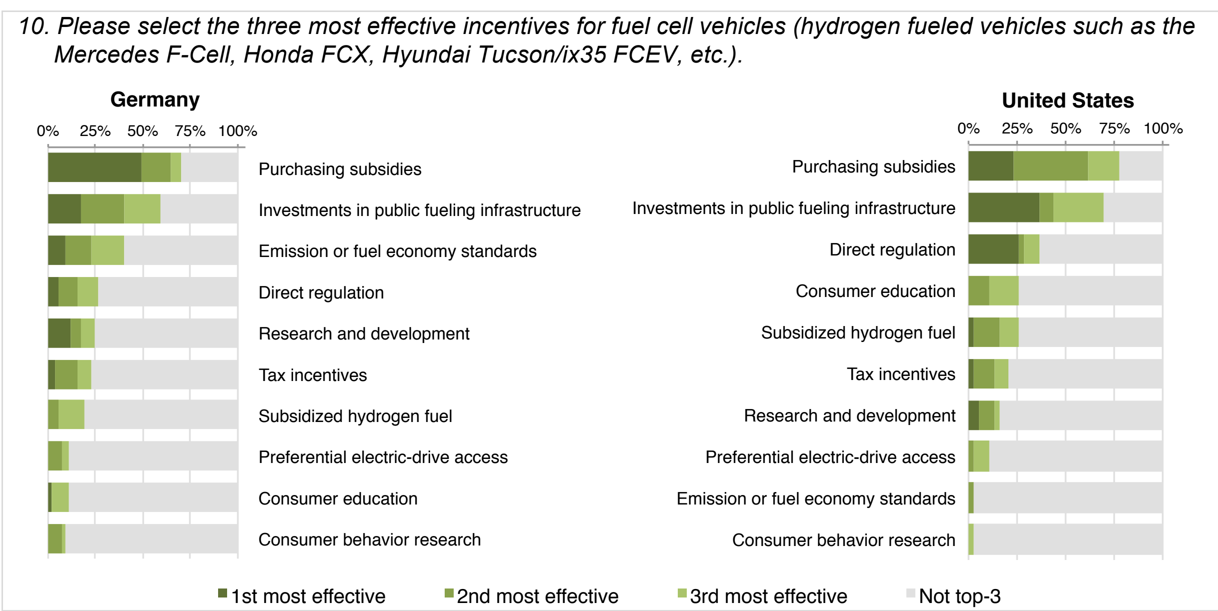


Figure 22. Ranked most effective incentives for uptake of fuel cell vehicles from survey responses in Germany and the United States

Survey results comparing electric-drive technology types

Whereas the results and discussion above are meant to rank and compare the Germany and US-based responses, the following discussion summarizes the data according electric-drive technology type (i.e., PHEV, BEV, and FCV). Figure 23 summarizes the combined results to Questions 5 (PHEV), 6 (BEV), and 7 (FCV) above on whether various items were significant obstacles. The average results shown in the figure include the following weighting: “Strongly agree” +2, “Agree” +1, “Neither” 0, “Disagree” -1, and “Strongly disagree” -2. The survey respondents’ differing views on which items present more significant obstacles for each technology are shown in the figure. Areas where FCVs are seen as having more significant obstacles are on the left, and areas where BEVs are seen as having more significant obstacles are on the right. As shown, FCVs’ more significant obstacles are in public refueling infrastructure and their very limited vehicle choices. BEVs’ obstacles, on the other hand, were relatively greater in terms of driving range and recharging time. The results indicate that PHEVs have less significant obstacles than one or both of the other two electric-drive technologies across all the factors. As shown in the figure, vehicle price was rated as being among the most significant obstacles for all three electric-drive technology types.

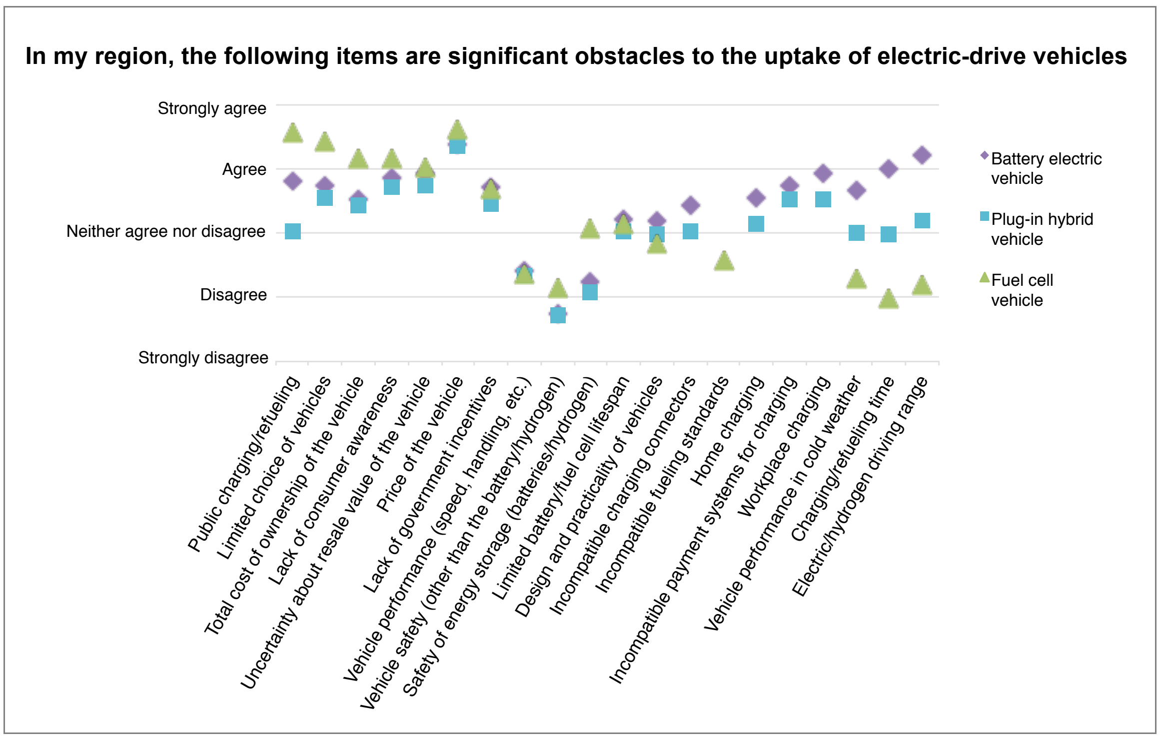


Figure 23. Survey results for significance of various obstacles for battery electric, plug-in hybrid, and fuel cell vehicles

In addition to the obstacles that were listed within the survey, respondents were allowed to add additional obstacles they view as significant. Table 1 summarizes the additional comments from survey respondents regarding significant obstacles in the three technology areas.

Table 20. Selected additional comments from survey responses on significant obstacles for PHEV, BEV, FCV technologies

PHEV	BEV	FCV
• **Uncertainty of total cost** of ownership is an important barrier • Redundant systems (petroleum and electric) needlessly increase vehicle cost but double potential **maintenance**. More all-electric vehicle choices are needed in our area, with **choices** of at least two different battery sizes. • A reason for government reluctance to subsidize PHEVs may be that there is no **monitoring made on the PHEV driving mode** (whether hybrid or pure electric mode). • **Consumer confusion** is a major barrier with PHEVs - they just don't understand what a PHEV is when compared to a BEV. And when government incentives are unequal for the BEV and PHEV, this reinforces the notion that the PHEVs aren't "real" electric vehicles. When in reality many, many consumers could be driving PHEVs today. • Plug-in-hybrids are not the best but the **worst of two worlds**. It just doesn't work. • Partly captured by TCO and availability of chargers at home, but **complexity and cost of installing home charging** is probably a significant barrier. • The top issues were: **performance on snow packed and dirt roads**, upfront cost of the vehicle, and range. • Attractive **GOOD looking vehicles** are needed.	• **Uncertainty of total cost** of ownership is an important barrier • Performance in **hot weather** as well--A/C demand • For vehicle choices, our market really needs a **minivan** type all-electric. Also need a **choice of at least two battery sizes** for all-electric vehicles. • Lack of government incentives may not be solely understood as a lack of direct purchase incentives. It may also be the case that e.g. the **tax level on conventional vehicles is too moderate** to gain a significant leverage efect if electric vehicles are tax-exempted (best practice Norway). • The high expectation that were raised and messages like 'breakthrough achieved' are counterproductive - as people became disappointed by **false expectations**.	• Government incentives for the deployment may be implemented post 2020. Current focus lies on R&D, especially on **renewable hydrogen production**. • **Too early** to say... • NOW / H2-Mobility have to be **faster to built filling stations** in Germany. • Federal government FCEV incentives have expired, currently **only state incentives**. • **None for sale** or lease in my community • Without ubiquitous fueling stations (gas station model) these will have a hard time. The **efficiency losses** make it a non-starter for us. We cannot access efficiency funds for anything but the most efficient "appliance". • Despite committed targets to have enough stations in Germany reality is far behind. e.g. since beginning of December **no station available** in Frankfurt area (nearest is Dusseldorf!)

Figure 24 summarizes the results on survey respondents' views on the most effective incentives for PHEVs, BEVs, and FCVs. As shown in the figure, purchasing subsidies were overwhelmingly seen as the most effective incentive for promoting electric-drive vehicles. As shown, 75-80% of respondents selected vehicle purchasing incentives as among the top-3 most effective in increasing vehicle uptake for all three technologies. The most pronounced difference in the results, when organized by technology type, is related to the importance of investing in public refueling/recharging infrastructure – 61% or respondents selected investing in hydrogen infrastructure as among the most effective for FCVs, compared to 26% for BEVs' and 17% for PHEVs' charging infrastructure. Direct regulation (e.g., the California ZEV program) and CO_2 standards were seen as the next most effective incentives.

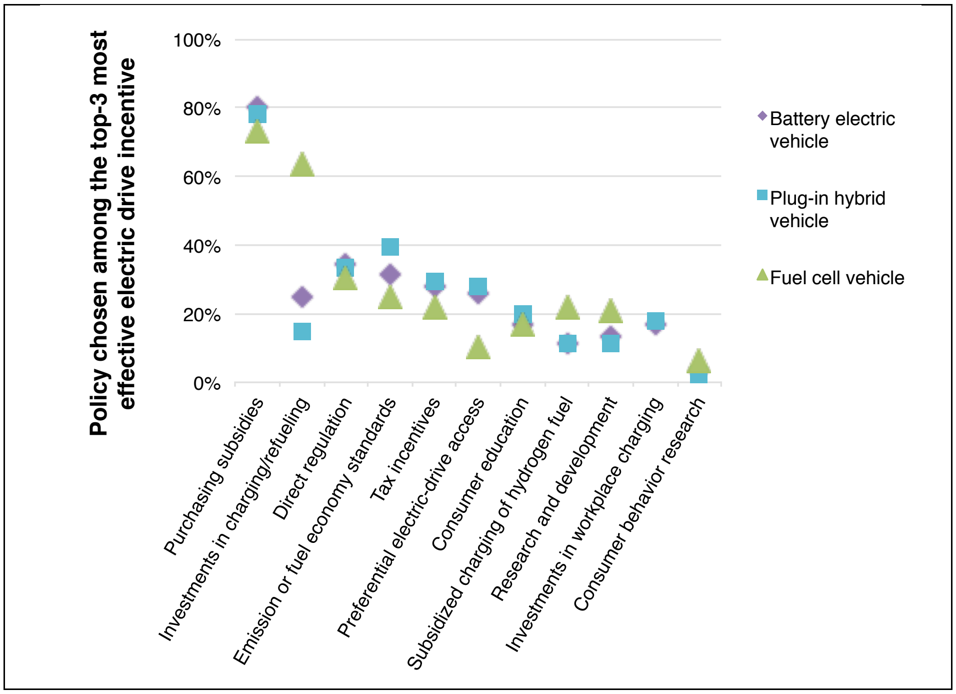


Figure 24. Survey results for most effective incentives to increase the uptake of battery electric, plug-in hybrid, and fuel cell vehicles

Table 21 summarizes the additional comments from survey respondents regarding their views on the most effective incentives for each of the three technology areas.

Table 21. Selected additional comments from survey responses on most effective incentives for PHEV, BEV, FCV technologies

PHEV	BEV	FCV
• Purchasing subsidies are very effective, but **only in the short run...** • Consumer education = promotion, awareness, and **butts-in-seats** • The effectiveness of a GHG emission standard depends entirely on how stringent the standard is. A 34.1 mpg by 2016 standard will do nothing. A **substantially more stringent standard** could have a different effect. • Is the **incentive referencing the manufacturer** or end user? Could be different priorities/answers.	• Consumer education = promotion, awareness, and **butts-in-seats** • Also key is some **DC fast-charging in meaningful public spaces** • Why not talking about competitors (petrol, Diesel) and **disincentives** for them? • For every public EV charger, 10 **signs** should be installed, **pointing the way to that charger**. Like the blue "H" signs for hospitals in the U.S., you don't need to build a lot of hospitals, but you do need many signs showing the way to the hospital!	• Why not talking about competitors (petrol, Diesel) and **disincentives** for them? • **None for sale** in my community • My answers are for the current moment, and may change as technology, awareness, infrastructure, etc. progress. • Fuel-Cell infrastructure **on the Autobahn**

Survey results on allocation of electric-drive funding

For the final question, survey respondents were asked about how they would allocate public funding to accelerate the deployment of, and help develop a sustainable market for, electric-drive vehicles. In asking this question, the respondents were prompted with the following statement and question:

Countries with various sizes of auto markets have budgets to support electric vehicle deployment that range from $100 million to several billion dollars per year. Imagine you are in control of this funding. You can allocate 100 chips of funding over the 2015-2030 period with the goal of accelerating deployment of electric vehicles to help create a sustainable market for all electric-drive technologies (one budget for plug-in hybrid, battery electric, and fuel cell vehicles). How would you spend the 100 chips?

Please enter the number of chips in funding that you would spend in the various areas related to electric-drive vehicles. Please make sure that your answers add up to 100 chips.

Figure 25 summarizes the results how the respondents would allocate public funding to promote electric-drive vehicles. The results are summarized for all the "chips" that were allocated by the Germany and US-based respondents. The results indicate general agreement between the German and US respondents, but with several subtle distinctions. In both cases, the highest allocation of public funding would be toward vehicle purchasing subsidies (37% for US and 27% for Germany). Combining tax incentives (e.g., reduction on vehicle ownership and registration taxes) with vehicle purchasing subsidies, the results were more similar (41% for US and 40% for Germany). This indicates the high importance of financial incentives, and it also suggests Germany experts' inclination to provide more of the incentive via taxation reductions for vehicle registration or ownership of electric-drive vehicles, rather than upfront subsidies. One difference shown in the results is Germany respondents' greater interest in allocating public funding to research and development (18% versus 11% for US). Both countries' respondents indicated that a large portion of the funding would ideally go toward fueling/charging infrastructure (including public, workplace, and home charging and subsidized fuel together), at about 29-33% of all the funding allocation. Consumer education and behavior research were both viewed as important parts of the allocation, receiving 13-15% of the public funding allocation.

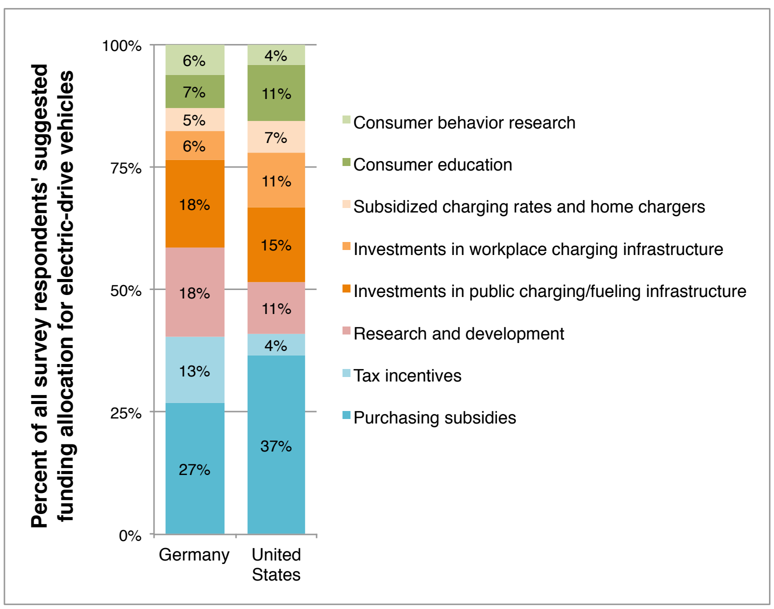


Figure 25. Survey respondents' funding allocation on electric-drive survey results for most effective incentives to increase the uptake of battery electric, plug-in hybrid, and fuel cell vehicles

VI. Conclusions

This report compares and contrasts the alternative fuel vehicle, electricity charging, and hydrogen refueling infrastructure policy landscape in California and Germany. The report's objectives are to assess the status of these two leading automobile markets' efforts to accelerate the transition toward an ultra-low carbon transport sector and identify the potential policy, infrastructure, and market environment barriers that precede future progress. The report includes a novel analysis of the California and Germany situations in accelerating the market for plug-in electric and hydrogen fuel cell vehicles and stakeholder interviews to identify and prioritize the most critical policy and market factors involved in the launch of these advanced technologies.

Summary of Germany-California differences

This report compiles information across many different dimensions of electric-drive vehicles, policy, infrastructure, and funding for Germany and California. There are many similarities and differences between the two jurisdictions. Related to electric-drive vehicle policy, both governments are driving technology into the market with progressively more stringent CO_2 standards. The 2020 European standards are slightly more stringent in absolute emissions-per-kilometer according to the laboratory test procedure, but the California standards are subject to a more rigorous in-use conformity program and provide additional electric-drive requirements through the ZEV program that have greatly accelerated the early electric vehicle market. California also supports the ZEV program with greater financial and non-financial incentives for consumers to purchase the advanced technology. In addition, California consumers are exposed to one of the more comprehensive systems of electric vehicle promotion actions, as compared to Germany's more fragmented system through its pilot programs. The two governments have each shown major commitments to infrastructure. California has provided more committed funding for charging and more support for workplace electric charging, whereas Germany has provided a stronger push for codes, standards and specification for industry. Both have committed to build out hydrogen refueling networks, with Germany's plans being more ambitious than California's. Both jurisdictions have built foundational government-industry initiatives to coordinate various stakeholder actions and outreach activities. Both governments promote action from low-carbon fuel providers and have programs to promote awareness and understanding among consumers. Finally, both governments have long-term climate planning that point toward deep carbon reductions to provide a vision for a shift to electric-drive in the transport sector.

Figure 26 summarizes the findings regarding new electric-drive vehicle sales in 2014 and the approximate value of per-vehicle incentives that are available to prospective new car buyers. The report also assesses the importance of many other policies, but the figure shows how substantially larger incentives are available in California, due to national and state fiscal subsidies and in the substantial approximate value of preferential use of the carpool lane. Together these California incentives are valued at about \$6,000 to \$11,000 per vehicle, compared to Germany's ownership and income taxation incentives that are valued at up to \$2,400 per electric-drive vehicle. Germany's and California's situations with respect to electric vehicle and infrastructure deployment, policy implementation, the usage and type of fiscal policies, and institutional organizations also differ quite considerably based on this assessment. In total, new electric-drive vehicle registrations in California in 2014 were about 60,000, compared to about 13,000 in Germany.

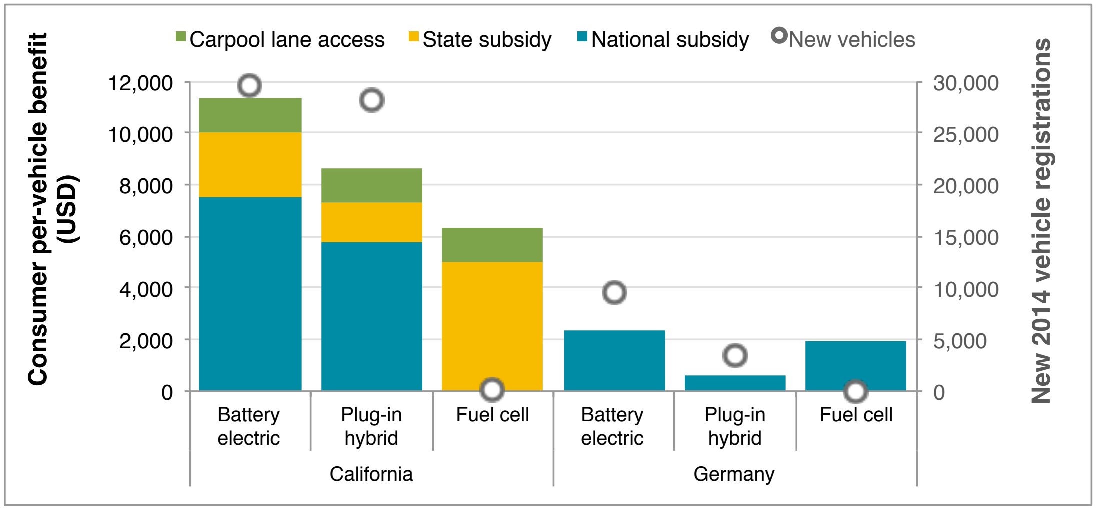


Figure 26. New vehicle registrations of electric drive vehicles and associated consumer incentives over six years for private cars and three years for company cars in California and Germany

Summary of results from expert survey

The survey of industry experts provided greater insight in questions about the foremost electric-drive obstacles, the most effective electric-drive incentives, and suggested funding to promote electric-drive vehicles in the United States and Germany. Questions were posed in each area for the three technology types – plug-in hybrid electric vehicle (PHEV), battery electric vehicle (BEV), and fuel cell electric vehicle (FCEV) – to help inform and prioritize unique obstacles and policies.

Responses from experts reveal that the obstacles for the new technologies are seen as quite similar in the two jurisdictions. For all technology types, the high vehicle price tends to most often be cited as a major obstacle. Also among the major obstacles are driving range and charging time for BEVs, as well as public refueling availability for FCEVs. Obstacles that are seen as more prominent in Germany include lack of government incentives and incompatible payment systems for PHEVs and BEVs, whereas US-based experts viewed lack of consumer awareness as a more significant obstacle for electric-drive vehicle uptake.

In reporting on the most effective incentives for PHEVs, BEVs, and FCEVs, the Germany and US-based respondents also offered several common and some differing views. For both jurisdictions for all three vehicle types, purchasing subsidies were cited as the most effective incentive. After consumer subsidies, Germany-based respondents viewed CO_2 standards more highly, whereas US-based respondents viewed the direct ZEV requirements and preferential vehicle access (e.g., carpool lane) as more impactful incentives to drive up PHEV and BEV sales. Both jurisdictions' respondents indicated that purchasing incentives and public hydrogen refueling infrastructure are the most effective actions for FCEVs.

After the questions about electric-drive vehicle obstacles and incentives, the Germany and US-based experts were asked to offer their views on the optimal allocation of funding to accelerate the market. Experts in both markets would put about 40% of the funding toward consumer incentives (subsidies and tax-based incentives), and about 25% of the funding toward charging and refueling infrastructure (including public charging, workplace charging, public hydrogen).

Respondents from both jurisdictions would put about 10-15% of the funding toward consumer education, outreach and awareness activities, and consumer behavior research. In the only moderate difference, Germany-based respondents would allocate about 18% of the funding to research and development, compared to 11% for US-based respondents.

Policy recommendations

This assessment points to a number of findings for Germany and California, as both jurisdictions look to accelerate the electric-drive market in the 2015-2025 timeframe. We draw the following five high-level recommendations for policy makers in Germany:

***Vehicle policy*.** Regulatory policy that sets a clear long-term signal to manufacturers for deeper carbon emission reductions will be necessary to drive investment and deployment strategies to develop the market for electric-drive vehicles. One important element in this respect is mandatory CO_2 standards for new vehicles that are increasingly stringent over the long-term. While the EU's CO_2 standards through 2021 – according to the laboratory test procedure – are still slightly more stringent than the respective standards in the U.S. and California, Europe will need to put more emphasis on 'real-world' enforcement of these standards by introducing not only a new test procedure but also additional in-production and in-use conformity testing from independent bodies. Test cycle improvements that aid in-use compliance, without proportional real-world CO_2 improvements, delay the shift to more advanced technologies, including electric-drive. Furthermore, the EU – with Germany playing an important role in these discussions – will need to introduce 2025 CO_2 standards that are at the lower end of the 68-78 g/km range suggested by the European Parliament in 2013, as well as 2030 standards that are in line with the long-term policy trajectories (*i.e.* around 50 g/km). This will help drive investment and deployment of more advanced combustion engines, hybrid-electric vehicles, and eventual a full electrification of the future vehicle fleet. Similarly, work in California toward 2026-2030 regulations that continue at least 4% per year CO_2 reduction for new vehicles would greatly help in its transition toward an electric-drive fleet.

Although stringent, long-term vehicle CO_2 standards are necessary, but they are insufficient by themselves in developing the early market for electric-drive vehicles without additional policy support. California's 2025 Zero Emission Vehicle requirements provide an unparalleled and strong investment signal in this respect. It is recommended that Germany consider a similar vehicle deployment requirement for manufacturers. Similar to the situation in the U.S., a ZEV-like policy could be implemented at state level (*i.e.* with Germany as the equivalent for California in the U.S.), complementing the EU-wide CO_2 standards, and helping to advance the German vehicle market into the lead market for battery and fuel-cell electric vehicles in the EU. As another alternative, the German government could consider making its continued public commitment to market development activities (like the showcase region projects), public incentive financing (e.g., rebates), or research and development funding contingent upon automaker's direct public pledges to increase electric-drive vehicle deployment at Zero Emission Vehicle-like levels (e.g., 10% of new vehicle sales in 2021-2022; 15% or greater by 2025). Stronger policies like this would likely be necessary to help achieve the German government's targets of 1 million electric drive vehicles by 2020 and 6 million by 2030. Making such policies technology-independent would best allow for companies to determine whether to deploy and help develop the market for plug-in hybrid electric, battery electric, or fuel cell electric vehicles.

Industry and economic assessments of the effects of an increasing electrification are outside the scope of this study. Yet, other studies point to the fact that in a scenario where Germany becomes a lead market for battery and fuel-cell electric vehicle production, this will help in securing and creating jobs and economic growth in the vehicle manufacturing industry (ELAB, 2012; ECF, 2013). In contrast to California, where there is relatively limited vehicle manufacturing, Germany's policies are key to not only drive the *demand* for electric vehicles but to lead in helping spur the *supply* for innovative electric-drive technologies. This provides another reason why electric vehicle deployment requirements should also be considered for Germany.

Public and private financing. CO_2 standards and ZEV-like vehicle deployment requirements need to be complemented by financial signals to guide the transition of consumers, infrastructure, and utilities toward an electric drive future. On the consumer side, our analysis shows that financial incentives for electric vehicles are substantially higher in California than in Germany. While purchase subsidies for electric vehicles certainly would be welcomed both by consumers and vehicle manufacturers, it is questionable whether this would be a sustainable avenue for a major market like Germany to incentivize the uptake of electric vehicles. Instead, it is recommended to adapt the vehicle taxation scheme in Germany to be in line with the policy objectives for reducing vehicle emissions and increasing the number of electric vehicles on the road. It is recommended that such fiscal policies promote plug-in hybrid electric, battery electric, and fuel cell electric vehicles to suit the automaker-specific technology strategies and the relative consumer advantages of each.

New financing and incentive policies could also be directly linked to vehicle technology in both Germany and California. A fee-bate scheme, taxing high-CO_2 emitting vehicles while providing a fiscal incentive to low-CO_2 emitting and particularly electric vehicles, is considered the best-practice option in this respect. Such a system would leverage the effect of vehicle CO_2 standards and ZEV-like deployment requirements and would help vehicle manufacturers to meet their respective targets, while at the same time ensuring revenue-neutrality for the German government, *i.e.* not resulting in any increased spending as would be the case with purchase subsidies. Such a program could also be important in California to create a long-term funding mechanism beyond 2020. In this context it is important to not only adapt the taxation scheme for private vehicles but also for company cars, as these account for the majority of new combustion and especially electric vehicle registrations.

On the infrastructure side, five to ten-year commitments to public and private financing for electricity charging and hydrogen refueling infrastructure enable improved automaker and infrastructure provider deployment decisions. Considering the differing growth of plug-in and hydrogen vehicles in the market, strategic planning with input on automakers' expected rollout strategies (e.g., at least 5 years forward), would ideally be a key input for the build out of charging and hydrogen refueling infrastructure over time.

Consumer engagement. Wide-ranging consumer awareness, education, and outreach regarding electric vehicles and their benefits will be critical in growing the early market. California consumers are exposed to a comprehensive and streamlined system of state and local incentives, charging infrastructure support, utility customer engagement, outreach events, and local informational tools. In comparison, the corresponding set of electric vehicle promotion actions in Germany appears to be more fragmented into many parallel pilot and incentive programs at a regional and local level, with the risk of confusing customers who are considering purchasing an electric vehicle. To engage early electric-drive consumers, it is recommended that Germany introduces **nationwide** fiscal (see point above on public funding) and non-fiscal incentives and awareness programs that draw from its own pilot program experience, as well as California's framework for comprehensive electric vehicle promotion action. Plug-in electric and hydrogen fuel cell vehicle types have substantially different consumer questions, and the two technologies are at different places with respect to their wider market development. We recommend that California and Germany continue to have separate programs devoted to helping overcome consumer understanding, awareness, and education issues for the two major technology types. Such activities could be led by prominent government-industry partnerships, with the associated consumer research by leading universities.

Stakeholder partnerships. Public-private partnerships are critical to align stakeholders' interests, assist and lead consumer and dealer outreach and awareness activities, as well as ensure that infrastructure investments and public expenditures are well prioritized. Both California (e.g., with the Plug-in Electric Vehicle Collaborative, and the California Fuel Cell Partnership) and Germany (e.g., with the Clean Energy Partnership and the SLAM project) have shown strong commitment to building such collaborative institutions. It is recommended to continue and extend these types of stakeholder partnerships in the future. Partnerships like these might be especially important in connecting the critical vehicle manufacturer, charging infrastructure provider, national and state government, local planning organization, and citizen group stakeholders to navigate broader issues in electromobility. The types of questions which are not yet well understood are how best to link early vehicle market development to public and company charging infrastructure, consumer awareness activities, public transit, car-sharing programs, and urban biking and walking.

International cooperation. Moving from this early phase in the development of an electric-drive market, past early adopters to a mainstream market, will require global cooperation to accelerate learning on consumer, financing, and policy best-practices. California and Germany would gain from continued technical and policy exchanges, with each other and with other leading electric-drive jurisdictions globally, in the years ahead. It is therefore recommended that the two jurisdictions increase their collaboration with each other through government ministries that are actively engaged on topics like vehicle technology, market data, incentives, infrastructure, and financing. It is also recommended that both jurisdictions foster international cooperation with the formation of, and increasing recruitment for, a global zero-emission vehicle fleet alliance that includes active participation from all leading electric vehicle markets.

The results from this assessment are broader than California and Germany. The readiness of these two markets for a transition to electric-drive is critical to the success in the US and Europe. Further, the potential for electric-drive commercialization success, potentially toward deep transportation carbon cuts for long-term climate stabilization, will require similar electric vehicle readiness actions and policy learning around the world. The success of electric vehicles in any one market will almost surely require that there is great success in electric vehicle deployment in many markets simultaneously. Commercial success throughout Europe, Asia, and the Americas would greatly increase innovation and economies of scale, and result in technology improvements and cost reductions. As a result, global policymaker cooperation, coordinated action and market signals, and continued re-assessment of best practices will be key.

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IMPRINT

Coordinated by:
National Organisation for Hydrogen and Fuel Cell Technology GmbH (NOW)
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Publication date:
March 2016