The deployment of BEV and FCEV in 2015

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This draft September, 2015

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Executive summary

In Europe the transport sector contributes about 25% of total GHG emissions, 75% of which come from road transport. Contrarily to industrial emissions road emissions have increased over the period 1990-2015 in OECD countries: California (+26%), Germany (0%), France (+12%), Japan (+2%), Denmark (+30%). The number of registered vehicles on road in these countries amounts respectively to: California (33 million), Germany (61.5 million), France (38 million), Japan (77 million), Denmark (4 million). Even if these numbers are not expected to grow in the future this calls for major programs to reduce the corresponding GHG emissions in order to achieve the global GHG targets for 2050. The benefits from these programs will spread out to non OECD countries in which road emissions are bound to increase.

Programs to promote zero emissions vehicles (ZEV) effectively started in the 2000ȏs through public private partnerships involving government agencies, manufacturers, utilities and fuel companies. These partnerships provided subsidies for R&D, pilot programs and infrastructure. Moreover, technical norms for emissions, global requirements for the portfolio of sales for manufacturers, rebates on the purchasing price for customers as well as various perks (driving bus lanes, free parking, etc.) are now in place. These multiple policy instruments constitute powerful incentives to orient the strategies of manufacturers and to stimulate the demand for ZEV. The carbon tax on the distribution of fossil fuels, whenever it exists, remains low and, at this stage, cannot be considered as an important driving force.

The cases studies reveal important differences for the deployment of battery electric vehicle (BEV) versus fuel cell electric vehicle (FCEV). BEV is leading the game with a cheaper infrastructure investment cost and a lower cost for vehicle. The relatively low autonomy makes BEV mostly suited for urban use, which is a large segment of the road market. The current level of BEV vehicles on roads starts to be significant with California (70,000), Germany (25,000), France (31,000), Japan (608,000) Denmark (3,000), but they remain very low relative to the targets for 2020: California (1.5 million), Germany (1 million), France (2 million), Japan (0.8-1.1 million for ZEV new registrations), Denmark (0.25 million). The developments and efficiency gains in battery technology along with subsidies for battery charging public stations are expected to facilitate the achievement of the growth. The relative rates of equipment (number of publicly available stations / number of BEV) provide indirect evidence on the effort made in the different countries: California (3%), Germany (12%),

[1] Chair Energy and Prosperity
[2] Chair Energy and Prosperity and Ecole Polytechnique
[3] CNRS and Ecole Polytechnique

France (28%), Japan (11%), and Denmark (61%). In some countries public procurement plays a significant role. In France Autolib (publicly available cars in towns) represents a large share of the overall BEV deployment (12%), and the government recently announced a 50% target for low emissions in all public vehicles new equipment.

FCEV is still in an early deployment stage due to a higher infrastructure investment cost and a higher cost for vehicle. The relatively high autonomy combined with speed refueling make FCEV mostly suited for long distance and interurban usage. At present there are only a very limited numbers of HRS deployed: California (28), Germany (15), France (6), Japan (31), Japan (7), Denmark (7), and only a few units of H2 vehicles on road: California (300), Germany (125), France (60), Japan (7), Denmark (21). However, a detailed analysis of the current road maps suggests that FCEV has a large potential. Targets for the 2025-2030 horizons are significant in particular in Germany (4% in 2030), Denmark (4.5% in 2025) and Japan (15-20% for ZEV new registrations in 2020). The California ARB has recently redefined its program (subsidies and mandates) to provide higher incentives for FCEV. France appears to focus on specialized regional submarkets to promote FCEV (such as the use of H2 range extending light utility vehicles). The financing of the H2 infrastructure appears as a bottleneck for FCEV deployment. Roadmaps address this issue through progressive geographical expansion (clusters) and a high level of public subsidies hydrogen refueling station (HRS) in particular in all countries except France.

At this stage of BEV and FCEV do not appear as direct competitors; they address distinct market segments. Unexpected delays in the development of infrastructure in FCEV, possible breakthroughs in battery technology, and the promotion of national champions may change the nature of this competition, making it more intense in the future.

1. Technical and economic factors that drive the deployment of BEV and FCEV

This section introduces the characteristics of both BEV and FCEV with the corresponding challenges linked to their deployments.

The ZEV fleet is composed of BEVs, FCEVs and sometimes PHEV. The two first segments are quite different in terms of utilizations and deployments.

As shown on the following figure, BEV has a short range of driving compared to FCEV, which has autonomy of more than 300 km. Thus, FCEV can be used for long distance, interurban and urban, while BEV are more suited for urban or a short interurban. In France, these different usages correspond approximately to 30% for urban, 40% for interurban and 30% for long distance[4].

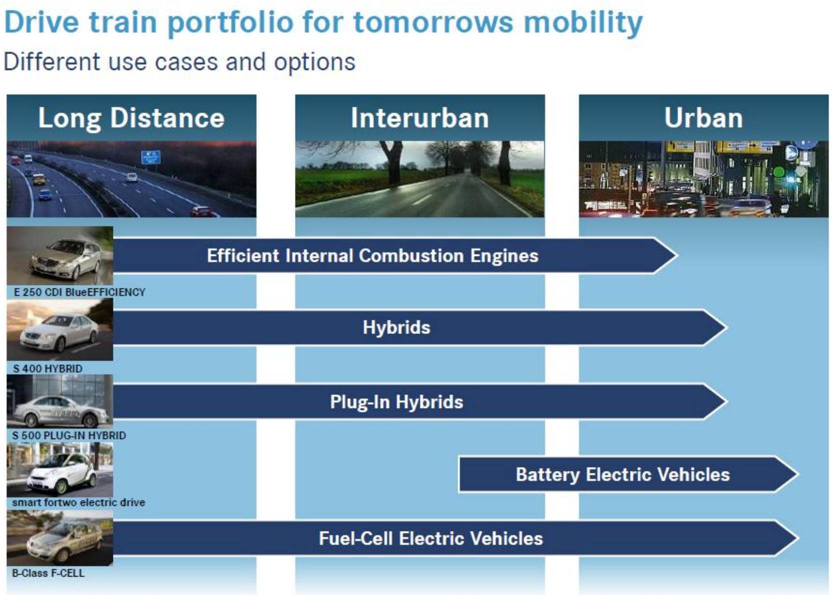

Figure: Drive train portfolio for tomorrows mobility[5]

While fuel cell technology had attracted a higher level of R&D funding than battery technology in the early 2000ŏs the situation has now reversed. In 2014, the number of patents published in battery and fuel cell fields are respectively 5,000[6] against 500[7].

Concerning the cost of the vehicle as such, direct comparison is difficult. BEV are mostly small vehicles for urban applications, FCEV are mostly sedan vehicles. The most sold BEV is the Nissan Leaf with a price around ú28k[8], battery included. The price of the Toyota Mirai should be around ú66k in Europe[9].

[4] *http://www.atmopaca.org/files/et/081105_AtmoPACA_note_synthese_transport_colloque_ORT.pdf*
[5] Mercedes
[6] *https://relecura.com/reports/Tesla_EV.pdf*
[7] *http://energy.gov/eere/articles/fuel-cell-technologies-office-reaches-major-patent-milestone*
[8] Nissan website
[9] Toyota website

In terms of fuel cost, it is around ú2/100km (ú10.5/kWh)[10] for BEV against ú10/100km (ú10/kgH2) for FCEV. For a comparable sedan ICE (consumption of 8l/100km) and a gasoline price of ú1.6/l, fuel cost would be ú12.8/100km.

In terms of energy efficiency a broad perspective need to be taken. For BEV the efficiency of the battery and transportation and distribution (T&D) reaches 75%.[11,12] For FCEV, as shown in the next figure, several steps should be considered, and the efficiency of these steps depends on the technology in use. While the fuel cell efficiency is around 40 to 60%, the final efficiency is around 24%. In comparison, the efficiency of ICE would be around 25% just by considering the engine.

Figure: Efficiency of hydrogen application for energy[13].

The deployment of BEV and FCEV requires the simultaneous ramp-up of vehicles and the deployment of the infrastructure. This is known as the chicken-egg-dilemma. On the one hand, the car manufacturers donôt want to sell FCEV in large series if they are not sure about the density of infrastructure available. On the other hand, nobody wants to invest in the infrastructures if there is no fleet to feed. This dilemma is particularly relevant for FCEV.

Two strategies to overcome this chicken-and-egg dilemma have been used for FCEV. The first one is to build on a captive fleet. A captive fleet is a group of vehicles (companies, governmental agencies with large delivery fleet). This greatly facilitates the forecasting of fuel consumptions, and the deployment needs of the corresponding network. The second strategy is to rely on public subsidies to quickly set up a large infrastructure, possibly focusing first in clusters and then on expansions to interregional roads. In this case, the state expects to gain the trust of car manufacturers and customers in favor of FCEV.

The infrastructure deployment issues of BEV and FCEV are different in many points. BEV deployment needs a higher density network because the range of BEV is lower than the one of FCEV. The location of the stations needs to take into consideration the necessary time to recharge the battery.[14] Terminals close to (or in) the usersô house and on her work location would be particularly appropriate. For FCEV the range is higher and filling time is much quicker (3-5 minutes) so stations location depends on the intensity of the corresponding traffic. Another important difference between these two deployments concerns the investment cost of the stations and their maintenance. In countries with a well-developed electrical network, the cost of BEV terminals is relatively low. There is no need for specialized maintenance. On the contrary, the deployment cost of the FCEV infrastructures is relatively high and requires a hydrogen distribution network. Moreover, HRS cannot be installed anywhere because of security and safety regulations.

[10] *http://www.breezcar.com/actualites/article/consommation-voiture-electrique-autonomie-et-batteries-2014*
[11] *http://large.stanford.edu/courses/2010/ph240/sun1/*
[12] *http://www.eia.gov/tools/faqs/faq.cfm?id=105&t=3*
[13]*http://www.iea.org/publications/freepublications/publication/TechnologyRoadmapHydrogenandFuelCells.pdf*
[14] The relatively low investment cost of electrical terminals, explains why a company like Tesla invests in its own high speed infrastructure network to encourage its sales.

2. Methodology

For each country the following grid of analysis is used.

1. Targets
    a. Global targets
        i. Current % of GHG emissions for road transportation and evolution relative to 1990
        ii. Total car park in 2015, average annual growth trend
    b. Roadmaps for BEV and FCEV
        i. Specific targets
        ii. Institutional framework (public, public private partnership)
        iii. Financing (global budget dedicated to the roadmap)
        iv. Miles stones
        v. Public procurement

2. Main Policy Instruments
    a. Manufacturers
        i. Technical norms and the way they are applied
        ii. Mandates (minimum requirements for portfolio with a market)
    b. Infrastructure
        i. Subsidies for different types of infrastructures
    c. Customers
        i. CO_2 tax (how it is operated; rough quantification of the level of the tax ú/t and ú/liter for a given car emitting xg/CO2 per km and xú/liter of fuel)
        ii. Rebates on purchase price
        iii. Perks (parking, driving lanes, private subsidiesé)

3. Deployment as of 2015
    a. Manufacturers
        i. How manufacturers have complied or intend to comply with the norms, the minimum requirements
        ii. Illustration of some global strategies of players: Tesla (Cal), Daimler (Germany), Symbio Fuel Cell (France), Toyota (Japan), Better Place (Denmark)
    b. Infrastructure
        i. How many stations, what types of stations, where
        ii. Who is actually operating the stations
    c. Customers
        i. Number of vehicles by segments (light duty vehicles, utility vehicles, of which through public procurement including auto lib, busesé)

3. Summary of the cases studies

Country	Total Car Park	Targets		Policy Instruments			Deployment as of 2015		
		BEV	FCEV	BEV	FCEV	Public Procurement	BEV	FCEV	ZEV+PHEV
California	33M 33% of GHG emissions +26% 2012/1990	1.5M (4.5%) in 2025	18.5k (.05%) in 2020	$360M for infra ($100/unit) $10,000 rebate BEV: ~ ú14.4 k ICE: ~ ú14.4 k	$20M for infra ($300/unit) 100 HRS in 2025 $12,500 rebate FCEV: ~ ú60.5 k ICE: ~ ú57.1 k	10% in 2015 25% in 2020	~ 2,500 public stations ~ 70k vehicles R = 3% (nb stations/nb vehicles)	28 HRS 300 vehicles	3.2%
Germany	61.5M 20% of GHG emissions 0% 2012/1990	1M (2%) in 2020	250k (.04%) in 2023 1.8M (3%) in 2030	ú130M for infra (ú150/unit) BEV: ~ ú25.5 k ICE: ~ ú15.8 k	ú350M for infra (ú1600/unit) 400 HRS in 2023 1000 HRS in 2030 FCEV: ~ ú78.5 k ICE: ~ ú62.7 k	10% from 2013	~ 2,900 public stations ~ 25k vehicles R = 12%	15 HRS 125 vehicles	0.2%
France	38M 25% of GHG emissions +12,4% 2009/1990	2M (5%) in 2020	No	ú50M for infra (ú26/unit) ú6,300 of eco bonus BEV: ~ ú19.4 k ICE: ~ ú16.2 k	No national subsidies ú6,300 of eco bonus FCEV: ~ ú72.9 k ICE: ~ ú63.5 k	50% in 2015	~ 8,600 public stations ~ 31k vehicles R = 28%	6 HRS ~60 vehicles	0.6%
Japan	77M 20% of GHG emissions + 2% 2012/1990	0.8-1.1M (15-20%) of new car registrations in 2020		ú11,000/station ú4,600 rebate BEV: ~ ú18.5 k ICE: ~ ú15.0 k	ú27M for demo and infra ú14,800 rebate FCEV: ~ ú57.6 k ICE: ~ ú59.5 k	n/a	~11,500 public stations ~ 608k vehicles R = 11%	31 HRS 7 vehicles	0.7%
Denmark	4M 22% of GHG emissions +30% 2010/1990	250k (6%) in 2020	110k (3%) in 2025 50% in 2050	ú5.4M /year for infra (ú4.5/unit) tax exemptions BEV: ~ ú26.8 k ICE: ~ ú33.0 k	ú30M for infra (ú166/unit) 185 HRS in 2025 tax exemptions FCEV: ~ ú82.5 k ICE: ~ ú153.2 k	n/a	~ 1,700 public stations ~ 3k vehicles R = 61%	7 HRS 29 vehicles	1.5%

Definition of the indicators used in the table

Total car park

The total car park includes all type of vehicles public and private (trucks, buses, passenger cars, etc.).

The percentage increase in GHG represents the variation of the road transport emissions in the country between the two dates indicated.

Targets

The targets concerning BEVs and FCEVs are given in percentage of the total car park.

Policy instruments

State investment is divided by the target to obtain a comparative indicator.

Subventions and rebates on a typical BEV (Renault ZOE) and FCEV (Toyota) are applied and the corresponding purchase car is compared to the purchase price of a similar ICE vehicle (Clio Diesel and Mercedes CLS).

The policies procurement is given as the percentage of ZEV, which has to be acquired by the public entities when they renew their fleet.

Deployment as of 2015

The figures concern deployed stations and vehicles on roads.

The ratio indicated in the BEV column is the number of stations divided by the number of corresponding vehicles.

The last column gives the ratio of ZEV divided by the passenger car fleet (not the total car park).

4. Case Studies

California

1. Targets
    a. Global targets

In 2015 California committed to a 80% decrease of its greenhouse gas emissions in 2050 relative to 1990, setting 40% as an intermediate target for 2030[15]. In 2013 its emissions amounts to 459 MMT (versus 431 in 1990).

Road transport in California accounts 33M vehicles. The market is mature and is expected to grow quite slowly in the future. Road transport amounts to 33% of total emissions[16]. Total emissions from road transport in the US increased by 26% from 1990 to 2012[17].

b. Specific targets for BEV and FCEV

In 2009 the American Recovery and Reinvestment Act set aside funds for research and industrialization of alternative vehicles and targeted to put 1 million environmentally friendly vehicles on US roads by 2015.[18]

In March 2012, California set a long-term target of reaching 1.5 million zero CO_2 emissions vehicles on its roadways by 2025 in the context of achieving Californiaǿs air quality, climate and energy goals. ZEVs include hydrogen fuel cell electric vehicles (FCEVs) and plug-in electric vehicles (PEV), which include both pure battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEV).

In 2013 the Assembly Bill 8[19] in California re-authorized multiple state wide programs, including the Air Resources Boardǿs (ARB), the Air Quality Incentive Program (AQIP) and the Energy Commissionǿs Alternative and Renewable Fuel & Vehicle Technology Program (ARFVTP), and renewed the commitment to invest in the development and deployment of advanced technologies through 2023.

c. Roadmaps for BEV and FCEV

15 Assembly Bill 32
16 California Environmental Protection Agency
17 US Environmental Protection Agency
18 The American Recovery and Reinvestment Act (ARRA) (2009) *http://www.recovery.gov/arra/About/Pages/The_Act.aspx*
19 Perea, 2013

Roadmap for ZEV (2013, PP) [20]

By 2015

- The state's major metropolitan areas will be able to accommodate ZEVs through infrastructure plans and streamlined permitting
- Private investment and manufacturing in the ZEV sector will be growing
- The state's academic and research institutions will contribute to ZEV market expansion by building understanding of how ZEVs are used

By 2020

- The state's ZEV infrastructure will be able to support up to 1 million vehicles
- The costs of ZEVs will be competitive with conventional combustion vehicles
- ZEVs will be accessible to mainstream consumers
- There will be widespread use of ZEVs for public transportation and freight transport

By 2025

- Over 1.5 million ZEVs will be on California roadways and their market share will be expanding
- Californians will have easy access to ZEV infrastructure
- The ZEV industry will be a strong and sustainable part of California's economy
- California's clean, efficient ZEVs will annually displace at least 1.5 billion gallons of petroleum fuels

Targets for public procurement of light duty vehicles (10% in 2015 25% in 2020)

Road map for FCEV[21]

A detailed road map for FCEV has been originally formulated in 2009. California is divided in 5 clusters (Berkeley, West LA, Coastal/South OC, South SF/Bay, Torrance). The vehicles fleet is expected to be deployed in the clusters and then be expended through the whole network.[22]

In 2014 the forecasts have been decreased. In 2017, a total of 6,600 vehicles is expected of which around 2,600 will be out of the clusters (versus 49,600 in the 2009 road map). In 2020, 18,500 units are now expected with 7,500 in the expended network, it would represent 2% of the targeted ZEV fleet.[23]

[20] 2013 ZEV action plan *http://opr.ca.gov/docs/Governor%27s_Office_ZEV_Action_Plan_%2802-13%29.pdf*

[21] 2009, 2014, PPP

[22] ñHydrogen Fuel Cell Vehicle and Station Deployment Plan: A Strategy for Meeting the Challenge Aheadòby California Fuel Cell Partnership,2009

23 ñA California Road Map : The Commercialization of Hydrogen Fuel Cell Vehiclesò by California Fuel Cell Partnership, 2014

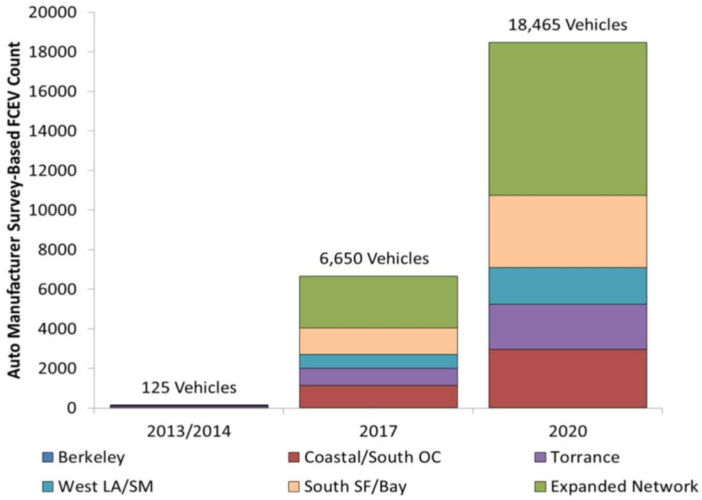

Figure: Cumulative Statewide FCEV Populations (By Cluster) from California Road map 2014

The case of the Hydrogen Refueling Stations (HRS)

100 HRS are expected to be built by 2020, after they planned to expand the capacities of the stations and increase their counts in the cluster regions of the high customer density. Then, there will be an open market for HRS and no more need to inject public money in the network.

To evaluate the HRS deployment, itôs important to compare the past roadmaps. The 2009 roadmap, made by the CaFCP was too optimistic (53000 kg/day in 2015 equivalent of almost 300 stations of 180kg/day) and the update of 2014 gave totally different numbers. There has been a significant delay in the deployment of HRS between the objectives fixed by the ARB in 2013 and those from CaFC in 2014. But this delay had no impact because the objectives remain the same. Indeed, as most of HRS planned had already been funded by the CEC or the State of California, the overall objectives can still probably be reached.

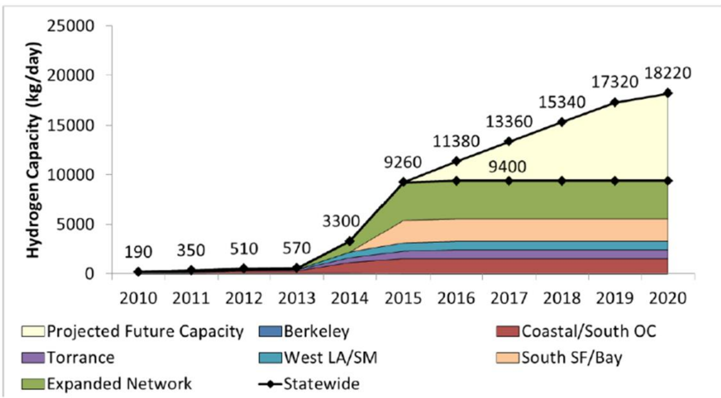

Figure: Hydrogen capacity planned[24]

[24] ñA California Road Map : The Commercialization of Hydrogen Fuel Cell Vehiclesò by California Fuel Cell Partnership, 2014

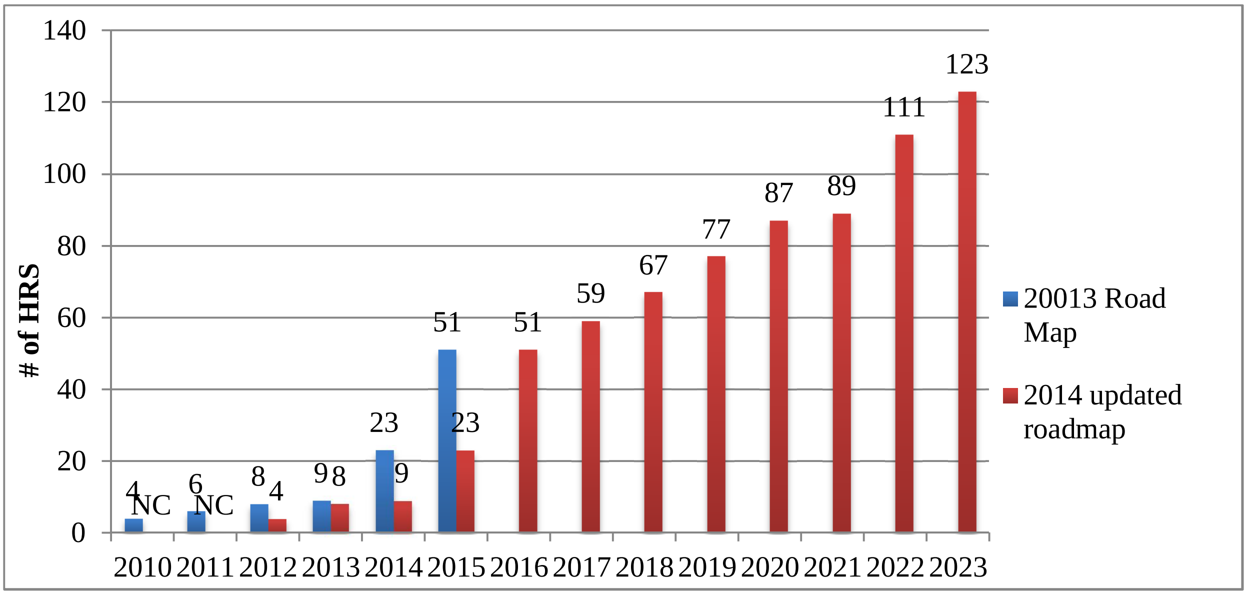

Figure: HRS deployment roadmap variations[25]

2. Main Policy Instruments

In the fiscal year 2015 Budget, the American government allocated $6.9 billion to clean energy technology programs including $5.2 billion for Department of Energy (DOE) projects. The Budget plans also the establishment of an Energy Security Trust that would invest $2 billion over ten years on cost-effective transportation alternatives[26,27].

a. Manufacturers

The reduction of greenhouse gas emissions for road transportation has been implemented in two phases. Up to 2018, manufacturers of passenger cars, light duty trucks, and medium duty vehicles with annual sales greater than 60,000 vehicles must deliver for sale in California a minimum percentage of ZEV for each period[28]:

Model Year (MY)	2010-2011	2012-2014	2015-2017
ZEV Requirement	11%	12%	14%

[25] ñAnnual Evaluation of Fuel Cell Electric Vehicle Deployment And Hydrogen Fuel Station Network Developmentò,2014 by ARB
[26] *https://www.whitehouse.gov/sites/default/files/microsites/ostp/Fy%202015%20R&D.pdf*
[27] *http://web.law.columbia.edu/climate-change/resources/climate-action-plan-tracker/cut/innovation*
[28] 13 Cal. Code Regs. § 1962.1

If the manufacturers fail to comply, they are subject to financial penalties outlined in Health and Safety Code 43211. These penalties include $5,000 (ú3,700) penalty for each ZEV credit not produced.

From 2018 mandates will be introduced through a market mechanism. The amount of ZEV credits generated from the sale of a ZEV is determined by the vehicleǿs range. For example, a vehicle with a range of 100 miles generates 1.5 ZEV credits. Vehicles with longer ranges can generate up to four credits per ZEV. Yearly requirements for delivering credits for each manufacturer are as follows:

Model Year	2018	2019	2020	2021	2022	2023	2024	2025
ZEV Requirement	4.5%	7%	9.5%	12%	14.5%	17%	19.5%	22%

Currently, there are 10 other States that have adopted Californiaǿs ZEV regulations: Connecticut, Maine, Maryland, Massachusetts, New Jersey, New Mexico, New York, Oregon, Rhode Island, and Vermont[29]. These states are committed to having at least 3.3 million ZEVs operating on their roadways by 2025. Their objectives in term of ZEV share by state are not the same because California is in advance.

The ZEV credits can be traded between companies of the same region without extra price whereas any credits traded between West region pool and East Region Pool will incur a premium of 30% of their value. For example if a company A from East region pool needs 100 credits to make up a car model, it has to buy 130 ZEV credits to the company B which is in West Region Pool.[30]

b. Infrastructure

For BEV infrastructure there is a tax credit of 30% of the cost, not to exceed $30,000 (ú27,000), for commercial EV charger installation; and a tax credit of up to $1,000 (ú900) for consumers who purchase qualified residential EVSE. A total budget of $360 million (ú331.2 million) for BEV infrastructure demonstration projects is allocated through federal funding via the EV project.

For the FCEV infrastructure there is a specific funding through the national program of the California Energy Commission. In June 2013, the California Energy Commission approved $18.69 million (ú13.7 million) in grants for projects that will expand the stateǿs fuelling infrastructure for FCEV[31]. The State of California has already provided co-funding

[29] CARB Staff Report, Initial Statement of Reasons, 2013 Minor Modifications to the Zero Emission Vehicle Regulation (Sept. 4, 2013)
http://www.arb.ca.gov/regact/2013/zev2013/zev2013isor.pdf.

[30] *http://www.arb.ca.gov/regact/2014/zev2014/zev14isor.pdf*
http://www.arb.ca.gov/regact/2014/zev2014/zevattachmentb.pdf

[31] Energy Commission Awards More Than $18 Million to Expand Hydrogen Fuelling Stations in California: *http://www.energy.ca.gov/releases/2013_releases/2013-06-*

for 9 public hydrogen-fuelling stations[32] and in September 2013 a provision to fund at least 100 publicly available hydrogen-refueling stations was signed into law with a commitment of up to $20 million (ú14.7 million) per year for 10 coming years[33].

c. Customers

The cap and trade introduced in California in 2012 includes fuel retailers.[34] The carbon price is set by a market mechanism. In 2015 it is around $12 (ú11), close to its floor set at $10 (ú9) (the ceiling is at $40 (ú36)). Floor and ceiling prices are increasing by 5% per year plus inflation over the period 2012/2020.

With a price of $3.5 (ú3.15) for a gallon, a car using 3 gallons and emitting 15 kg/CO2 for 100km, the impact of the carbon price is approximately less than 2%.

California State provides a wide range of incentives for consumers in form of direct subsidies. The total purchase subsidies for ZEV (Federal tax credit, California clean vehicle rebate) can reach ú12,500 (for FCEV) and ú10,000 (for BEV).[35] To obtain this significant subsidy, the consumer has an access to different programs:

- Federal New Qualified Plug In Electric Drive Motor Vehicle Credit.[36] It is an income tax credit of zero to $7,500 (ú6,600) for the purchase of a new qualified plug in electric drive motor vehicle.
- Since 2014 the Clean Vehicle Rebate Project offers rebates of up to $5,000-2,500 (ú4,600-2,300) per passenger vehicle (FCEV-BEV) to individuals, nonprofit and government entities and business owners who purchase or lease a new eligible zero CO2 emissions vehicle.[37] A total of $55.7 million (ú41 million) has been allocated between 2009 and 2013 under Clean Vehicle Rebate project. For 2014-15, the California Energy Commission approved the transfer of $5 million to CVRP to augment funding freeway capable ZEVs certified for four or more passengers.[38]
- San Joaquin Valley Air Pollution Control District (SJVAPCD) administers the Drive Clean! Rebate Program, which provides rebates for the purchase or lease of eligible new vehicles (including qualified natural gas, hydrogen fuel cell, propane, zero-emission motorcycles, battery electric, neighbourhood electric, and plug-in electric

12_award_expand_CA_hydrogen_fueling_stations_nr.html

32 Government Funded Hydrogen Stations http://www.arb.ca.gov/msprog/zevprog/hydrogen/hydrogen_stations.htm

33 Governor Brow Signs Assembly Bill 8
http://cafcp.org/getinvolved/stayconnected/blog/ governor_brown_signs_ab_8

34 http://www.arb.ca.gov/cc/capandtrade/capandtrade.htm

35 Income dependent as of July 2015. http://www.roadandtrack.com/car-culture/buying-maintenance/news/a26001/california-fuel-cell-bev-phev-tax-rebates/

36 26 U.S. Code § 30D
https://www.law.cornell.edu/uscode/text/26/30D

37 Clean Vehicle Rebate Project
http://energycenter.org/clean-vehicle-rebate-project

38 Source: Center for Sustainable Energy at https://energycenter.org/clean-vehicle-rebate-project.

vehicles). The program offers rebates of up to $3,000 (ú2,700), which are available on a first-come, first-served basis for residents and businesses located in the SJVAPCD.[39]

Moreover, companies such as Google and SONY Picture Entertainment offer $5,000 (ú4,600) to their employee whenever they buy an electric car. Software company Evernote subsidies $250 (ú230) every month to their employee who bought an electric car. Many companies in Silicon Valley also offer free workplace charging such as Facebook, Amazon, Microsoft, etc.

3. Results as of 2015

a. Manufacturers

The manufacturers can generate ZEV credits by exceeding minimum standards on ZEV. Moreover, they are allowed to transfer the credits earned. Between October, 1st 2013 and September, 30th 2014, seven manufacturers transferred credits out of their balances, and seven more transferred credits into their balances. The transfer of credits allows each manufacturer to strategically comply with the regulation.

In 2014 the market price of ZEV credits was estimated to be around $4,000 (ú3,700).[40]

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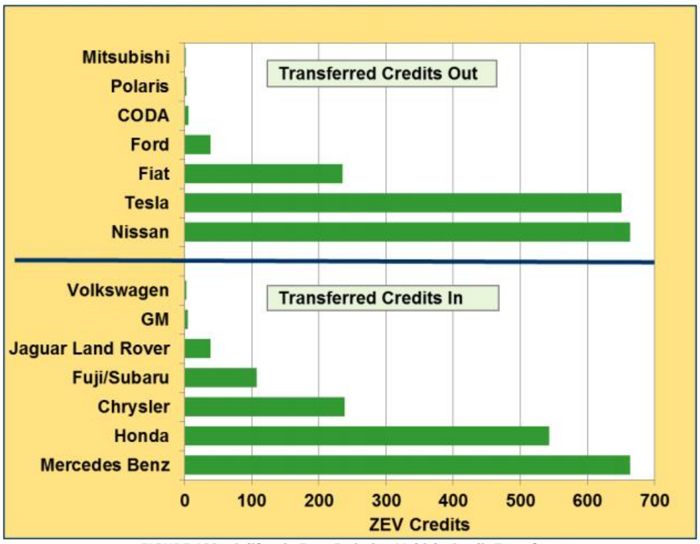

FIGURE 122. California Zero Emission Vehicle Credit Transfers

Note: Transfers between October 1, 2013 and September 30, 2014.

Source:
California Air Resources Board, "2013 Zero Emission Vehicle Credits," http://www.arb.ca.gov/msprog/zevprog/zevcredits/2013zevcredits.htm, accessed February 10, 2015.

The chart above shows that Nissan and Tesla transferred over 500 ZEV credits out while Honda and Mercedes Benz transferred over 500 credits in.

[39] Drive Clean! Rebate Program
http://valleyair.org/grants/driveclean.htm
[40] http://wattsupwiththat.com/2014/03/12/analysis-tesla-may-have-made-over-100-million-off-the-carb-enabled-battery-swap-scheme/

The new-born ZEV credits market generates extra revenue models for companies, which produce a large number of BEV (like Tesla and Nissan) and sell ZEV credits to its pollutant competitors. For example, in 2013 Teslaês sales of ZEV and U.S. Corporate Average Fuel Efficiency credits generated $194.4 million, or about 9.7% of its annual revenue.

Three automakers sell FCEVs in California: Honda with the FCX Clarity, Toyota with the Mirai, and Hyundai with the ix35 model. More, several automakers have announced collaboration on FCEV technology (BMW Group and Toyota Motor Corporation in June 2012, Daimler with Ford Motor and Nissan Motor Company in January 2013, GM and Honda in July 2013).

Tesla

Tesla Motors is a California based automotive and energy storage company that designs, manufactures, and sell electric cars, electric vehicle power-train components, and battery products. Tesla first gained widespread attention following their production of the Tesla Roadster, the first fully electric sports car. The company's second vehicle is the Model S, a fully electric luxury sedan, and its next two vehicles are the Models X and 3. As of March 2015, Tesla Motors has delivered about 70,000 electric cars since 2008.

The key of its success could lie in the integrated approach to the BEV manufacturing and sells. Tesla develops in house almost all components across the BEV value chain, including battery packing, EV manufacturing and sale, infrastructure manufacturing and deployment and operation. Moreover, Tesla develops and implies an innovative approach towards all components: vehicle itself, battery, and infrastructure.

Teslaês revenue model is original. Tesla sells BEV within an ownership-as-usual model (including expensive batteries). It generates an additional income both by licensing products and technology on battery management and power-train to other OEMs (Daimler-Smart/ Toyota RAV4); and by trading EV credit in ZEV program. As it was said above, in 2013 Teslaês sales of ZEV and U.S. Corporate Average Fuel Efficiency credits generated $194.4 million, or about 9.7% of its annual revenue.

Tesla also enjoys government support: it received an US government loan and benefits from government incentives which vary across different states and countries. However, according to different estimations Tesla will not turn profitable before 2020.

Innovative approach towards battery lies in providing an expanded autonomy, which creates a strong differentiation feature compare to other car manufacturers. Teslaês battery characteristics include: 70 or 85 kWh battery pack (vs 16-24 kWh battery pack), 335 km autonomy (vs 100 km to 160 km), and a good knowledge on management system. The battery (even for a high cost) is sold to customers along with the vehicle, accompanied by possibility for extra purchase.

Innovative approach towards infrastructure system is highlighted by the fact that Tesla deploys the recharging infrastructure alone. Tesla covers all the cost: installment, maintenance and network reinforcement if needed. Moreover, it provides an open source patents for its competitors. Teslaǿs infrastructure provides a free entrance for Tesla users.

Tesla created a new value configuration leading to more integration. It introduced new Powerwall home batteries for storing home solar energy and so provides independent and carbon free solutionǿs package, which includes solar panel, Tesla home battery, and Tesla electric vehicle.

b. Infrastructure

The state of infrastructure in place for both BEV and FCEV is given in the following table:

	BEV	**FCEV**
Number of stations	As for May, 2015, 2,216 public charging stations[41]	As for May, 2014 9 HRS existing and 19 HRS under development[42]

Charging stations have been manufactured by different companies (Blink, Nissan, GEé) and deployed by ECOtality[43] with many partners[44] of the EV project. ECOtality filed for bankruptcy protection in 2013 and has been bought by Car Charging Group one month later.[45]

At the end of 2015, 68 HRS are to be installed in California of which 51 providing hydrogen for public utilization: 45 in the cluster and 23 for the expended network. The deployment in the South Clusters will be higher the North. Only few stations with high capacity (210kg/day average) have been built in the North whereas in the South there will be more stations with lower capacity (150kg/day average). These stations deliver hydrogen under 70MPa or/and 35MPa and are operated by entities like Chevron, Shell, Air Product, Air Liquide.

c. Customers

The current ramp-up for ZEV in California is given in the following table:

[41] Alternative Fuels Data Center
http://www.afdc.energy.gov/fuels/stations_counts.html
[42] California Energy Commission
http://www.energy.ca.gov/releases/2014_releases/2014-05-01_hydrogen_refueling_stations_funding_awards_nr.html
[43] *http://www.theevproject.com/overview.php*
[44] *http://www.theevproject.com/partners.php*
[45] *http://www.carcharging.com/about/*

Registrations		2010	2011	2012	2013	2014
BEV[46]	#	300	5,302	5,990	21,912	39,536
FCEV[47]	#					125
PHEV[48]	#	97	1,662	14,103	20,633	29,935

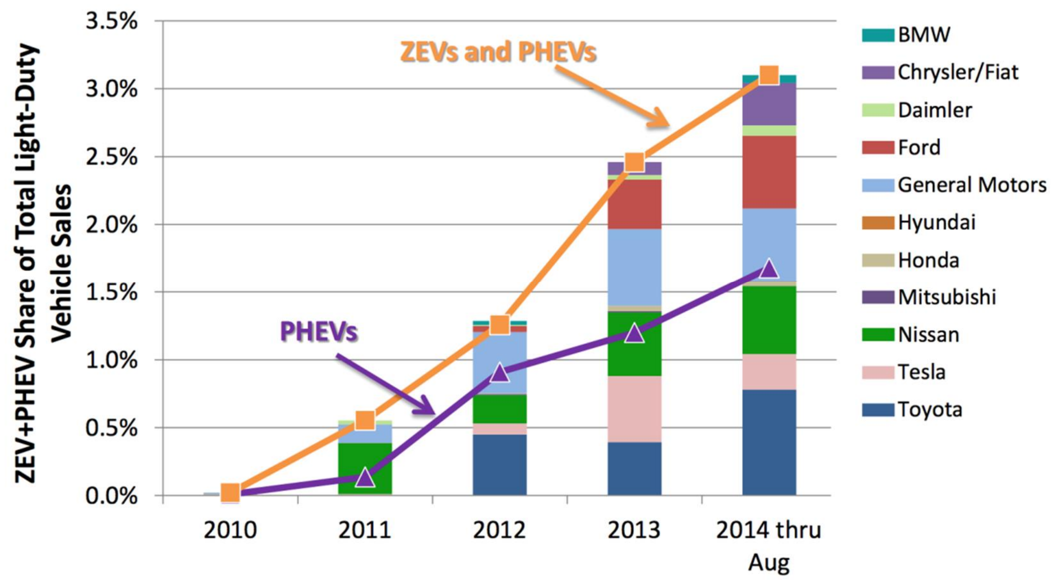

Figure: ZEV+PHEV share[49]

[46] IHS Automotive
http://www.cncda.org/CMS/Pubs/Cal_Covering_4Q_14.pdf
[47] 2014 Update: Hydrogen Progress, Priorities and Opportunities (HyPPO) Report
http://cafcp.org/sites/files/Roadmap-Progress-Report2014-FINAL.pdf
[48] IHS Automotive
http://www.cncda.org/CMS/Pubs/Cal_Covering_4Q_14.pdf
[49] *http://www.theicct.org/sites/default/files/5c_ARB_ZEV.pdf*

Germany

1. **Targets**
    a. Global targets

Officially launched in fall 2010, Germanyôs ñEnergy Conceptò is a long-term energy strategy for the period up to 2050. The aims of the plan are ambitious in their sweep but simple in their intent: the securing of a reliable, economically viable and environmentally sound energy supply to make Germany one of the most energy-efficient and green economies in the world.

In 2007 Germany has set itself the ambitious target of achieving a 40% reduction on 1990 CO2 emission levels by 2020. Germany has so far (2014) achieved a reduction of 27% on 1990 CO2 emission levels[50]. In the energy industry sector, which is responsible for the largest share of Germanyôs greenhouse gas emissions (around 40%), emissions fell by 24% between 1990 and 2014, while the transport sector only reduced its emissions by 0.2%. Road transport in Germany accounts 61.5M vehicles. There are around 880 vehicle models on the German market today with emission levels of about 130g/km of CO2[51].

Germany is the largest European market in terms of new passenger car registrations. New passenger car registrations reached 3.1 million in 2012. New passenger car registrations dominated the one of light commercial vehicles (LCV): among 3,682,000 of new registered both PC and LCV, the 93% share of new registrations was due to passenger cars[52].

German passenger car market becomes saturated and the growth is supposed to be marginal in the future[53]. The total passenger car fleet for all owner groups is predicted to increase from 44.2 million today (2014) to a maximum of 45.2 million in 2022 and then fall to 42.7 million passenger cars in 2040[54].

    b. Specific targets and roadmaps for BEV and FCEV
        i. Vehicles

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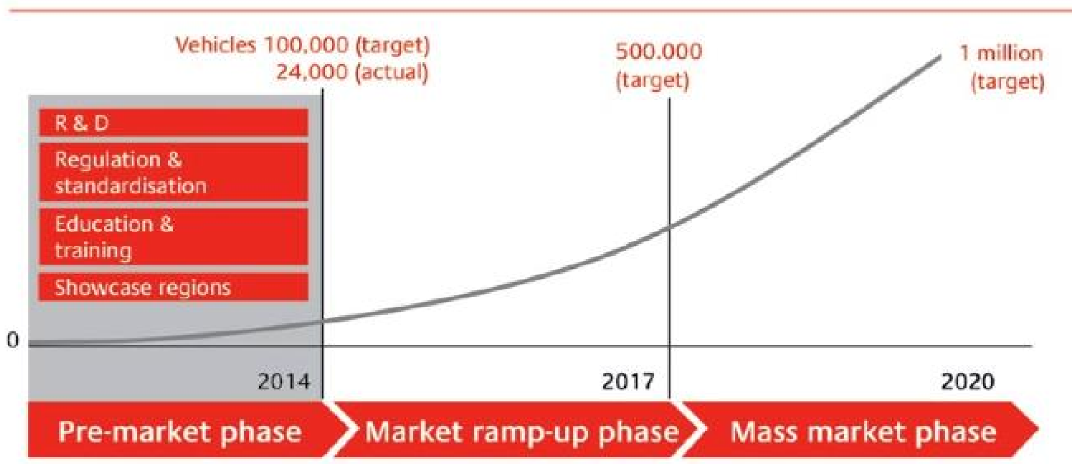
[50] Clean Energy Wire *https://www.cleanenergywire.org/factsheets/germanys-greenhouse-gas-emissions-and-climate-targets*
[51] Germany Trade & Invest, 2015, Electromobility in Germany:Vision 2020 and Beyond http://www.gtai.de/GTAI/Content/EN/Invest/_SharedDocs/Downloads/GTAI/Brochures/Industries/electromobility-in-germany-vision-2020-and-beyond-en.pdf
[52] ICCT 2013, European Vehicle Market Statistics Pocketbook 2013
[53] Shell Passenger Car Scenarios up to 2030
[54] Shell, 2014, Shell Passenger Car Scenarios for Germany to 2040 http://www.prognos.com/uploads/tx_atwpubdb/140900_Prognos_Shell_Studie_Pkw-Szenarien2040_summary_EN_01.pdf

Germany sets ambitious ZEV deployment objectives. In its program for electric mobility announced in May 2011, the German federal government has set a goal of one million EV on German roads by 2020 as part of its "National Electromobility Development Plan"[55].

The target curve for market evolution 2010-2020 is the following[56]:



Germany is Europe's leading nation in the field of hydrogen and fuel cell technology. In 2008, the National Organization for Hydrogen and Fuel Cell Technology (NOW) was set up to promote the development and commercialization of internationally competitive hydrogen and fuel cell technology products.

The announced road map targets 250,000 FCEV at the end of the market preparation in 2023. Furthermore, the installation of a small mass market is supposed to result in 1.8 million of FCEV on the German roads by 2030[57].

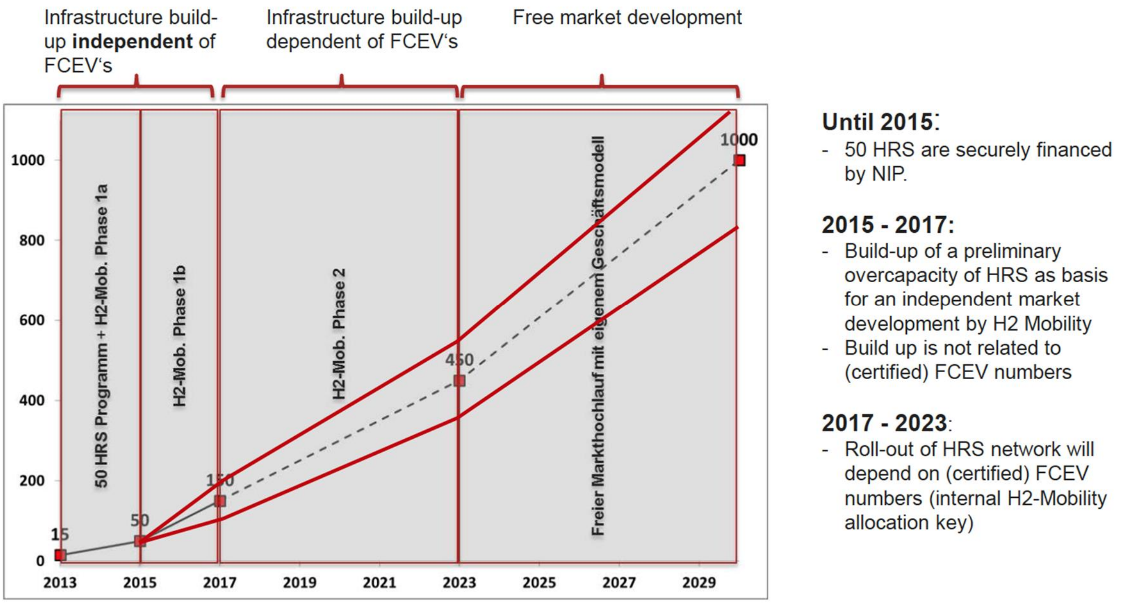
ii. Infrastructure

BEV: In 2013 the European Commission suggested a minimum number of recharging points is required for each Member State. This number is based on the number of electric vehicles planned in the Member States. For Germany these requirements are represented in the following table[58]:

[55] National Development Plan for Electric 2020 Mobility, 2009
[56] NPE, Progress Report 2014
[57] H2 mobility Germany
[58] The European Commission communication
http://europa.eu/rapid/press-release_MEMO-13-24_en.htm

Existing infrastructure (charging points) 2011	**Proposed targets of publicly accessible infrastructure by 2020**	**Member States' plans for # of electric vehicles for 2020**
1,937	150,000	1,000,000

FCEV: The roadmap for hydrogen infrastructure deployment establishes objectives of 100 HRS in 2018, 400 HRS in 2023 and 1000 HRS in 2030[59]:



The deployment strategy set up by 3 entities: H2 mobility, the Clean Energy Partnership and the German State.

iii. Institutional framework (public, public private partnership)

BEV: In February 2010 the Federal Ministry of Economics and Technology (BMWi) set up a dedicated electromobility co-ordination office with the Federal Ministry of Transport, Building and Urban Development (BMVBS) in the guise of the Joint Agency for Electric Mobility (GGEMO). The agency has been specially created to bundle and coordinate the Federal Governmentȍs electromobility tasks. GGEMO supports both the Federal Government and the National Electric Mobility Platform to implement and further develop the National Electromobility Development Plan.

FCEV: The Federal Ministry of Transport, Building and Urban Development is promoting the Clean Energy Partnership as a lighthouse project within the National Innovation Program Hydrogen and Fuel Cell Technology (NIP). This association of leading industrial enterprises

[59] NOW, 2014 available at *http://www.hydrogen.energy.gov/pdfs/review14/h2in_butsch_2014_o.pdf*

is running one of the worldôs largest demonstration projects at present, testing the system capability of hydrogen in the transport sector.

Furthermore, in September 2009 representatives of major industry companies founded the H2-Mobility. The six partners in the H2 Mobility initiative ï Air Liquide, Daimler, Linde, OMV, Shell and Total ï have agreed on a specific action plan for the construction of a German hydrogen refueling network for fuel cell powered electric vehicles with the aim to promote its commercialization.

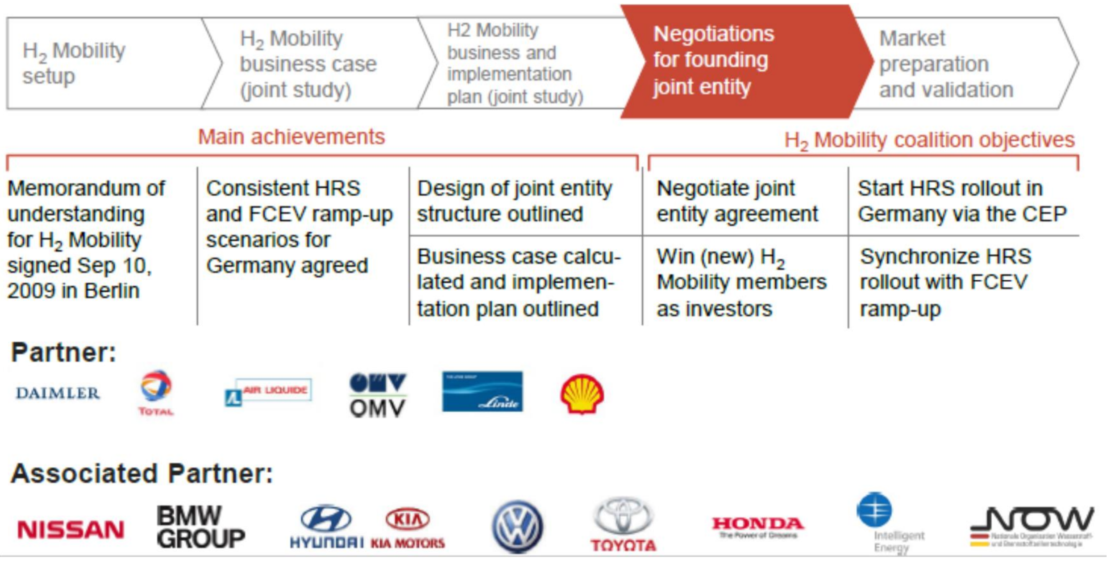


Figure: H2 Mobility is a common initiative for an establishment of a nation-wide HRS infrastructure[60]

iv. Financing (global budget dedicated to the roadmap)

BEV: To date (2015), the German Federal Government has invested in the region of ú1.5 billion in electric mobility development. Over the same period, the automotive industry has ploughed ú17 billion into electric vehicle development.

FCEV: The German Federal Government has set aside a total budget of ú1 billion for hydrogen and fuel cell technology research, development and demonstration projects over a ten-year period.

2. Main Policy Instruments

a. Manufacturers

The EU legislation setting binding targets for CO2 emissions from passenger cars, introduced in 2009, has shown itself to be effective. The annual CO2 reduction rate for new cars on the

[60] NOW Hydrogen Energy: *http://www.hydrogen.energy.gov/pdfs/review14/h2in_butsch_2014_o.pdf*

market has increased from about 1% prior to 2008 to about 4% since then. In 2012, the average emission level was 132 g/km ï very close to the 130 g/km target established for 2015. Emission levels vary widely among Member States, with Germany at the upper end (143 g/km) and France at the lower end (125 g/km) of the spectrum. A key reason is differences in vehicle fleet characteristics: passenger cars sold in Germany are on average 11% heavier and 25% more powerful.

In 2012, the European Commission indicated an average CO2 emissions target for 2020 of 95 g/km, which translates into a fuel consumption of about 3.8 l/100 km.

b. Infrastructure

BEV: The ñElectric Mobility in Pilot Regionsò program has allocated a total of ú130 million to eight pilot electric mobility projects located across Germany. Eight model regions were selected to test the application of battery driven mobility within Germany.

FCEV: Within the ñH2 Mobilityò initiative, a total investment of around ú350 million is to be required for this future-oriented infrastructure project.

c. Customers

i. CO2-based tax

<u>Annual circulation tax:</u> In Germany, the annual circulation tax for cars registered as on 1 July 2009 is based on CO2 emissions. It consists of a base tax and a CO2 tax. The base tax is ú2 per 100 cc (petrol) and ú9.50 per 100 cc (diesel) respectively. The CO2 tax is linear at ú2 per g/km emitted above 95g/km. Cars with CO2 emissions below 95 g/km are exempt from the CO2 tax component.

ZEV are exempt from circulation tax for a period of 10 years from the date of their first registration. However, the savings are relatively small: ú20 per year in the case of the Renault Zoe.

ii. Rebates on purchase price

None

iii. Perks (parking, driving lanes, private subsidiesé)

The German Federal Government put in place road traffic measures in favor of BEV: special parking places for electric vehicles, suspension of restricted entry access for electric vehicles, authorized use of bus lanes for electric vehicles, and special traffic lanes for electric vehicles.

3. Results as of 2015

a. Manufacturers (Daimler)

Daimler, an industry partner of H2 Mobility project, has a long history of fuel cell activity, spearheading the development of PEMFC for automotive use with its 1994 NECAR. The company remained active in the years after, producing four further variants of the NECAR before revealing its first-generation fuel cell passenger vehicle, the A-Class F-CELL, in 2002. Its second-generation vehicle, the B-Class F-CELL (above) entered limited series production in late 2010 offering improvements in range, mileage, durability, power and top speed. A fleet total of 200 vehicles is now in operation across the world, including more than 35 in a Californian lease scheme. Daimler has been leasing Mercedes-Benz B-Class F-CELL vehicles to Californian customers since December 2010: $849 (about ú770) per month, three year period, including fuel.

Daimler has been commercializing its third-generation F-CELL since 2014, an update to the B-Class F-CELL that is currently in widespread demonstration, that will likely adopt the improved chassis design featured on 2012 edition conventional B-Class vehicles. Production of this vehicle will be limited and sales are targeted at markets with supporting infrastructure. Daimler has been proactive with its involvement in German infrastructure-building initiatives. The German market is expected to be the largest early European market for FCEV, and the domestic manufacturer has positioned itself to take advantage of this. However, Daimler says that the scale of market introduction is intrinsically linked to cost reduction, so true volume production of the F-CELL will coincide with the fourth generation of the car, around 2017[61].

In 2013, Daimler AG, the Ford Motor Company, and Nissan Motor Co., Ltd. have signed a three-way agreement for the joint development of a common fuel cell system for use in mass-market cars from 2017.

The goal of the collaboration is to jointly develop a common fuel cell electric vehicle system while reducing investment costs associated with the engineering of the technology. Each company will invest equally in the project. The strategy to maximize design commonality, leverage volume and derive efficiencies through economies of scale will help to launch the worldôs first affordable, mass-market FCEVs as early as 2017[62]. The cost is predicted to be about the same as a comparable hybrid[63].

b. Infrastructure

[61] Fuel Cell Today published óFuel Cell Electric Vehicles: The Road Aheadô
http://www.fuelcelltoday.com/media/1711108/fuel_cell_electric_vehicles_-_the_road_ahead_v3.pdf
[62] Daimler Group communication
http://www.daimler.com/dccom/0-5-7171-1-1569731-1-0-0-0-0-0-12037-0-0-0-0-0-0-0-0.html
[63] Digital Trends
http://www.digitaltrends.com/cars/2017-mercedes-benz-fuel-cell-vehicle-may-be-price-competitive-with-hybrids/#ixzz3jBHGyL3K

The state of infrastructure in place for both BEV and FCEV is represented in the following table:

	BEV	FCEV
Number of stations	2,800 slow chargers and 50 fast chargers in 2013[64]; 4,800 charging points in 2014[65]	15 publicly available HRS in operation as of September 2013[66]; 50 HRS by the end of 2015 (NOW)

c. Customers

The current ramp-up for ZEV in Germany is represented in the following table:

Registrations[67]	**2010**	**2011**	**2012**	**2013**
EV, FCEV incl. PHEV ramp-up	288	2,221	3,699	7,381
EV, FCEV incl. PHEV market share	0,01%	0,07%	0,12%	0,25%

Germany had comparably small market shares in 2013 (about 0.25%), but at the same time it showed a strong increase from 2012 levels (about 105% increase). One possible interpretation is that in 2013, many new EV models from German manufacturers were introduced into the market, resulting in relatively high registration numbers on the part of the manufacturers themselves for test drives, outreach activities, etc.

The NPE chairman argued that Germany could only reach the one-million-target if additional monetary and non-monetary incentives are introduced[68]. The recommendations of NPE target mostly introducing more charging stations and tax write-offs.

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[64] Amsterdam Roundtables Foundation and McKinsey, 2014. Electric vehicles in Europe: gearing up for a new phase?
[65] NPE, Progress Report, 2014 http://www.bmvi.de/SharedDocs/EN/Anlagen/VerkehrUndMobilitaet/Strasse/NPE-progress-report-2014.pdf?__blob=publicationFile
[66] Leading industrial companies agree on an action plan for the construction of a hydrogen refuelling network in Germany *http://www.linde-healthcare.nl/nl/news_and_media/press_releases/news_20130930.html*
[67] EUROPEAN VEHICLE Pocketbook, 2014
[68] NPE, Progress Report, 2014 *http://www.bmvi.de/SharedDocs/EN/Anlagen/VerkehrUndMobilitaet/Strasse/NPE-progress-report-2014.pdf?__blob=publicationFile*

France

1. Targets

a. Target of transport emissions

The evolution of the French car park is represented in the next figure. In 2005, there were 36,039 millions of vehicles on the roads versus 38,408 millions on January 1st, 2015. Thus there has been a growth of 6.6%, in ten years. Despite a lower growth between 2011 and 2013, due to the economic crisis, we can notice a barely stable car park development.

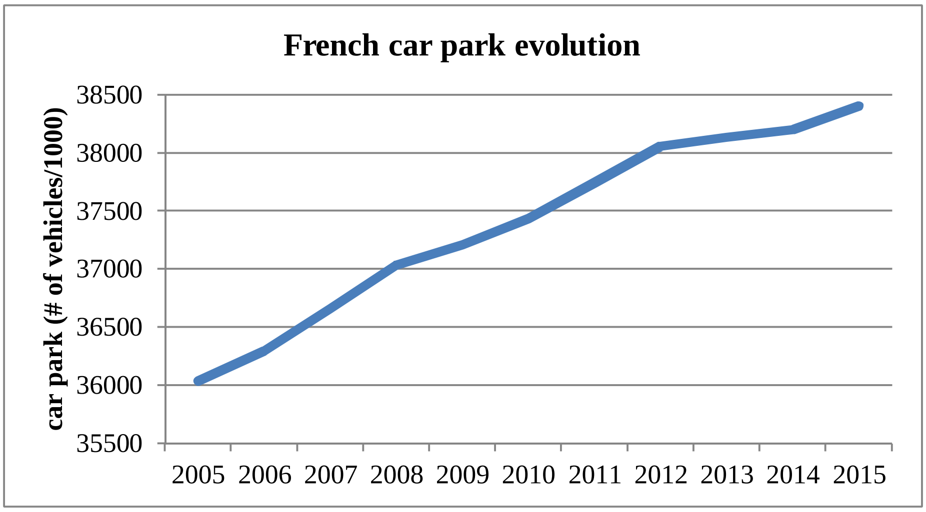

Figure: French car park evolution from 2005 to the January 1st, 2015[69]

The French automotive park composition on January 1st, 2015 is represented on the following figure. This car park is divided into four categories: passenger vehicles, light duty vehicles, industrial vehicles (trucks), and coaches/buses.

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[69] CCFA

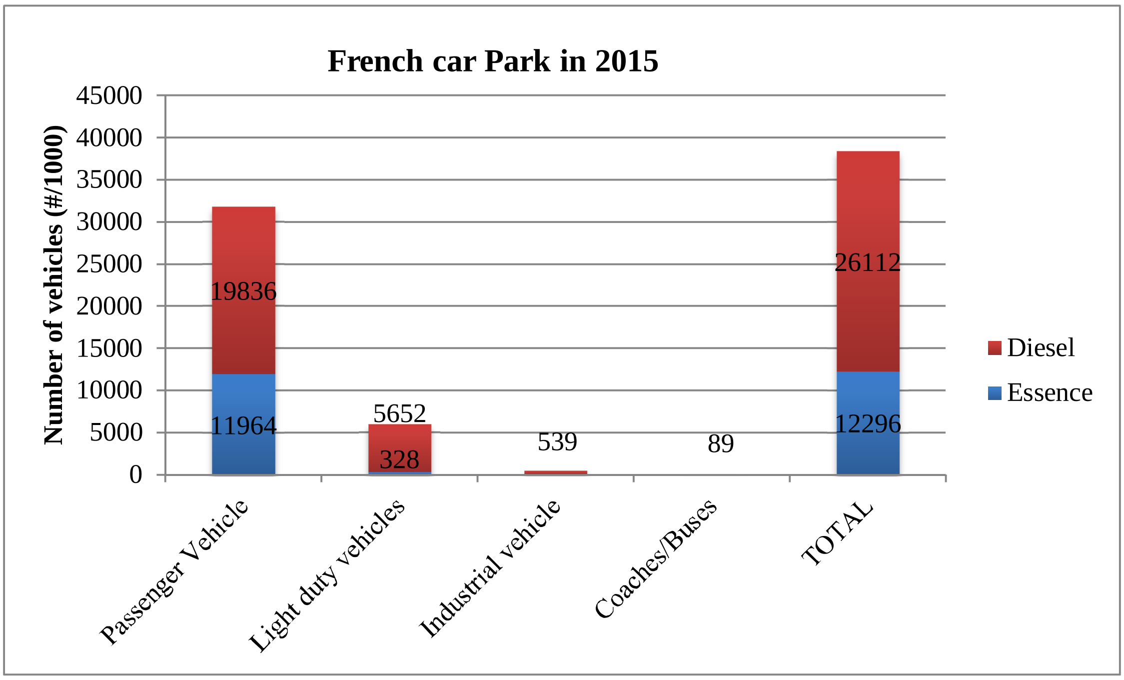

Figure: Composition of the French car park in 2015[70]

We can notice the high share of diesel which represents 68 % of the French park and which increases of approximately 1% a year.

In 2008, transport sector was the biggest CO_2 emitter, with 26% of the total greenhouse gas emission in France versus 21% for agriculture, 20% for industry and 18% for construction. In the figure below is exposed the evolution of transport emission between 1990 and 2009. We can notice an increase of 12.4% during this period. More specifically, there was an increase of 20% until 2001, then a stabilization until 2007 followed by a decrease[71].

[70] CCFA
[71] French Ministry of Ecology

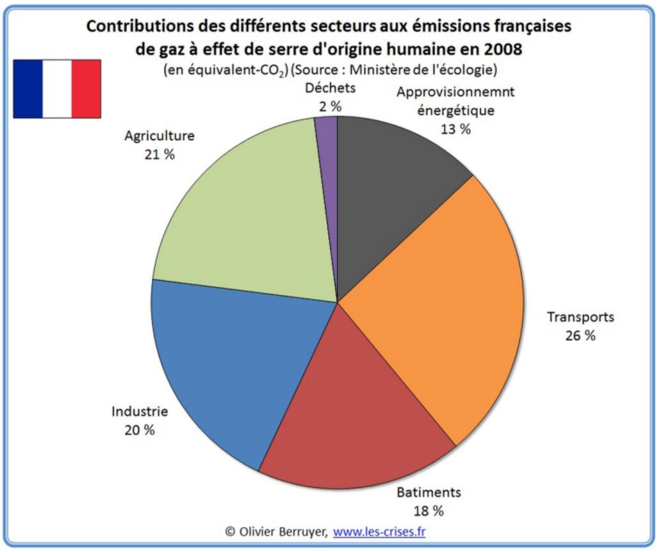

Figure: Repartition of the Greenhouse gases emission in France in 2008[72]

Transport, as it can be seen, has become the biggest greenhouse gas emitter in France.

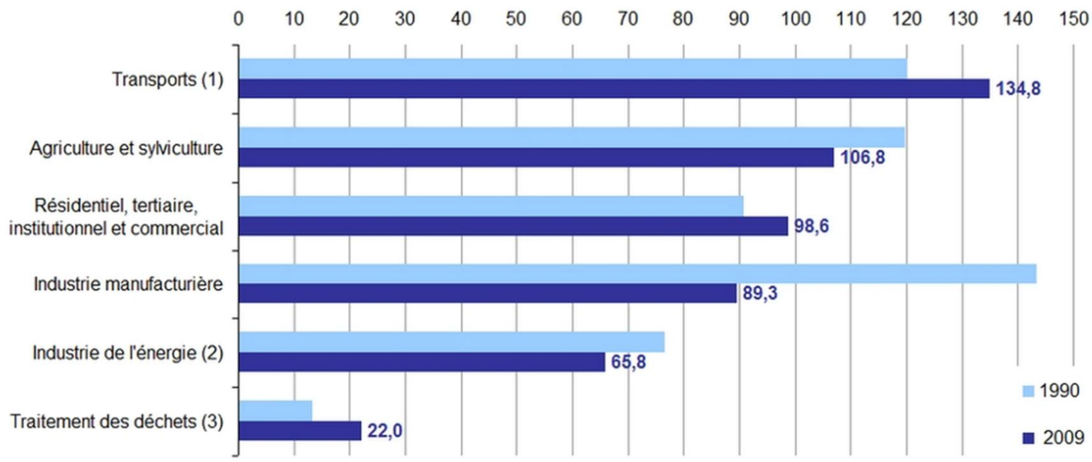

Figure: Evolution of transport CO_2 emissions in mTCO2eq between 1990 and 2009[73]

The next figure shows the gas emissions per type of vehicle from 2005. Although the document is ten years old, we assume that this repartition has not changed significantly and that passenger cars are still the most important emitters with 55% of the total CO_2 emissions, followed by light duty vehicles, which represent 17% of the emissions.

[72] French Ministry of Ecology

[73] *http://www.statistiques.developpement-durable.gouv.fr/lessentiel/ar/199/1080/emissions-gaz-effet-serre-secteur-france.html*

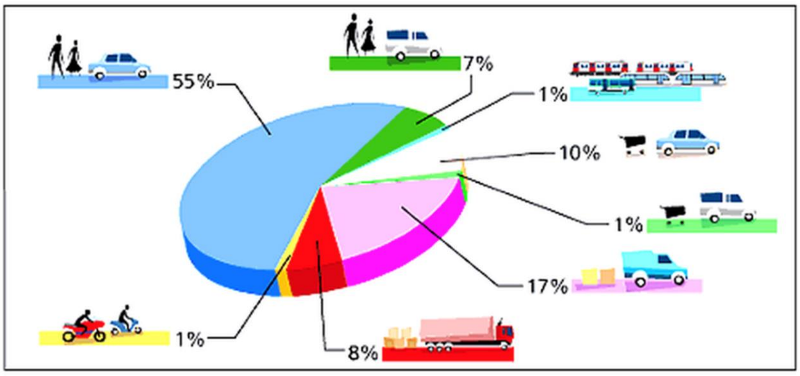

Figure: Repartition of C02 emission in means of the transport[74]

In 2012, the European Commission set for 2020 an average CO_2 emission target of 95 g/km, which corresponds to a consumption of approximately 3.8 l/100km. At that moment, France has an average emission of approximately 125 g/km and has set an objective of 2 l/100km[75].

France targeted a decrease by 20% of the gas emission of the total transport share by 2020, in order to reach emission results equivalent to those of 1990[76]. This target has evaluated with the transition law voted in August 2015, which targets a decrease of 40% of the total greenhouses emission by 2030 and of 75% by 2050 compared to 1990 level.

b. Targets and roadmaps for BEV and FCEV

In 2009, concerning BEV, the Ministry of Ecology set up a target to 2 million vehicles (5% of the park) and 4.4 million charging stations by 2020. Moreover, the creation of a French made battery was announced, with an investment of ú625 million, dedicated especially to Flins Renault Factory. The same year, Carlos Ghosn announced the objective of Renault-Nissan group to sell 1.5 millions of BEV by 2016, with an investment of ú4 billion[77].

The target set in 2015 is a network of 7 millions of charging points by 2030, in order to support the BEV deployment proposed by local communities, private initiatives and the equipment of newly-built flats.

Concerning FCEV, there is no national roadmap. Nevertheless, the H2 mobility France public/private partnership helps deployment projects of FCEV and HRS, with a national support (Ministry of Ecology and ADEME). Projects may depend on decisions taken by a regions or may be, just as well, launched by smaller entities, such as cities or private companies.

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[74] *http://www.moto-station.com/article1660-p2-pollution-consommation-et-2-roues-le-dossier-m-s.html*
[75]*http://www.legifrance.gouv.fr/affichTexte.do;jsessionid=D50364FE8B16B6CC646568142D1ABAE0.tpdila18v_3?cidTexte=JORFTEXT000031044385&categorieLien=id*
[76] *http://www.developpement-durable.gouv.fr/Transports,34304.html*
[77]*http://www.lesechos.fr/21/05/2014/LesEchos/21692-040-ECH_voiture-electrique---les-raisons-d-un-faux-depart.htm*

As an example, it can be interesting to know the roadmap of the most ambitious hydrogen project in France: Normandy hydrogen demonstrator. This deployment is managed by both the Normandy Region and the EHD 2020[78] consortium.

Thus, the next Figure shows the project roadmap with a fast growth of utility vehicles and Sedans and with the launch of 5 Van Hool hydrogen buses in Cherbourg (project 3emotion) in 2016 and of trucks after 2019.

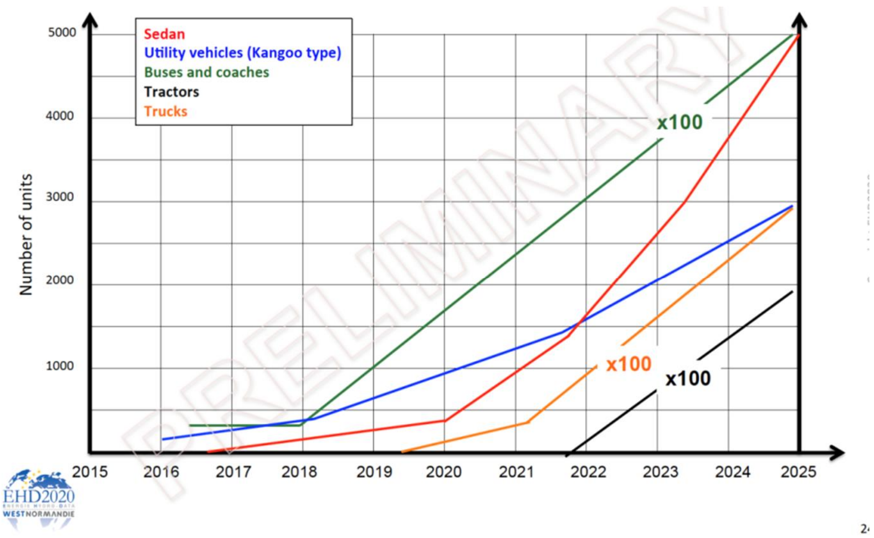

Figure: EHD2020 roadmap for the Normandy project[79]

The hydrogen infrastructure needed for the starting up will be subsidized by the European DG transport and more precisely by the project TEN-T. Thus, the Normandy project was granted a fund of approximately ú4 million, in order to install 12 stations with capacities of 10-15 kg/day and 3 stations of 50-60 kg/day. These installations are due between 2015 and 2018[80].

2. Main Policy Instruments

a. Manufacturers

In 2012, the European Commission indicated an average CO_2 emission target for 2020 of 95g/km, which can be assimilated to consumption around 3.8 l/100km. For now France has an average emission around 125g/km.

To accompany the recovery of automotive industry in France, the Minister of Productive Recovery, Arnaud Montebourg, presented an automotive industry support plan on July 25,

[78] *http://www.afhypac.org/images/documents/manche_hydrog_ne_pr_sentation_belfort_22_09_14_2_lecture_seule_.pdf*
[79] EHD 2020-presentation to the DG move January 2015
[80] Press release from Region Basse-Normandie

2012[81]. The government considers the development of cleaner vehicles as being essential to support the recovery of automotive industry. In this plan, the French government increases support for ZEV. It proposes a set of measures including the evolution of the bonus/malus system, the government commitment to purchase ZEV fleets and the continuation of the investments for the future.

A ú400 million funding for R&D and demonstration projects on low carbon vehicles (vehicles development, charging infrastructure) over 2008-2012 has been established, including ú90 million for research on EV technology.

b. Infrastructures

For BEV infrastructure, funding is provided through the National Investment for the Future program (*Programme dôInvestissement dôAvenir*). The total of ú50 million budget was assigned in the form of subsidies (Hitrzman mission launched on October 3rd, 2012) to cover 50% of EV charging infrastructure (cost of equipment and installation)[82].

The finance law of 2015 announced a tax credit of 30% on energetic transition income applied to the acquisition of charging systems. This tax was created to facilitate the equipment of buildings.

In 2015, the Bolloré group received the agreement from the Ministry of Ecology and Economy to operate a network of 16,000 charging infrastructures in France. If there are no real subsidies given by the state, Bolloré will be granted a tax exemption on the occupation of public land[83].

For the hydrogen refueling infrastructure, there is no national support program. The entities, which take the initiatives to construct HRS, are usually supported by Europe (FCH-JU and TEN-T project) or by French Regions.

c. Customers

First, concerning the public procurement in BEV: in 2012, the national government agreed for 25% of the cars it buys to be hybrid or electric[84]. This objective was exceeded in 2013 with

[81] Montebourg & Sapin, 2012
[82] French Ministry of Ecology, Sustainable Development and Energy *http://www.developpement-durable.gouv.fr/Le-renforcement-de-l.html*

[83]*http://www.usinenouvelle.com/article/bollore-va-operer-un-reseau-de-16-000-bornes-de-recharge-electriques.N311813*
[84] Plan Automobile (2012), *http://www.entreprises.gouv.fr/files/files/directions_services/secteurs-professionnels/industrie/automobile/dp-plan-soutien-automobile-2012-07-25.pdf*
video the French Car Industry Strategy*: http://lci.tf1.fr/economie/social/plan-auto-perennisation-des-sites-demandes-en-echange-de-l-aide-7425570.html*

1,271 commands of battery-driven and hybrid vehicles, which constituted 29% of the vehicle purchase by public entities. Moreover, a procedure of grouped purchase of 50,000 battery-driven vehicles (HEV and EV) allowed the organization and the pooling of needs of public and private enterprises, as well as those of local and central authorities. The delivery of the first vehicles is planned for 2016[85].

The minimum share of renewal fleet, which has to be low emission vehicles for the State and the public establishments owning more than twenty vehicles was set to 50% by the Energy Transition Law (Loi Transition Energétique) in August 2015. For local public structures and companies, which have non-competitive activities, this rate is set to a minimum of 20%. All these directives apply only if the corresponding fleets contain more than 20 vehicles. The rate is set to 50% for all fleets of vehicles, which are heavier than 3.5 tons. Moreover, car rental companies have to renew 10% of their fleets with low emission vehicles. As a reminder, the new threshold of low emission is 2l/100km.

Secondly, in 2012, the government modified the existing annual eco-label for the average CO_2 emissions of new passenger cars and proposed a system based on bonus-malus (tax-deduction/tax-penalty), which promotes low-CO_2-emission vehicles. An allowance is granted for the purchase of a new car when its emissions are of 105 gCO2 /km or less. This allowance may vary between ú4,000 and ú6,300, depending on emissions levels[86]. For both BEV and FCEV, the bonus is ú6,300[87] (and limited by 27% of the purchase price).

Inversely, the malus can be compared to a carbon tax on vehicles. Thus, for an emission ranging between 130 g/km and 200 g/km, the corresponding tax, at the car purchase, varies between ú150 and ú8,000. Moreover, since 2004, a tax was also decided in order to take into account second-hand vehicles. Owners of vehicles emitting more than 200 gCO_2/km must pay a tax, at each new registration. An annual tax of ú160/year is applied on emitters above 190 g/km.

It is interesting to notice that a few companies, such as Renault, offer free electricity charging to their employees. This kind of services should be generalized in the future. In the same prospect, in a city like Paris where drivers have difficulties to find car parks, the BEV users are allowed to use Autolib parking places.

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[85] French Ministry of Ecology, Sustainable Development and Energy

http://www.developpement-durable.gouv.fr/Soutien-a-l-achat-des-premiers.html

[86] French Ministry of Ecology, Sustainable Development and Energy
http://www.developpement-durable.gouv.fr/Bonus-Malus-definitions-et-baremes.html

[87] French Ministry of Ecology, Sustainable Development and Energy
http://www.developpement-durable.gouv.fr/Bonus-Malus-2014.html

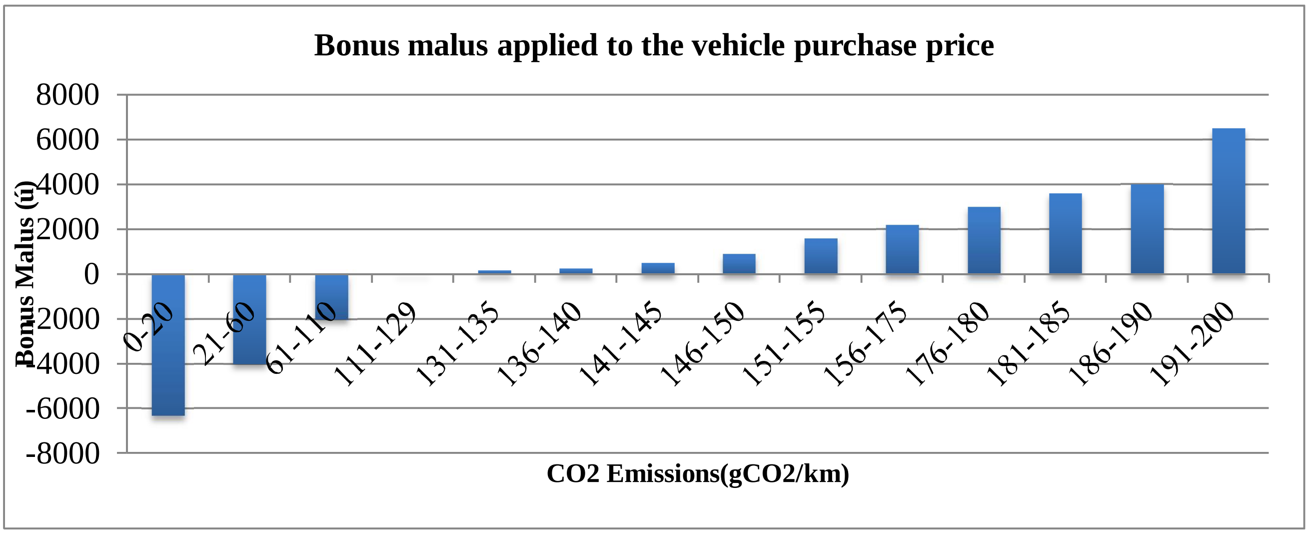

Figure: Bonus/Malus applied to vehicle purchase prices[88]

Discounts allowed to consumers buying efficient vehicles correspond to an amount of ú405 million, 90% of which being refunded by taxes on inefficient vehicles. The remaining 10% (ú45 million) are obtained by a direct subsidy[89]. The Bonus/Malus system is not always balanced: results show a ú43 million surplus in 2012 and a ú100 million deficit in 2013.

3. Results as of 2015

a. Manufacturers

Autolib car sharing project in Paris: Bollore strategy

Launched in December 2011, Autolibô is an all-electric car sharing program proposed by Paris City and the French holding company Bolloré, supplier of a small 160-mile range EV, called ñBluecar.ò The service consists in proposing 2,200 cars and 4,300 charging stations deployed throughout Paris. In a little more than two years, approximately 120,000 unique users have logged a total of 3.5 million rentals. Assuming that most of these drivers had never been in an electric car previously, these results are really significant.

By 2030, it can be expected that this system will replace more than 25,000 privately owned cars and will reduce carbon dioxide emissions by 75 metric tons.

On one hand, in order to facilitate the deployment of charging infrastructure, the City of Paris invested ú35 million and assigned numerous parking spaces to Autolibô. On the other hand, Bolloré has provided the fleet of vehicles and pays back the Cityôs investment, thanks to the subscription income and a parking space leasing arrangement. At Autolib launch, Bolloré had

[88] *http://vosdroits.service-public.fr/particuliers/F19911.xhtml*
[89] *Trigg, Telleen, Boyd, & Cuenot, 2013*

scheduled to pay back the City by 2018, but the business success will enable them to do so in approximately half the expected duration[90].

ñAutolibô has exceeded our expectations in terms of user acceptance which has a direct impact on our business plan; if the trend continues, we will reach the breakeven point by 2015, that is three years ahead of schedule,ò says Morald Chibout, Director of Autolibô.

Billionaire Vincent Bollore invests in London's electric car sharing. The green campaign, a four-wheel extension of Londonôs environment-friendly ñBoris Bikesò program, will let Londoners hire electric cars for 15 minutes slots[91]. Bolloré Group already runs similar programs in France and in United States of America.

FCEV delivery fleet deployment: SymbioFCell strategy

In France, at the moment, the H2 mobility strategy is based on one product: The Hykangoo manufactured by SymbioFcell. Thus, this company is a pioneer of the hydrogen field and more particularly of the hydrogen mobility in France.

SymbioFCell is a French company created in 2010, which manufactures fuel cells. Two different fuel cells were designed: one PEM-based hydrogen fuel cell range extender (5kW - 20 kW) and one full power hydrogen system (80-300 kW). Highly focused joint development programs have been set up with leading-edge industries, such as CEA-Liten and Solvicore, in order to build an ecosystem of expert companies, within the field of Fuel Cell.

In 2013, SymbioFcell, in collaboration with CEA-Liten, presented a new generation of Fuel Cells[92].

Michelin, which had worked on Fuel cell since 2003[93], entered the SymbioF cell capital in 2014, in order to find practical applications to their investment.

Concerning mobility, SymbioFcell assembles the Hykangoo : this consists in installing their range extender on the Renault maxi Kangoo ZE.

Hykangoo history started by a partnership with ñLa Posteò, which acquired a fleet of maxi Kangoo ZE and which had to deal with this model limitation range. As a matter of fact, with a range of 120 km in urban cycle (speed around 50-60 km/h) and a charging time of 6 - 8 hours, the Kangoo ZE was not a viable product in rural regions.

The range extender, installed on electrical models, adds a driving distance of 180 km to the original range of 120 km (urban driving). Thanks to a tank containing 1.8 kg of hydrogen

[90] CleanTechnica
http://cleantechnica.com/2014/04/02/autolib-electric-carsharing-program/
[91] Forbes
http://www.forbes.com/sites/natalierobehmed/2014/03/12/french-billionaire-vincent-bollore-invests-in-londons-electric-car-sharing/
[92] http://www.tenerrdis.fr/images/actualite/CPCEASymbio%20FCell21112013.pdf

[93] http://techno-car.fr/pile-a-combustible-michelin-se-rapproche-de-symbio-fcell/

under 350 bars, to the 5 kW Fuel Cell and to a fully charged battery, the HyKangoo can run all day long, even for delivery companies.

Moreover, the use of intelligent software regulates the vehicle consumption. In case of low speed, the fuel cell feeds directly the motor, and in case of high speed, both fuel cell and battery provide power. Once the battery is under 80% of its full charge, the fuel cell charges it. In fact, as the battery charging is much longer than that of the hydrogen tank (5 to 6 minutes), it is preferable to keep the battery charged and to empty the tank.

Thus, the range extender system offers several solutions. To begin with FCEV remain rather expensive at the moment, even if prices decrease rapidly, along with the development of first serial models (Mirai by Toyota and ix35 fuel cell by Hyundai). Thanks to the ecologic bonus and a support from the FCH-JU of ú10,000 the Hykangoo is sold for ú33,000 (no VAT). This price is still higher than that of diesel alternatives, but is much lower than full hydrogen car prices. Secondly, with the electricity-hydrogen energy mix, fuel costs are lower than those of diesel or fully hydrogen models. Finally, this product permits to launch hydrogen distribution, on the territory. As this vehicle is able to function with electricity, the installation of hydrogen refueling stations can be progressive.

The choice made by SymbioFcell to concentrate on the Kangoo model is justified by the fact that this model is the utility vehicle the most sold in Europe. If this product gives satisfaction as a consequence a large market will be opened for the company. According to this prospect, SymbioFcell will set up a 700 bar tank, in order to launch their model on the German market.

SymbioFcell strategy has reached a new step with the development of a starter kit, which is a mobile HRS of 20kg/day. This kit costs approximately ú200k and is able to feed 30 Hykangoo (with one refueling each two days). A current problem for hydrogen distribution is linked to the delay of high capacity HRS installation. As an example, an 18 month period is needed between the application to obtain European funding and the installation of a 80 kg/day station (DREAL verification included). After that, the starter will be available in 3-4 months and will launch the use of the future HRS. Once the high capacity HRS is installed, the starter kit will be moved and will be used to feed another fleet.

In September 2015, 60 Hykangoos have been sold in France and a little less than that in Scotland and Netherlands. The objectives are set up at 250 vehicles at the end of 2015 and 1,000 at the end of 2016, among which 50% in France, the rest in UK, Germany and North Countries. Once this volume of 1,000 is reached, Michelin should activate a serial fuel cell production and prices should consequently decrease[94].

b. Infrastructure

The state of infrastructure for both BEV and FCEV is represented in the following table:

[94] Interview of SymbioFcell

	BEV	FCEV
Number of stations	Non-residential charging points installed: 749 (among which 42 fast chargers) in 2013[95] 1,700 slow chargers and 100 fast chargers in 2013[96] 4,252 in 2015[97]	6[98] on industrial sites, whereof 0 publicly available

Usually, charging infrastructures are operated by automakers: Renault-Nissan, Tesla, Bolloré. Energy and construction companies, such as EDF and Colas, have also proposed a national deployment plan to the Ministry of Ecology, at the same time as Bolloré's.

At the moment, HRS are operated by several entities. In Normandy, the first HRS is operated by Saint-Lô City, with the support of Air Liquide and most of the future stations should be operated by SERFIM. HyWay project HRS are operated by GNVert in Lyon and Air Liquide in Grenoble.

c. Customers

The current ramp-up for ZEV in France is represented in the following table:

[95] Global EV Outlook 2013 http://www.iea.org/publications/globalevoutlook_2013.pdf

[96] Amsterdam Roundtables Foundation and McKinsey. Electric vehicles in Europe: gearing up for a new phase? (2014)

[97] *http://chargemap.com/stats/france*

[98] According to the LBST and TÜV SÜD operated information website H2stations.org. Data for number of hydrogen stations available comes from the web site, supported by industry. The data is rather optimistic because a lot of stations mentioned on this web site are not publicly available. However, they could represent a suitable proxy for evaluation of hydrogen infrastructure deployment effort in each country.

Indicators		**2010**	**2011**	**2012**	**2013**	**2014**	**2015 (May)**
BEV new registrations[99]	#	184	2,626	5,663	8,779	10,555	5,670
Bollore[100]	#	0	399	1,843	658	1,170	387
BEV vehicle penetration rate (according to new passenger car registration)	%	0,01%	0,12%	0,30%	0,49%	0,59%	

At the end of 2012, more than a dozen EV models (both BEV and PHEV) were commercially available in France. It is estimated that approximately 33,000 EV were circulating on French roads in early 2015. 8,779 electric cars were registered in 2013, with an increase of 55% since 2012, and the all-electric market share of new car sales increased from 0.3% in 2012 to 0.49%. We can notice that the increase of EV on French roads is mostly due to the use of Bolloré Bluecars, within Paris Autolib car sharing service.

Electric car-sharing projects in France are extremely important for the deployment of EV and, particularly, of electrical terminals. In 2015, thanks to these projects, there are more than 4,500 EV on the French roads. The most important projects are Bolloré's: 3,300 Bluecars (Autolib) in Paris, 250 Bluecars and 50 Twizy (Bluely) in Lyon, 200 Bluecars (Bluecub) in Bordeaux [101]. More than 13% of the whole EV French fleet are due to these projects, 10% of which being due to Bolloré.

Concerning FCEV[102], 60 vehicles can be counted: most of them being Hykangoos under delivery fleet projects, and a few among them being passenger FCEVs (Hyundai ix35) bought by Air Liquide and Region Basse-Normandie[103].

[99] Automobile Propre
http://www.automobile-propre.com/dossiers/voitures-electriques/chiffres-vente-immatriculations-france/#Evolution_des_immatriculations_de_voitures_lectriques_en_France

[100] Marklines data set
http://www.marklines.com/

[101] *http://avem.fr/index.php?page=libre_service_ve*

[102] SymbioFcell

[103] *http://www.airliquide.com/fr/presse/communiq ues-de-presse/air-liquide-receptionne-les-deux- premiers-vehicules-electriques-a-hydrogene-immatricules-en-france.html*

Japan

1. Targets

a. Global targets

In 2008, Japan devised the Low Carbon Technology Plan and set a long-term goal of reducing the current level of emissions by 60 to 80% by 2050. In addition, the Japanese Prime Minister has announced plans to reduce the countryós domestic CO2 emissions by 25% by 2020 compared to 1990 levels. The Japanese government is also supporting the shift to low CO2 vehicles and the development of fuel cell and energy storage technologies

The entire transport sector represents 19.4% of Japan's total CO2 emissions, 49% of that is due to passenger car emissions. Thus CO2 emissions from passenger cars represents about 9.5% of Japan's total emissions[104,105].

Total demand for passenger cars and commercial vehicles in calendar year 2013 finished at 5.38 million units, up 0.1% over the previous year, with sales of passenger cars and commercial vehicles, excluding mini-vehicles, totaling 3.26 million units, down 3.8% from 2012, and sales of mini-vehicles reaching 2.11 million units, up 6.7%[106].

For the future market growth there are concerns about a possible decline in consumer demand triggered by the consumption tax hike (VAT hike from 5% to 8%). Registrations are expected to fall in the second half of 2015 for a -2% annual contraction in the volume of sales[107].

b. Specific targets and roadmaps for BEV and FCEV

i. Vehicles

In 2011 the Ministry of Economy, Trade and Industry (METI) requested ¥17.5 billion (about ú160 million) in order to subsidize the introduction of clean-energy vehicles. The aim is to reach a fraction of 15-20% of new car registrations by the year 2020 which should increase to 20-30% until 2030.

In December 2013, the METI established a Council for a Strategy for Hydrogen and Fuel Cells, and since then the council has been studying ideal approaches to the future utilization of hydrogen energy, through collaboration between industry, academia and government. On

[104] JAMA, 2011 Report on Environmental Protection Efforts ï Promoting Sustainability in Road Transport in Japan
http://www.jama-english.jp/publications/env_prot_report_2011.pdf
[105] Naono, 2011, Overview of Japanós HDV Fuel Efficiency
[106] JAMA, 2014
http://www.jama-english.jp/statistics/forecast/2014/140131.html
[107] Euler Hermes, 2014, The global automotive market
http://www.eulerhermes.com/mediacenter/Lists/mediacenter-documents/Economic-Outlook-The-global-Automotive-market-Sept14.pdf

June 23, 2014, the council compiled measures to be taken by people involved in realizing a hydrogen society into a Strategic Road Map for Hydrogen and Fuel Cells, and METI hereby publicizes the road map.

Concerning the utilization of hydrogen, METI focused on the difference in time periods required for solving technical challenges and for securing economic efficiency, and decided to advance efforts by categorizing them into three phases, as follows[108]:

Phase 1: Expanding the scope of applications for fuel cell technology, e.g., fuel cells for households and fuel cell vehicles (which have been brought into use recently), and aiming to achieve important energy conservation as well as acquiring a new global market (scheduled to begin in 2014);

Phase 2: In terms of the supply side measures, establishing a system for supplying hydrogen using unconventional energy resources imported from other countries, while, for the demand side, aiming to enhance energy security measures, keeping an eye on full-fledged introduction of hydrogen power generation (time frame: putting the technology into practice by the late 2020s); and

Phase 3: Targeting the establishment of a carbon-dioxide-free hydrogen supply system using renewable and other energy (time frame: putting the technology into practice around 2040).

In 2014 there was no real FCEV fleet on the Japanese roads. The situation should drastically change in 2015 because of purchasing of new FCEV, which have a more affordable cost (Mirai, ix35, forthcoming FCX clarity, etc.) and planned deployment of hydrogen refueling stations (from 17 to 100 HRS are planned to be deployed by the end of 2015).

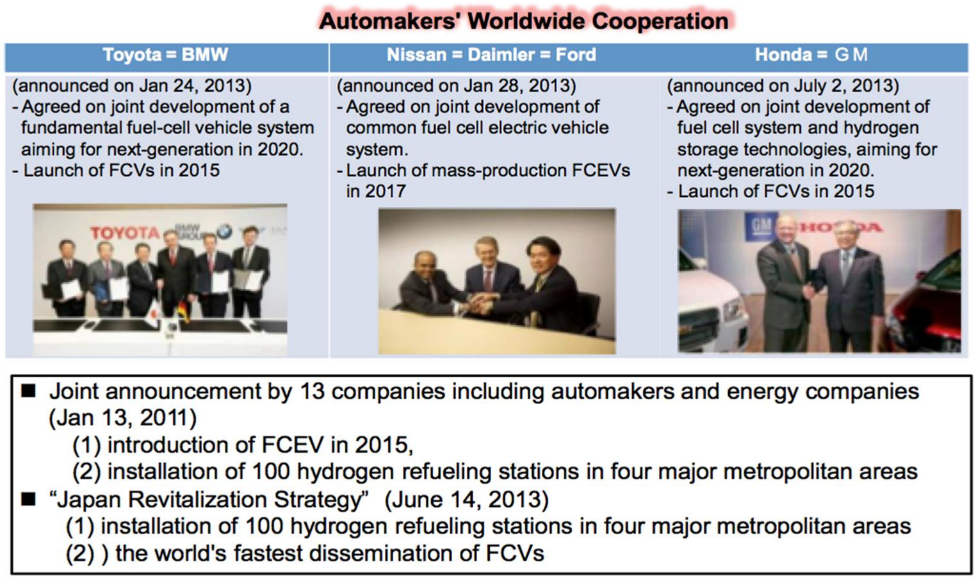

Figure: different automakers cooperation to promote the FCEV

108 Strategic Road Map for Hydrogen and Fuel Cells, 2014 available at http://www.meti.go.jp/english/press/2014/pdf/0624_04a.pdf

ii. Infrastructure

The objective for the FCEV infrastructure is to install 100 HRS in the 4 major-populated-areas (Tokyo, Aichi, Osaka and Fukoka) by the end of 2015. The last update on June 2014 announced 31 stations already budgeted and one large hydrogen production facility.

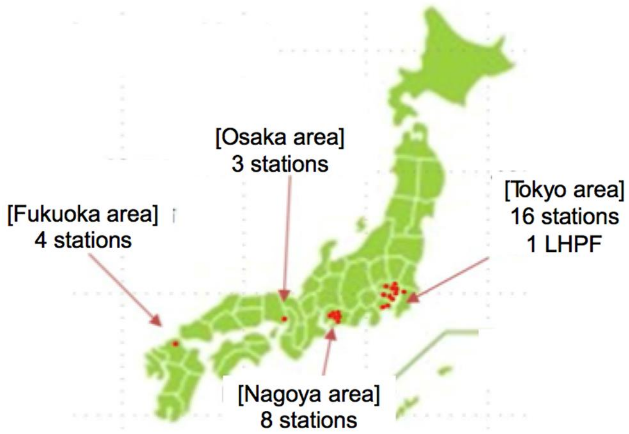

Figure: Stations already budgeted in June 2014[109]

These stations are built by the Research Association of Hydrogen Supply/Utilization (HySUT) consortium with financial support of the METI.

iii. Institutional framework (public, public private partnership)

Both government and private groups insure the deployment of ZEV infrastructures in Japan.

FCEV: the HySUT consortium was created in 2009 with the objective to solve the issues of technology, consumer awareness, social acceptance and to assist business establishment by the term of 2015. This consortium was composed of 19 companies from different fields (petroleum, city gas, automotive, etc.)[110]. In 2014, the METI (Ministry of Economy, Trade and Industry) announced a 50% subsidy for the 100 HRS[111].

BEV: the situation is similar to the one of the FCEV, with the consortium ñNippon Charge Serviceò composed of Nissan, Mitsubishi, Honda and Toyota.

[109] NEDO 2014: Hydrogen infrastructure in Japan
[110] NEDO 2014: Hydrogen infrastructure in Japan
[111] New Japanese Joint Venture to Focus on Hydrogen Infrastructure » by fuel cell insider

2. Main Policy Instruments

a. Manufacturers

Introduced in 1999 by the Japanese Government, the Top Runner Fuel Efficiency Standard sets binding fuel efficiency targets for passenger cars. The Top Runner program uses an industry-driven process whereby the fuel efficiency of the best vehicle in each weight class ï the top runner ï is taken on as the target for the next target-cycle (5 years)[112]. Thus, if the class-leading vehicle's fuel consumption were 25 km/l (4 l/100km) in 2005, this value would become the minimum target for all vehicles in this weight class for 2010. The targets settled upon were (for gasoline powered vehicles): 14.4 km/l (159.7 gCO2 /km) in 2010 ï met in 2005, 16.8 km/l (136.9 gCO2/km) in 2015 and 20.3 km/l (113.3 gCO2/km) in 2020.

b. Infrastructure

The Japanese government also decided to support and to pay for half of the price of electric vehicles supplies equipment up to ¥1.5 million (ú11,100) per charger[113]. In 2012, Japan invested approximately ú170 million in fuel cell and hydrogen energy programs including hydrogen infrastructure & vehicle demonstration projects (ú27 million) and various fuel cell and hydrogen energy R&D projects (ú67 million)[114].

c. Customers

In 2010, the Japanese government introduced temporary tax reductions or exemptions for FCEV, BEV for three years period. Moreover, the government decided to support and to pay for half of the price gap between electric vehicles and corresponding internal combustion engine vehicles. The bonus is capped at ¥850,000 (ú6,300).

On January, 14, 2015, Japanese cabinet tightened requirements for eco-car tax reduction and extended the program period to March 2017. Currently, 3% acquisition tax is imposed on the acquisition price of private vehicles (excluding mini-vehicles). The tax exemption for EV, other green vehicles, and models respecting 2015 fuel efficiency standards +20% remains unchanged.

3. Results as of 2015

a. Manufacturers (Toyota)

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[112] Onoda (OECD/IEA) 2008,

[113] 2011 Hydrogen and Fuel Cell Global Policies Update *http://www.iphe.net/docs/iphe_policy_update_120911_web.pdf*

[114] Japanôs Hydrogen and Fuel Cell Research Funding Tops $240 Million *http://www.fuelcells.org/uploads/Japan2012Fu elCellFunding.pdf*

Sales of the Toyota Mirai began in Japan on December 15, 2014[115]. Pricing starts at ¥6.7 million (ú57,400) before taxes and a government incentive of ¥2 million (ú17,100). Initially, sales were limited to government and corporate customers and not available to individual retail customers. As of December 2014, domestic orders had already reached over 400 Mirais, surpassing Japan's first-year sales target, and as a result, there is a waiting list of more than a year[116].

Among advantages of being emission free and having nice driving performances, Toyota put an emphasis on the fact, that Mirai can be used as a power supply and double the high capacity power supply during emergencies[117]. This point is very important for Japanese customers, who have a high concern on energy supply after Fukushima accident.

Toyota plans to focus heavily on the customer experience for Mirai owners, Fay, Group Vice President and General Manager of Toyota, said, to make sure that "the only thing early adopters will have to worry about is how to answer all the questions they'll get from their neighbours." The Mirai will come with free roadside assistance, access to a live 24-hour concierge service whose assistants are specially trained on fuel-cell vehicle issues, and three years of free maintenance. Toyota also intends to provide free hydrogen fueling for the first three years[118].

However, Former European Parliament President Pat Cox estimates that Toyota will initially lose about $100,000 (ú90,000) on each Mirai sold[119].

b. Infrastructure

The state of infrastructure in place for both BEV and FCEV is represented in the following table:

	BEV	**FCEV**

[115] The Wall Street Journal *http://blogs.wsj.com/japanrealtime/2014/12/15/toyotas-fuel-cell-powered-mirai-hits-showrooms/*
[116] Green Car Reports *http://www.greencarreports.com/news/1095511_2016-toyota-mirai-priced-at-57500-with-499-monthly-lease*
[117] Toyota *http://www.toyota-global.com/innovation/environmental_technology/fuelcell_vehicle/*
[118] Green Car Reports *http://www.greencarreports.com/news/1095511_2016-toyota-mirai-priced-at-57500-with-499-monthly-lease*
[119] CleanTechnica *http://cleantechnica.com/2014/11/19/toyota-lose-100000-every-hydrogen-fcv-sold/*

Number of stations	As of December 2012, 1,381 public quick-charge stations and 300 slow chargers[120].	14 HRS operated by JHFC[121]; 17HRS in 2013-target of 100 by end of 2015 (in which 31 are already budgeted).

According to the Nissan Motor Co., the number of power points in Japan, including fast-chargers and those in homes, has surged to 40,000, surpassing the nationôs 34,000 gas stations in 2015[122].

One fast-charging standard designed for electric vehicles is dubbed CHAdeMO, a primarily Japanese-backed technology. The major proponents of the technology are Japanese automotive OEMsð including Toyota, Nissan, Mitsubishi; and Japanese industrial giantsð including Fuji Heavy Industries Ltd., Tokyo Electric Power Co. and more.

CHAdeMO, which the abbreviation for ñCharge de Moveò, began deployment in 2009 in order to accelerate the adoption of electric vehicles in Japan, where EV have found positive reception[123]. The charging station maps for Japan, shows that CHAdeMO DC quick chargers blanketing every major route from north to south and east to west, thanks in part to pro-electric car incentives and a nationwide ð rather than regional ð approach to charging station deployment. In January 2015, there were more than 2,819 CHAdeMO DC rapid chargers installed across the country, far more than the 1,532 installed in the whole of Europe or 854 found in the U.S[124].

c. Customers

The current ramp-up for ZEV in Japan is represented in the following table:

[120] Global EV Outlook
http://www.iea.org/publications/globalevoutlook_2013.pdf
[121] Japan Hydrogen Fuel Cell Project
http://www.jari.or.jp/Portals/0/jhfc/e/station/index.html
[122] Bloomberg
http://www.bloomberg.com/news/articles/2015-02-13/japan-has-more-car-chargers-than-gas-stations-carbon-climate
[123] IHS press
http://press.ihs.com/press-release/design-supply-chain-media/number-fast-charging-stations-electric-vehicles-set-rise-nea
[124] Transport Evolved
https://transportevolved.com/2015/02/17/official-japan-now-electric-car-charging-spots-gas-stations/

Registrations[125]		**2010**	**2011**	**2012**	**2013**	**2014**
BEV	#	2359	13449	15942	16657	16257
FCEV	#	2	0	1	4	7
PHEV	#	0	0	7241	14122	15352
ZEV total	#	2361	13449	23184	30783	31616
ZEV market share		0,06%	0,38%	0,51%	0,67%	0,67%
Total new	#1000	4212	3525	4572	4562	4700

In Japan, every fifth new car is an electrified vehicle ð most of them being hybrid-electric. In the worldwide BEV market, Japan holds the largest share due to sales of the Nissan LEAF.

The data shows that the fraction of ZEV in 2014 represents only 0.67%. It seems to be difficult to achieve 15-20%, planned by the METI in 2020 with this starting point.

[125] Marlines
http://www.marklines.com/en/report/rep1370_201502

Denmark

1. Targets

a. Target for transport emission

Denmark has a population of 5.5 million habitants and a car park of 4 million vehicles[126]. The transport sector was responsible for 22% of total greenhouse gas emission in 2010:

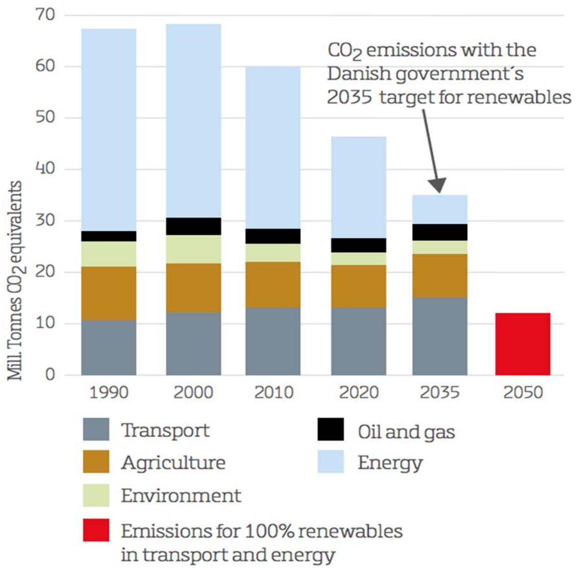

Figure: Historical and projected Danish greenhouse gas emission without policy changes[127]

This figure shows that without new policies, the GHG emission of the transport segment will increase by 33% by 2020. At the same time, almost all others sectors are expected to decrease their GHG emissions compare to 1990 level.

[126] *https://www.tispol.org/guides/denmark.pdf*
[127] *http://www.ens.dk/sites/ens.dk/files/policy/danish-climate-energy-policy/danishclimatepolicyplan_uk.pdf*

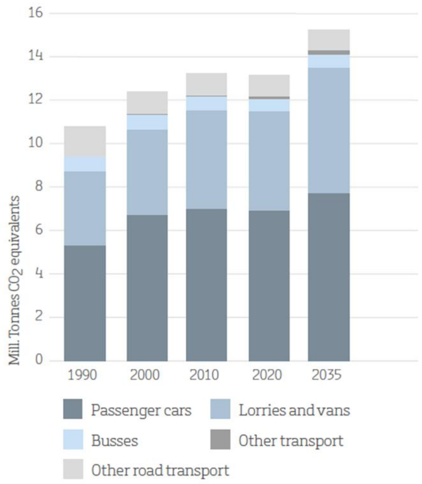

Figure: Transport sector emissions[128]

As it is the case in many countries, the passenger cars represent the biggest part of GHG emissions with approximately 54% of the total emissions induced by the light duties vehicles.

The goal fixed by the Danish government is to reduce greenhouse gases emissions by 40% by 2020 compared to 1990 level. The long-term benchmark is a reduction by 80%-95% by 2050. The target for the transport sector is even more radical: all Denmarkôs energy supply, including transport energy consumption, shall be based on renewable energy by 2050[129].

b. Target for ZEV

The Danish government sets an ambitious objective of independence from oil by 2050. It acknowledges that ZEV can significantly contribute to a reduction in the use of fossil fuels and address environmental stakes. Denmark sees large potential for EV with regards to a more efficient exploitation of its renewable energy sources (mainly wind energy which represented 33% of final energy consumption in 2013). Hydrogen could also play a significant role for smoothing the excess wind electricity production via electrolysis.

The goal of the Danish Energy Agreement passed in 2008 is to replace a quarter of the 2 million passenger cars in circulation with electric cars by 2020 and achieve a penetration rate of 94% on the market of new vehicles.

Danish are the pioneers in term of FCEV. Their first vehicles were in demonstration in 2001[130] following by 11 fuel cell range extender vehicles between 2008 and 2010. Since 2011 they have deployed the ix35, which had been homologated by EU in 2013. Even if there is a plan for a high share of FCEV in the future (50% in 2050), the current deployment is limited

[128] *http://www.ens.dk/sites/ens.dk/files/policy/danish-climate-energy-policy/danishclimatepolicyplan_uk.pdf*
[129] http://www.ens.dk/sites/ens.dk/files/policy/danish-climate-energy-policy/danishclimatepolicyplan_uk.pdf
[130] *http://brintbiler.dk/wp-content/uploads/2015/03/HIT-NIP-Denmark_3rd-final_June-2014.pdf*

to the demonstration projects because of the vehicles prices and the lack of infrastructure. Today, there is a test fleet of 29 FCEV on the roads of Denmark. However, the Danish Partnership for Hydrogen and Fuel Cells expects a market introduction between 2016 and 2025 with around 110,000 FCEV and more than 185 stations[131]. Denmark is a member of the Scandinavian Hydrogen Highway Partnership, which by 2015 targets the circulation of 100 FC buses, 500 cars and 500 utility vehicles[132].

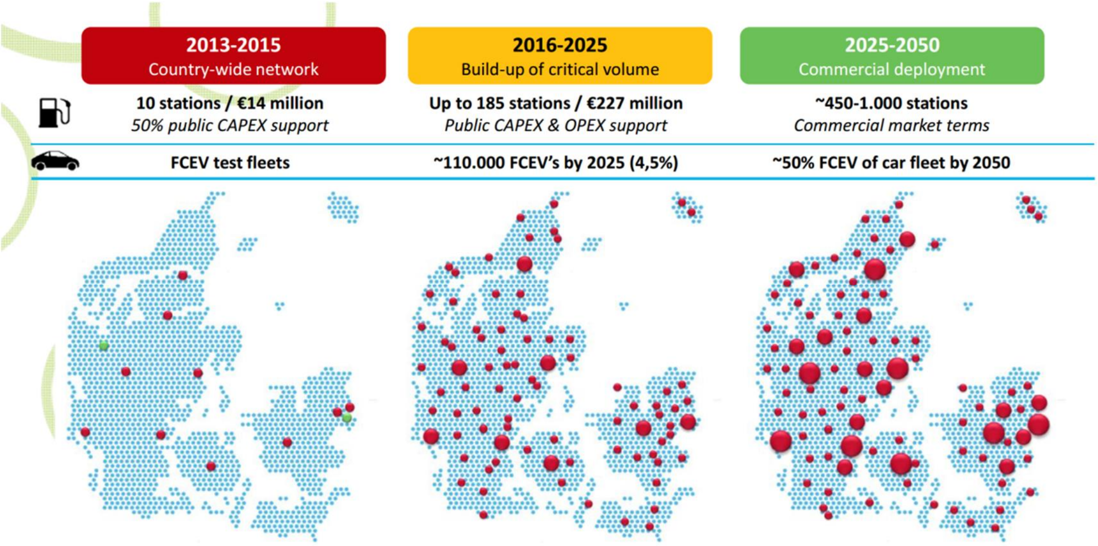

Figure: Road map of the HRS and FCEVs deployment in Denmark[133]

2. Main Policy Instruments

In 2011 a new Danish Energy Strategy ñOur Future Energyò was released aiming towards a higher share of renewable energies, which shall deliver independence from fossil fuels and a reduction in CO2 emissions. Lately, a new Danish Energy Agreement was published by the Ministry of Climate, Energy and Building. The Agreement contains a wide range of ambitious initiatives, bringing Denmark a good step closer to the target of 100% renewable energy in the energy and transport sectors by 2050. Denmark plans to achieve four major goals: (i) more than 35% renewable energy in final energy consumption, (ii) approximately 50% of electricity consumption to be supplied by wind power, (iii) 7.6% reduction in gross energy consumption in relation to 2010, and (iv) about 35% reduction in greenhouse gas emissions in relation to 1990. These goals are related to the Danish Energy Strategy 2050, which sets the objective of being independent from oil in 2050.

A precedent Danish Energy Agreement was passed in 2008 that dedicated ú4 million for

[131] *http://www.iphe.net/docs/Meetings/SC22/Meeting/Denmark_SC22.pdf*
[132] *http://www.scandinavianhydrogen.org/about-shhp*
[133] *http://www.iphe.net/docs/Meetings/SC22/Meeting/Denmark_SC22.pdf*

promotion and demonstration of battery electric vehicles.

As a part of the 2012 Energy Agreement, DKK 70 million (ú9.4 million) was allocated for a strategy for energy-efficient vehicles (EV, natural gas vehicles, and FCEV).

a. Manufacturers

A total budget of ú160 million (annual basis) is dedicated to energy technology since 2014, with 26% of this budget to support the research on Hydrogen and Fuel Cell.

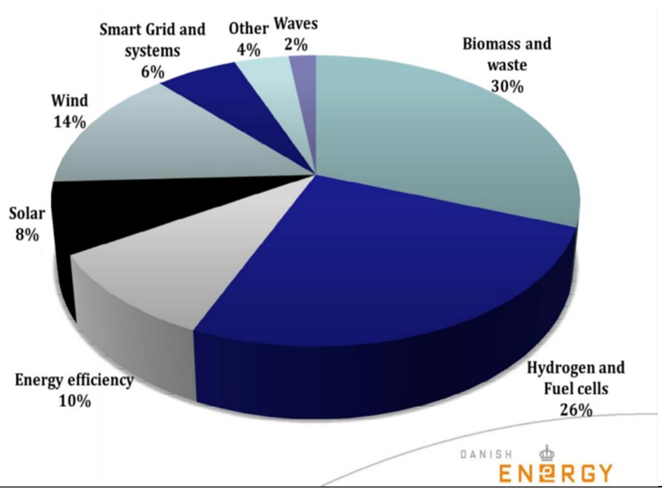

Figure: repartition of the budget of R&D in energy technology in 2014[134]

b. Infrastructure

<u>BEV:</u> Government funded initiatives to add more fast-charging stations along highways to facilitate intercity travel. A budget of DKK40 million (ú5.4 million) was allocated for development of charging infrastructure in 2013 and 2014.

There is a $100 million (ú90 million) partnership between Dong Energy, the country's biggest power company, and Better Place, a venture-backed international company that developed and sold battery-charging and battery-switching services for electric cars.

There is a strategy for energy-efficient vehicles with a pool of ú9.3 million for electric, hydrogen and gas infrastructure dedicated to heavy vehicles.

134 *http://www.iphe.net/docs/Meetings/SC22/Meeting/Denmark_SC22.pdf*

FCEV: Today, there are 5 HRS deployed and 3 under construction under HyTEC project. HyTEC is supported by the Danish EUDP and European FCH-JU programs and has a total budget of ú29.5 million[135]. There is a total of 7 HRS on the territory of Denamrk.

c. Customer

Since 2008, Electric car pilot scheme is in place in Denmark with subsidies for the EV and FCEV deployment projects. They allocated ú700 k per year until 2012 and ú2 million for 2013 to 2015[136].

Further incentives are given by tax reductions based on CO2. The annual circulation tax is based on fuel consumption. EVs weighing less than 2,000 kg are exempt from the registration tax, VAT and road taxes.

Registration tax: EVs weighing less than 2,000 kg and FCEV are exempt from the new car registration tax since 1985. The registration tax in Denmark is based on the vehicle's purchase price of the vehicle, and is set at 105% if the vehicle price is below DKK 76,400 (around ú10,200) and 180% if the price is above DKK 76,400[137].

Annual circulation tax: EV weighing less than 2,000 kg and FCEV are exempt from relatively small circulation tax based on fuel consumption. The average annual circulation tax is around DKK520 (ú70) for petrol driven passenger cars, consuming below 5 l/100 km[138].

l/100 km	0-5.0	5.0-6.0	>6.0	é	>22.2
ú	0	68	198		2400

3. Results

a. Manufacturer (BETTER PLACE)

Part of the appeal for Dong Energy, the country's biggest power company, is the ability to capture wind power at night, when it is usually plentiful, but when demand is low. With enough electric cars plugged in, that energy could be used to recharge batteries and thus be stored for use during the next day (or whenever the EVs are driven).

135 *http://www.hydrogenlink.net/eng/copenhagen.asp*
136 http://www.ens.dk/sites/ens.dk/files/info/news-danish-energy-agency/fact-sheet/elbiler%20engelsk.pdf
137 Confederation Fiscale Europeenne *https://www.cfe-eutax.org/taxation/road-tax/denmark*
138 Confederation Fiscale Europeenne *https://www.cfe-eutax.org/taxation/road-tax/denmark*

In 2008 there was a $100 million (ú90 million) partnership between Dong Energy and Better Place, a venture-backed international company that developed and sold battery-charging and battery-switching services for electric cars, to install charging stations and battery swap stations.

Under the terms of the agreement, DONG Energy assisted the Better Place Denmark network rollout as well as was the preferred supplier of renewable energy to power the network. The move sets the stage for Better Place and DONG Energy to execute as planned their commitment to enable the widespread adoption of mass-market electric vehicles by 2011.

BETTER PLACE was publicly launched in 2007 by Shai Agassi. The company proposed a solution to install EV at a large scale by avoiding (decreasing) the charging time. The solution was the replacement of empty batteries by full batteries in ñswapò stations. Thus, in only few minutes, the consumer could benefit of a full range of driving. At that moment (2008) just the Tesla roadster, with a price of $100,000 (ú90,000) was available and the idea of BETTER PLACE was to propose an alternative family car with the battery swap.

For this purpose Better place signed a Memorandum of Understanding with Renault-Nissan to build charging stations and propose a corresponding EV (Renault ZE Fluence). BETTER PLACE raised, in January 2011, around $700 million (ú620 million) in a venture funding in which third was spend in setting up the battery switch stations.

However, six years after its creation and 1400 vehicles sold, BETTER PLACE felt in bankruptcy.

There are many articles[139,140] which try to explain the BETTER PLACE bankruptcy. These studies highlight many challenges of new markets as the zero emission mobility.

A major criticism of the company strategy was that BETTER PLACE was founded with no market research or competitor analysis, but just according to the vision of Shai Agassi who was convinced of the popularity of his idea. In comparison, Tesla did its own research and arrives on the market with its own battery. Thus, the company started on an unstable basis. Moreover, there were a lot of mistake in the development of the project, which progressively pushed the company into the bankruptcy.

First, the roadmaps and prices announced by the company were too optimistic. Indeed, Agassi announced, in 2009, that 100,000 vehicles would hit the market in the first year of launch in 2011. Moreover, BETTER PLACE estimated the price of the swap station around $500,000 (ú440,000) while the actual cost is more $2 million (ú1.8 million). All these elements created distrust for the project from the consumer and industrials.

Second, the initialization of a market needs a well-defined footholds to demonstrate the utility of the technology quickly and win the trust of industrials and customers. BETTER PLACE

[139] http://yourstory.com/2014/08/famous-failures-better-place/
[140] http://www.forbes.com/sites/stephenwunker/2013/05/28/288/

has never precisely defined what footholds it was pursuing. They just said that they projected to penetrate markets in USA, Australia, Israel and Denmark. Itôs interesting to compare this strategy to the approach of Autolib project in France where the localization is well defined (Paris, Lyon), the principle very simple and the network very ample.

Third, at the step of starting market, competitors work generally in the same direction because they now that competition is necessary to install a stable environment. The strategy of BETTER PLACE was very aggressive and self-centered. For example, Shai Agassi sent a text message to a major carmaker:òIôll be offering $20,000 (ú18,000) cars in a market where youôre selling $60,000 (ú53,000) cars. How many have you planned to sell in Denmark? Because I recommend you take them off your planò and refused collaboration with GE for building the charging stations.

Finally, while BETTER PLACE was confronted to the chicken-and-egg situation, Renault ZE sold 800 units of Fluence the month of commercialization in France just with the option of home charger. Moreover, the super charger emerged with an important decrease of the charging time. These parameters rendered the battery swap investment irrelevant.

b. Infrastructure

The state of infrastructure in place for both BEV and FCEV is represented in the following table:

	BEV	**FCEV**
Number of stations	3,800 slow chargers and 120 fast chargers in 2013[141]	6 HRS in operation and 6 HRS under development[142]

The hydrogen initiatives in the Danish Energy Plan 2020 provide a strong basis for establishing the hydrogen infrastructure needed to enable market introduction of FCEV beyond 2015. The Government initiatives follow the recommendations from a Danish industry coalition analysis & roadmap on *"Hydrogen for transport in Denmark onwards 2050"*.

c. Customer

The current ramp-up for ZEV in Denmark is represented in the following table:

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[141] Amsterdam Roundtables Foundation and McKinsey. Electric vehicles in Europe: gearing up for a new phase? (2014)

[142] H2 stations.org
http://www.netinform.net/H2/H2Stations/H2Stations.aspx?Continent=EU&StationID=-1

Registrations	2010	2011	2012	2013	2014
EV, FCEV incl. PHEV ramp-up	46	459	547	544	1610
EV, FCEV incl. PHEV market share	0,03%	0,27%	0,32%	0,30%	1,54%

The number of EV deployed in Denmark during 2012 did not meet the expectations of several Danish EV stakeholders. The vehiclesô high purchase prices, uncertain resale values, range anxiety, and limited selection of models are generally perceived as the main barriers to EV market penetration. The secondary EV market is nascent.

The ZEV penetration rate in 2014 was 1.54% for new vehicle registrations. There is still a long way to go to achieve a targeted penetration rate of 94% on the market of new vehicles in 2020.

5. Glossary

ADEME	Agence de lôEnvironnement et de la Maitrise de lôÉnergie
BEV	Battery Electric Vehicle
cc	Cubic Centimetres
CCFA	Comité des Constructeurs Français dôAutomobiles
CO2	Carbon dioxide
CVPR	Clean Vehicle Rebate project
EHD 2020	Energie Hydro Data 2020
FCEV	Fuel cell Electric Vehicle
HIT	Hydrogen Infrastructure for Transport
HRS	Hydrogen Refuelling Station
HySUT	Research Association of Hydrogen Supply/Utilization
JAMA	Japan Automobile Manufacturers Association
k	thousand
kg	kilogram
l	liter
LCV	Light Commercial Vehicles (commercial carrier vehicle with a gross vehicle weight of not more than 3.5 tons)
M	million
METI	Ministry of Economy, Trade and Industry Japan
NIP	National Innovation Programme Hydrogen and Fuel Cell Technology
NOW	National Organization for Hydrogen and Fuel Cell Technology
NPE	National Platform for Electro mobility (Nationale Plattform Elektromobilität)
PC	Passenger Car (road motor vehicle, other than a motor cycle, intended for the carriage of passengers and designed to seat no more than nine persons

(including the driver). The term "passenger car" therefore covers microcars (need no permit to be driven), taxis and hired passenger cars, provided that they have fewer than ten seats. This category may also include pick-ups[143].

PEV	Plug-in Electric Vehicles
PHEV	Plug-in Hybrid Electric Vehicle
PP	Public Partnership
PPP	Public-Private Partnership
TEN-T	Trans-European Transport Network
ZEV	Zero Emission Vehicle

[143] OECD, *https://stats.oecd.org/glossary/detail.asp?ID=3524*