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Electric vehicles in France: A fifteen-year financing plan for massive rollout

Oliver Sartor, Thomas Spencer (IDDRI), Oliver Fryatt (Department for Business, Energy & Industrial Strategy, UK Government)

CURRENT DEPLOYMENT RATES ARE NOT ON TRACK WITH DEEP DECARBONISATION

Numerous studies have acknowledged the importance of massive deployment of full battery electric vehicles (BEVs) and plug-in hybrid vehicles (PHEVs) in order to reduce environmental externalities from personal road transport, in particular CO_2 emissions. Good news about declining battery costs and ambitious output pronouncements by major car manufacturers may give the misleading impression that mass-penetration of electric vehicles is just around the corner. But current deployment rates of EVs are significantly off track for deep decarbonisation of the French transport system by 2050. In the short to medium term, large scale penetration is far from assured, unless there are further policies to address a number of barriers.

THE FINANCING CHALLENGE

In the short term to around 2020-2025, EVs will remain more expensive to purchase and run than equivalent internal combustion engine (ICE) vehicles. In the medium term beyond 2020-2025, EVs are likely to become competitive on a lifetime cost basis. However, they may still confront other financing challenges, such as higher upfront purchase costs (as opposed to lifetime costs). This barrier may be particularly important if consumers are myopic and discount future fuel savings, or if they are credit constrained. In the longer run, EVs will create other challenges for governments to deal with, such as fuel tax revenue erosion. EV support policy should therefore be designed with a dynamic, at least decadal perspective. In this paper, we consider a three-phase financing strategy corresponding to the above described challenges.

CONSIDERING DISTRIBUTIONAL ISSUES

A range of fiscal policy tools are likely to be needed as part of any feasible regulatory framework for supporting mass-EV roll out. But this raises the critical issue of the distributional impacts of the transition to EVs, which has to be addressed in the design and monitoring of EV support policy. The upfront financing challenge may be particularly relevant for lower income households, while at the same time, massive rollout of EVs will require that middle and lower income households start to purchase electric vehicles. The progressive compensation of declining fuel tax revenues through fuel tax increases and the ratcheting up of malus policies on ICEs could also have important distributional impacts.

THE EV FINANCING CHALLENGE IS FEASIBLE, IF WE CAN GET THE MIX AND TIMING OF POLICIES RIGHT

The EV financing challenge is eminently feasible, and we can be optimistic about the capacity of a judicious policy mix to push the massive deployment of EVs. However, one should not be deluded by the hype currently surrounding EVs: rapid deployment will not occur without further policy push, which should be fiscally neutral if possible; be phased out once the technology reaches maturity; and pay attention to the distributional aspects of policy.

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Electric vehicles in France: A fifteen-year financing plan for massive rollout

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EXECUTIVE SUMMARY

Current deployment rates are not on track with deep decarbonization

Numerous studies have acknowledged the importance of massive deployment of full battery electric vehicles (BEVs) and plug-in hybrid vehicles (PHEVs), in order to reduce environmental externalities from personal road transport, in particular CO_2 emissions. Studies indicate that this would have multiple other benefits not least reducing France's dependence on imported fuels.

Declining battery costs and ambitious output pronouncements by major car manufacturers may give the misleading impression that mass-penetration of electric vehicles (EVs) is just around the corner. **But current deployment rates of EVs are significantly off track for deep decarbonization of the French transport system by 2050.** In the short to medium term, large scale penetration is far from assured, unless there are further policies to address a number of barriers.

Box 1 : What this study does not deal with

- In order to study a limited and manageable case, this study makes a number of simplifying assumptions. These are some of the factors that are not dealt with:
- The study does not take into account the potential that collaborative mobility solutions and autonomous vehicles reduce vehicle ownership and purchase rates. Thus the scenarios developed in this paper involve sales rates of EVs that would be necessary to decarbonise transport assuming that current ownership patterns persist. Making this assumption also allows us to illustrate one of the interesting potentials of such mobility services, namely their capacity to overcome the upfront purchasing cost challenge of EVs by shifting the purchase burden of EVs and increasing utilisation rates and hence the aggregate number of EVs required to satisfy a given service demand.
- This study does not take into account the potential that consumer preferences could change, allowing some of the incremental purchase cost of EVs to be defrayed by reduced expenses on non-essential vehicle components. Thus all incremental cost estimates for EVs versus ICEs assume that everything else is held equal.
- The deployment scenarios and hence technology learning rates are exogenous to the policy choices assessed. Learning will be a function of global deployment of EVs, and thus we assume rapid global deployment drives rapid technology learning. The objective of the paper is to study the financial consequences of mass deployment, and thus deployment rates are an exogenous input to the model of financial impacts.

Technology learning – very rapid cost declines but is this enough?

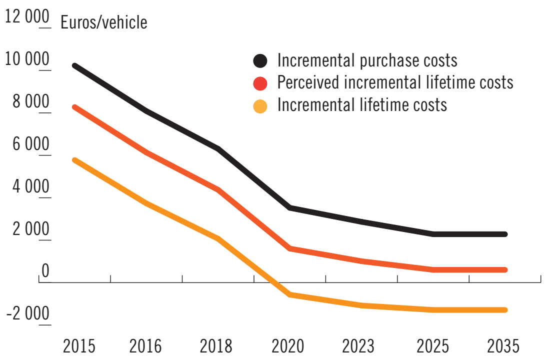
The improvement of battery technology is proceeding very rapidly, with learning rates of about 10% per year in recent years. In this report, we take a current estimate for a battery cost of €228/kWh for EV batteries, and apply a learning rate of 10% per year until 2025; cost declines are then assumed to slow before stabilising at a floor of €80/kWh in 2030. If we assumed a midrange vehicle with a battery capacity of 45 kWh and hence an autonomy range of >300 km, this would give an incremental purchase cost, compared to an equivalent international combustion engine (ICE), of ca. €8,084 today falling to €2,281 by 2030, before fuel savings across the vehicle lifetime are accounted for.

This brings up an important point regarding the cost structure of EVs, which are characterised by higher capital costs and lower operating (fuel) costs. Thus we should distinguish between three different definitions of the 'incremental cost' of EVs *versus* internal combustion engine vehicles (ICEs):

- *Incremental purchase cost*: this is the purchase cost difference between EVs and ICEs, without taking into account any fuel cost savings over the life of the vehicle.
- *Incremental lifetime cost*: the incremental purchase cost of EV *versus* ICE, minus non-discounted fuel savings across the lifetime of the vehicle. Once the technology is mature, it is expected that incremental lifetime costs will be negative for EVs compared to ICE vehicles.
- *Perceived incremental lifetime cost*: a lot of evidence suggests that consumers discount, often heavily, future operating cost savings in their purchase choices. Thus perceived incremental lifetime cost is the incremental purchase cost minus discounted full savings across the lifetime of the vehicle. Even when the technology is mature, perceived incremental lifetime cost for EVs may still be positive, depending on the extent of discounting of future fuel savings.

The difference between these perspectives is shown in Figure E1:

Figure E1. Impact of consumer myopia on EV economics: incremental lifetime cost versus perceived incremental lifetime cost



Source: IDDRI. Note this assumes a battery pack of 45 kWh.

The analysis presented in Figure E1 **highlights the importance of the upfront financing challenge to the rollout of EVs. Moreover, if one assumes that some consumer myopia leads to a discounting of future fuel savings, then effective financing solutions will be needed to overcome this challenge in the longer run, even once the technology reaches its long-run equilibrium.**

The importance of the upfront financing challenge

This paper thus addresses the issue of how to overcome the upfront financing challenge for EVs. In this regard, three problems can be identified:

- *Phase 1*: In the short term to around 2020-2025, EVs will remain more expensive to purchase and run than equivalent internal combustion engine (ICE) vehicles.
- *Phase 2*: In the medium term beyond 2020-2025, EVs are likely to become competitive on a lifetime cost basis. However, they may still confront other financing challenges, such as higher upfront purchase costs (as opposed to lifetime costs). This barrier may be particularly important if consumers are myopic and discount future fuel savings, or if they are credit constrained.
- *Phase 3*: In the longer term after 2025, if the EV deployment strategy is successful, the deployment of EVs could begin to significantly erode fiscal revenues from fuels. Governments will have to think proactively about how to manage this fiscal revenue erosion.

In the short term, e.g. in the period from now out to 2020-2025, fiscal policies will have an important role to play in closing the cost competitiveness gap between EVs and equivalent ICE vehicles. During the phase of technological learning, there is an argument for governments to continue to subsidise EVs, so due to the positive spill-overs benefits of rapid deployment on their long-run cost all consumers. At the same time, subsidy of a massively growing market (if early subsidies are effective) is not economically or politically sustainable. Mid-term policy will have to think about how to phase out subsidies, and but still ensure that both the upfront financing challenge is overcome. Moreover, if rollout is successful, a growing share of EVs will start to erode fiscal revenues from transport fuels, which means considering policies to compensate the decline of fuel tax receipts, but still in such a way as to support continued rollout of EVs.

Thus EV support policy should be designed with a dynamic, at least decadal perspective. In this paper, we consider a three-phase financing strategy corresponding to the above described challenges. This strategy would i) minimize net government outlays; ii) take into account the evolving role for policy as technology learning occurs, markets mature and costs come down.

The importance of considering distributional issues

The above discussion leads to a second important issue: the distributional impacts of the transition to EVs. First, the upfront financing challenge may be particularly relevant for lower income households, while at the same time, massive rollout of EVs will require that middle and lower income households start to purchase electric vehicles. This requires that policy consider how to ensure access to EVs for such consumers (phase II). Second, the progressive compensation of declining fuel tax revenues through fuel tax increases and the ratcheting up of malus policies on ICEs could also have important distributional impacts (phase III).

Thus EV support policy should also be designed and monitored with distributional impacts in mind, in order to ensure its social acceptability. Distributional issues are considered in a cross-cutting way throughout this paper.

Policy recommendations

The analysis developed in this paper leads to five recommendations:

1. The EV financing challenge is eminently feasible, and we can be optimistic about the capacity of a judicious policy mix to push the massive deployment of EVs. However, one should not be deluded by the hype currently surrounding EVs: rapid deployment will not occur without further policy.

2. This policy push should be fiscally neutral if possible; be phased out once the technology reaches maturity; and pay attention to the distributional aspects of policy.

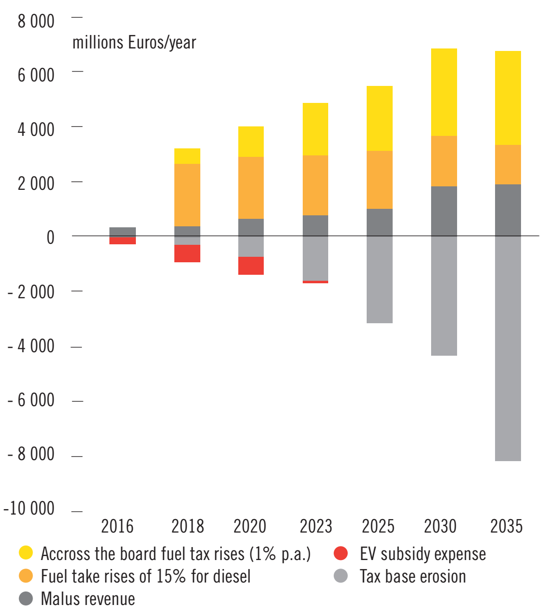
3. In the short term we recommend a subsidy that covers the perceived incremental purchase cost of about €8,000 per vehicle in 2016, falling annually at a rate consistent with technology learning. This should be combined with a corporate fleet procurement mandate, announced early and phased in to a progressively higher share of the fleet, as the technology reaches competitiveness on an incremental lifetime cost basis (i.e. reaching 100% with potentially some case-by-case derogations by 2020-2025). The fiscal effects of the subsidy should be offset by an increase of fuel taxation on diesel in order to bring it into line with the level on gasoline.

4. In the medium term beyond 2020, it is reasonable to expect that credit markets (either loans or leasing) can cover the perceived incremental lifetime costs that remain between EVs and ICEs. However, even if credit markets step in, some lower income consumers may not be able to access credit at sufficiently low cost. Such consumers would traditionally turn to the second-hand car market. Policymakers could consider in this phase supporting such consumers to purchase EVs through lower cost credit, targeted subsidies for the replacement of batteries in the second-hand car market, and information standards or guarantees on residual battery performance to underpin confidence in second-hand EV markets.

5. In later phases of EV deployment, the erosion of fiscal revenues from fuel could become significant. The results of this analysis suggest relatively large losses in total fuel revenue, reaching approximately €5.5 billion by 2025 and €16 billion by 2035. We therefore recommend, in addition to the equalisation of diesel tax rates with petrol, that a regular rise in fuel taxation be put in place from 2020, coupled with a progressive rise in the *malus* on residual ICE sales from 2020. This would compensate, at least out to 2035, fuel tax base erosion. In the very long term, as vehicle technology becomes more digitalised, other measures could be explored, such as kilometric-based taxation.

This combination of measures gives the fiscal impacts displayed in the figure below, for a massive rollout of EVs.

Figure E2. Integrated analysis of fiscal impacts of the EV support strategy



1. INTRODUCTION

Numerous studies have shown the importance of massive deployment of electric vehicles (EVs), including battery electric vehicles (BEVs) and plug-in hybrid vehicles (PHEVs), in order to reduce environmental externalities from personal road transport, in particular CO2 emissions. Globally, the International Energy Agency advocates an ambitious deployment of 150 million EVs by 2030, relative to a current stock of 1.26 million. The Deep Decarbonization Pathways Project (DDPP) country scenarios foresee a similarly ambitious penetration if temperatures are to be kept below 2°C.

Of course, BEVs and PHEVS are not the only low-carbon solution; however, they are expected to be a dominant technology moving forwards.

There is considerable excitement at present about the emerging potential of electric vehicle technology. Several constructors have announced ambitious plans to come forward with new and improved passenger electric vehicles by 2020 and to make EVs an important share of their product range.

There is evidence that battery costs are beginning to decline rapidly, potentially enabling greater range at lower cost for consumers. The "Dieselgate" scandal of 2015 and increasing concerns about the public health related risks of internal combustion engines (ICE) has added further impetus to these trends.

These developments are indeed encouraging. At the same time, it is also important to keep sight of the scale of the challenge that still needs to be confronted. The deployment trajectories for EVs that will probably be required to achieve societal climate goals are very demanding. Moreover, the pathway is far from obstacle free, with a number of remaining barriers. It is therefore important to compare current penetration trends with what experts estimate to be required and to keep a healthily critical attitude about the adequacy of current policy settings.

There are several current barriers to EV deployment that have been identified, including range anxiety, concerns about charging infrastructure availability, limited choice of models. However, this paper explores challenges related to a key aspect of electric vehicle deployment that is not widely discussed in the literature—notably their incremental purchase and lifetime cost.

In the short-term to around 2020-2025, EVs will remain more expensive to purchase and run than equivalent ICE vehicles. In the medium term beyond 2020-2025, EVs are likely to become competitive on a lifetime cost basis. However, they may still confront other financing challenges, such as higher upfront purchase costs (as opposed to lifetime costs). At the same, subsidy of a massively growing market (if early subsidies are effective) is not sustainable. Moreover, if rollout is successful, a growing share of EVs will start to erode fiscal revenues from transport fuels, which are a significant source of government receipts.

In this context, this paper aims to address the following question:

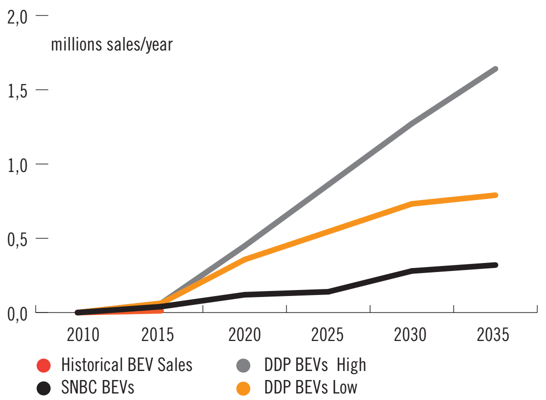
- What would a decade-scale financing strategy for the massive rollout of EVs look like, taking into account technology learning, market development, and distributional aspects?

2. KEY ASSUMPTIONS AND METHODOLOGY

2.1. The necessary rate of vehicle deployment

Figure 1 and Figure 2 illustrate a number of scenarios for annual sales of BEVs and PHEVs respectively. These are drawn from the literature on long-term decarbonisation scenarios for France. Note that these figures concern just passenger vehicles. The figures show three different kinds of scenarios. Firstly, they show the two scenarios for annual sales that were developed under the French Deep Decarbonisation Pathways Project Country Report, a high and low scenario. Second, they show the most recent scenarios that were developed in support of France's official National Low-Carbon Strategy (SNBC). This scenario includes all measures that were in place and planned as of January 2014. Finally, the recent sales figures from 2010 to 2015 are included.

Figure 1. BEV sales scenarios

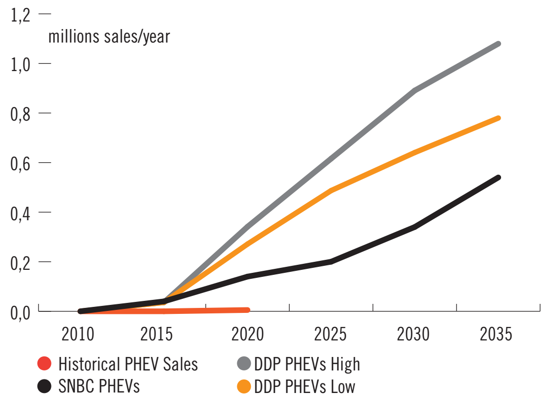


Source: IDDRI based on data from DDPP, MEDEM,[1] Automobile-propre.com

A striking feature of these two graphics is the difference between the sales rates in the two DDPP scenarios and the SNBC, on the one hand, and the current sales on the other. This finding also appears to be confirmed by recent data on 2016 sales, which show only a very modest increase in annual sales in 2015 for both PHEVs and BEVs in the order of a few thousand vehicles.[2] Thus current deployment rates are not on track, although it is still early days, compared to long-term scenarios for the decarbonisation of the French transport system.

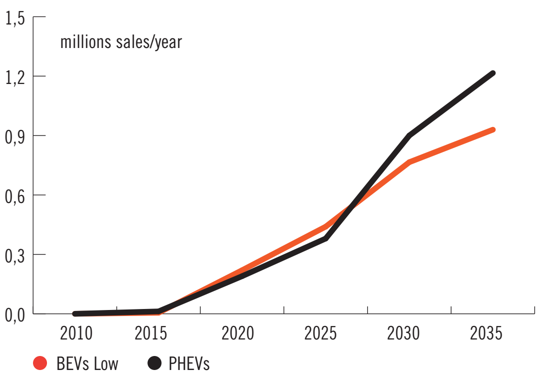
These data suggest that a significant increase in the rate of deployment would be necessary to put France onto a pathway consistent with the modelling scenarios underlying its National Low-carbon Strategy (SNBC). Moreover, the DDPP analysis suggests that significantly higher penetration rates than the SNBC projections would be necessary to be consistent with ambitious 2050 decarbonisation pathways for light passenger and light utility vehicle transport.[3] A part of this difference between the DDPP and SNBC scenarios may be explained by different assumptions about other drivers of transport decarbonisation, e.g. the potential for modal shift, new mobility services, demand management and alternative fuel technologies.

Figure 2. PHEV sales scenarios



Source: IDDRI based on data from DDPP, MEDEM,[4] Automobile-propre.com

Figure 3. Assumed roll-out scenarios for BEVs and PHEVs



Source: IDDRI.

The scenario that we use in this study is based on a high EV deployment scenario that essentially splits the difference between the high and low DDPP scenarios. It also recalibrates the roll-out

1. MEDEM Scenarios prospectifs de l'énergie September 2015
2. www.Automobile-propre.com
3. Approximately 3.5 million personal use and light utility vehicles are sold per year in France (INSEE)
4. MEDEM Scenarios prospectifs de l'énergie September 2015

rates to take account of the current levels of sales in the French market. Note that this scenario is also calibrated to ensure that France achieves 2020 roll-out rates that are implied by modelling underlying the SNBC. Faster roll out are assumed thereafter in order for sales to 'catch up' to the DDP roll out rates once costs and other barriers are better addressed. Figure 3 shows the deployment rates assumed in the financing scenarios analysed in this paper.

2.2. Estimating EV incremental costs

A second step requires us to make assumptions regarding the incremental cost of EVs versus ICE vehicles. Here we should distinguish between three different definitions:

- *Incremental purchase cost*: this is the purchase cost difference between EV and ICE
- *Incremental lifetime cost*: the incremental purchase cost of EV versus ICE, minus non-discounted fuel savings across the lifetime of the vehicle. Once the technology is mature, it is expected that incremental lifetime costs will be negative for EVs, i.e. compared to ICE vehicles.
- *Perceived incremental lifetime cost*: a lot of evidence suggests that consumers discount, often heavily, future operating cost savings in their purchase choices. Thus perceived incremental lifetime cost is the incremental purchase cost minus discounted full savings across the lifetime of the vehicle. Even when the technology is mature, perceived incremental lifetime cost for EVs may still be positive, depending on the extent of discounting of future fuel savings.

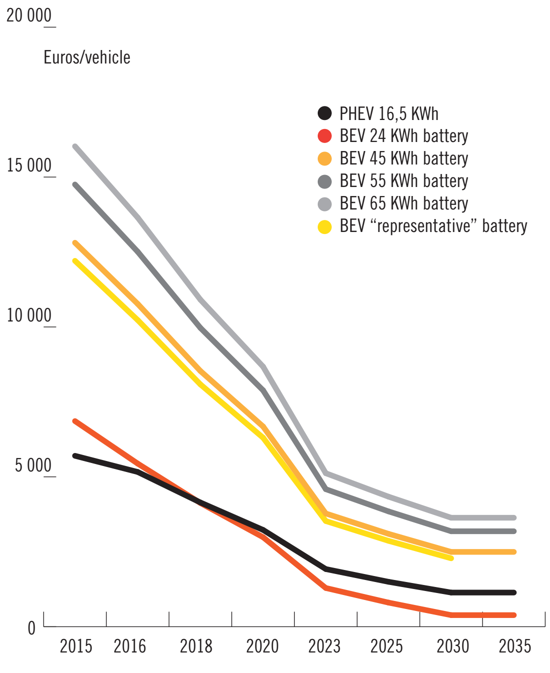
This section details the assumptions that we make regarding each of these three variables, in order to integrate them into the scenario modelling conducted in the rest of the paper.

2.2.1. Incremental purchase costs

BEVs and PHEVs have a higher initial purchase price, relative to a comparable ICE vehicle. This high purchase price is due to the prevailing battery technology. Current battery costs, per kWh, vary considerably and are likely to decrease over time. The most recent literature and surveys of company projections, suggests that, if roll out rates are sufficiently high, they call fall by approximately -6% to -10% per annum for the coming 5 to 10 years.[5] To estimate incremental purchase costt we use a current estimated pack price of USD 240/kWh (~228 EUR/kWh) for all vehicles[6] and apply a 10% p.a. rate of technological learning to these costs until 2025.[7] Cost declines are then assumed to slow before stabilising at a floor of 80 EUR/kWh in 2030.

These values were then use to estimate battery costs for a range of vehicles with different battery sizes and with or without hybrid technology. The incremental cost of the batteries was then adjusted (credited) to reflect reductions in the cost of the electric drive train compared to ICE drive train.[8] A credit for the expected cost of meeting new fuel economy regulations for ICE was included in the evolution of the incremental cost of EVs.[9] A further cost increment was added for the cost of a home charging station.[10] The results of this give the following curves for the incremental purchase cost of EVs as described in Figure 4.

Figure 4. Incremental purchase cost of BEV and PHEV vehicle purchase with different battery sizes



Source: IDDRI.

5. Nykvist & Nilsson (2015).

6. This number comes from a variety of sources and is a best estimate of current market costs.

7. IEA 2015 notes that in recent years cost declines of roughly 9% per annum have been observed.

8. For full EVs, approximately 1500€ in 2015

9. Assumed to rise gradually rise to roughly 1200€ in 2030

10. Assumed to start at 1500€ and fall to 850€ including installation by 2030

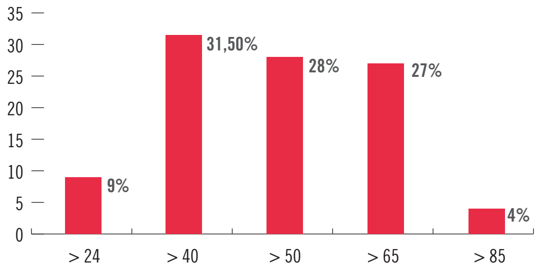
These figures are only upfront purchase costs, and do not yet include the costs of fuel savings or reduced maintenance, or battery replacement that will impact the incremental lifetime costs of EVs. Nonetheless, they help already to highlight a couple of important features of the economics of the EVs:

- Firstly, that the incremental purchase cost of EVs is still quite significant compared to ICE vehicles. Even despite rapid cost declines and improvements in battery technology, this is expected to remain the case for some time *on an upfront purchase cost basis* unless the purchase cost of ICE vehicles rises significantly.
- Secondly, the figure shows how much the incremental upfront cost of an EV is highly sensitive to the size of the battery. This is important because the battery size critically affects the autonomy range and other performance features of the vehicle. In turn, this suggests that batteries of different sizes (and thus EVs of different costs) will be needed to meet the different demands of consumers on the car market. For instance, a 16-30 kWh battery is currently sold in the most of the full EV models on the market in Europe. These tend to be small cars for city dwellers, and have an autonomy range of between 100 to 150 km. Meanwhile, a Tesla Model S, which is more of a large luxury sedan, has battery options that range from 65 to 85 kWh, and thus has a much higher range of autonomy (closer to 400-500 km) and is a larger and heavier vehicle. In the middle of this range are cars like the Renault Zoe (41 kWh battery and a range of close to 240 km).

To simplify our analysis, we focus in this paper on a battery size of 45 kWh for full BEVs and of 16.5 kWh for PHEVs. The 45 kWh size was chosen because EV manufacturers have identified that unless vehicles have a range of autonomy of at least 300 km, it can be difficult to overcome "range anxiety" of drivers.[11] Based on current vehicle technology, a 51+ kWh battery is roughly necessary to achieve this range of autonomy for a 2 tonne vehicle. However, the decline in the size of batteries and thus the weight, together with other possible innovations in car materials and design, suggests that in the medium term slightly smaller batteries may be adequate to achieve the necessary range during the period of the study. Furthermore, "bottom up" analysis of the kinds of vehicles sold in the passenger and light utility vehicle market in France suggests to us that a 45 kWh battery might be sufficient to meet consumer needs for roughly two thirds of car sales (Figure 5).

11. http://www.hybridcars.com/200-plus-mile-range-electric-cars-were-looking-forward-to/

Figure 5. Battery sizes that may be necessary to meet performance requirements (as % of vehicle sales)



Source: IDDRI

Finally, note that the concept of an 'incremental cost'—the EV or PHEV retail price relative to an ICE—assumes all other car characteristics, unrelated to a vehicle's engine, are held equal. In particular, it assumes no changes in preferences over time allowing the reduction in 'non-essential' aspects of vehicle purchase costs in order to offset incremental cost of EVs. This is not necessarily likely to be the case in reality. For instance, drivers may be willing to substitute expensive seats for cheaper alternatives just to mitigate the high cost of a battery engine. Again for the purposes of this study we assume that the current paradigm remains in terms of consumer preferences. Theoretically, "pod-like" autonomous vehicles could be low-frills and thus offer low-cost transport services in big cities (see above).

2.2.2. Incremental lifetime cost and perceived incremental lifetime cost

Another important feature of the economics of electric vehicles is their different cost structure to ICE vehicles. This stems in part from the fact that EVs are more energy efficient than ICE vehicles and that electricity is a significantly cheaper fuel than gasoline or diesel in most countries. Over the 8 year life of an EV battery, a consumer driving 13000 km per year (a typical French driver) could expect to save around 4700 € on fuel costs by switching from diesel to electricity. However, in reality, literature suggests that consumers are likely to discount future savings heavily (consumers are myopic).[12,13] We assume a discount rate of future fuel savings that implies that only the first 4 years of savings are accounted for in the purchase decision (i.e. around €2,350).

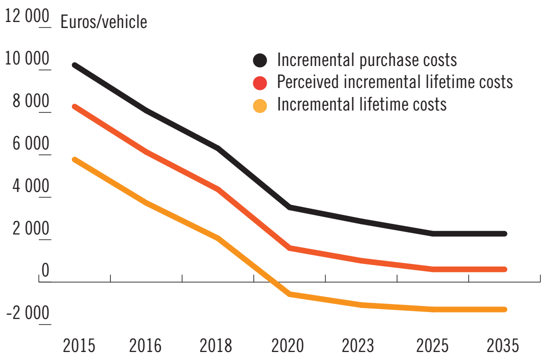
Of course, such estimates need to be taken with caution, as energy prices—particularly oil-based

12. See Diamond (2009) and Gallagher & Muehlegger (2011).
13. See Van Dender & Crist (2011) for discussion of the literature on this question.

products—can be volatile. For the purposes of this analysis, it is assumed that current fuel prices are maintained in real terms for the foreseeable future (unless where otherwise stated). Note that this assumption is realistic, not only based on recent developments in global oil markets, but also if one takes the global roll out of EVs and alternative fuel vehicles as pledged under the Paris Agreement seriously, which would decrease demand and hence the price of oil based fuels.[14]

This analysis gives the results shown in Figure 6. It can be seen that if consumers are fully myopic and discount all future savings, then EVs remain significantly more expensive out to 2035 (incremental purchase cost). If consumers are moderately myopic and discount some fuel savings, there remains a small perceived incremental lifetime cost even once battery technology has reached maturity (perceived incremental lifetime cost). On the other hand, if consumers are perfectly rational and equipped with perfect foresight, EVs can be competitive compared to ICE already by the early 2020s (incremental lifetime cost).

Figure 6. Impact of consumer myopia on EV economics: incremental lifetime cost versus perceived incremental lifetime cost



Source: IDDRI.

In reality, consumer decision making will lie somewhere in between the extremes represented in Figure 6. Consumer discount rates will vary depending notably on incomes, capital availability, financial sophistication, etc. In this paper, we take as a base case for incremental costs the perceived incremental lifetime cost as shown in Figure 7, unless otherwise stated.

14. Countries collectively pledged to increase the share of alternative fuel and low-carbon vehicles to 20% of the global vehicle fleet by 2030.

2.3. Summary

This section presented the central hypotheses in terms of deployment rates, technology learning and battery sizes and hence incremental purchase cost of EVs, and consumer discounting of future fuel savings. The following sections present step by step the analysis of a systematic yet smart policy for supporting mass deployment of EVs.

3. PHASE 1: FINANCING TECHNOLOGY LEARNING AND NICHE MARKET CREATION

3.1. Objectives of Phase 1

The objective of this phase is to ensure the rapid deployment of EVs in order to ensure continued technology learning such that EVs reach their long-term equilibrium purchase cost differential relative to ICEs (around 2025-2030 in Figure 6). Related concerns during this phase are to i) minimize net costs to the public sector; ii) ensure that incentives are structured in such a way as to kick-start the necessary market structures that will eventually take over the funding of EVs notably credit markets and the second hand car market.

In this section we develop three subsidy scenarios in order to demonstrate the fiscal impacts of different strategies to support the rollout of EVs, and in particular possible sequencing of measures as technologies and markets evolve.

3.2. Scenario analysis

3.2.1. Scenario 1: Full subsidy of perceived incremental lifetime cost

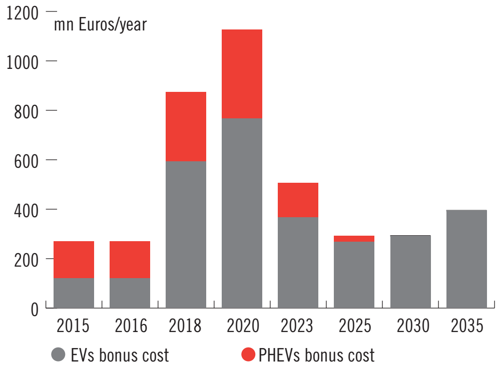
In this scenario, the public policy subsidizes the full "perceived" incremental cost of the EV vehicle versus the ICE vehicle. The results are shown in Figure 7. This shows the sum of the individual vehicle subsidy times the annual vehicle sales derived from the deployment scenarios shown in Figure 3. The subsidy cost for an individual vehicle are derived from the incremental purchase costs, deducting only four years of fuel savings from running an electric vehicle. In other words, the perceived incremental cost of EVs assumes a degree of consumer myopia, leading to the discounting of fuel savings across the lifetime of the vehicle.

Scenario 1 gives two important results:
- In the short term, full subsidy of perceived incremental costs of EVs during Phase 1 of rollout, characterised by rapid technology learning but

still high incremental costs, would lead to high, and probably unacceptably high, aggregate subsidy costs (see the peak 2018-2023).

- In the longer-term, overcoming the market failure of consumer myopia solely through continued upfront subsidy of purchase would lead to a stabilisation of subsidies at continued unacceptably high levels. Although the per vehicle subsidy falls as the technology costs decline, the cost structure of EVs and the assumption of consumer myopia means that a perceived incremental lifetime cost remains and hence the subsidy. Another way would need to be found in order to overcome the market failure of consumer myopia.

Figure 7. Aggregate annual subsidy cost of scenario 1



Source: IDDRI.

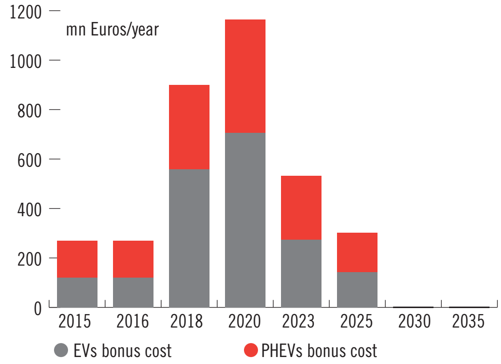
3.2.2. Scenario 2: Subsidy of only the technology learning phase

We thus develop a second scenario, in which we try to phase out the long-term costs of subsidizing the remaining perceived incremental cost between an EV and ICE. In this scenario the public policy subsidizes only the phase of technology learning, and is phased out once the EV technology reaches is long-term performance equilibrium (i.e. battery costs of about €80/kWh). To put this in terms of the incremental cost trajectory presented in Figure 6, the subsidy covers full perceived incremental costs up to 2025; thereafter the subsidy is phased out. Figure 8 shows the results of scenario 2.

Two main conclusions can be drawn:

- By design, the scenario manages to phase out all subsidies for EVs from 2025 onward. This means, however, that other public policy options may be required to overcome the market failure resulting from consumer myopia (this is notably the subject of section 4 below).
- It can be seen, however, that the peak annual subsidy cost remains high in the period 2018-2023, as the perceived incremental cost of individual vehicles is still high, albeit falling rapidly.

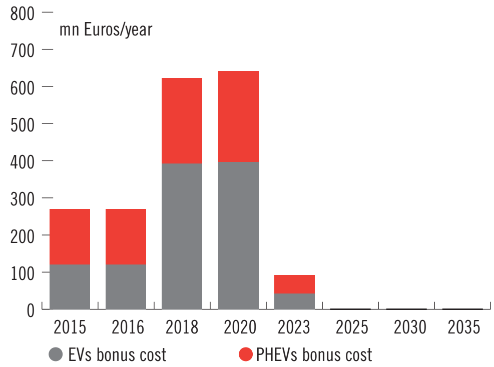
Figure 8. Aggregate annual subsidy costs of scenario 2



Source: IDDRI.

3.2.3. Scenario 3: Subsidise the technology learning phase and progressively increase fuel taxation

Figure 9. Aggregate annual subsidy cost of scenario 3



Source: IDDRI.

We thus introduce a further measure, namely a progressive increase of fuel taxation by 20 cents/l over the period 2018-2023. This consists of a progressive increase of diesel taxation in order to bring it into line with taxation on gasoline (rise of 15 cents/l), followed by a 5 cents/l rise in both gasoline and diesel taxation. This has a double effect of lowering the perceived incremental cost between EVs and ICE, by raising fuel savings; and providing additional fiscal revenues that can offset the subsidy cost on EVs. The results of this scenario are shown in Figure 9. This leads to a faster phase out of subsides and a smaller total annual subsidy during the intensive phase of technology learning (2018-2023). Nonetheless, it still represents a doubling of subsidies compared to current net expenditure on bonuses under the French *bonus-malus* scheme. In a context of fiscal constraints it can be questioned whether this is sustainable politically. In the following section, we therefore explore the potential of a corporate fleet mandate to contribute to the rollout of EVs, and hence lower the number of EVs that would need to be subsidised to meet rollout targets.

3.2.4. The role of corporate and public vehicle fleets

In this section we consider whether in the early phases of roll-out, a higher share of the burden of achieving higher roll-out rates for EV technology shouldn't fall on corporate and public vehicle fleets. There are several reasons why pushing higher use of EVs by corporate or public vehicle fleets this might be an attractive option to facilitate faster roll-out of EVs. Firstly, corporate vehicle fleets, particularly larger ones, are generally less financially constrained than many households in their ability to finance the acquisition of more expensive EVs. This may help overcome some of the initial financial barriers to purchase cited above.

Secondly, corporate and public vehicle fleets make up a large share of the car market (with light duty commercial vehicles and company cars accounting for roughly 20% of all vehicle sales or more in many EU countries, such as France).[15] Since most commercial vehicles are leased, this sector of the market tends roll over vehicles relatively quickly than household consumers. With the right regulatory incentives in place, commercial light vehicle sales may thus be a reliable source of demand for manufacturing companies looking to ensure that a market exists.

Thirdly, if EVs are targeted towards corporate and public sector drivers, this may facilitate a part of the initial task of rolling out charging infrastructure. Specifically, if corporate parks or parking lots are identified as early target locations for installing new EV charging infrastructure, this may make it more economical to pay for some of the necessary local infrastructure costs of installing EV charging stations.

Against this proposal, it may be argued that corporate or public vehicles would not necessarily be well-suited to full BEVs, since they may travel high distances per day or struggle to find remote charging locations. However, discussions with industry experts suggest that the majority of light duty corporate vehicles or company cars are not used in a way that would incompatible with full battery electric technology.[16]

15. ICCT 2016: European market statistics pocketbook 2015/2016. http://www.theicct.org/sites/default/files/publications/ICCT_EU-pocketbook_2015.pdf
16. Pers comm. discussion with representative of Arval.

3.3. Conclusion

During the first phase, rapid technology learning must take place through large-scale deployment. Incremental EV costs are relatively high, even though battery prices drop precipitously. This is exacerbated if one assumes, as the microeconomic literature suggests one should, that consumers are myopic to a certain degree, and hence discount fuel savings. The analysis in this section suggests that:

- The long-term objective of public policy must be to phase out EVs subsidies, and hence find other solutions to the market failure of consumer myopia or upfront capital constraints. These issues are addressed in the following section.
- A judicious mix of i) subsidies calibrated to cover the phase of technology learning, ii) progressive fuel price increases notably to equalise the gasoline-diesel tax rate, and iii) potentially a corporate fleet mandate, could ensure the creation of a rapidly expanding niche market and a rate of deployment required for the early phase of the deep decarbonisation of the transport sector.

4. PHASE 2: GETTING INCENTIVES RIGHT FOR MASS MARKET UPTAKE

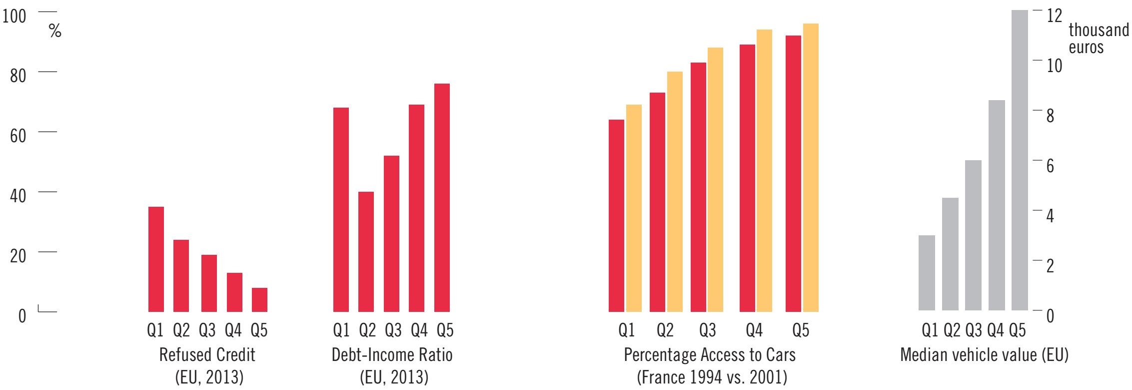
4.1. Objectives of Phase 2

As noted in section 2, the rollout of EVs required for the deep decarbonisation of transport is extremely ambitious. The scale and speed of this rollout has two consequences, which are explored further in this section. These are:

- For the required deployment rate to hold, at some point in the 2020s EVs need to become truly mass-market, i.e. accessible to even medium and low-income households.
- Because of the scale of the rollout, continued subsidy is not possible. Therefore other solutions are required to overcome remaining market failures, which may be particularly relevant to middle and low-income households, namely consumer myopia, capital constraints and potential dysfunctions of second-hand markets.

The nature of these two problems is exacerbated if one considers that the previous scenarios included a progressive rise in fuel taxes (which would be further required as EVs erode the fuel tax base—this is further described in section 5 below). In this context, if EVs are not accessible to mass consumers, the distributional impacts of support policies may become serious. Policies thus need to focus on

Figure 10. Stylised facts about consumer credit, income and vehicle purchases



avoiding 'stranded consumers', by ensuring that EVs become an accessible mass market option. This challenge is explored in this section.

4.2. Who buys cars and what does it mean for EV support policies?

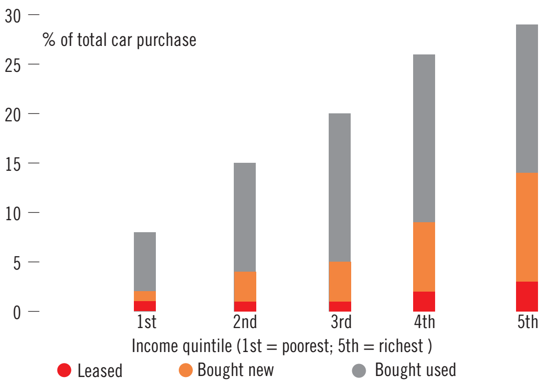
EV "pioneers" often demonstrate a higher willingness to pay as well as other characteristics, and are expected to continue being fundamental to the technology's success in the near future.[17] However, the scale of vehicle production in mass deployment scenarios implies that more mainstream consumers will be required to start adopting the technology *en masse* by the mid-2020s. These consumers are likely to be more financially sensitive, i.e. would purchase an EV based upon household economics rather than the novelty.[18]

In the medium term, our analysis suggests that in the medium term (2025), the economics of EVs would be as follows assuming a mid-range EV of 45 kWh:

- The incremental purchase cost would be in the order of €2,865
- The perceived incremental lifetime cost would still be in the order of €1,000
- The incremental lifetime cost would be in the order of -€1000 (i.e. the EV is competitive on the lifetime basis if no discounting of fuel savings)

For a middle to low income household, the incremental purchase cost of a mid-range EV would represent a moderate to significant cost increment for some new vehicle purchasers (Figure 10, right panels). In addition, middle or low income households may in general subject their upfront purchasing decisions to higher discount rates, and thus fall on the upper end of the continuum presented in Figure 7. The combination of consumer myopia and capital constraints, particularly among lower income households, suggests that **an important part of the financing strategy in Phase 2 should be the development of credit markets for EV purchase, in the form of vehicle loans or leasing arrangements.** However, lower income consumers tend to be subject to higher credit constraints (see Figure 10, left panels). For some lower income consumers, financing new EVs purchases may therefore prove more challenging, and so a preference for vehicles in the second hand car market may be stronger.

Figure 11. Percentage of total vehicle purchases by income quintile



Source: IDDRI, Pazskiewicz, L. (2003) (Note: US data used due absence of FR data).

This suggests that an important element of any plan to roll out a large share of EVs is the structure of first hand versus second hand purchases compared to income levels of different households. Figure 11 and Figure 11 show that in the US and UK (French data was not available) vehicle ownership is skewed towards higher income households. Moreover, among the share of passenger

17. See Deloitte (2007) and Krupa *et al.* (2014).

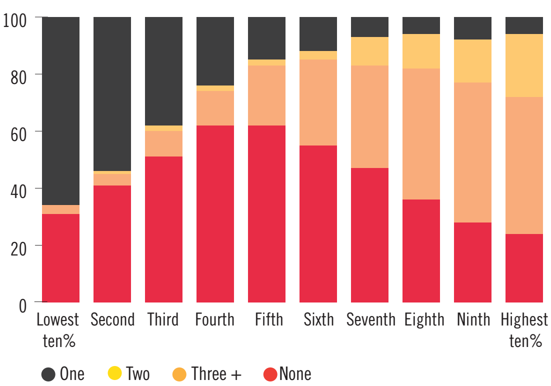
18. Indeed, there is some evidence to suggest that non-EV pioneers have a lower willingness to pay for EVs and tend to prefer PHEVs to EVs (Axsen, Goldberg, & Bailey, 2016).

vehicles sold, new vehicle purchases and leases are strongly skewed towards the top and second income quintiles of the population. The risk of disenfranchising lower income earners is all the greater if second hand BEVs or PHEVs also remain prohibitively expensive or otherwise too difficult for them to access. (For example, if second hand vehicle purchasers faced a choice between an EV with a used and potentially short-lived battery or the need to purchase a brand new replacement battery costing more than the value of the car.)

In summary, this section makes three important points for policy design during the second phase of an EV deployment strategy:

- Extremely ambitious rollout scenarios required for the timely deep decarbonisation of transport require that EVs begin to reach the truly mass-market by the mid-2025. Such consumers may be more price sensitive, and potentially more subject to market failures of myopia or capital constraints.
- Given this and the fundamental cost structure of EVs once the technology learning equilibrium is reached (high CAPEX, lower OPEX), the development of credit markets or leasing arrangements for EVs should be a particular focus of policy.
- Likewise, given the need to reach mass-market deployment, it is important to monitor and understand the functioning of second-hand markets for EVs, and potentially consider policy to promote EV penetration in EV second hand markets.

Figure 12. Car ownership by income decile 2014



Source: UK Office for National Statistics. Note: UK data used due absence of FR data.

4.3. Leasing and residual value risk for EV batteries

At present, some of the trends described above have already begun to emerge in the fledging market for new EVs. For instance, most new EVs in France are "bought" on a leasing arrangement, whereby either the EV and/or the battery is used based on an upfront payment followed by monthly instalments over a 3 to 4 year period.[19] At the end of the lease, the owner can then either return the vehicle (and/or battery) or buy them out by paying the residual value of the vehicle.

In the context of EVs, leasing has the additional advantage for individual purchasers that it allows them to hedge the inherent risks of a new technology. In essence, they pay a premium to the car dealership to bear the risk of the resale value of the vehicle in 4 years, in exchange for the possibility to change the vehicle at that time if they are no longer satisfied, or if technology has moved on. In some cases, leasing also appears to be advantageous to the car dealers, since it allows them to achieve higher turnover rates of vehicles and vehicle models in a fast evolving market. Aside from individual users, vehicle leasing arrangements are also traditionally popular among corporate fleet managers.

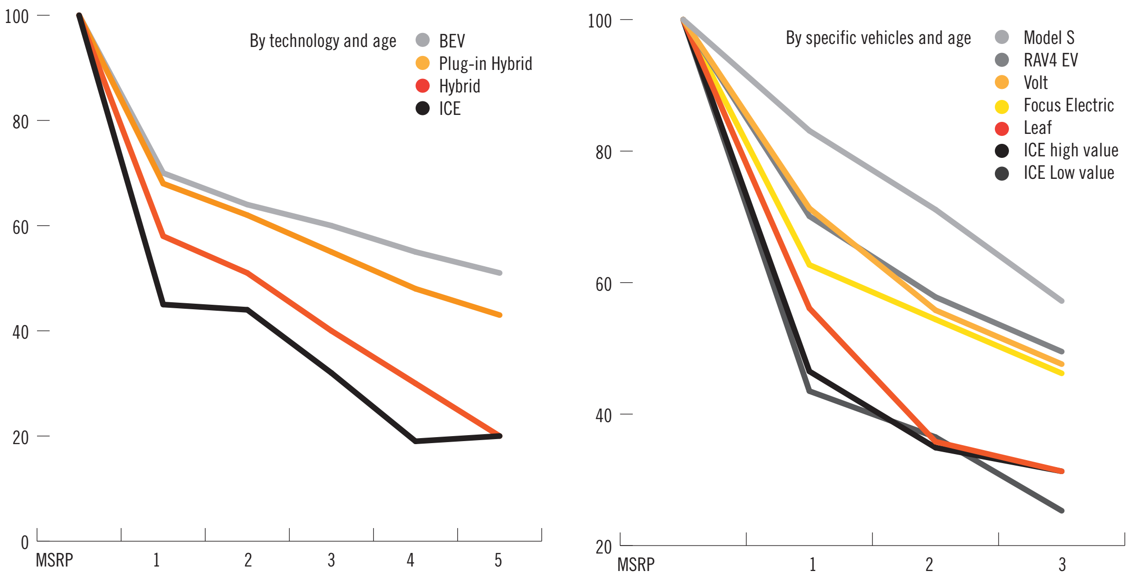
Leasing therefore appears to have been popular with EVs. Leasing penetration in the American EV market jumped from roughly 26% in 2011 to approximately 75% in 2015.[20] In Holland estimates put leasing rates as high as 80% of all EV ownership.[21] Additional evidence from California suggests that leasing is also a more popular financing choice with lower income consumers.[22]

It appears likely that leasing can help to reduce some of the upfront cost increase that will be created by the arrival of EVs. However, leasing also comes with some drawbacks. One very important drawback is that leasing tends to be a more expensive way of getting access to a vehicle than outright purchase. This is partly because no equity is accumulated in the car by the consumer during the leasing period. It is also because a lease effectively means that the car dealer is paid a premium to bear the risk of the resale value of the car after four years (i.e. "residual value risk").

In fact, **residual value risk is currently a key challenge affecting the competitiveness of EVs in the current car market (**see Figure 13**)**. This is because significant uncertainty remains about the resale value of the car on the second hand car market. This is partly due to a lack of data on second

19. Indeed, the popularity of leasing has grown in the car market as a whole of late, since it often allows consumers to have access to vehicles that they would other struggle to afford if they had to purchase them outright.
20. Edmunds (2015)
21. Leaseurope (2013)
22. Center for Sustainable Energy (2016)

Figure 13. How the residual value of EVs compares to ICEs



hand car sales. However, it is also because there is significant uncertainty about the value and cost of replacing the battery inside the vehicle for the vehicle's second owner. This phenomenon explains why many corporate fleet managers consider that leasing BEVs for their companies is not economically attractive at the present moment, even despite the existence of generous EV subsidies in some EU countries.[23] Given uncertainty about the residual value of the batteries, they tend to assume a value of zero.

Interestingly, the residual value of PHEVs is much more easily maintained, as thus PHEVs tend to be competitive with existing subsidies. This difference can be explained by the fact that PHEVs batteries are expected to last for longer than the typical EV battery (because they will be used less intensively to drive the car) and because they batteries are generally smaller and cheaper to replace than in full EVs when the time comes.

How can the risk relating to used EV batteries be better managed in order to give higher confidence to potential second hand EV purchasers and thus support high leasing rates of new EVs by corporate fleets and individuals?

One source of the residual value problem is a fundamental lack of information, especially about the expected effective battery performance over its lifetime and the cost of battery replacement for second hand users. Thus, part of the solution could be to require battery and/or car companies to provide more detailed information about the expected performance of batteries depending on their use.[24]

Another part of the solution could also be to require the battery manufactures or sellers to make guarantees to consumers for the replacement of the batteries after they reach a certain agreed level of "wear-out". Since the car companies themselves are the best placed to estimate the future cost of battery replacement, it makes sense that they should have a role in limiting the associated risks of the cost of battery replacement for consumers. It appears that car companies have not yet done so to date, in part because the market for used EVs is not yet large enough to make this kind of offer commercially attractive to them. Thus, there may be a chicken and egg problem and hence a push from regulators may therefore have value added.

Another part of the solution to the challenge of the fast falling residual values of EVs might be for governments and companies to speed up the development of the market for second hand batteries. After all, part of the challenge that leasing companies face is a lack of a liquid market that provides real world data on the value of the batteries. Some industry experts suggest that second hand car batteries could be exploited for either home storage of distributed renewable electricity solutions, or alternatively, be mounted into larger storage units composed of a multitude of similar battery packs

23. Pers comm. with Corporate Vehicle Observatory representative, 25 November 2016.

24. This is particularly relevant when one considers that second hand markets, in particular car markets, are characterised by information asymmetries between sellers and purchasers, as Akerlof noted in his seminal paper, "The Market For Lemons: Quality Uncertainty and the Market Mechanism".

that serve the electricity grid directly. Recent declines in battery costs have already seen electricity capacity market tenders in the UK being won by companies offering large scale battery-based storage solutions.[25] Further support for used batteries from the demand side may therefore be of value both to electricity markets and to EV markets simultaneously.

The above discussion highlights a broader point: A liquid first hand market for EVs depends on a liquid second hand market for EVs (and their batteries) and vice versa. It is therefore important that policies to promote EV sales do not only focus on supporting first hand purchases. They must also keep an eye on how well EVs are being taken up in the secondary market and the interactions between them, and identify policies that are needed to remove potential bottlenecks.

4.4. Credit markets

An alternative to leasing is the purchase of an EV through a combination of equity and debt, i.e. via the retail credit market. Generally speaking, the retail credit market for vehicle purchases is highly liquid and competitive, consisting of both 'captive' and 'non-captive' lenders. A captive lender is the financing arm of a vehicle producer, which can benefit from attractive financing costs in wholesale markets as well as a network of dealerships and excellent customer knowledge. As with the autosector more broadly, retail credit markets are being disrupted by the emergence of digital technologies and new lending platforms.

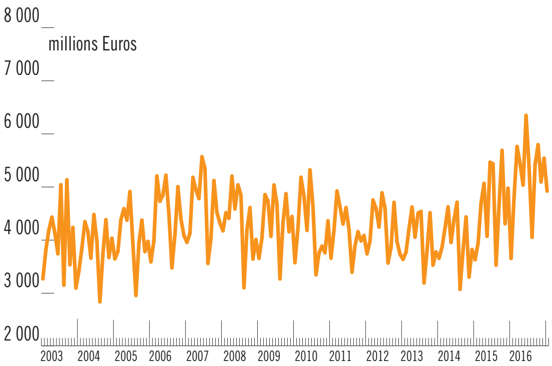
Compared to leasing, debt financing for vehicle purchase means that the consumer directly acquires equity in the vehicle, and assumes the residual value risk of the vehicle on the second hand market (under leasing, this is assumed by the vehicle manufacturer). In the case of EVs, this may prove to be somewhat of a disadvantage given the uncertainty in the ability of EVs, as a rapidly moving technology, to hold equity value after purchase.

In the first 9 months of 2016, retail credit institutes allocated about €2 billion in loans for the purchase of new vehicles and €2.4 billion for the purchase of second hand vehicles (ADF, 2017). Generally speaking, retail credit markets including for autos are becoming more and more competitive, as a result of new entrants, overall loose monetary conditions, and the role of captive financing institutions. In France, captive financing accounted for 34% of vehicle sales, non-captive financing 47% and non-credit financed vehicles for 19% (Roland Berger, 2016). Captive financing can offer very competitive interest rates, even compared to the already competitive interest rates offered by banks. Market actors expect the retail credit market to become increasingly competitive, as new entrants increase the supply of credit products. Figure 14 and Figure 15 show the overall very conditions in the consumer credit market in France since 2003.

Figure 14. Average interest rates on consumer credit, France (% per year)

Source: ECB (2017).

Figure 15. Volume of consumer credit France (€million/month)



4.5. Conclusion

During this phase of EV deployment, EVs should become a truly mass market product, reaching both middle-income and second hand markets. Technology learning is the key to achieving this, in order to make EVs more financially attractive to more price-sensitive consumers. However, even with the rapid technology learning assumed in the scenarios defined in Section 2, the cost structure of EVs requires continued attention to the upfront financing challenge for more myopic or capital constrained consumers. The discussion in

25. https://cleantechnica.com/2016/12/13/energy-storage-wins-first-agreements-uk-capacity-market-auctions/

the preceding sections allows us to develop the following conclusions and recommendations:

- The mobilisation of credit markets is essential for the EV deployment strategy in this phase (both consumer credit but also leasing arrangements). Fortunately, credit markets are i) increasingly used already for vehicle financing in the context of vehicle price inflation seen in recent years; ii) increasingly competitive and value for money for consumers.
- It thus appears probable that credit markets could assume the upfront cost of EVs during this deployment phase, as indeed is assumed in Scenario 3 developed in section 3.2.3 of this report. This provides a further argument for subsidies being progressively removed as technology performance improves, provided that CO_2 performance standards are sufficiently robust to drive continued deployment.
- Nonetheless, some specific policies could be considered in order to prime the development of second hand markets for EVs and credit markets. These include for example:
  - information standards on residual battery performance to underpin confidence in second hand EV markets; and potentially policy
  - potentially limited fiscal advantages to credit providers or leasers to 'seed the market' for EVs financed through credit or leasing, in particular for low-income households (comparable to low-income loans for building renovation).

5. PHASE 3: ANTICIPATING THE LONG-TERM EROSION OF FISCAL REVENUES FROM FUELS UNDER HIGH EV PENETRATION

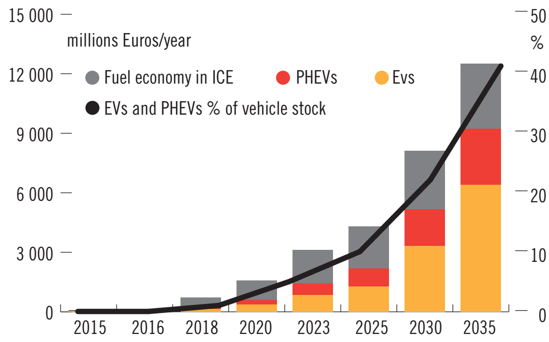
5.1. Objectives of Phase 3

In this phase, starting in the mid to late 2020s, it is assumed that EVs have started to reach significant levels of penetration, thanks to the technology learning and policy pull that has been instituted in the previous phases. The objectives of this phase are to start to restructure energy and potentially vehicle taxation in order to recover lost revenues from fuel taxes, which would be eroded as EVs grow in market share.

5.2. Understanding the orders of magnitude of fuel tax erosion

An indirect impact of a penetration of a high share of EVs and PHEVs in the car fleet is the erosion of existing government revenue bases from fuel taxation. We thus extend the above analysis to estimate the implied fuel tax revenue losses that the French government would have to manage.[26]

Figure 16. Foregone motor fuel tax revenues in France with rising EV penetration



Source: IDDRI.

Figure 16 shows the respective contribution of EVs, PHEVs and improved fuel economy of remaining non-electric vehicles to this revenue loss. The results for EV and PHEVs are based on the assumptions that the average EV purchaser between 2016 and 2035 would be paying approximately €650 in fuel tax revenue per year if they had not changed technologies. It is also assumed, for simplicity, that current fuel tax rates remain constant and that average fuel economy of non-electric vehicles improves by 1.5% per year on average over the period. The total number of vehicles in the passenger and light duty vehicle fleet is also assumed to remain constant.

The results highlight the fact that government tax receipts from road fuel taxation are likely to take a significant hit, in the order of several billion euros per year, and rising over time. In the short run, this effect is likely to be mainly driven by improving fuel economy of vehicles. However, as the share of EVs ramps up, after 2025, the impact of EVs on fuel substitution begins to contribute the majority of the erosion of the fuel tax base.

The results of this analysis suggest relatively large losses in total fuel revenue, reaching approximately €5.5 billion by 2025 and €16 billion by 2035. To put this into perspective, in 2015, annual road fuel tax revenue including VAT was in the order of 2.7% of total government revenue in France (Enerdata, Eurostat, n.d.). In the Germany and the UK it is closer to 3.3% and 4.6%, respectively. Thus, while fuel taxation is not the

26. Note that we ignore refinery profits here, which are, in any case, very low as a share of total tax revenue in France.

core of the national budget, it is still an important component.

5.3. Strategies for replacing fuel tax revenue

There are several options that may be considered for replacing this revenue, even if one only looks at the field of transport. One option is to move fuel taxes to electricity. We estimate that replacing 50% of current revenues associated with fuel taxes would require an increase in electricity prices of between 1.8 to 2.6c/kWh in Germany, 3 and 4c/kWh in France, 5.3 to 7.5c/kWh in the UK.[27] These ranges correspond to whether it is assumed that industrial consumers contribute or not to paying the tax increase. This would have the downside of running counter to the objective of incentivizing EV uptake.

Another option is to digitally track mileage driven, irrespective of technology, and introduce taxes on mileage driven rather than fuel consumed. It is sometimes argued that taxing mileage would incentivise more socially efficient choices about whether and how much consumers drive. Thus it could reflect the implicit costs of the use of public road infrastructure and other driving externalities like congestion and accidents. The real world efficiency gains of such taxes can be complicated, of course, by infrastructure lock-in effects and a lack of available alternatives for driving decisions. Such an approach would require the installation of generalised tracking technology within cars and this may raise privacy concerns for consumers. On the other hand, in the medium term, higher use of digitalised (and potentially autonomous) vehicles may make such approaches more publically acceptable and easier to manage for governments.

A third alternative is to raise purchase or annual registration taxes on all cars. This approach could in theory be coupled with stronger taxes on ICE vehicles to promote a gradual shift towards EVs (see discussion of "bonus-malus"). Another option would be to raise upfront taxes on new purchases, and include a malus on ICEs. Such a strategy could also be combined with a progressive increase in fuel taxes after 2025, beyond what is already factored into Scenario 3 developed in Section 3.2.3.

Several principles can be elucidated to determine the right strategy for compensating fuel tax erosion: i) it should support the public policy objective of supporting EV rollout; ii) it should be clearly signalled well in advance and implemented progressively in order to give consumers the time to transition to the new technology and avoid being 'stranded' with a high cost ICE; iii) even with this signalling, it should pay attention to distributional issues.

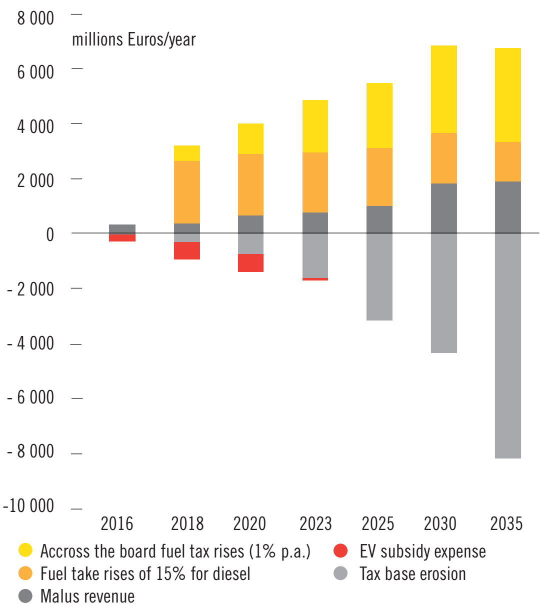
5.4. A fiscal scenario for supporting EVs: Bringing it all together

In this concluding section we bring together the scenario analysis developed in Section 2 and develop a proposal for progressively compensating fuel tax erosion. The elements of this scenario are as follows:

- Upfront subsidy on BEVs and PHEVs of the perceived incremental purchase cost of EVs above the level of the long-term equilibrium once the technology reaches maturity, phased out once the technology reaches maturity
- Fuel tax base erosion as described in Figure 16
- Equalisation of the tax level of diesel verses gasoline effective from 2018 (i.e. 15% rise), and rising progressively thereafter on both fuels at a level of 1% per year
- Continuation of the current malus on polluting ICE vehicles rising progressively from 2020 to reach a level of ca. €1,000 per ICE vehicle by 2035

These assumptions give the following results presented in Figure 17.

Figure 17. Integrated analysis of fiscal impacts of the EV support strategy



Source: IDDRI.

27. These results assume current electricity consumptions levels remain constant and that EV usage compensates for alternative sources of consumption due to improving energy efficiency.

6. CONCLUSION AND RECOMMENDATIONS

This paper has explored some of the financial implications of achieving mass scale roll-out of electric vehicles in the timeframe from 2016 to 2035, using the example of France and current vehicle ownership patterns to illustrate a number of issues. A first conclusion of this paper is that current and projected roll out rates of EVs in France (as in other countries) are falling well short of what may be necessary to achieve significant decarbonisation of passenger and light commercial transport by 2050. This appears to be largely related to a combination of issues for consumers, including: range anxiety, charging anxiety, a currently limited range of vehicle models, and residual value issues for commercial fleet managers.

Our analysis finds that, although EV battery costs are falling quickly, there are a number of reasons to believe that EVs will continue to be viewed by consumers as more expensive than equivalent ICE vehicles for some time. This implies that fiscal policies will have an important role to play in closing the cost competitiveness gap between EVs and equivalent ICE vehicle. This analysis suggests that a mix of policies, such as raising taxes on ICE vehicles, raising taxes on oil-based fuels (especially where implicit subsidies exist, e.g. diesel), and a temporarily expanded use of subsidies paid for out of these tax revenues, may be required to manage this cost gap while being financially neutral and politically sustainable from a fiscal policy perspective. Without such policies, there is a danger that EVs will struggle to overcome narrow niche market status due to high incremental costs for vehicles with sufficient range to compete with mainstream models in a range of market segments.

From the perspective of vehicle users, the higher upfront costs of EVs may pose some challenges for the capacity of some consumers—particularly those in middle and lower income groups—to finance their purchases. An open question in this regard therefore concerns the capacity of attractive leasing or other financial offers for EVs and/or their batteries to be developed. For leasing to catch on as an affordable large scale solution, more work needs to be done to resolve concerns around the residual value risk of EVs and their batteries. Better information and guarantees from car companies and/or battery makers seem necessary to tackle this challenge to reduce residual value risk for leasers and also to help promote a robust second-hand market for EVs—a crucial element of an effective mass penetration strategy.

Given various challenges of financing the necessary roll-out rates of EVs necessary for achieving deep decarbonisation goals in the short term, one option that policy makers may wish to consider further is, to what extent corporate and commercial and public light duty vehicles could be asked to lead the way towards electrification. This may have a number of advantages in terms of ensuring steady and high volume demand for new models from manufacturers, better possibilities for onsite parking and charging infrastructure to be installed cost effectively, and lower concerns about financing challenges for upfront purchase.

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