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Overview of government policies to promote ultra-low emission vehicles

EXECUTIVE SUMMARY

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To achieve carbon neutrality by 2050, the French government climate plan presented in July 2017 by the Minister of State for Ecological and Inclusive Transition, seeks to ban sales of cars emitting greenhouse gases by 2040. Other countries have announced their commitment to ban the sale of internal combustion engine vehicles (ICEV), with different scopes and timelines. This summary reviews the content of these bans and the development strategies for ultra-low emission vehicles to anticipate them. It examines government policies in eight countries: Germany, the United Kingdom, the Netherlands, Spain, Norway, the United States, India and China.[1] Like these government policies, this summary focuses on electric cars, even though it also outlines buses, light commercial vehicles and fuel cell electric vehicles (EVs).[2]

In 2017, worldwide sales of electric vehicles reached 1.2 million units, i.e. 1.5% of new car sales, an increase of almost 60% compared to 2016

Eight countries – China, the United States, Japan, Norway, the United Kingdom, France, Germany and Sweden – account for 90% of worldwide sales, with China largely dominating the market with 600,000 sales, of which 80% are made up of battery electric vehicles (BEVs) and 20% plug-in hybrid electric vehicles (PHEVs). Four countries have set medium-term targets for halting the sales of new cars with internal combustion engines: by 2030 in the Netherlands, by 2032 in Scotland and by 2040 in France and in the United Kingdom. Norway has announced its intention to achieve 100% sales of EVs by 2025 without banning the sales of internal combustion engine vehicles, relying on financial incentives to achieve this result. California will impose quotas on manufacturers for the sale of EVs. China is expected to follow suit from 2019 and has set targets for sales of alternative energy vehicles (2 million by 2020 and 7 million by 2025). India, which had initially announced its (probably unrealistic) intention to fully electrify its car park by 2030, is now targeting a (more attainable but still ambitious) objective of 30% of electric cars by the same date. That being said, sales of EVs in 2017 did not exceed a few hundred, even a few dozen, in more than fifteen countries in the European Union.

Advances in battery technology have boosted development of EVs

To date, EVs in France have mainly been used for daily commuting because of their limited driving range: fast charging stations on highways are rarely used. Recent technological advances of lithium batteries (with cathodes principally composed of nickel, manganese and cobalt) have slashed their cost in half.

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1. This is the executive summary of the report "Overview of Government policies to promote ultra-low emission vehicles" published on France Stratégie's website. The report was written by Dominique Auverlot, Nicolas Meilhan, Bérengère Mesqui and Aude Pommeret and is based on documents provided by the Treasury DG's regional economic offices in Berlin, The Hague, London, Madrid, Oslo, New Delhi, Beijing and Washington.
2. EVs include battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs) and fuel cell electric vehicles (FCEVs). It does not include hybrid electric vehicles (HEVs) as they can only drive in all-electric mode for a few kilometres (the electricity being provided by recovering the vehicle's kinetic energy).

New electric cars equipped with a 40 kWh batteries now allows journeys up to 250 km (150 km on highways), with less than half an hour required to recharge batteries by 80%.[3] This is expected to boost sales of battery electric vehicles (BEVs), which are still mainly used for daily commuting. In 2019, longer distances (400 km on roads and 250 km on highways) should become possible with new BEVs using high-capacity batteries (60-100 kWh). Tesla and a number of other vehicle manufacturers are betting on this.[4] This will require the presence along main roads of well signposted and, if possible, rain-sheltered, fast charging stations with capacities exceeding 150-200 kW. As is already the case in China, it is likely that each EV model will be offered with a range of battery capacities and associated driving range (as well as pricing).

For long distances, PHEVs are in direct competition with BEVs equipped with high-capacity batteries

PHEVs combine two powertrain, having both internal combustion and electric engines with an electric driving range of a few dozen kilometres. Although they only represent half of BEV sales worldwide, they are on par with BEV sales in Europe. In 2017, the respective sales of BEVs and PHEVs were balanced, with a slight advantage for PHEVs (143,974 compared to 135,369). However, BEVs and PHEVs share in EV sales vary a lot among European countries as it is highly dependent on local government incentives.[5]

BPEV and RHEV sales in 2017

	France	The Netherlands	Norway	Spain	Sweden	Germany	United Kingdom
BPEVs	24 910	9 897	33 025	3 920	4 217	25 056	13 597
RHEVs	11 868	1 158	25 165	3 370	15 447	29 439	31 154

Source: ACEA.

When government incentives result in comparable retail prices, sales of PHEVs, which do not have any driving range constrain, are higher than BEV sales. However, several countries offer limited (if any) incentives to PHEVs as they are still mainly used in combustion engine mode hence emit significantly more greenhouse gases than BEVs. Furthermore real-driving emissions measured in the Netherlands identified a gap of one to three between the homologation tests and real driving conditions, which should prompt a review of PHEV homologation rules for CO_2 emissions in order to avoid bargain purchase to benefit from tax incentives.

Reducing or ending subsidies too suddenly always results in a sales collapse, as it happened in the Netherlands with PHEVs and in Denmark with BEVs. PHEVs development prospects will therefore depend on their relative cost compared to BEVs, as well as on government incentives. Future regulations should encourage their use in electric mode: new PHEVs equipped with an electric driving range of over 60 km covering 80% of daily commuting and an internal combustion engines for long-distance trips would help us reach this objective.

Fuel cell electric vehicles (FCEVs) are also capable of long distance. However, only 3,000 FCEVs were sold globally in 2017: their high costs currently limit their use to highly subsidized demonstrations for “captive fleets” and heavy duty trucks.[6] Mass market penetration of such vehicles seems unlikely before 2030.[7] Nevertheless the Japanese government remains very ambitious regarding FCEV: it targets 40,000 FCEVs on the roads by 2020, 200,000 by 2025 and 800,000 by 2030, fuelled by 160 hydrogen refuelling stations in 2020 and 320 in 2025.

3. On highways, electricity consumption is closer to 20-25 kWh/100 km.
4. Non-exhaustive list: the Kia Niro planned for 2018 with a 64 kWh battery, the Nissan Leaf for 2019 with a 60 kWh battery, the Hyundai Kona for 2018 with a 60 kWh battery, the Jaguar I-pace with 90 kWh battery and the Audi e-tron SUV with 95 kWh battery, on top of a large number of Chinese models that were presented in April 2018 at the Beijing Motor Show.
5. In terms of the EU-28 and the EFTA (Switzerland, Norway, Iceland and Lichtenstein).
6. Around €66,000 for the Toyota Mirai.
7. See the work done by the CEA/DGEC on the use of hydrogen in the energy transition.

Electric vehicle penetration exceeds 10% in Norway, a couple of cities in China such as Beijing, Shanghai and Shenzhen as well as thirty cities in California

With less than 3% EV penetration, French and German cities are a far behind. In the Netherlands, EV penetration was close to 10% in 2015 but the end of PHEV subsidies over two years had a drastic impact on EV sales which were divided by 4. Each of these pioneering areas has a number of specific characteristics.

- **Norway:** The government has implemented financial incentives on a large scale, both direct (exemption from import tax and VAT) and indirect (exemption from toll roads, free access to road ferries and access to bus lane lanes). EVs are therefore less expensive to buy than their Internal Combustion Engine equivalent and also benefit from a low hydropower electricity cost. The extent of these benefits is such that reaching 100% EV sales target by 2025 does not rely on banning ICE sales but on consumer preference only. The fast deployment of EVs stems from a deliberate effort of this oil-producing country, which has one of the highest levels of GDP per capita in the world thanks to its fossil fuel exports, to combat climate change.[8]

- **California:** In 2016, California accounted for 50% of EVs sold in the United States, with Los Angeles representing as much as 20% US EV Sales. Firstly, a recent trend has seen many wealthy consumers being seduced by the new local manufacturer Tesla, which managed to combine in a single car environmental protection and digital technology to recreate "car desire". California has been promoting EVs since the 1990s, with its "Zero-emission vehicles" programme, which requires manufacturers to sell increasing EV quotas year after year. On top of national subsidies, which amount to $7,500 per vehicle for the first 200,000 EVs sold in the United States by a single manufacturer, California has introduced a purchase grant programme to help low income in acquiring an Electric Vehicle.[9] Finally, Los Angeles allows EVs to use carpooling lanes, which is also a significant incentive.

- **China:** Half of EV sold globally are currently sold in China, who wants to develop its automotive industry and lead the Electric Vehicle industry globally. A "Zero-emission vehicles" programme based on the Californian scheme will be implemented in 2019. The current boom in EVs results from strong financial incentives at a national level with purchase grants restricted to Chinese models, which may also be combined with local and regional incentives. National and local incentives can add up to more than 50% of purchase price. These subsidies are, however, due to decrease over the next few years as EV sales quota for manufacturers increases from 2019 onwards. In addition, Beijing and Shanghai impose an increasing share of EVs – 60% in Beijing in 2018 – in new license plates released. Finally, China provides strong incentives for electric two-wheeler (30 million sold in 2017), electric buses (90,000 sold in 2017) and Low Speed EVs (1.2-1.5 million sold in 2017) which are electric quadricycles.

  This overview of government policies shows that EVs deployment need strong and long-term financial incentives for the end-customer, but also indirect incentives as well as EV sales quotas for vehicle manufacturers. Keeping in mind the importance of incentives, and without mentioning the steady increase in the carbon component of the TICPE already provided for by law, several measures could be assessed in more detail before being implemented in France or in Europe.[10]

- *Sales quotas for electric and low-emission vehicles could be imposed on manufacturers*

  By regularly lowering emissions standards of manufacturers' new vehicles average emissions, the European Union is as a matter of fact implementing a sort of quota which is a significant incentive for manufacturers to adapt their strategy. For the time being, manufacturers have focused on reducing ICE vehicles emissions and developing hybrid vehicles. German manufacturers have however realized that developing EVs would allow them to reduce the amount of penalties they may incur.

  When defining the emissions standards roadmap until 2030, the European Parliament wanted EV sales quotas to be implemented from 2025 onwards, thus providing each manufacturer with a target. The European Automobile

8. In third place behind Luxembourg and Switzerland in 2017.
9. Tesla and General Motors , which have already sold 178,000 and 176,000 EVs respectively in the United States, are approaching the 200,000 vehicle threshold, above which national subsidies are expected to decrease substantially. In order to avoid a sharp decline in sales, these two manufacturers will need to significantly reduce their prices: this is Tesla's gamble with its Model 3 which is expected to be much cheaper than its Model S (69,000 euros). Unless the government, aware of the manufacturers' interests, chooses to raise this threshold: https://electrek.co/2018/03/16/electric-vehicle-tax-credit-cap-tesla-gm/.
10. Domestic Consumption Tax on Energy Products.

Manufacturers' Association, however, opposed this measure since its achievement would heavily depend on local governments' incentives. The use of such quotas in Europe would nevertheless be required should EV deployment stagnates.

- *Maintaining financial incentives in place is needed* as long as the Electric Vehicle purchasing price is higher than the ICE vehicle. Grants could be related to income, as is the case in California, or limited to EVs costing less than €60,000, as is the case in Germany, in order to help the people who most need it. Those financial incentives are due to eventually fading away as electric vehicle production costs fall.[11]

- *More indirect incentives could be implemented in France:* exemption from toll roads for EVs and electric LCVs, free access to car parks equipped with charging points, preferred parking rates for EVs, and access to bus lanes. Germany is currently considering exempting electric Medium Commercial Vehicles from toll roads.[12]

- *Introducing congestion charging or low-emissions zones* would give EVs a strong advantage. "Limited traffic zones" (ZCR) established under the 2015 Energy Transition Law for Green Growth could be used as an alternative to urban tolling.[13]

- *Financial incentives (such as a bonus/malus) increasing with BEV driving range* would partially offset the additional cost associated to a larger battery and would promote the development of BEVs able to cover medium to long distance trips. This approach is aligned with California quota system where the more the EV driving range is large, the higher the vehicle contributes to reaching the quota.

- *Financial incentives increasing as well with PHEV electric driving range*, aligned once again with California's quota system, would significantly reduce incentives for PHEVs with very limited electric driving range. It would, on the other hand, stimulate the development of new PHEVs able to drive at least 60 km in all-electric mode.

The coordination of national and local incentives to promote EVs is an important issue. The state is responsible for providing direct financial incentive while indirect incentives and public charging points should be implemented by cities; regions or utilities should be responsible for installing charging points across their area. Rather than looking for complementarity through an *a priori* role allocation, the United Kingdom preferred to foster innovation with a project tender that allocated several dozen of million euros to four cities that were keen to heavily promote EVs: such an approach should result in sharing best practices between cities in order to improve public spending efficiency.

In Norway and California, EVs deployment is boosted by the high share of individual housing, which allows people to recharge their vehicles at home. On the other hand, space scarcity in Tokyo is strong restrain to EV deployment: 60% of the population lives in 130,000 flats, while 90% of EV owners live in detached houses. In cities where flats account for a significant share of housing, EV deployment will only be possible if enough charging points are installed in parking lots and garages as well as on-street for residential parking.

There will not be a real boom in EV development until they become affordable to households with lowest income[14]

This will require a significant price reduction of EVs: excluding the EV purchase grant, the Renault Zoé price including the battery is €32,600, more than twenty-five times that of the net monthly minimal income (SMIC).[15] It will also require the development of a second hand market for EVs, which is obviously very limited for the time being since it lags behind the new vehicle market by a couple of years.[16] The main concern for potential second-hand buyers is the state of health

11. The grant available to purchase an EV in France in 2018 is 27% of the purchase price, including VAT as well as the cost of the battery if hired, up to €6,000. The total cost of ownership (TCO) is a more relevant indicator; however, private consumers tend to make choices based on the purchase price rather than TCO.
12. According to the *Süddeutsche Zeitung* newspaper, and reproduced on the TRM24 website.
13. In order to combat atmospheric pollution, this 17 August 2015 law introduced the option of creating "limited traffic zones" in cities and in areas where a Plan for the Protection of the Atmosphere (PPA) has been adopted or is under development or review.
14. I.e., the third decile in France: in 2015, 17.1% of households did not have access to a vehicle, www.insee.fr/fr/statistiques/3303447?sommaire=3353488.
15. https://droit-finances.commentcamarche.com/faq/3567-smic-2018-montant-mensuel-du-smic; www.insee.fr/fr/statistiques/1375188.
16. Except in Iceland, where the limited number of EV models on sale has led to imports of second-hand EVs, and where tourism has led to a significant increase in vehicle hire. See S. Friðleifsson (2017), personal communication, Icelandic Energy Agency, 6 November 2017.

of batteries : the best way to address this concern would be for vehicle manufacturers to warranty batteries performance for a long enough period of time, eight years period for example (or to offer second-hand customers to hire them). The implementation of Ultra-Low Emissions Zones (ULEZ) accessible only to vehicles not emitting greenhouse gases could also prevent a rapid depreciation of their residual value.[17] Finally, purchase grants for companies as well as vehicle hire companies are an effective way to stimulate this second-hand market.[18] However, EVs with a real driving range of 250 km are not expected to reach the French second-hand market in significant numbers before 2020-2021.

Electric light commercial vehicles and heavy duty vehicles are a niche for the time being

Electric mobility could have started with the development of Light Commercial Vehicles (LCV) as many of them only travel in well-defined areas that could be subject to regulations such as low-emission zones: this is however not the case currently. Outside China only 20,000 electric were sold globally in 2017.[19] Their limited driving range, their high costs as well as the limited range of models available are key restrains for potential buyers. Future urban access restrictions for the most polluting vehicles in several European cities should however boost electric LCV sales. Specific financial and tax incentives could also be introduced. Moreover, the deployment of electric Heavy Duty Vehicles (HDV) of up to 20 tonnes (GVWR) by a couple of truck manufacturers around 2020-2021 will help to assess the technical and economic viability of these vehicles.[20]

The deployment of charging points is a necessary but insufficient precondition for the development of EVs

According to the ministerial delegate (*délégué ministériel*) for the territorial development of electro-mobility, the double target which could be set in France would consist in installing a national average of one charging point per 5-6 vehicles (which was the case in early 2018, with 23,300 charging points accessible to the general public for approximately 150,000 EVs on the roads) and a minimum of one charging point per 10 vehicles in all departments (*départements*). The provision of fast-charging stations is more problematic. In February 2018, the British equivalent of RTE (National Grid) referred to the installation of 50 ultra-fast charging stations on Great Britain's highways, directly connected to the electricity transmission grid and supplying up to 350 kW of power for charging BEVs, LCVs and HDVs.

There will be a major challenge for all stakeholders during the next thirty years. We are at an early stage of deployment of charging points, which must naturally follow that of EVs (without necessarily being strictly proportional). However, the number of EVs could increase from today's figure of 150,000 to 4.5 million during the next fifteen years, i.e. thirty times more than the current park. In addition, recharging power will have to increase with the increase in battery capacity. In the various relevant countries, government funding is generally provided on a massive scale at first, in particular for the installation of slow charging points, but this contribution then decreases as the private sector takes over. In the United States, after a phase of joint funding from both government and private sectors which began in 2009, the majority of the charging points were financed through utilities and automobile manufacturers. In Europe, the company Fastned is developing a network of ultra-fast charging stations in the Netherlands (without subsidies) and in Germany (with subsidies). Conversely, 18 countries in the EU-28 did not award any subsidies in 2016 for the installation of charging points, thereby preventing an increase in the use of EVs on their territory. In light of this combined private/public sector involvement, from local authorities to the European Commission itself, it is the responsibility of public authorities to:

- ensure that the rate of deployment of charging stations facilitates and keeps pace with the development of EVs to avoid "charging anxiety" as witnessed in Norway (fear of having to queue at charging stations);
- promote private sector funding by removing potential legal and regulatory obstacles (planning, transferability of contracts, etc.) and by making the installation of a certain number of charging points a requirement in the licensing specifications for highway service stations;
- allow drivers to recharge their EVs at any charging point accessible to the public. A decree (*décret*) of January 2017 makes this compulsory for new charging points. This requirement has yet to be applied to charging points which were

17. Global EV Outlook 2017, IEA 2017.
18. *Reconsidering the Future of Electric Vehicles in Iceland*, AARHUS UNIVERSITY.
19. Where 60,000 light commercial vehicles were sold in 2017.
20. Daimler, Commins, Tesla, Nikola Corp., Renault Trucks.

already in place in France when this decree was issued and to all charging points in Europe.[21] In California, this right of free access was introduced to prevent charging points becoming subject to commercial practices such as requiring drivers to take out a subscription (which would oblige drivers of EVs to subscribe to numerous charging point networks); [22]

- provide financial aids, following the example of Denmark, the Netherlands and the United Kingdom, for the installation of charging points, upon request, in public areas for households without a parking;

- provide financial aids, in conjunction with the relevant authorities, and following Tokyo's example, covering all or part of the installation of charging points in parking lots and garages of collective buildings (*logements collectifs*), including social housing;

- in general, remove obstacles to recharging at home and at work in order to limit the need to install charging points in public areas.

The examples of Norway and the United Kingdom demonstrate that certain precautionary measures should be taken with respect to recharging at home and that the consequences of EVs using electricity distribution and transmission networks need to be anticipated. Regarding recharging at home, a designated outlet is advisable or, failing this, the compliance of the recharging facilities should be checked (e.g. state of the ground connection). The fires reported in China in electric bus depots during recharging confirm that this risk must be constantly monitored under ICPE regulations (the classification of sites for the purpose of protecting the environment).

The development of EVs should be considered within a more general debate on the future of the power grid

EVs will lead to additional constraints in the management of the power grid but may also provide solutions. As Norway's example demonstrates, it is necessary to plan in advance the reinforcement of distribution and transport networks. The ten-year scheme for increasing the capacity of the electricity transmission network, established under the Energy Code (*Code de l'énergie*), should take into account the possibility of a dramatic increase in the use of EVs by envisaging, for example, that sales of EVs will represent 30% of sales of new vehicles by the year 2030, and by providing a management system that can deal with peak demand. But it should also specify the assistance that EVs could offer the power grid, not only by responding to demand and adjustments in frequency but also, ultimately, by their batteries' capacity to supply the power grid or households with electricity during peak times (as an extension to the experiments carried out in Denmark and in California). Legislation could also oblige operators of distribution networks to consider the modifications that their networks will require in ten years' time so as to be able to support this development.[23]

Finally, in support of these works, legislation could provide the development of a blueprint of publicly available charging points, for a regional implementation.

The number of EVs worldwide is expected to be in the millions of vehicles by 2030, with an annual market revenue in the tens of billions of dollars

The European automobile industry, which has mastered the internal combustion engine technology, could lose a significant number of jobs was car electrification, even though there is no consensus amongst the numerous studies that have been published on this topic which rather show a positive trend. What matters is not so much whether new jobs associated to electric vehicle production will compensate for the job lost for ICE vehicles production. What matters is whether the French and European automobile industry will be able to leverage the EVs new opportunity. Jobs will actually depend mainly on market shares and value added value by the French and European industries, especially with competition from China which masters battery technology and currently produces more than half of electric cars in the world and the vast majority of—if not all—buses, electric quadricycles (LSEVs) and electric bikes.

21. Article 4, Point 9 of Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the deployment of alternative fuels infrastructure provides : "All recharging points accessible to the public shall also provide for the possibility of electric vehicle users to recharge on an ad hoc basis without entering into a contract with the electricity supplier or operator concerned".
22. https://www.afdc.energy.gov/laws/11067
23. These modifications should reflect developments in renewable energy.

As the strategy adopted by the UK (but also China and Germany) demonstrates, the development of the automobile sector and its associated jobs in France and Europe require the implementation of i**ndustrial policy measures in favour of EVs**.

- *A significant R&D effort is needed*, primarily on batteries but also on new materials, digital technology as well as recycling. If, in the medium term, the European Union does not manage to produce its own batteries, it will have to pay significant imports costs on every car (which would be reduced if the final assembly of batteries takes place in Europe and if battery cells are produced in oversea manufacturers plants located in Europe) and will depend on the countries controlling the supply chain of critical materials.[24] It must therefore provide strong support for R&D regarding next-generation batteries, as part of the Horizon 2020 programme or its successor, mobilizing resources allocated to societal issues or critical technology, or as part of a European disruptive innovation agency. Without being overly prescriptive of technology, in order to avoid suboptimal choices, it could explore various options (sodium-ion and solid-state batteries, etc.) and have a back-up plan based on another technology (lithium iron phosphate for example which does not depend on cobalt). Lithium-air batteries should also be an important research programme: progress in this technology (which offers a significantly higher energy density than existing lithium-ion batteries) could revolutionize electric mobility. This is why the United Kingdom has created the *Faraday Battery Challenge*, with £246m of funding over four years.

- *Initial and ongoing trainings need to be reinforced* to develop the new skills that the automotive industry will require, especially in electronics, mechatronics, digital technology, high-voltage management and new materials.

- *A policy supporting EV demand in the ramp-up period* (purchase grants, subsidies to install charging points) must be introduced in order for manufacturers to have access to a sufficient market to be able to continue to innovate.

  The speech on the European Union given by the France's President at the Sorbonne in September 2017 mentioned the implementation of a significant carbon tax in Europe, associated to a carbon border "'that will also protect our economic sectors against imports from countries that do not respect the same objectives and decide not to engage in this environmental transition".[25] Such a carbon tax would enable France and Europe to retain a larger share of the value added from the production of tomorrow's vehicles and would also provide an incentive for manufacturers to produce their ultra-low emission cars and batteries in ultra-low emission countries.

This same speech suggested "the implementation of a European industrial programmeme supporting clean vehicles and deploying common infrastructures to make it possible to travel through Europe without damaging it". Such a programmeme could have two legs: a "supply" leg, which gives priority to R&D initiatives and to training, and a "demand" leg, providing incentives for purchasing EVs and installing universally accessible charging points.

Annual sales of EVs have now exceeded one million. Even if it is difficult to accurately predict the number of EVs that will be sold worldwide by the year 2040, the corresponding car park will represent tens of millions of vehicles by 2030 and an annual market of several tens of billions of dollars. EVs constitute an industrial opportunity for France and the European Union that we should not miss out on.

Key terms: electric vehicle, hybrid vehicle, energy transition, automobile market.

24. See European Battery Cell Randl Workshop Final Report, European Commission, 12 February 2018.
25. For a transcript of this speech, see the Elysée website.

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