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Plug-in Hybrid and Battery Electric Vehicles

Market penetration scenarios of electric drive vehicles

Françoise Nemry and Martijn Brons

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2 Glossary

AER	All Electric Range
BEV	Battery Electric Vehicle
CD	Charge Depleting
CS	Charge Sustaining
EDV	Electric-Drive Vehicle
PHEV	Plug-in Hybrid Electric Vehicle
SOC	State of Charge

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Executive summary

Electric-drive vehicles (EDVs) are currently emerging in the market and are seen as a promising option towards a less carbon intensive road transport.

This report presents a prospective analysis in relation with two of the current bottlenecks for the diffusion of electric vehicles. These concern batteries performance and cost, and the access to charging infrastructures. Based on projections on these factors, the analysis develops scenarios for the future market for electric cars and provides indicative estimations of the impacts on energy consumption and CO2 emissions at EU level.

To this end, a modelling approach was developed, enabling to assess the future market penetration of electric vehicles and evaluate the effects of some key factors determining electromobility, including battery costs and performance and access to grid to for recharging. It offers some possibilities to assess the effects of policies such as infrastructure investment and incentives to car consumers.

The approach is mainly demand driven in the sense that the effects and, also, possible constraints from the electricity grid and from the power generation sector are not considered. The effects of a growing electricity demand and possible charging profiles are also not addressed at this stage. This is currently being carried out by using a EU-TIMES-based model of which conclusions will be reported in a subsequent report.

Conclusions drawn from this analysis are as follows:

- The deployment of pure electric cars is expected to remain very limited at least until 2020. The access to charging infrastructures at home, in working and urban public places will be the first barrier to a large scale market development of electric cars. This holds true both in the near and longer term. Faster market penetration would be achieved in the case of PHEVs as soon as they are commercialised (~2020). A voluntarist development of standards and charging infrastructure would contribute to doubling the market penetration of both BEVs and PHEVs by 2030 compared with what would happen under a much more limited development.

- Battery costs make EDVs upfront costs much higher than conventional car costs. Different business models currently tested would help spreading these costs over the car life and help improving the attractiveness of those cars. However, on a lifetime perspective, EDVs are also still less cost effective than their conventional counterparts. Progress in battery performance and costs are possible and would largely improve both the cost performance and autonomy range. This would represent the second driver for the future success of EDVs market, and particularly for pure electric cars. The considered scenarios however suggest that the full benefits of these progress on batteries would manifest the most in the case where charging infrastructure deploy.

- At EU level, the impacts on fuel and electricity consumption by road passenger transport would be negligible until 2020-2025. Effects would become significant later and the magnitude of fuel savings could be in a 6%-20% range by 2030 compared with a reference scenario where electromobility doesn't develop. By 2030, electricity demand from road transport would be 140,000 to 550,000 TJ at EU level (~1% to 4% of the projected total electricity consumption).

- This would also result in a reduction of the CO2 emissions from road passenger transport by 4% to 12% compared to the reference scenario. The situation at country level would be largely affected by the power generation mix.

3 Introduction

Electric-drive vehicles (EDVs) are currently emerging in the market and are seen as a promising option towards a less carbon intensive road transport.

A first JRC/IPTS report (Nemry et al, 2009)[1] overviewed the current state of the research and development in that field and compiled information and datasets to characterise the energy efficiency and costs of battery electric vehicles (BEVs) and plug-in electric drive vehicles (PHEVs). This was carried out as part of a JRC research of future penetration pathways of such vehicles in the EU27 market and of their impacts on energy security, GHG emissions and on the economy.

This report develops a prospective analysis of two of the key aspects which currently represent the bottleneck for the diffusion of electric vehicles. This concerns the batteries performance and cost, and the access to charging infrastructures. Based on assumed trends regarding these factors, the analysis develops possible scenarios for the future market developments for electric cars and provides indicative estimations of the impacts on energy consumption and CO2 emissions at EU level. To this end, a modelling approach was developed as a new TREMOVE model version.

The approach is mainly demand driven in the sense that the effects and, also, possible constraints from the electricity grid and from the power generation sector are not considered. The effects of a growing electricity demand and possible charging profiles are also not addressed at this stage. This is currently being carried out by using a EU-TIMES-based model of which conclusions will be presented reported in a subsequent report.

The report first discusses the different issues at stake. Then it describes four scenarios about the key considered factors determining the future electromobility. The assumptions, modelling approach and results for the corresponding possible market penetration scenarios of electric cars are then presented.

4 The electric drive vehicles market: barriers and drivers

4.1 Introduction

The deployment of electric vehicles will depend on a large variety of factors. This includes the performance and costs of batteries, the access to the distribution grid and its efficiency, the type of business model implemented to supply the consumer with reliable batteries and electricity, the acceptance by the consumer of new vehicle types and possible implied driving habits.

This diversity of, and interlinkages between these factors make any market projection extremely difficult and impossible to define one single scenario about the penetration of electric vehicles. Several sets of assumptions can be made on the above-mentioned aspects, resulting in different expectations on the market penetration of electric cars. Figure 2 and Figure 1 illustrate the diversity of scenarios found in the literature on BEVs and PHEV respectively.

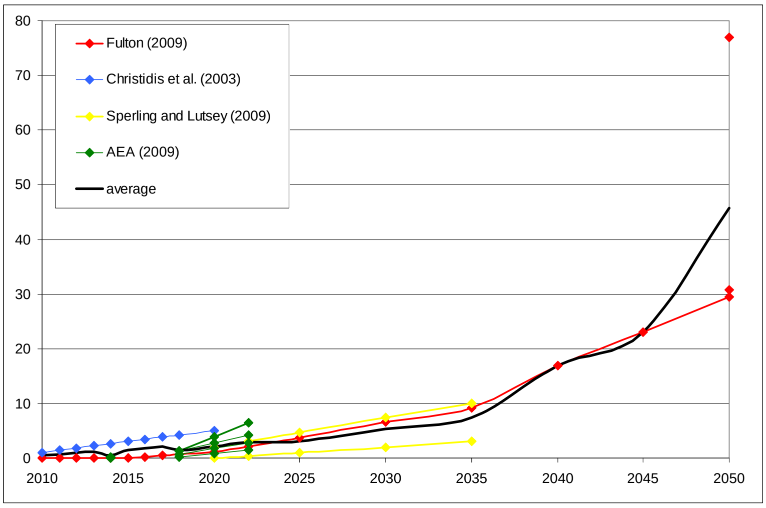

Figure 1: Scenarios about the market penetration of BEVs (share in new car registration)

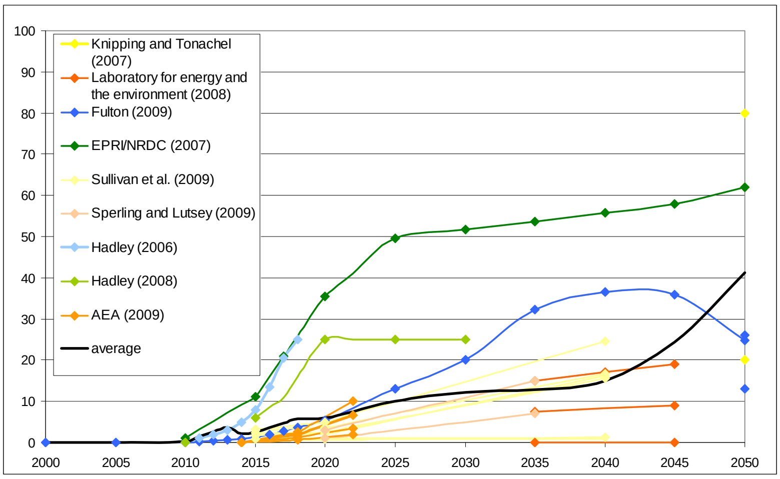

Figure 2: Scenarios about the market penetration of PHEVs (share in new car registration)

4.2 Vehicle performance and costs

The present analysis builds upon the vehicle technology characterization developed in a previous contribution (Nemry et al, 2009)1, which included estimations of fuel and electricity consumption and costs of the different vehicles (BEVs, PHEV40). Over the longer term, significant technical and process developments are expected, especially in the field of batteries. In general, Li-ion batteries are currently seen as the best available option to fulfil the performance requirements. Other options (e.g. in terms of applied chemistry) are however not excluded and this could open new perspectives both in terms of performance and costs. The following summarises the key elements on which to base further assumptions regarding future possible trends, mainly on batteries and infrastructures.

4.2.1 Battery performance

Both the energy and power density of batteries are important aspects for automotive applications. Energy density is particularly essential for BEVs. In the case of PHEVs, progress on power density is the first priority. Typical densities are currently around 140 Wh/kg and 730 W/kg.

These performances are expected to improve in the future, resulting in increased electric autonomy ranges, which could double in the case of pure electric car (100-150 km in the near term (see for instance IEA, 2010)[5] to 200-300 km). The power density could improve even more. This is for instance the goal expressed in the new roadmap established by NEDO in Japan. The timing and level of these improvements are not yet clear. This is where differentiated assumptions have to be made.

The stated autonomy ranges can also significantly differ from what would be achieved in real-world conditions. It is estimated that, in practice, the autonomy could be only 70%-80% of the standard value (thus reducing the near-term range to ~70-120 km). This difference is explained by charging patterns, driving behaviours, weather conditions and on-board energy consumptions[1]. Clear information will be particularly essential to ensure consumer trust in these new vehicle technologies.

Battery durability is another crucial issue. Current battery cycle life is reported to be >1000 deep discharge cycles and could increase to 3000-5000 deep discharge cycles by 2014 (Global Insight (2009)[2]). The current life (>3 years) would thus increased up to more than 10 years by 2014 reports figures on. Options for a second life of batteries (stationary energy storage) which is not suitable anymore for vehicles are currently envisaged, resulting in an extension of the battery life.

4.2.2 Battery costs

In the previous report, current costs were found in a range 700-1000 $/kWh. More recent information suggests that the lower bound (and possibly even less) is probably a realistic value[3].
Future cost reductions are expected, as a result of innovations on processes and components. Learning effects and economy of scale effects (this is the most expected at battery pack manufacturing level e.g. moving from batch to continuous manufacturing process) will also contribute to this decrease. The different drivers for future battery costs reductions have been thoroughly analysed by Anderson (2009)[4].

The pace and extent of cost reduction is will depend on many factors.

As previously reported, different expectations are found in the literature and while current price is in a range 700-1000 $/kWh, costs as low as 300-400 are seen achievable by 2020. Many different trends might in reality occur, including less favourable evolutions. This again has to be considered when building possible scenarios for the future.

In its Technology Roadmap on electric vehicles, the IEA[5] considers that, in the case of BEVs, economies of scale can be achieved for production levels beyond 50000-10000 vehicles per year. Such effects would be faster in the case of PHEV because of the already sold hybrid vehicles.
One can't exclude that other options (other raw materials, technologies) will later emerge which could be used to store energy for transport purpose.

4.3 Commercial strategies

4.3.1 Car manufacturing plans

OEM's plans have been recently reviewed in different literature sources (see City of Westmister report[9], Hacker et al, 2009[6]).

The impact of these plans on a future mass market will depend on both the manufacturing capacities and on the number of car models proposed to the consumer. This last aspect will indeed determine the variety of choices offered for the consumer, and thus the probability of purchase of BEVs and PHEVs.

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[1] Global Insight reports that extensive use of HVAC systems for cabin heating and cooling will increase energy consumption and reduce the range by as much as 40%

Several BEVs models are already commercialised in small quantities, or planned to be commercialised very soon by several companies. Some of the models announced are actually classified as quadri-cyles, and not all comply with car safety standards (e.g. G-Wiz by REVA). Besides passenger cars, vans (especially used for delivery in urban areas) also represent a future market for pure electric vehicles. Some of the models fall into the minivan category.

In the recent literature reviewed, it is generally expected that PHEV marketing will not come before 2015 and that large scale market is unlikely before 2020. This analysis uses the same assumption (large scale market from 2020 onwards). This assumption could be modified in a subsequent analysis in the light of recent car industry developments[2]. The assumption of an earlier market deployment (2015) will be discussed in section 6.

Once commercialised, PHEV might offer the consumer non negligible advantages (higher autonomy range, the promotion effect from the already existing hybrid cars) compared to BEVs and could thus be more successful in mass market penetration. PHEVs. They are also seen as a transition technology before a wider market deployment of BEVS enabled by sufficient progress on battery performance and costs.

The following table summarises the main assumptions and main arguments for each of them.

	BEV	PHEV
Small size	This is the immediate candidate for BEV. Most of early models fall in this category	Vehicle packaging problem and excessive price are obstacles.
Medium size	Very few model are expected in the short term. This would however emerge later with battery cost decline and increased performance	Priviledge segment, but marketing is unlikely before 2020
Large size	Large car are usually used for long distance trip. Battery capacity is an obstacle. This would be limited to specific market (e.g. luxurary cars)	Priviledge segment, but marketing is unlikely before 2020

Table 1: Expectations about the marketing of EDVs

4.3.2 Business models

The main barrier to the market penetration of EDVs relates to batteries. Reflecting this cost into the vehicle price will result in high upfront costs compared to other similar cars' price. Also, risks associated with EDVs are mainly linked to the battery (durability, energy capacity, technology maturity), representing another barrier to EVs and PHEVs purchase.

AEA[7] has identified three main risks:

- Battery failure would translate into an important bill for the car owner.
- The value of the battery upon re-sale of the vehicle will represent a large proportion of the value of the vehicle. In case of vehicle re-sale, the battery may need to be inspected prior to re-sale. The question is also how the residual battery value would be priced, given that battery performance (with most battery chemistries) degrades with use and charging. In general a

[2] See for instance the recent announcement by General Motors (Opel Ampera, Chevrolet Volt) for late 2011

massive penetration of EDVs might significantly affect the second-hand car market in the future.

- The lithium-ion battery technology is still relatively new to automotive market. This could exacerbate fears amongst consumers of a potentially costly battery failure.

To cope with this consumer risk perception, various business models are being explored and tested, involving the automotive industry and new emerging business companies that are investing in the area. This includes:

- **Battery leasing**: The basic concept of battery leasing is to sell the car to the consumer and lease the battery (e.g. Th!nk). The battery leasing could represent a ~80-100€ monthly for the car owner, covering maintenance, insurance and replacement of the battery. This thus reduces the upfront cost and financial risks are reduced for the consumer. In case of car re-sale, the monthly fee for leasing the batteries simply switches from the original owner to the new owner. Batteries are expected to be replaced every 5-6 years. When the renewal takes place, the latest battery technology will be implemented, which may have improved performance and range.
- **Mobile phone style subscription service**: This business model has been introduced by the Better Place Company[3]. In this model the company owns both the battery and charging network and proposes different subscription pricing packages under which the consumer **accesses to the network of charging points and battery stations**. This can also cover the electricity used to charge the battery. This also covers **battery swapping.**

- **Vehicle leasing**: Vehicle leasing is already applied for the conventional car market, especially when business cars are concerned. This is a more extended version of battery leasing which is being proposed by Mitsubishi for the i-MiEVs. This of course reduces the up-front costs, but of course, the consumer has to be ready to pay a high monthly fee (~ 600 euros/month).
- **Car-sharing**: This model already operates in some cities in Europe with conventional cars, but still in a limited scale. Consumers can pay to rent a car on an hourly, daily or weekly basis as and when they need it. Cars are reserved in advance and collected from a local parking space.

4.4 Charging infrastructure

Costs are certainly not the only criteria in the case of electric car purchase. Access to charging infrastructure and car all electric range is obviously two key aspects. The following shortly reviews the types of charging options and their costs and then discusses the possible needs and limitations of deploring these options.

4.4.1 Types of charging spots, costs and mode of payment

The characteristics of the different charging methods are summarized in following table. It suggests the potential location in each case and costs associated (see Morrow et al, 2008 and Westminster City, 2009[9]).

Despite clear advantages compared to the other charging options, fast charging (10-20 minutes) might still be perceived slow in case this is used on e.g. motorways station and long queues. Technical challenges need also to be addressed. Heat produced can for instance damage batteries.

[3] http://www.betterplace.com/

	standard charging	semi-fast charging	fast charging
Voltage/Amperage	230V, 16A	230 V, 32A	480 VAC
Typical charging power	3.5 kW	7-10 kW	60-150 kW
Charging speed for a 10 kWh battery	~5-8 hours	~1-2 hours	<10 minutes
Compatible charging facility	Private charging facility	Private and collective charging facilities	Collective charging facilities
Vehicle equipment requirement	Higher battery capacity required	Higher battery capacity required	Low battery capacity required
	On-board charger	On-board charger	
Infrastructure requirement	Cable from electricity outlet to the vehicle	Stationary charger	Stationary charger
	New dedicated circuit	Cable from electricity outlet to the vehicle	Three phase
		New dedicated circuit	
Applicable location	dwellings, public parking in residential areas	office and apartments parking's, leisure places (restaurant, sportive centres, cinema…), shopping centres	motorways, urban areas, shopping centres
Number of outlets	1	2	2
Installation cost, including integration in the urban environment (euro/charging post)	650	1 084	41 000
maintenance (€/year)	-	267	267
Administration (€/year)	-	4 000	4 000
annual total cost per socket - 10 year life (€/year)	65	4 321	6 317

Table 2: Methods for recharging
Source: SWELTRAC12, Vande Bosshe et al[8]

4.4.2 Car use patterns and infrastructure requirement

The bulk of car trips occur during the day and relate to commuting trips, meaning that, in case of purchasing an electric car, people will need to have their car charging before leaving in the morning.

Charging in Residential zone
It is sometimes foreseen that electric cars would indirectly promote new car ownership modes (e.g. car sharing). If this becomes reality, this would nevertheless take some time to become popular. Therefore, under the currently prevailing car ownership model, it is likely that the electric car will be recharged at

home[4]. The means that the limited share of population having a place to recharge the car at home (garage or shared parking place) is a non negligible barrier to the market penetration of electric cars, at least over the coming years.

Very few estimations of population having a garage or shared parking places are found in the literature. According to EUROSTAT, 24% of population lives in urban areas. Assuming that 10% of the urban population and 30% of the other population have access to garage would mean that ~25% of population has access to a garage. However, not all garages and parking places are fitted with the appropriate plug where to charge a car. Extension of electric circuit, in compliance with safety standards, for instance would be needed in many cases. These adaptations will also be made if the electric car purchaser is also the tenant of the dwelling. It can thus be assumed that a maximum of 10% of car purchasers could be in a condition to charge their car at home. Much lower figures in for urban areas (~2.5%) are even reported in the literature[9].

Charging in workplaces
In the case of commuting trips, electric cars could be charged in few workplaces, meaning that for commuting trips longer than ~40-50 km, the round trip would be risky with an electric car. An extension of charging facilities are work place is thus a key condition to promote electric cars.

Charging in other places
In case of non commuting short trips, similar needs for charging infrastructure would also to be met, especially in urban zones (e.g shopping parking's, leisure places, restaurant, gymnasium) where people tend to stay over 1-2 hours and during which the car could be recharged (via semi-fast charging – see section 4.4.1).

It is also very often argued that as the majority of trips are short distance trips, electric car would be very suitable to meet most of car user needs. This however neglects the fact that currently, the car purchase decision is based on the maximum demand on performance and range. This condition could not be fulfilled by electric-vehicles in the near term, unless it is used as a second car or complemented with public transport. It can't be excluded that, in case more attractive and flexible car rental or car sharing solutions would develop in the future, people would be ready to buy cars (possibly electric car) to drive over the short distance trips, and use an other option for the longer trips. This is however far from being reality in the near term.

This means that, when planning a long trip, the owner of a pure electric car, would always wonder about his chance that the battery doesn't discharge before having the possibility to recharge. In addition, if the trip has to be interrupted to recharge the car, it should be fast and safe enough. In this respect, fast charging enables to charge after 10-15 minutes, but this is still long, especially in case of charging along motorway and if long queues are to be expected. Fast charging also entails faster battery deterioration, which the consumer should be made aware of.

Battery swapping is currently investigated by Renault in collaboration with the company Better Place. Large scale implementation for all electric car types is not yet proven to be feasible – standardization of battery pack and location where it is fitted to the vehicle would be needed. The swapping process would also take 10 minutes.

Required infrastructure density
Concerning motorways (and non urban roads), in theory, the distance between recharging spots should be matched to the typical car autonomy range (~80 km). In reality, it is assessed in the literature that a 40 km distance would be required to remove any risk perception the driver.

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[4] It can not be excluded that new ownership models will develop together with the marketing of electric cars. Car sharing, car leasing might for instance gain more popularity as it would release the burden of car charging by the user.

Concerning urban areas, it is not straightforward to estimate an optimal density and distribution of charging spots, and of the number of charging sockets. The required density in the case of London has been estimated to 4.3 charging points per square km (~2.6 per 1000 inhabitants)[10]. This figure might however be seen as overestimated[9].

Cost estimates for the EU

The order of magnitude for the overall expenditure entailed by a full charging infrastructure deployment at EU level can be derived from the annual costs per charging spot (see Table 2), above mentioned densities and road network and population statistics (Eurostat). In total, the aggregated cost of the recharging infrastructure for the EU27 would amount to approximately 3 billion € (see assumptions and costs details inTable 3). Higher costs per charging spot are reported by e.g. ETE (2009)[11]. The estimates should be also compared with cost assessments made in the framework of the different national plans.

<table>
<tr><th colspan="4">urban</th><th colspan="3">motorways</th><th rowspan="2">Total</th></tr>
<tr><td colspan="3">urban population (1000 inhab)
nb charger / 1000 inhab
% standard charging
% fast charging</td><td>118 983
13
0.7
0.3</td><td colspan="2">nb of outlets per charging station
distance between station (km)</td><td>10
40</td></tr>
<tr><td>Number of chargers</td><td>standard charging</td><td>fast charging</td><td>annual cost (10^6 €)</td><td>Motorway length (km)</td><td>number of recharging stations</td><td>annual cost (10^6 €)</td><td>annual cost (10^6 €)</td></tr>
<tr><td>1 546 779</td><td>1 082 745</td><td>464 034</td><td>3 001</td><td>55 533</td><td>13 883</td><td>56</td><td>3 057</td></tr>
</table>

Table 3: Estimation of annual costs related to charging infrastructure (own elaboration)

4.5 Current and planned policies

In Europe, and in other countries (e.g. in Japan, US, China), Central and local Governments are implementing policies and planning investments in favour of electromobility. These plans include:

- Financial and fiscal incentives for the purchase of electric vehicles by private consumers (e.g. Subsidies, tax exemptions)
- Green Purchase Procurement procedures
- Investments in charging infrastructures

With these initiatives, Governments aim to achieve some targets in terms of EDVs market sales. Achieving 1 million EVs and PHEVs on the road by 2020 is the target in Germany. The Spanish Government aims at the same amount (electric and hybrid vehicles) already by 2014. Table 4 gives the quantitative sales targets announced in some European countries.

Denmark	200 000
France	2 000 000
Germany	1 000 000
Ireland	350 000
Netherlands(1)	10 000
Spain(2)	1 000 000
Sweden	600 000
UK	1 550 000
Total	6 710 000

Table 4: Announced national EDV sales targets for 2020
(except for Netherlands – 2015; and Spain – 2014)
Taken from IEA, 2010[5]

Charging infrastructure plans are adopted national or local governments (Portugal, Denmark, Netherlands, Spain, Germany,…) or public utilities and private companies. (e.g Total is committed to install charging spots in gasoline stations in Belgium). An ex-ante assessment of the effects of these plans in terms of effects on electric car market (and consequences on environment and energy) and on public budget were not found. The expenditure could be later charged to the car user. The question of when, how much and where to invest in charging infrastructure is however not an easy one.

In a survey carried out on behalf the South and West London Transport Conference (Sweltrac), towns - followed by home, work and supermarkets – appeared to be the most popular location for charging points (SWELTRAC, 2007)[12]. In many cases, Governments plans are targeting specific areas and networks (first residential areas and urban zones) and niche markets. Several plans concentrate in cities (Berlin[5], Paris[6], London)[7].

In such an approach, risky investments can be kept limited while experience could be gained on the different aspects of electromobility. This could contribute to cost reductions after sufficient market deployment. Later, in the light of experience and improvement achieved (including on infrastructure charging itself and, also on the grid), and also better assessment of the "optimal" density and location, a wider infrastructure deployment could be envisaged.

According to this, the strategy could be to focus the BEVs market niche on short distance trips (which matches with the current and near term autonomy), without seeking for extended autonomy ranges through wider charging infrastructures along e.g. motorways. PHEVs future marketing would later extend electromobility without requiring such a wide infrastructure deployment.

Besides charging spots in towns, incentives can also be created to broaden the access to the grid at home and at work place. For instance, the French Government plans to require, by 2012, new apartment's buildings with parking to include charging stations. It also plans to make the installation of charging sockets mandatory in office parking lots by 2015. Member States are introducing incentives to companies to install recharging spots (21.5% tax exemption is granted in Belgium). The requirement

[5] Two projects planned covering 100 electric vehicles and 500 charging points (Daimler and RWE)

[6] A network charging was already installed by EDF over the last ten years (84 charging points through 20 Arrondissements in Paris)

[7] It is to be noted that the incentive to electric cars in cities might result in an encouragement to use cars in town, possibly in contradiction to the use of public transport. Car sharing could in the future represent an intermediate option between these two ways (see for instance the Autolib electric car-sharing system in Paris, with a 4000 car fleet, also planned to be extended to other European cities with 700000 electric vehicles)

of installing charging infrastructure could also be integrated into sustainability housing plans and renewable energy targets (see for instance Sheffield – UK).

5 Scenarios definition and modeling approach

5.1 Introduction

The following part of the report represents a scenario building exercise drawing some plausible trends about the future market of electric cars, focusing on the two key drivers discussed before:

1. The expected progress regarding batteries (capacity, durability and costs).
2. The expected deployment of charging infrastructure

For both drivers, two contrasted scenarios are considered and their combination results in four different prospective scenarios on the market deployment of electric cars. The following section describes the common assumptions made for all scenarios. Next, the specific assumptions for the individual scenarios are described and discussed.

5.2 Common assumptions

The following table summarizes the main common assumptions for the four scenarios:

Conventional cars	Energy efficiency improves in accordance to the EU target: 2015: 135 g CO_2/km; 2020 115 g CO2/km 2025-2030: 95 g CO2/km. This is assumed to be achieved with vehicle motor technology improvement and additional measures (Low resistance tyres and labelling; low viscosity liquids)
Batteries	Battery costs: 700 €/kWh in 2010
	Durability: 6 years in 2010
	Battery capacity: Energy capacity enabling a 100 km real car autonomy in 2010
BEV large scale commercialisation	From 2011 onwards for small BEV, from 2015 onwards for medium BEVs. Commercialisation of large BEVs is not expected.
PHEVs large scale commercialisation	From 2020 onwards for medium and large. No small PHEV.
Business model	Business models are in place to offer the consumer the possibility to spread battery costs over the car life.
Charging infrastructure	Residential places (garage, private parkings): 10% in 2010
	Other places (mainly work places): 0.5% in 2010
Electricity	Cost: In a first assumption, electricity is assumed to be charged to consumers according to the current tariffs (domestic or commercial).
	Well-to-wheel emissions assumed for electric cars is based on the average emission factor of power generation. The power generation mix is based on the PRIMES reference scenario 2009. Emission factors for each country for electricity are assumed accordingly.

Table 5: Commons assumptions for the scenarios presented in this report

5.3 Scenario assumptions

As discussed above, batteries performance and costs are expected to improve in the future, resulting. Battery performance improvements could include a certain degree of energy capacity increase, higher usable state of charge (SOC) window, consequently affecting the achievable car autonomy, battery weight. Battery durability would also increase as a result of both better inherent performance and options to extend the battery life in non-automotive applications.

With respect to the technological development of **batteries**, two alternative scenarios are considered, assuming different trends in these performance and costs factors. The assumptions are summarized in Table 6. In the Batt1 scenario, technical progress is slow and limited to a better durability while the usable SOC window remains unchanged. A continuous cost reduction is assumed, up to ~300 €/kWh. In the Batt2 scenario, progress is faster and more radical (200 €/kWh by 2030). Technology progress results in a much better durability and, also a higher useable SOC window.

	Scenario Batt1			**Scenario Batt2**		
	Battery life (yr)	Battery cost (€/kWh)	Useable SOC window (%)	Battery life (yr)	Battery cost (€/kWh)	Useable SOC window (%)
2010	6.0	700	70%	6.0	700	70%
2015	7.7	571	70%	9.7	514	74%
2020	9.8	465	70%	15.0	377	77%
2025	10.0	379	70%	15.0	277	81%
2030	10.0	309	70%	15.0	203	85%

Table 6: Assumptions on batteries (performance and costs)

The progress achieved in the Batt1 scenario enables a limited improvement in car autonomy and annual user cost. In the second scenario, the battery performance and costs improvements enable to increase the all electric range of cars while also reducing the annual cost of the battery (see Table 6 for the case of medium electric cars).

	Scenario Batt1		**Scenario Batt2**	
	Annual cost (€/yr)	AER (km)	Annual cost (€/yr)	AER (km)
2010	3 208	100	3 208	100
2015	3 301	161	2 185	161
2020	3 274	250	1 544	259
2025	2 609	250	1 621	400
2030	2 127	250	1 104	400

Table 7: Assumptions on batteries (car autonomy and annual battery cost)

With respect to **infrastructure** charging, given the already planned investments in various countries, the access to charging facilities is expected to increase in the future. At least, current charging possibilities – mainly at home, where garages exist - are already or will be extended in a relatively short term. These existing national plans are implicitly considered in the first scenario (Inf1 scenario) but are not assumed to get much more ambitious in the future. In a second scenario (Inf2 scenario), an even larger scale infrastructure charging deployment is assumed for all countries. The respective trends are depicted in Figure 3.
It is to be noted that the potential role of fast charging is neglected in both scenarios. This takes into account the remaining questions mentioned in section 4.4. On the other end, the high battery capacity assumed in the Batt2 scenario implies to achieve much faster charging solution than what standard or semi-standard charging offers.

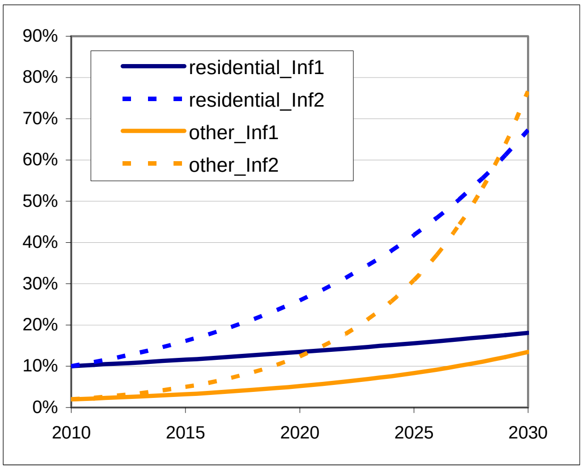


Figure 3: Assumed progress on charging infrastructure

Combining the two above described sets of assumptions results in four scenarios labelled as

- Batt1_Inf1
- Batt2_Inf1
- Batt1_Inf2
- Batt2_Inf2

5.3.1 Car Purchase choice

Vehicle costs (including battery costs), fuel costs, autonomy range and access to charging infrastructures will be the key criteria electric car purchase. The Tremove model version 3.1 (and upcoming version 3.4) does not consider electric cars. Criteria to buy a conventional car are thus more limited. The market share allocation to different conventional cars is based on discrete choice modeling, calculating the probability of selecting each type of car.

The choice of car type depends *inter alia* on the acceleration and on various cost elements (annualized non fuel costs and fuel costs) of the car types in the choice set. The set of coefficients that represent the impact of each of these explanatory variables on the choice probability were estimated (calibrated) based on historical values of these variables and the sales for each car type within the choice set.

In the case of BEVs and PHEVs, historical data on consumer choices are obviously not yet available. This lack of data is particularly problematic when car autonomy and access to charging infrastructure are concerned. In order to cope with these limitations, the approach was developed as a two step one:

First step

1. For each year, the estimated car sales was broken down into three tiers:
- Tier1: A first part corresponds to purchases potentially made by consumers that are in conditions to access to the charging infrastructure required by BEVs (see below). When buying a car, they can thus choose between all available alternatives, including BEVs and PHEVs.
- Tier 2: A second part is composed of car purchases made by consumers that are in conditions to access to the charging infrastructure required by PHEVs (see below), but not sufficient for BEVs, given their more limited electric range. When buying a car, they can thus choose between conventional; cars and PHEVs.
- Tier 3: In the third tier, concerned consumers are those that do not have the access for charging infrastructures. When buying a car, they can thus choose only a conventional car.

The boundaries between the three tiers are quantified by considering the assumed autonomy range, access to charging infrastructure and applying the following reasoning:

Pure electric car: As regards BEVs, the market for cars can be divided into two main segments according to intended car use, i.e. (i) the market for cars that are intended to be used for short distance trips only and (ii) the market for cars that are intended to be used for both short and long distance trips.
- First segment: the option of charging at home (garage, private parking place, or public parking place with charging facilities) is a necessary condition for considering buying a BEV. Charging at work and autonomy range as high as the distance of the trip to work are two other conditions.
- Second segment: the option of charging both at home and at the activity end of the journey is a necessary condition for considering buying a BEV. The actual share of concerned households is assumed to depend on the autonomy range of the battery and increases linearly from zero to one for an autonomous range of 100 km and 400 km respectively.

Plug-in cars
PHEV is only a choice option for households that have access to charging infrastructure at home or at the activity end of the trip.

Scenarios with the lowest infrastructure are similar over all the period and offer few chances for consumers to purchase electric cars. For the other scenarios, more consumers would have the whole range of purchase options open, especially after 2020.

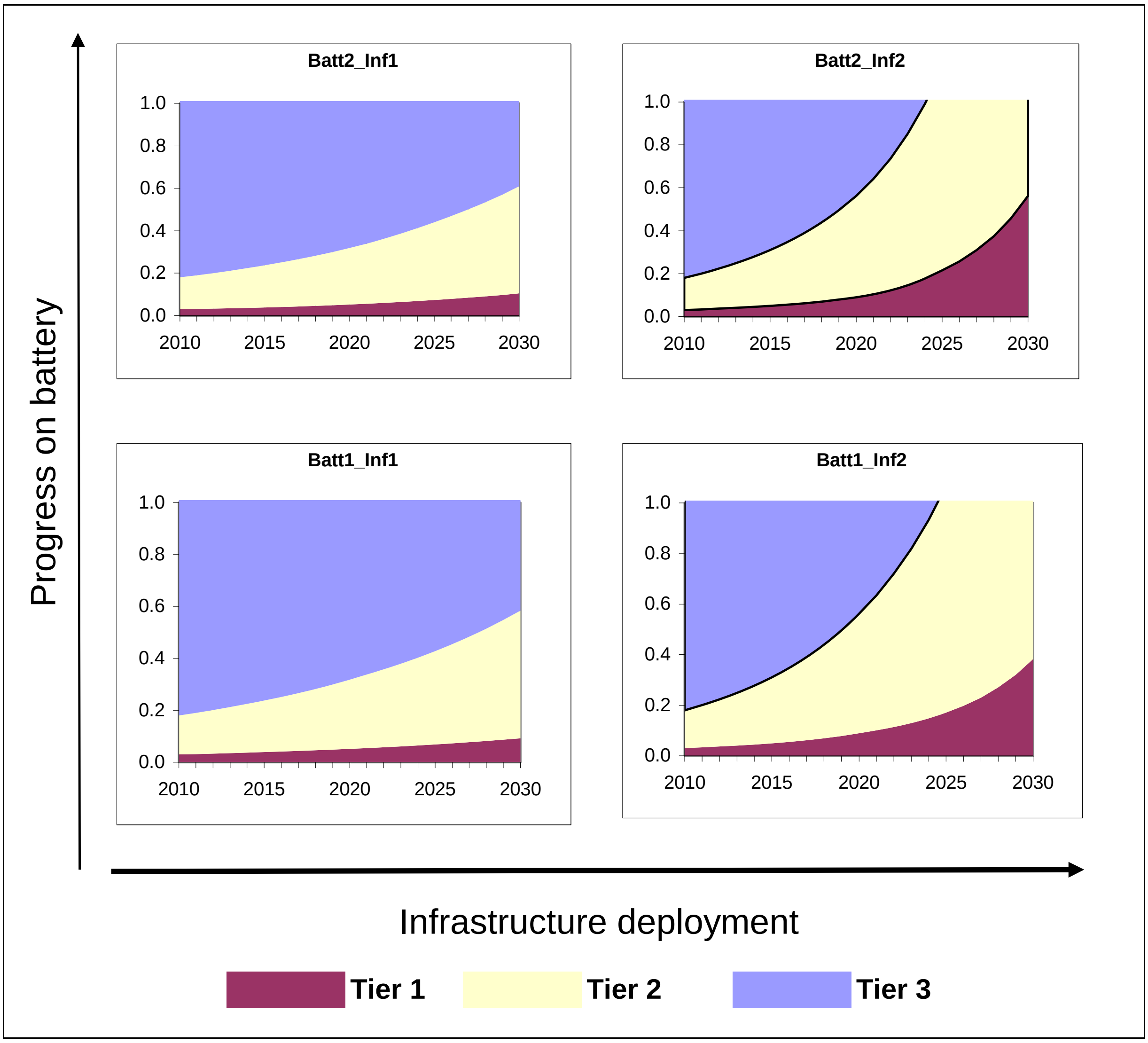
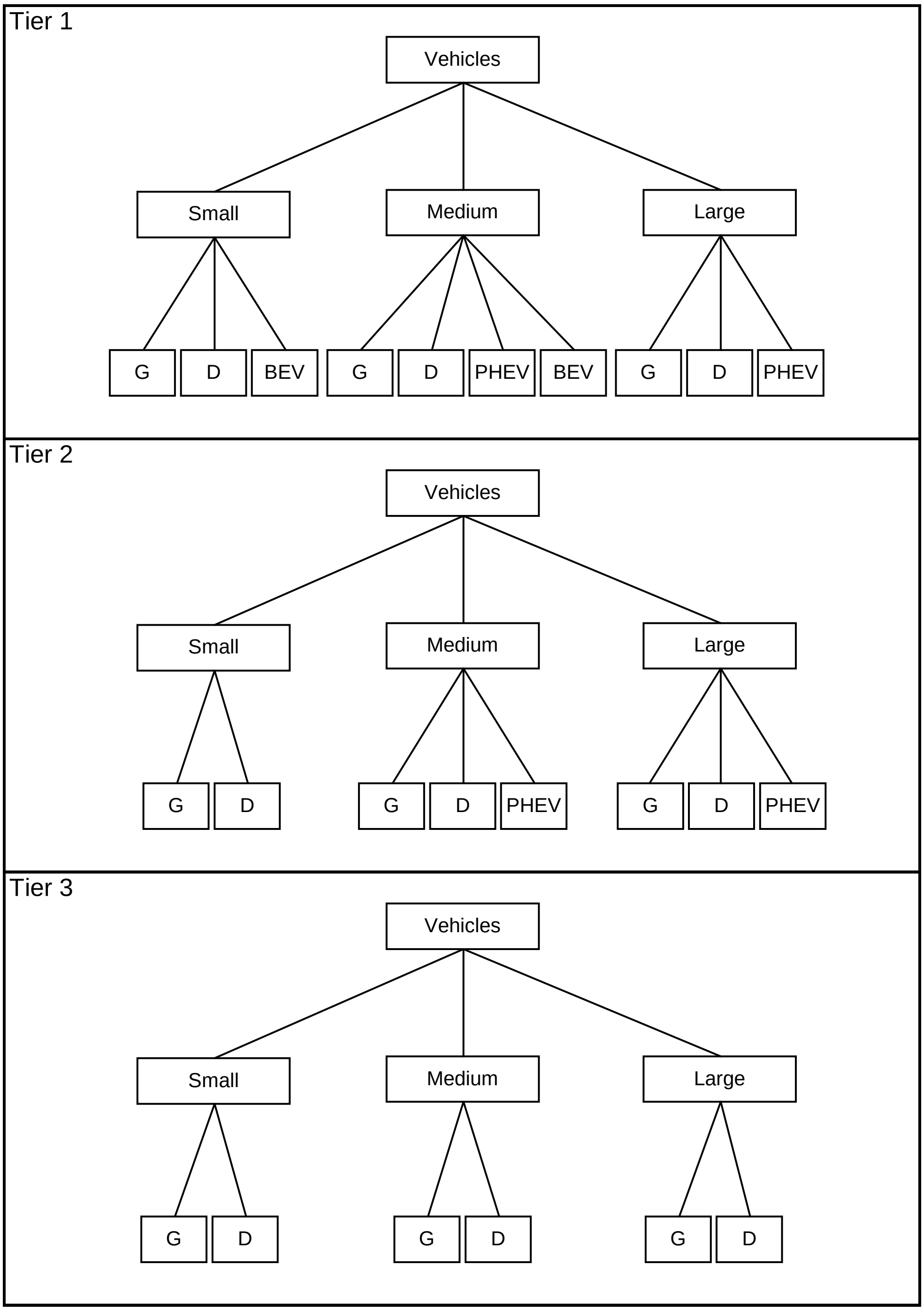


Figure 4: Tiers boundaries in the four scenarios

<u>Second step</u>

Within each tier, once available options are identified, it can then be assumed that the consumer would decide on the basis of the same parameters as assumed for conventional cars (non fuel costs, fuel costs, performance, income). Therefore, for each tier, a different variant of the TREMOVE logit model is used to model the car choice (see Figure 5). For modeling the choice within Tier 1 the TREMOVE logit model was extended to incorporate BEVs and PHEVs by adding both alternatives to the lower level choice sets of fuel technology, while for Tier 2 only PHEVs were added to the lower level choice sets. For Tier 3 BEVs and PHEVs were not included in the model structure.

At this level, the key variable that will influence the decision of selecting an EDV is the cost (battery cost and electricity costs).



G=Gasoline, D=Diesel, PHEV=Plug-in hybrid electric vehicle, BEV = Battery-electric vehicle

Figure 5: Structure of the car type choice model for Tier 1, 2 and 3.

5.4 *Electricity power mix generation*

As a first approximation of the carbon intensity of electricity supplied to electric cars, the PRIMES baseline scenario 2009 was considered. The corresponding average emission factors are given in Table 8.

A growing electricity demand and charging load curve could also influence the future power generation mix, on its turn determining the "plug-to-wheel" CO2 emissions.
Such feedbacks are being investigated with a EU TIMES-based model.

t CO2/TJ	2005	2010	2015	2020	2025	2030
AT	66	58	52	51	51	39
BE	67	55	57	58	89	110
BG	165	178	179	145	62	51
CY	219	205	136	122	114	97
CZ	218	209	173	160	123	103
DE	147	134	128	134	106	68
DK	150	132	113	108	95	88
EE	301	289	269	238	223	213
ES	108	86	84	80	74	42
FI	81	99	71	68	57	44
FR	23	18	19	13	10	7
GR	217	192	177	162	153	147
HU	135	118	103	95	77	65
IE	165	132	128	122	113	101
IT	129	115	112	101	85	63
LT	75	230	222	110	66	60
LV	120	104	82	73	62	59
Mt	231	222	148	135	113	98
NL	142	129	124	106	103	93
PL	290	287	284	255	227	193
PT	147	100	87	79	71	36
RO	174	152	143	114	90	64
SE	10	12	11	10	7	6
SI	113	109	114	115	55	39
SK	90	109	88	86	84	61
UK	135	131	122	98	82	52
EU27	**117**	**108**	**103**	**94**	**80**	**60**

Table 8: Average emission factors for electricity (based on PRIMES 2009 baseline scenario)

6 Scenario results

6.1 Introduction

The above assumptions and approach were applied in the new developed model version for the majority of EU27 countries[8]. These results, both at country level and EU27 level provide first indicative trends regarding plausible market penetration rates, energy consumption and well-to-wheel (WTW) CO2 emissions. They were all compared with a reference scenario in which electric cars were assumed to be unavailable up to 2030.

6.2 Reference scenario

The reference scenario considered is a scenario in which the electric vehicle market doesn't develop. It was build with the TREMOVE version 3.1 and includes the assumptions that the energy efficiency of ICE cars improve in accordance to the target on CO2 emissions. On the average, new ICE cars emissions would evolve as follows:

- 2015: 135 g CO2/km;
- 2020 115 g CO2/km;
- 2025-2030: 95 g CO2/km.

Car sales in Europe and their distribution into different options are depicted in Figure 6.

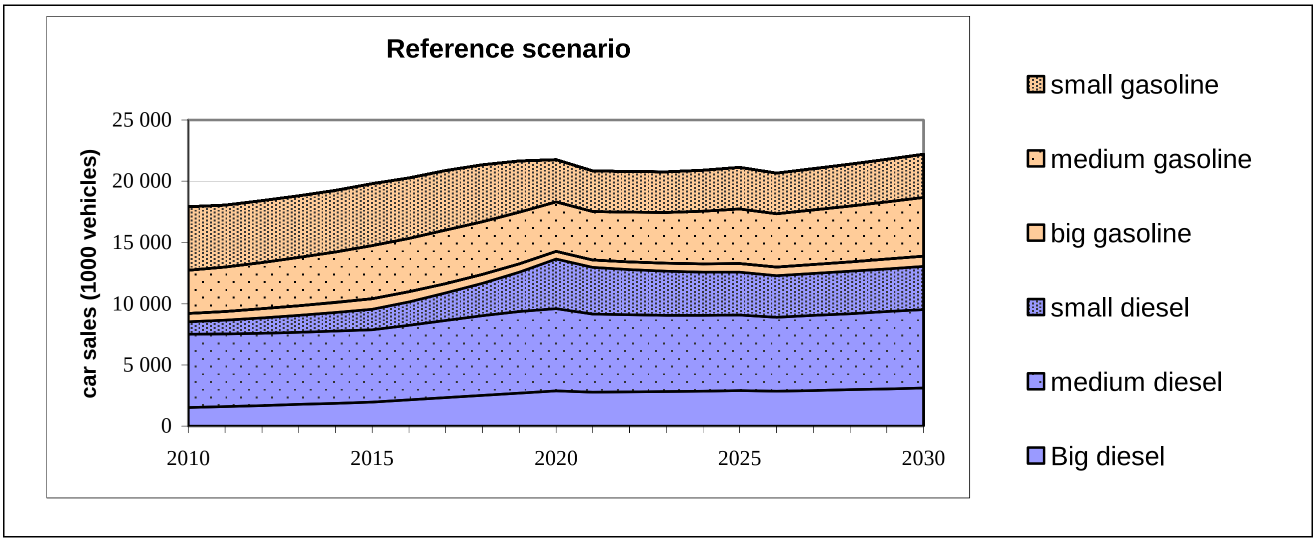


Figure 6: Car sales in the reference scenario

[8] Greece, Cyprus, Slovenia and Malta could not be incorporated in the exercise as the model choice in the current version is not implemented. Exogenous shares are indeed considered. They will be included in a later step.

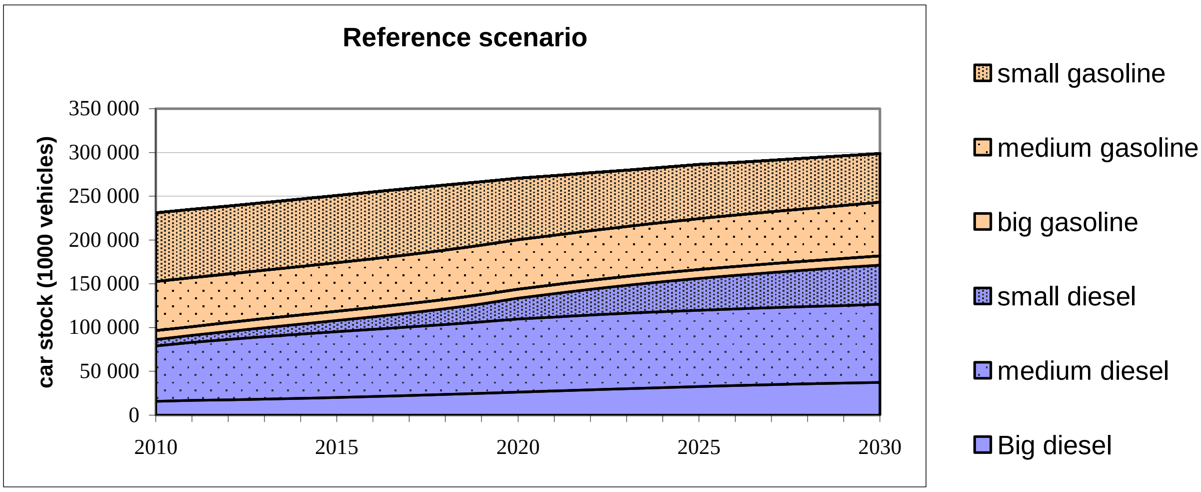


Figure 7: Car stock in the reference scenario

6.3 Sales shares and fleet

Figure 8 compares the projected market penetration of BEVs and PHEVs up to 2030 at EU level for the four scenarios.

Without surprise, the estimated market shares of electric cars (BEVs and PHEVs) are shown to increase when charging infrastructure deployment and battery progress are fast and significant. Charging infrastructure deployment (through a wide access to the grid at home and in other places (especially work places) contribute to offer to more car purchase a wide range of car options able to meet their need – not only conventional car but also electric cars. Battery progress contributes to make the electric cars more performing and cost efficient so that it can better compete with its conventional counterparts.

In all cases however, the BEVs sales shares remain limited until 2020 (0.5% to 3%). On the contrary, PHEVs, rapidly penetrate as soon as they are available on the market. This results from the fact that battery and charging infrastructure represent higher constraints for BEVs.

The graphs also suggest that the progress in access to charging infrastructure is by far the most influencing factor, especially during the period 2020-2030.

It is to be noticed that the aggregated demand for new cars is the same as in the reference scenario, reflecting the fact that passenger road transport is not influenced by the penetration of electric cars.

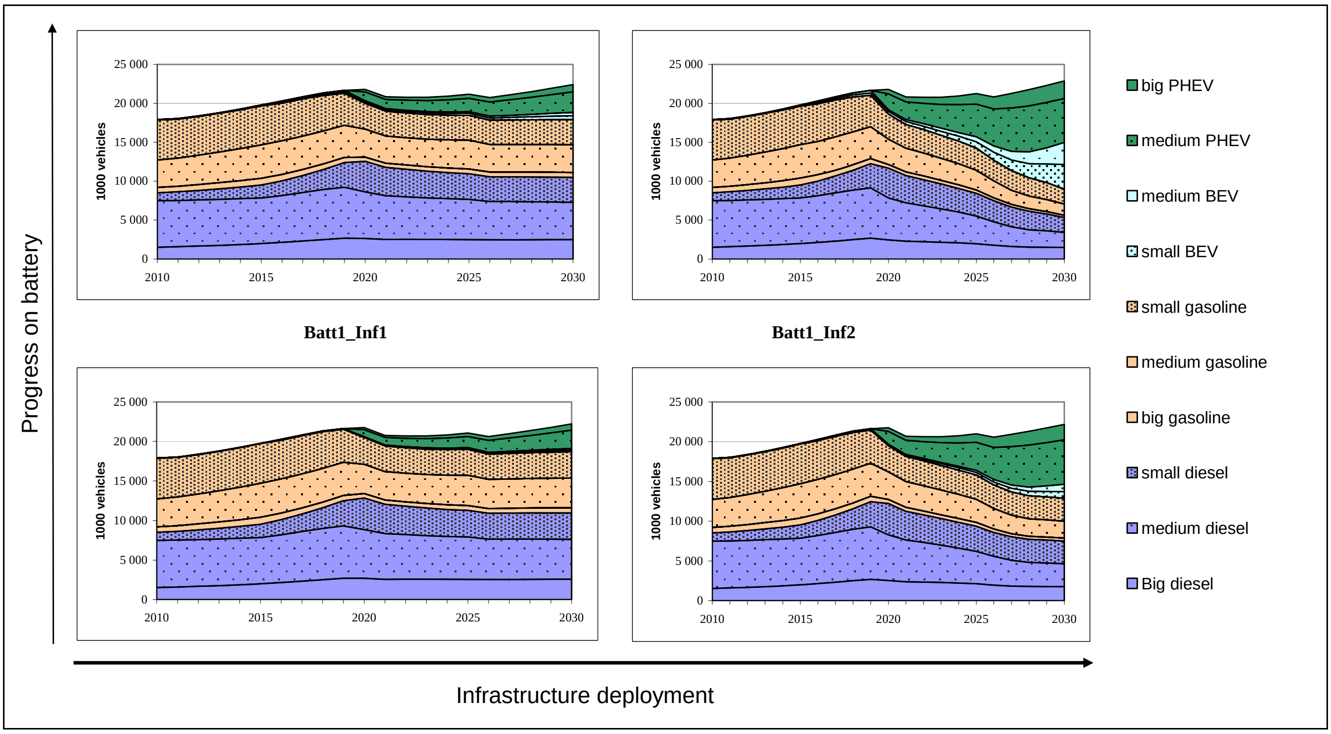


Figure 8: Comparison of scenarios in terms of vehicle sales (EU level)

When this progress is slow, the expected shares for BEVs are limited. On the contrary, even with modest battery improvement, the rapid extension of charging infrastructure would enable to achieve important shares in 2030.

	2020				2030			
new car sales	**Batt1_Inf1**	**Batt1_Inf2**	**Batt2_Inf1**	**Batt2_Inf2**	**Batt1_Inf1**	**Batt1_Inf2**	**Batt2_Inf1**	**Batt2_Inf2**
conventional	94.5%	90.2%	92.0%	85.7%	84.6%	58.5%	80.0%	38.4%
PHEV	5.0%	8.9%	6.4%	11.4%	13.5%	32.5%	15.4%	32.6%
BEV	0.5%	0.9%	1.6%	2.9%	1.9%	9.0%	4.7%	29.0%

Table 9: New car sales shares in 2020 and 2030

In the most voluntarist scenario, BEVs sales seem to catch-up PHEVs market deployment. This results from the combined effect of cheaper batteries, increasing autonomy and widely deployed charging infrastructures. All this contributes to make BEVs almost perfect substitute to the other competing technologies. In such conditions, plug-in cars could be envisaged to be the true transitional technological option for full electromobility based on BEVs.

The penetration of electric cars in the fleet will be slower. The expected shares range from 1% to 2% by 2020 and 7% and 27% by 2030, as shown in in Figure 9.

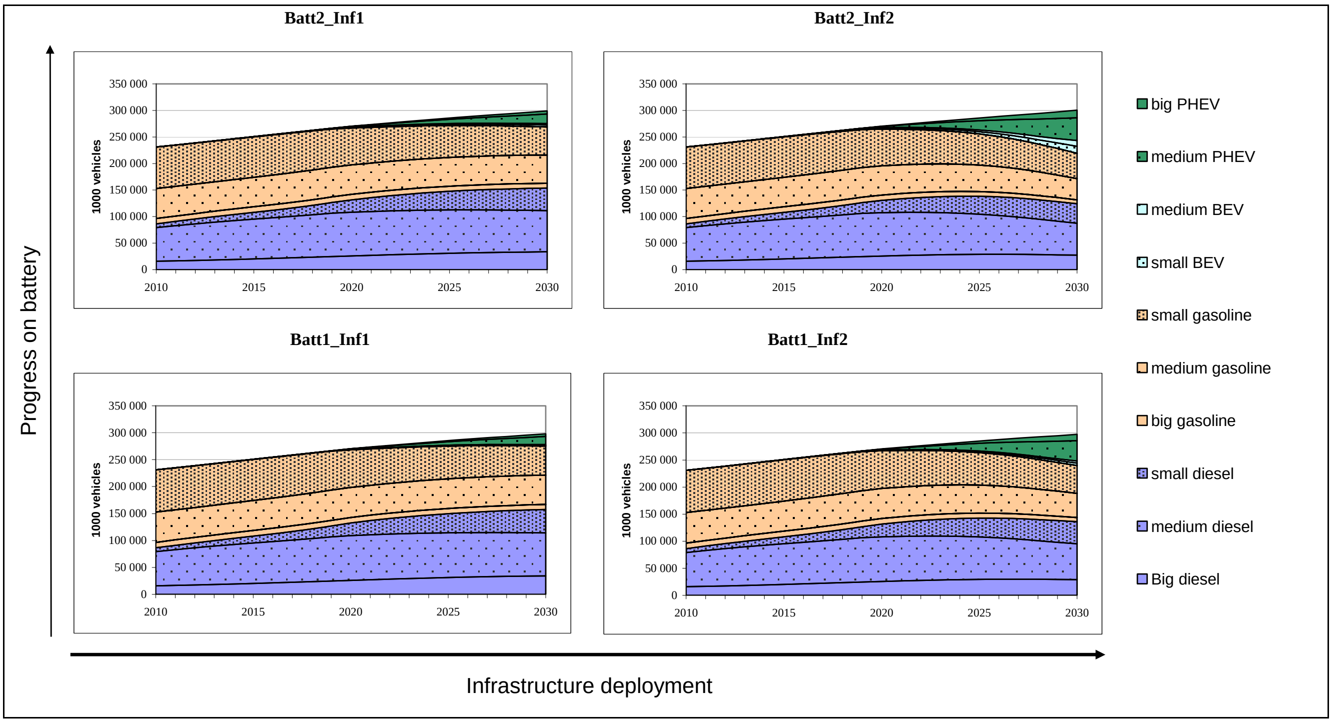


Figure 9: Comparison of scenarios in terms of vehicle fleet

	2020				2030			
car fleet	**Batt1_Inf1**	**Batt1_Inf2**	**Batt2_Inf1**	**Batt2_Inf2**	**Batt1_Inf1**	**Batt1_Inf2**	**Batt2_Inf1**	**Batt2_Inf2**
conventional	99.3%	98.8%	98.7%	97.9%	92.7%	81.4%	90.1%	73.4%
PHEV	0.4%	0.7%	0.5%	0.9%	6.3%	15.6%	7.6%	17.9%
BEV	0.3%	0.5%	0.8%	1.2%	1.0%	3.0%	2.3%	8.7%

Table 10: Fleet shares in 2020 and 2030

The above patterns are similar at country level, even though some country specific conditions could result in slower of faster market deployments. This is illustrated in the following table for the scenario Batt2_Inf2. The biggest shares are expected for Germany. Lower shares are projected for Poland. The differences are stemming from several factors (car taxation levels, labour costs, income, …) which, in the applied discrete choice model, result in different expected consumer preferences.

	2020				2030			
	DE	ES	FR	PL	DE	ES	FR	PL
conventional	85.6%	89.9%	89.5%	92.1%	38.1%	51.1%	45.9%	59.7%
PHEV	10.9%	7.6%	7.0%	5.1%	32.2%	23.6%	21.0%	14.7%
BEV	3.5%	2.5%	3.5%	2.7%	29.8%	25.3%	33.1%	25.6%

Table 11: Sales shares in Germany, Spain, France, Poland (scenario Batt2_Inf2)

As explained in section 5.2, the considered scenarios assume that PHEV would not massively penetrate the market before 2020. Assessment has been made to estimate the impact of an earlier market penetration (2015). In that case, the expected share of PHEV in total fleet would grow to maximum (scenario Batt2_Inf2) 3.6% and 19.5% by 2020 and 2030.

6.4 Energy consumption and CO2 emissions

The substitution of conventional cars with BEVs and PHEVs will result in a substitution of fossil fuel with electricity. Final energy consumption from passenger cars thus changes both in fuel shares and in total amount.

The estimated final energy consumption for EU (as proxied with the 23 countries considered) is given in the following tables, and compared with the reference scenario in which EDVs are assumed unavailable.
The impacts by 2020 are low, even in the most optimistic scenario. It becomes significant and even high in the most favourable case (up to 12% final energy consumption reduction) by 2030. In total, electricity consumption would represent from 143000 TJ to 545000 TJ (2.7% to 10.5% of the total), i.e. ~1% to 4.2% of the total EU electricity consumption.

energy consumption (TJ)	**2020**								
	reference	**Batt1_Inf1**		**Batt1_Inf2**		**Batt2_Inf1**		**Batt2_Inf2**	
fuel (conv cars)	6 763 016	6 723 568	*99.8%*	6 723 568	*99.7%*	6 698 810	*99.7%*	6 660 921	*99.4%*
fuel (PHEVs)		1 935	*0.0%*	3 453	*0.1%*	2 448	*0.0%*	4 375	*0.1%*
electricity (PHEV)		7 620	*0.1%*	13 600	*0.2%*	9 643	*0.1%*	17 232	*0.3%*
electricity (BEV)		4 454	*0.1%*	6 342	*0.1%*	10 872	*0.2%*	16 222	*0.2%*
total	**6 763 016**	**6 737 576**		**6 746 963**		**6 721 773**		**6 698 750**	
% reference		*100%*		*100%*		*99%*		*99%*	

	2030								
	reference	**Batt1_Inf1**		**Batt1_Inf2**		**Batt2_Inf1**		**Batt2_Inf2**	
fuel (conv cars)	5 910 636	5 511 715	*96.7%*	4 901 651	*91.0%*	5 511 715	*95.8%*	4 569 738	*87.6%*
fuel (PHEVs)		35 196	*0.6%*	88 173	*1.6%*	42 094	*0.7%*	102 762	*2.0%*
electricity (PHEV)		138 618	*2.4%*	347 266	*6.4%*	165 787	*2.9%*	404 725	*7.8%*
electricity (BEV)		15 757	*0.3%*	49 382	*0.9%*	36 680	*0.6%*	141 914	*2.7%*
total	**5 910 636**	**5 701 286**		**5 386 471**		**5 756 275**		**5 219 139**	
% reference		*96%*		*91%*		*97%*		*88%*	

Table 12: Final energy consumption by passenger cars per vehicle type (2020 and 2030)

Exhaust gas CO2 emissions are inevitability reduced because of the shift from fuel to electricity but also because of the better energy efficiency of PHEV in charge sustained mode. Tank-to-Wheel (TTW) emissions are thus expected to decline, partly compensated by Well-to-Tank (WTT) emissions (or "plug-to wheel" emissions) from the electricity consumed.

According to Table 13, WTW CO2 reductions are, in relative terms, of the same magnitude as for the final energy consumption. They are slightly higher (maximum 15% by 2030).

CO2 emissions (Mt)	2020								
	reference	Batt1_Inf1		Batt1_Inf2		Batt2_Inf1		Batt2_Inf2	
WTT (fuel)	87.3	86.8	*15.1%*	86.5	*15.1%*	86.5	*15.1%*	86.0	*15.0%*
WTT (electricity)	0.0	1.1	*0.2%*	1.8	*0.3%*	1.8	*0.3%*	2.9	*0.5%*
TTW (Conv cars)	490.2	487.4	*84.7%*	485.7	*84.6%*	485.6	*84.6%*	482.8	*84.4%*
TTW (PHEV)	0.0	0.2	*0.0%*	0.3	*0.1%*	0.2	*0.0%*	0.4	*0.1%*
total	**577.4**	**575.4**		**574.3**		**574.1**		**572.2**	
% reference		*100%*		*99%*		*99%*		*99%*	

	2030								
	reference	Batt1_Inf1		Batt1_Inf2		Batt2_Inf1		Batt2_Inf2	
WTT (fuel)	74.1	69.7	*14.5%*	63.0	*14.1%*	68.5	*14.4%*	59.1	*13.8%*
WTT (electricity)	0.0	8.4	*1.7%*	21.3	*4.8%*	11.1	*2.3%*	29.6	*6.9%*
TTW (Conv cars)	428.0	399.2	*83.0%*	355.0	*79.3%*	391.4	*82.4%*	330.9	*77.1%*
TTW (PHEV)	0.0	3.4	*0.7%*	8.4	*1.9%*	3.9	*0.8%*	9.6	*2.2%*
total	**502.2**	**480.6**		**447.7**		**475.0**		**429.2**	
% reference		*96%*		*89%*		*95%*		*85%*	

Table 13: CO2 emissions per fuel and vehicle type (2020 and 2030)

In the case of a market penetration of PHEV in 2015 instead of 2020, slightly higher energy consumption and CO2 emission reductions by 2030 (respectively up to ~13% and ~16% reductions compared to reference scenario) would be expected.

The above results will differ from country to country, depending on the specific electricity mix. This is illustrated for four countries (Germany, Spain, France and Poland) where the power generation mix significantly differs (Figure 10). The relative reductions expected for both energy consumption and CO2 emissions are very similar in the case of France (13% emission reductions) where nuclear energy and renewable represent the biggest electricity production share. On the contrary, due to the high share of coal expected in Poland , the CO2 emission reduction is only ~3%, even in the most optimistic scenario.

These figures are preliminary trends of how CO2 emissions could be affected by the penetration of electric cars. They will be later updated based on the new PRIMES reference scenario and a more on-depth analysis of possible impacts of electromobility on the power mix (load curve) with the TIMES model.

CO2 emissions (Mt)	DE		ES		FR		PL	
WTT (fuel)	14	*13.4%*	8	*14.3%*	9	*14.5%*	3	*12.5%*
WTT (electricity)	10	*9.8%*	2	*3.4%*	1	*1.0%*	4	*16.6%*
TTW (Conv cars)	77	*72.5%*	46	*81.9%*	52	*82.9%*	16	*70.5%*
TTW (PHEV)	5	*4.4%*	0	*0.5%*	1	*1.6%*	0	*0.4%*
total	**107**		**56**		**62**		**22**	
% reference	*86%*		*87%*		*79%*		*97%*	

Table 14: CO2 emissions from passenger cars in 2030 in four countries (scenario Batt2_Inf2)

	DE	ES	FR	PL
Emission factor of electricity (t CO2/TJ)	68	42	7	93
Final energy consumtpion	86.9%	91.5%	88.2%	89.8%
CO2 emissions	86.0%	86.9%	78.8%	97.0%

Figure 10: Final energy consumption and CO2 emissions reductions in four countries – scenario Batt2_Inf2 (% of reference scenario)

7 Concluding remarks

This report both elaborate a modelling approach enabling to assess the future market penetration of electric vehicles. It offers a tool to evaluate the effects of some key factors determining electromobility, including battery costs and performance and access to grid to for recharging. It offers some possibilities to assess the effects of policies such as infrastructure investment and incentives to car consumers.

The report also analyse different options for the future in terms of the future market deployment of EDVS, depending on the expected trends on the key drivers. Conclusions drawn from this analysis are as follows:

- The deployment of pure electric cars expected to remain very limited at least until 2020. The access to charging infrastructures both at home, working place and urban public areas will be the first barrier to a large scale market development of electric cars. This holds true in the near term but also up to 2030. Faster market penetration would be achieved in the case of PHEVs as soon as they are commercialised (~2020). A voluntarist development of standards and charging infrastructure would double the market penetration of both BEVs and PHEVs by 2030 compared with a scenario with much more limited development. A public intervention would be particularly key to make this possible.

- Battery costs make EDVs upfront costs much higher than conventional cars. However, if these costs can be spread over the car life via the different business models currently tested, the attractiveness of those cars could be improved. On a lifetime perspective, EDVs are however still less cost effective than their conventional counterparts. Progress in battery performance and costs are possible and would largely improve both the cost performance and autonomy range. This would represent the second driver for the future success of EDVs market, and particularly for BEVs. The considered scenarios however suggest that the full benefits of this progress on batteries would better manifest in the case where charging infrastructure deploys.

- At EU level, the impacts on fuel and electricity consumption by road passenger transport would be negligible until 2020-2025. Significant effects would occur later and, in 2030, the magnitude of fuel savings could be in a 6%-20% range compared with a reference scenario where electromobility doesn't develop. By 2030, electricity demand from road transport would be 140 000 to 550,000 TJ at EU level (~1% to 4% of the projected total electricity consumption by 2030).

- By 2030, electric vehicles could result in a reduction of CO2 emissions from passenger road transport which would range between 4% and 12% of the emissions projected in the reference scenario. The situation at country would be largely affected by the power generation mix.

8 Annex I TREMOVE

TREMOVE is a policy assessment model for studying the effects of different transport and environmental policies on the emissions of the transport sector. Given a policy measure, the model estimates the effects on transport demand, the resulting modal shifts, the vehicle stock renewal, the emissions of air pollutants and the effects on welfare. The model can be applied for the analysis of different policies such as road pricing, public transport pricing, emission standards, subsidies for cleaner cars, etc. TREMOVE models both passenger and freight transport, and covers the period 1995 - 2030.

The model consists of 31 parallel country models[9], each of them consisting of three inter-linked modules: a transport demand module, a vehicle turnover module and an emission and fuel consumption module.

The **transport demand module** describes transport flows and the users' decision-making process in terms of modal choice. Starting from the baseline level of demand for passengers and freight transport per mode[10], period, region etc., the module describes how the implementation of a policy measure will affect the choice of the users and of the companies between the different transport modes. The key assumption is that the choices are made based on the generalized price for each mode: cost, taxes or subsidy and time cost per kilometre travelled. The output of the demand module consists of passenger-kilometres (pkm) and ton-kilometres (tkm) that are demanded per transport type for a given policy environment. The pkm and tkm are then converted into vehicle kilometres (vkm).

The **vehicle stock turnover module** describes how changes in demand for transport or changes in vehicle price structure influence the share in the stock by age and vehicle type. The output of the vehicle stock module is twofold: total fleet and the number of km for each year according to vehicle type and age.

The fuel consumption and **emissions module** calculates fuel consumption and emissions (greenhouse gas and air pollutants emissions), based on the structure of the vehicle stock, the number of kms driven by each vehicle type, and the driving conditions using the COPERT methodology.

Outputs from the vehicle stock and fuel consumptions and emissions modules are fed back into the **demand module**. As fuel consumption, stock structure and usage influence usage costs, they are important determinants of transport demand and modal split.

In addition to the three core modules, the TREMOVE model includes a well-to-tank emissions and a welfare cost module. The **well-to-tank emissions** module calculates the emissions during the production of fuels and electricity.

The **welfare cost module** enables a calculation of the cost to society associated with emission reduction scenarios in European urban and non-urban areas. The welfare effect of a policy change is calculated as the discounted sum of changes in utility of households, production costs, external costs of congestion and pollution and benefits of tax recycling. These benefits of tax recycling represent the welfare effect of avoiding public funds being collected from other sectors, when the transport sector generates more revenues.

[9] EU27 countries + Norway, Iceland, Switzerland and Turkey
[10] TREMOVE is not a transport network model and doesn't enable to project baseline transport activity. It therefore requires an exogenous baseline demand projection.

Next figure shows an overview map of the model.

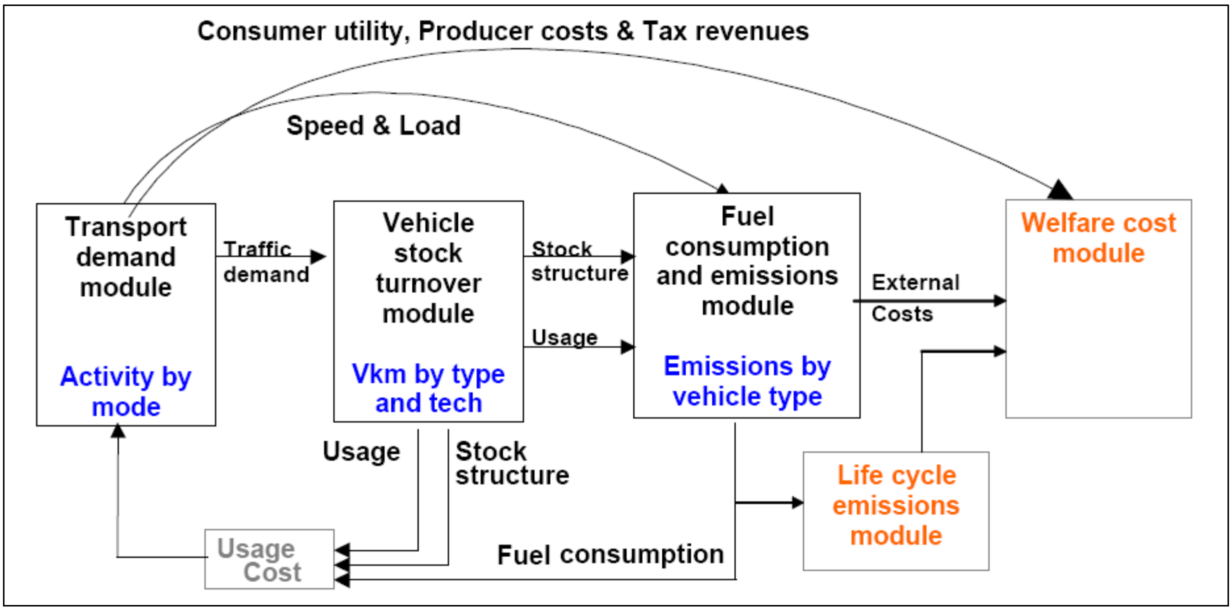


Figure 11 : Modular Structure of TREMOVE

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Abstract

Electric-drive vehicles (EDVs) are currently emerging in the market and are seen as a promising option towards a less carbon intensive road transport.

This report presents a prospective analysis in relation with two of the current bottlenecks for the diffusion of electric vehicles. These concern batteries performance and cost, and the access to charging infrastructures. Based on projections on these factors, the analysis develops scenarios for the future market for electric cars and provides indicative estimations of the impacts on energy consumption and CO2 emissions at EU level.

To this end, a modelling approach was developed, enabling to assess the future market penetration of electric vehicles and evaluate the effects of some key factors determining electromobility, including battery costs and performance and access to grid to for recharging. It offers some possibilities to assess the effects of policies such as infrastructure investment and incentives to car consumers.

The approach is mainly demand driven in the sense that the effects and, also, possible constraints from the electricity grid and from the power generation sector are not considered. The effects of a growing electricity demand and possible charging profiles are also not addressed at this stage. This is currently being carried out by using a EU-TIMES-based model of which conclusions will be presented reported in a subsequent report.