EXPLORATION OF THE IMPACT OF ELECTRIC VEHICLE POLICIES ON VEHICLE REGISTRATIONS, EMISSIONS AND COST-BENEFIT-ANALYSIS

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1. INTRODUCTION

The member states of the European Union (EU) have agreed to path a way towards a towards a fossil fuel free future in the transport sector in order to reduce carbon emissions (EC 2011). In order to fulfil its national obligations within these supranational ambitions, the German government identified a mitigation potential of approx. 7-10 million tonnes of greenhouse gas emissions (GHG) within its Climate Action Programme 2020 (BMUB 2014). One key component of the GHG mitigation strategies is the promotion of electric vehicles in passenger transport. For that reason, the support of research on the technological development and mechanisms to foster the market introduction of electric vehicles has been intensified in all member states.

First of all, the applied methodology for the scenario calculation of market penetration pathways and their socio-economic impact estimation for the deployment of electric passenger vehicles are described. The framework and calculation prerequisites as well as the results are presented for EU28 and for the focus country Germany. After the elaboration of the scenario settings, which covers parameters such as energy prices, well-to-tank emissions as well as emission cost factors to monetarize them, two different scenario alternatives (Business-as-Usual, Policy-Driven) are analysed. The development of the market shares of different propulsion technologies for total sales of new passenger cars as well as the total passenger car stock are displayed. Furthermore, corresponding socio-economic (e.g. emission costs, cost of owning and operating) impacts for the specific regional focus and the alternative scenarios are discussed.

2. METHODOLOGY

The competition between different powertrains and efficiency technologies for the new vehicle market is simulated with the agent based vehicle technology scenario model VECTOR21 (Fig. 1; Mock, 2010). 900 different agents, characterized by vehicle segment, annual mileage, requirements on charging infrastructure and range as well as a willingness to pay an additional amount for more efficient and environmentally friendly technologies, choose the least cost intensive car with given CO_2 emission targets. Within the costs, the relevant costs of ownership[1] are taken into account; more precisely fix costs (purchase cost, sales tax, one-time-incentives if applicable and tax on ownership) and variable costs (cost and taxes for fuel and electricity).

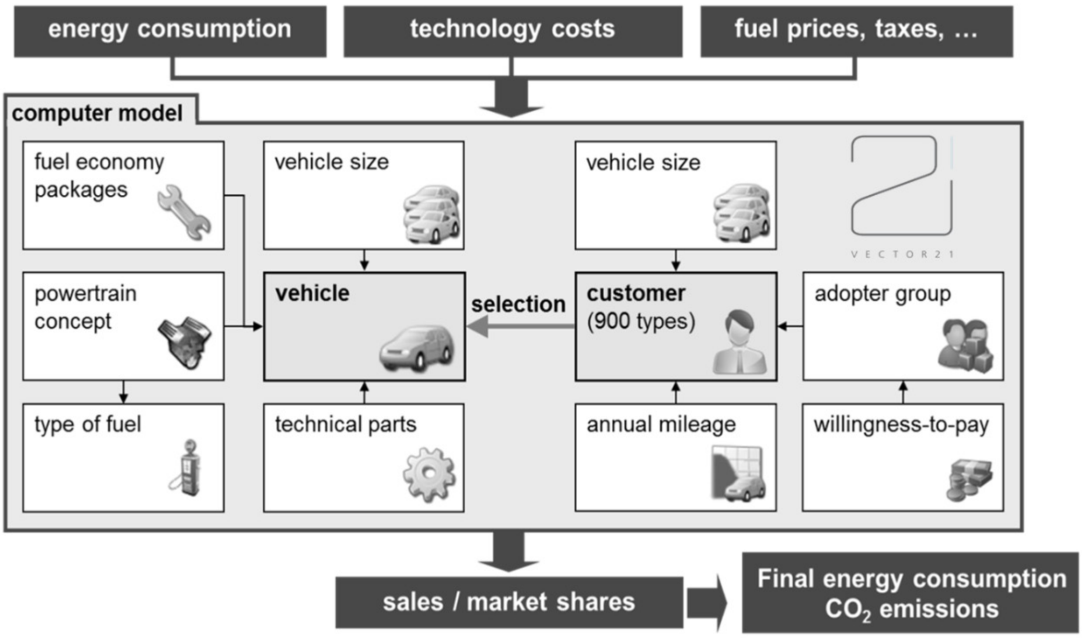

Fig. 1: Illustration of the vehicle technology scenario model VECTOR21

Passenger cars in VECTOR21 are defined by their type of powertrain concept (conventional internal combustion engine vehicle (ICE), Hybrid-Electric (HEV), Plug-In HEV (PHEV), Range Extended Electric (REEV), Battery Electric (BEV) and Fuel Cell (FCV), their type of fuel or energy source (gasoline (G), diesel (D), compressed natural gas (CNG), electricity or hydrogen) and by their vehicle segment (small, medium and large). Furthermore, technology packages, reducing the fuel consumption and thereby the CO_2-emissions are defined with their energy consumption reduction potential and their costs. Within these packages technologies like lightweight construction, low resistance tires and engine internal measures complete the product range.

Based on the cumulated sales of batteries, power electronics or electric machines over previous years as well as the respective learning rates of these technologies, the cost and price for EV powertrain concepts is calculated. Thus, the prices decrease depending on the market uptake of electric vehicles, and are calculated endogenously in the model.

Cost-benefit analysis (CBA) is the most known and most used methodology for determining the worth, value and feasibility of a supporting measure (VTPI 2011). CBA is based on welfare economics using the Kaldor-Hicks criterion: a policy measure is efficient when it makes some people better off without making other people worse off. Thus CBA shows whether it is profitable to the society to use productive resources (labour, capital) to provide EVs and infrastructure to achieve savings of resource consumption (in this case energy and environmental pollution). Both sides – resource use (costs of electromobility) and the resource savings (benefits of electromobility) – are expressed in monetary terms in order to build the ratio out of them. When the benefits exceed the costs (benefit-cost ratio > 1), it is profitable from the society point of view. The ratio does not only show profitability but also allows ranking alternative scenarios of electromobility.

What is important by conducting a CBA is that only net costs are regarded. This means that taxes and subsidies are not part of the CBA. The CBA regards the deployment costs, costs of infrastructure and the production costs of e-vehicles as costs. Benefits result out of decrease of costs of operating and owning, costs of emissions and costs of noise.

- Costs of operating and owning: Costs of owning and operating do not include the purchase costs. They are already incorporated in the production costs. The conducted CBA regards relevant costs of owning and operating (for example energy costs). They are output of VECTOR21.
- Costs of emissions are at first CO_2-costs but other emissions are regarded, too. Emission costs are caused by production and by use of energy. Thus we distinguish well-to-tank (WTT) emissions and tank-to-wheel (TTW) emissions. Base for evaluation emission costs is the newest Update of the Handbook on External Costs of Transport (Korzhenevych et al. 2014).
- Costs of noise: One of the main characteristics of e-vehicles is that they are very silent compared to conventional combustion cars up to a certain speed. Noise costs are evaluated on the base of the European Handbook on External Costs, too.

Compared to CBA, the analysis of wider economic aspects (WEA) does not only consider welfare economical use of resources. It deals with macro-economic effects such as employment, production, incomes, profits, fiscal revenues. There are a lot of economic, political and social aspects in the area of electromobility, which have to be analysed in order to make well founded decisions.

Besides the CBA a wider economic analysis was conducted to compare economic impact of scenarios in terms of employment, gross value added and fiscal revenues.

The calculated economic impact of electromobility scenarios covers the following areas:

- Buying and using ICE-Vs and EVs means different impact on employment and income. Purchasing cars leads to effects in the car manufacturing industry (OEMs and suppliers) and in the trading sector. During the cars lifetime spendings for fuel, electricity, insurances, maintenance and so on lead to economical effects in the corresponding sectors.
- Furthermore the impact of investment in charging infrastructure and their operating costs are calculated. Starting point are public and private expenditures.

3. SCENARIO SETTING

The scenarios taken into account for this paper are the Business-as-Usual scenario (BaU) as a reference and Policy-Driven scenarios to evaluate alternative policies to enhance electrified vehicles in Germany (PoD-GER) and the EU28 (PoD-EU). The EU28 was not explicitly modelled, but is represented by the 6 major car markets Finland, France, Germany, Italy, Poland and the UK, covering ¾ of all new vehicle sales per year in the EU28 (ACEA 2014, Eurostat 2015). These were then upscaled to 100% of all annual sales (see Schimeczek et al. (2015) for more details).

3.1 Scenario calculation parameters

In the BaU scenario, current policies and technologies and their evolution over time are incorporated. Most important model parameters for the political and techno-economic BaU framework are given in Tab. 1. For more details, e.g. data on the chosen layout for EV technologies like traction battery, electric motor and power electronics, refer to Kugler et al. (2015). EV component prices were calculated based on the number of sold units using learning curves (see Schimeczek et al. (2015) and Kugler et al. (2015)).

Tab. 1: BaU main scenario parameters

		Unit	2010	2020	2030	Source
Energy prices	Crude oil	$\$_{2011}$/bbl	108	120	124	IEA (2012)
	Hydrogen	€$_{2010}$/kg	20	8	6	McKinsey (2011)
	Electricity (Household Germany)	€ct$_{2010}$/kWh	24	29	32	Nitsch et al. (2012), own calculations
Regulation	CO_2 fleet targets	g CO_2/km	130 (2015)	95 (2021)	75	Regulation (EU) No 333/2014 until 2020, own assumptions afterwards
Well-to-tank CO_2 emission intensity	Electricity (Germany)	g/MJ	152	88	55	Nitsch et al. (2012)
Infrastructure coverage	Electricity (Germany)	%	5 (2011)	25	50	Own assumptions

The German automobile taxation scheme includes VAT (19%), taxes on ownership and fuel taxes. Annual taxes on ownership consist of a tax on displacement size and a tax for CO_2 emission exceedances (e.g. >95 g/km from 2014 on). Owners of diesel cars have to pay higher tax rates. Taxes on fuel are a sum of excise duties and VAT. Excise duties on fuels are 0.6545 €/l gasoline and 0.4704 €/l diesel. For CNG in transport, there is a reduction in excise duties until the end of 2018 to 13.90 €/MWh (ca. 0.19 €/kg). From 2019 on, excise duties on CNG are 31.80 €/MWh (ca. 0.44 €/kg). Taxes and levies on electricity are a sum of levies for renewables, network maintenance and concession, combined heat and power as well as energy taxes and VAT.

The two Policy Driven scenarios explore 1) EU-wide policies (PoD-EU) and 2) national policies (PoD-GER) to promote EV. In the EU-wide PoD-EU scenario, the effect of decreasing the EU CO_2 emission target for passenger cars to 60 g CO_2/km in 2030 is modelled, while no additional country wise measures are taken into account.

In the PoD-GER scenario for Germany, bundles of policies are modelled from 2016 on:

- Lowering purchase costs by 1,500 € for EV (PHEV, REEV, BEV, FCEV) by tax exemptions/purchase premiums up to 2020,
- Exemption from the renewable energy levy for public charging stations [2],
- Increasing investments and thus coverage in charging infrastructure by 10% [3] per year,

- Raising awareness for electrified vehicles by advertisement campaigns, showcase projects and thus increasing the customers' willingness-to-pay by 10% [3].

3.2 Savings in costs of air pollution

The calculation of savings in air pollution costs are calculated based on information about the distribution of the EURO emission standards in the passenger car stock (scenario results) and air pollution cost factors (in € ct/vkm[4]) per EURO standard and fuel type (diesel and petrol car including PHEV and REEV). According to the Handbook on External Costs of Transport, the damage costs for the main pollutants ($PM_{2,5}$, NO_x, NMVOC and SO_2) are considered. The air pollution cost factors are multiplied with the mileage of the respective cars depending on the area, where the air pollutants are emitted. The air pollution costs in € ct/vkm for passenger cars are differentiated by area and road type according to respective share of each country, for which respective damage costs are applied.

Tab. 2: Damage costs of main pollutants from transport, in €$_{2010}$ per ton

Country	$PM_{2,5}$ (exhaust and non-exhaust)			NO_x	NMVOC	SO_2
	Rural	Suburban	Urban			
Germany	48,583	73,221	220,461	17,039	1,858	14,516
EU	28,108	70,258	270,178	10,640	1,566	10,241

In the update of the Handbook on External Costs of Transport, for each EURO emission standard (EURO 0 to EURO 6) an emission factor is assigned. This emission factor (g/ vkm) is multiplied with the appropriate damage cost factor for the air pollutants (€/t) in order to get the air pollution costs per vkm (see Tab. 2). Marginal external cost values for passenger cars per kilometre are used, which were calculated using damage costs and emission factors. These unit values are representative for the EU and are calculated for the vehicle types actually present on European roads. An excerpt of these data for small cars is shown in Tab. 3.

Tab. 3: Excerpt of the air pollution costs for passenger cars (TTW, EU average), in €ct$_{2010}$ per vkm

Vehicle	Engine	EURO-Class	Rural	Suburban	Urban
Diesel car	< 1.4l	EURO 2	0.8	1.5	3.6
		EURO 3	0.8	1.2	2.5
		EURO 4	0.6	0.9	1.7
		EURO 5	0.4	0.6	0.9
		EURO 6	0.2	0.3	0.7
Petrol Car	< 1.4l	EURO 0	2.2	3.2	3.5
		EURO 1	0.3	0.7	1.0
		EURO 2	0.2	0.4	0.7
		EURO 3	0.1	0.2	0.4
		EURO 4	0.1	0.2	0.4
		EURO 5	0.1	0.2	0.4
		EURO 6	0.1	0.2	0.4

For electric vehicles, the air pollution costs are calculated based on the up- and downstream processes of the electricity production. The share of electricity production by fuel type (e.g. coal, nuclear, renewables) and the pollution factors from energy production in g/GJ are considered. Based on this data the emission factors induced by electricity use can be calculated. The electricity consumed by all electric vehicles in the stock is a result of the VECTOR21 model and can be used to calculate the costs of air pollution. The energy consumption (in GJ) is multiplied with the emission factors from electricity use in g/GJ.

Tab. 4: Damage costs for emissions from electricity production, in €$_{2010}$ per ton

Country	NMVOC	SO_2	NO_x	$PM_{2.5}$
Germany	1,850	13,600	13,550	33,750
EU	1,550	9,350	8,050	18,850

To achieve the total costs of air pollutants, the tons of air pollutants are multiplied with the damage cost values (see Tab. 4) for emissions from electricity production (in €/t).

3.3 Savings in CO_2-costs

The tons of CO_2 emissions, with regard to the different powertrain technologies, are an output of the VECTOR21 calculations. There is a large spread in CO_2 cost factors in literature. We use that one that is suggested by

Umweltbundesamt and thus common in Germany. It is assumed that one ton CO_2 has climate costs of 145 €$_{2010}$ (UBA 2012; average value, medium term 2030). The emissions depend on the fuel consumption, the fuel type and the energy mix (in case of EV) on an European respectively country specific level. For vehicles with combustion engine (diesel, petrol, CNG) the well-to-wheel CO_2 emissions are calculated.

In the regarded time horizon 2010 to 2030 a country specific development of the electricity production by resource type is considered. For electric vehicles the costs of CO_2 emissions are calculated based on the up- and downstream processes of the electricity production. As in the calculations of the costs of air pollutants, the share of electricity production by resource type and the CO_2 emission factors from energy production by fuel type are considered. As result the emission factors from electricity use are obtained. This emission factor (g/GJ) is multiplied with the used energy of the electric vehicles in the stock in order to get the total climate change costs.

3.4 Savings in noise costs

In an urban environment e-vehicles are very silent compared to conventional combustion cars up to a certain speed. Because of different shares of electric vehicles in the scenarios there are differences in noise emissions between scenarios and the savings in noise costs have to be evaluated. These costs are calculated on the base of the Update of the Handbook on External Costs of Transport (Korzhenevych et al. 2014). There the cost values for road noise are calculated based on a bottom-up noise exposure model from the German directive for road noise protection (RLS-90: Richtlinien für den Lärmschutz an Straßen). In the CBA reduced costs for electric vehicles are used. In urban areas for example noise costs of e-vehicles (per vehicle kilometre) are between 9 ct. (dense traffic day) and 39 ct. (thin traffic night) lower than those of vehicles with combustion engine. Thus - if the share of EVs in the vehicle stock increase, the vehicle kilometres driven by these cars will increase and the noise costs decrease.

3.5 Wider economic impact

Wider economic effects on employment, value added and taxes are calculated by using purchases and expenditures in the scenarios and national figures and input-output-data.

The calculation of economic impact of the different scenario development is based on Input-Output-analysis. By these effects of intermediate production is contained, too. The impact of investment and running costs of cars as well as of infrastructure are calculated on the base of input-output-tables. These tables show the sale and purchase relationships between producers and consumers within an economy. They are produced by using the flows between the sales and purchases (final and intermediate) of industry outputs or by illustrating the sales and purchases (final and intermediate) of product outputs. In Germany for example the Input-Output-tables are provided by national statistic. The last ones are from 2014 describing the year 2010 (Statistisches Bundesamt 2014).

4. RESULTS

4.1 New vehicle sales

In Germany, there are no significant fiscal incentives for EV and financial penalties for CO_2 emission-intensive vehicles are comparatively low. Additionally, electricity prices in Germany are high. Under BaU scenario assumptions, therefore, conventional diesel and gasoline cars keep their market dominance up until 2025 (Figure 1). After that, market balance is shifted towards electrified powertrains, with a share of 65% in 2030 (of which a third is equipped with a plug-in device – PHEV, REEV and BEV to a small amount).

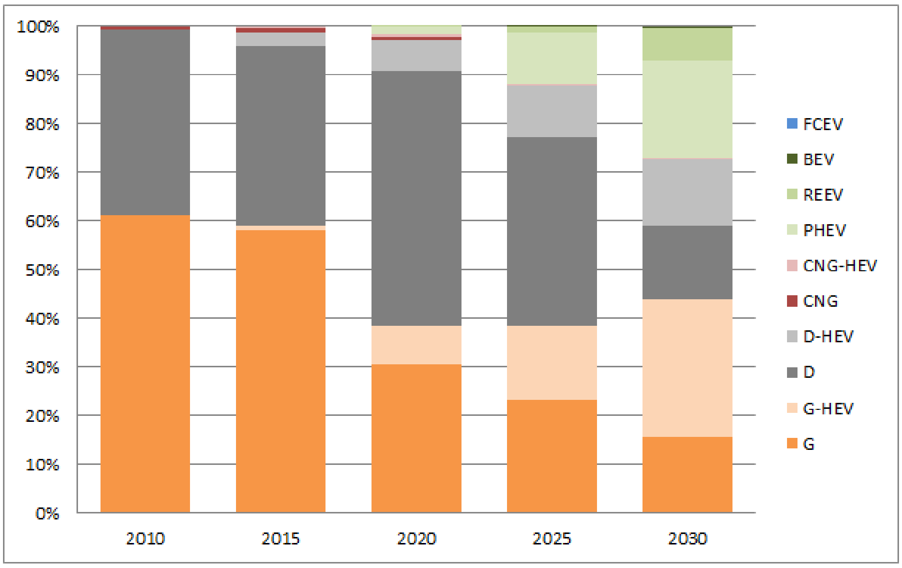

Figure 1: BaU scenario: total sales of new passenger cars in Germany

Although the evolution of the German new car market is more or less conservative in the BaU scenario, the share of electrified powertrains in stock is around 35% in 2030, of which a third are PHEV, REEV and BEV (Figure 2). Accordingly, together with increased efficiencies of conventional powertrains, total energy consumption and well-to-wheel CO_2 emissions of the German passenger car fleet are decreasing by around 30% in 2030 compared to 2010. A part of these CO_2 emission savings is due to an increasing share of renewables in electricity production where Well-to-Tank CO_2 emissions are lowered by over 60% in 2030 compared to 2010 (Nitsch et al., 2012).

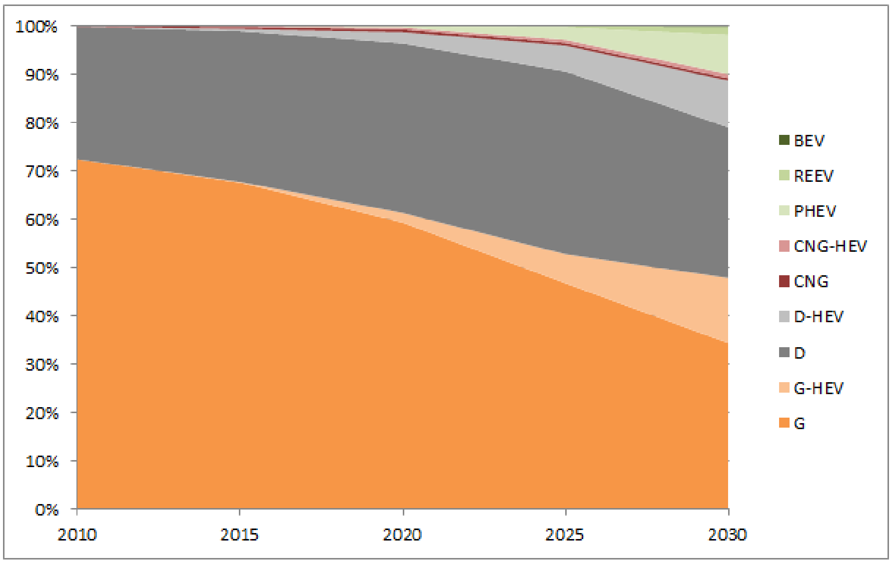

Figure 2: BaU scenario: total passenger car stock in Germany

For the EU28, conventional powertrains (diesel, gasoline and CNG) keep their market dominance up to 2025 under the assumptions of the BaU scenario (Figure 3). Electrified powertrains, mostly PHEV as well as gasoline and diesel HEV enter the market from 2020 on and are able to gain a share of almost 50% in 2030. CNG passenger cars are sold mainly in Italy due to a well-developed refuelling infrastructure and relatively low CNG prices.

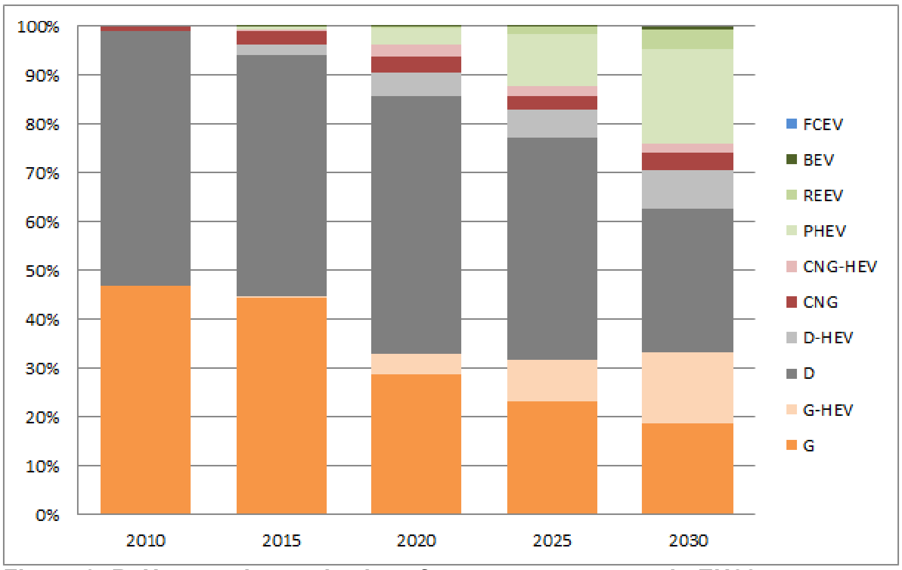

Figure 3: BaU scenario: total sales of new passenger cars in EU28

Within the BaU scenario, the composition of the passenger car stock in the EU28 changes in accordance to the evolution of newly sold cars that enter the total fleet (Figure 4). Although conventional diesel and gasoline cars are dominating the stock up until 2030, electrified powertrains (G-HEV, D-HEV and PHEV) are able to reach a total share of 20% in 2030. Due to increasing efficiencies of conventional powertrains and an increasing number of electrified powertrains, energy consumption and WtW CO_2 emissions of the EU28 passenger car stock decrease by almost 30% in 2030 compared to 2010.

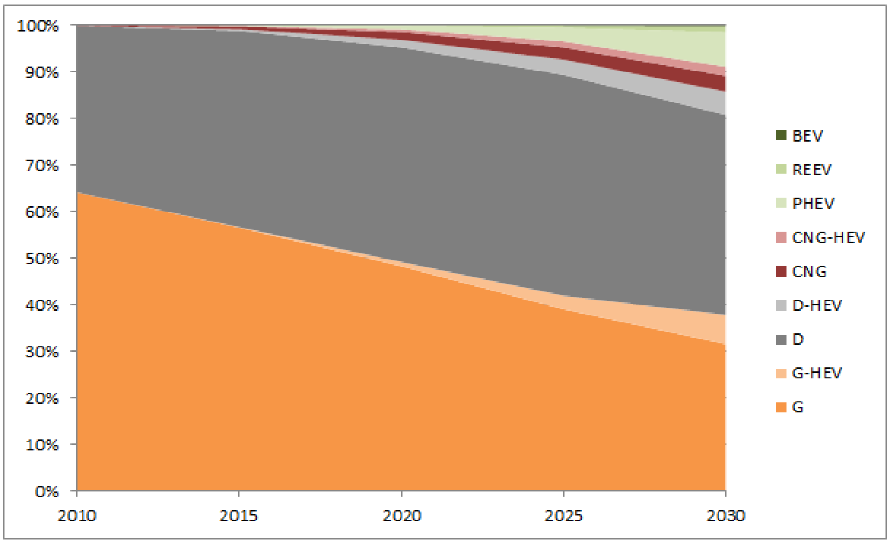

Figure 4: BaU scenario: total passenger car stock in EU28

PoD-GER scenario

Due to bundles of policies to enhance the market penetration of electrified vehicles (see chapter 3), market shares of electrified vehicles increase significantly and electrified vehicles are able to enter the market earlier (Figure 5). Starting just before 2020, conventional diesel and gasoline as well as their hybridized counterparts slightly decrease their share for the benefit of PHEV, REEV and BEV (40% in 2030 compared to around 30% in the BaU scenario).

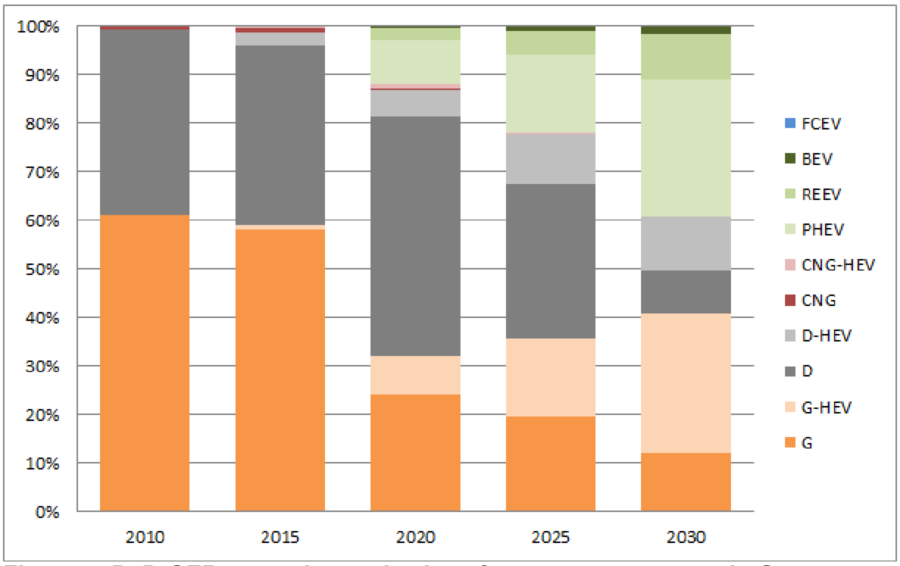

Figure 5: PoD-GER scenario: total sales of new passenger cars in Germany

Following the sales in the new vehicle market, the market penetration of EV in the German stock is slightly faster and EV shares are slightly larger in the PoD-GER scenario compared to the BaU case (Figure 6). In 2030, electrified powertrains are able to reach a share of just above 40% (of which 45% are plugin electric vehicles, i.e. PHEV, REEV and BEV). Energy consumption and WTW CO_2 emissions of the German passenger car stock in the PoD-GER scenario are slightly reduced compared to the BaU scenario (less than 5% in 2030 compared to BaU). Overall, the tank-to-wheel CO_2 Emissions could be lowered from 69 million tonnes per year to 67 million by meeting the German target of one million electric vehicles (PHEV, EREV, BEV) in 2020 (up to 2030 the CO_2-savings account to approx. 4 million tonnes). These results are similar to the estimations for the emissions reduction potential of the increased use of electric drives in vehicles within the German Government's Climate Action Programme 2020 from 2014 (BMUB 2014) [5].

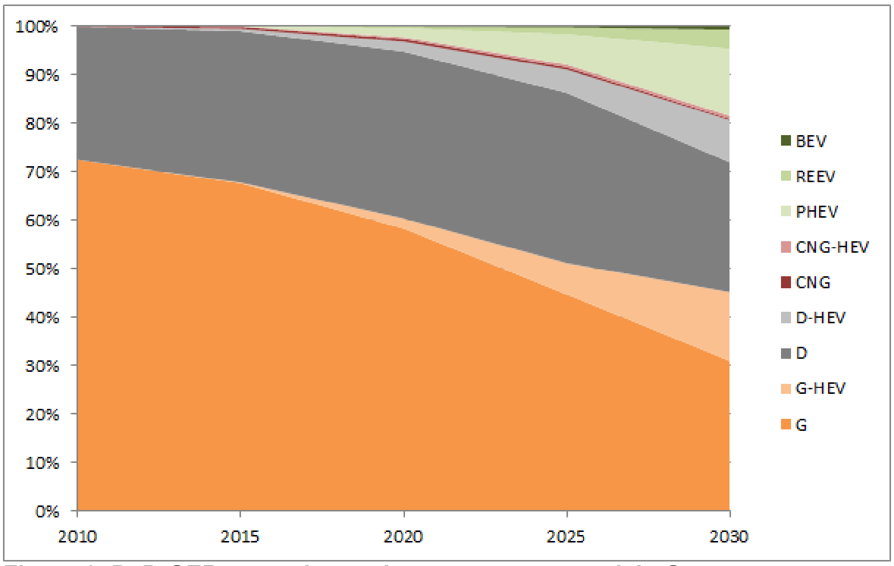

Figure 6: PoD-GER scenario: total passenger car stock in Germany

PoD-EU scenario

Following the EU climate policy path by lowering the EU CO_2 target for passenger cars to 60 g CO_2/km leads to a slightly faster and more pronounced market penetration of electrified vehicles in EU28 after 2021 compared to the BaU pathway (Figure 7). In 2030, EV have a significant share of total new vehicle sales in the EU28 markets and take up a share of 60% (of which approximately one half are plugin electric vehicles, i.e. PHEV, REEV and BEV).

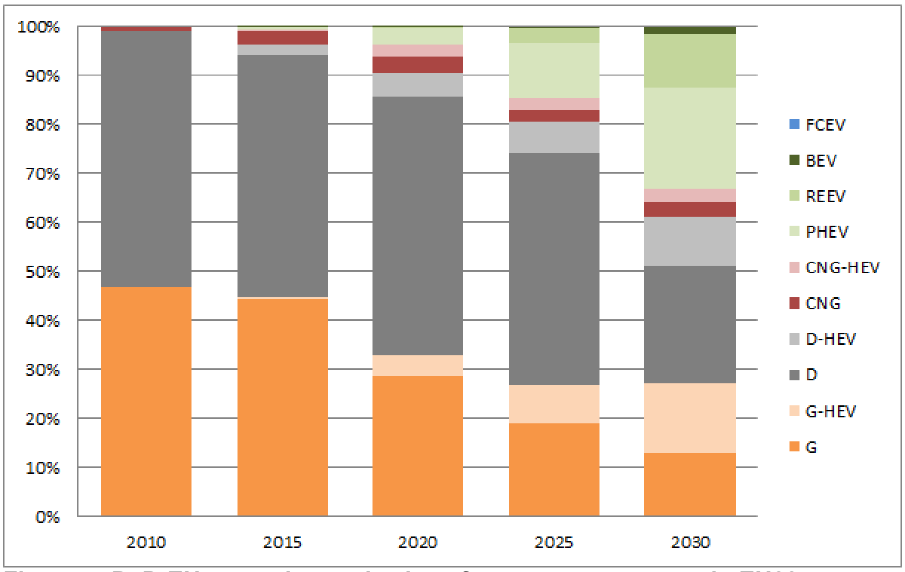

Figure 7: PoD-EU scenario: total sales of new passenger cars in EU28

As in the BaU scenario, conventional gasoline and diesel powertrains are dominating the passenger car stock in 2030 in the PoD-EU scenario (Figure 8). The share of electrified powertrains reaches ¼ of the fleet in 2030 and is, thus, slightly higher as modelled in the BaU scenario. Among them, plug-in electric vehicles (PHEV, REEV and BEV) gain a share of 45% in 2030. Compared to the BaU scenario, WTW CO_2 emissions and energy consumption of the passenger car stock are slightly reduced (< 5% in 2030).

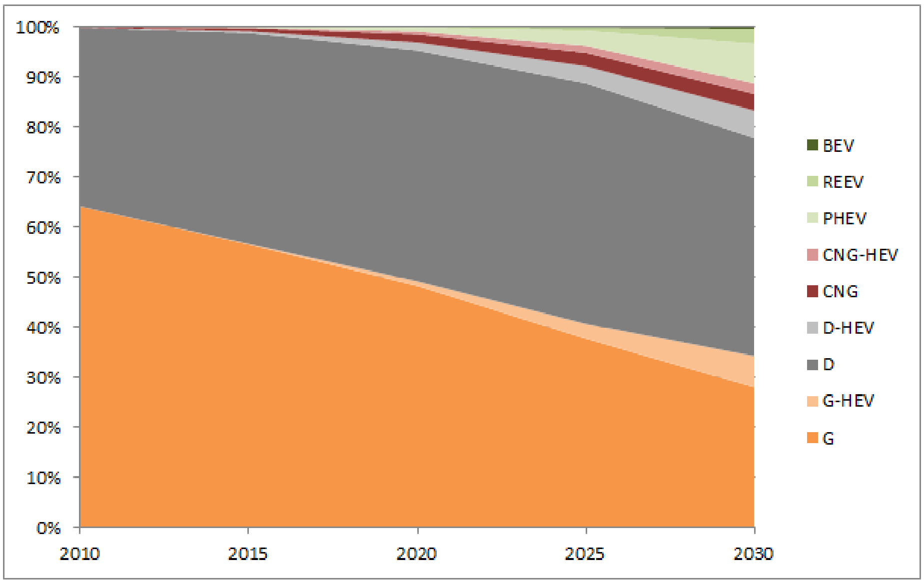

Figure 8: PoD-EU scenario: total passenger car stock in EU28

4.2 Results of Cost-benefit analysis for EU and Germany

Comparing the PoD-EU scenario for EU28 to BaU, a significant acceleration of the electrification of the fleet is shown in the last decade of the PoD-EU scenario, between 2020 and 2030 (Figure 1).

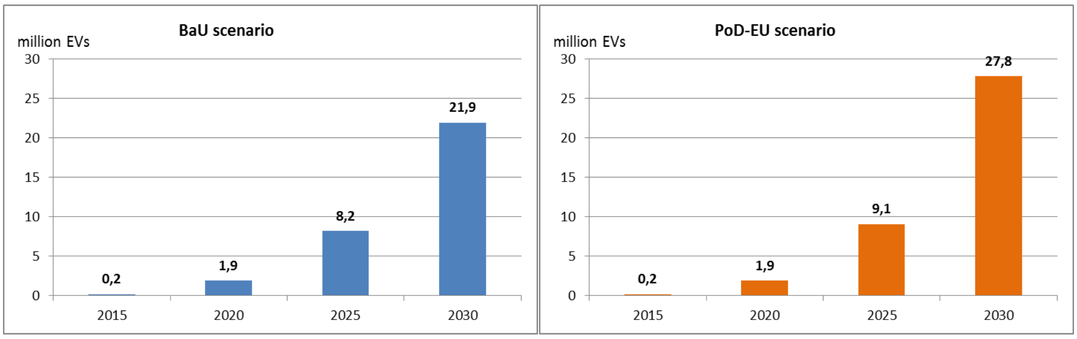

Figure 9: Development of EV in stock in EU28

CBA results shown in Figure 2 compare the PoD-EU scenario to the reference BaU. The Figure shows the net present values for the whole period (2010 to 2030). The costs of the PoD-EU scenario surpass the benefits by over 22 billion euros. In consequence the benefit-cost-ratio is less than 1 (0.5) and thus PoD-EU scenario is not efficient.

The costs are mainly caused by higher production cost (net costs without taxes) as consequence of higher EV market share. The main benefits are caused by savings in CO_2 emissions and by lower costs of owning and operating.

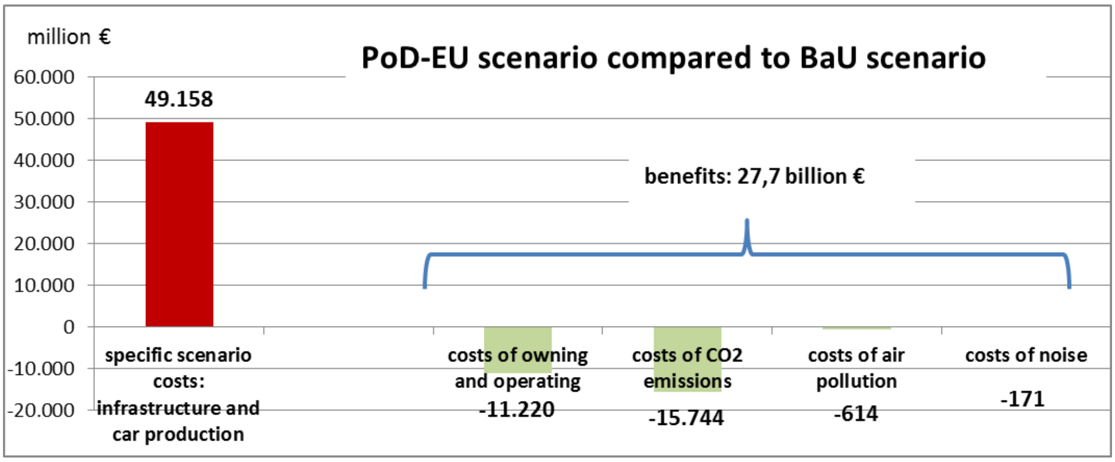

Figure 10: Costs and Benefits of PoD-EU scenario (EU28 2010-2030)

Compared to German BaU scenario the number of EVs in stock in the PoD-GER scenario will be nearly twice as high in 2030. In 2020 the German national goal of 1 million EVs will be reached.

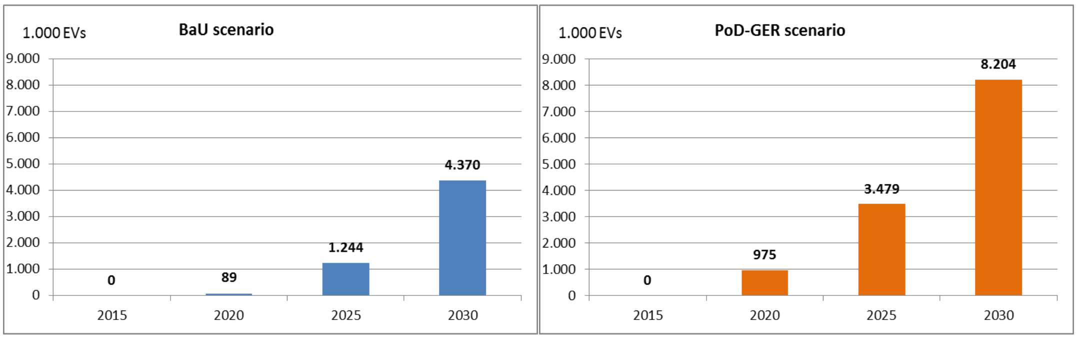

Figure 11: Development of EV (German scenarios)

Comparing the PoD-GER scenario to the BaU scenario the costs and benefits are in balance; the Benefit-Cost-Ratio equals 1.0.

The costs (net present value) over the whole period from 2010 to 2030 will reach an amount of nearly 10 billion €. The cost surplus is mainly caused by higher production costs of electric vehicles. Besides this, infrastructure costs are an important cost factor, too.

The benefits over the whole period sum up to 10 billion €. Savings in CO_2 emissions can be expected as the factor with the most significant influence, followed by less costs of owning and operating and savings in air pollution.

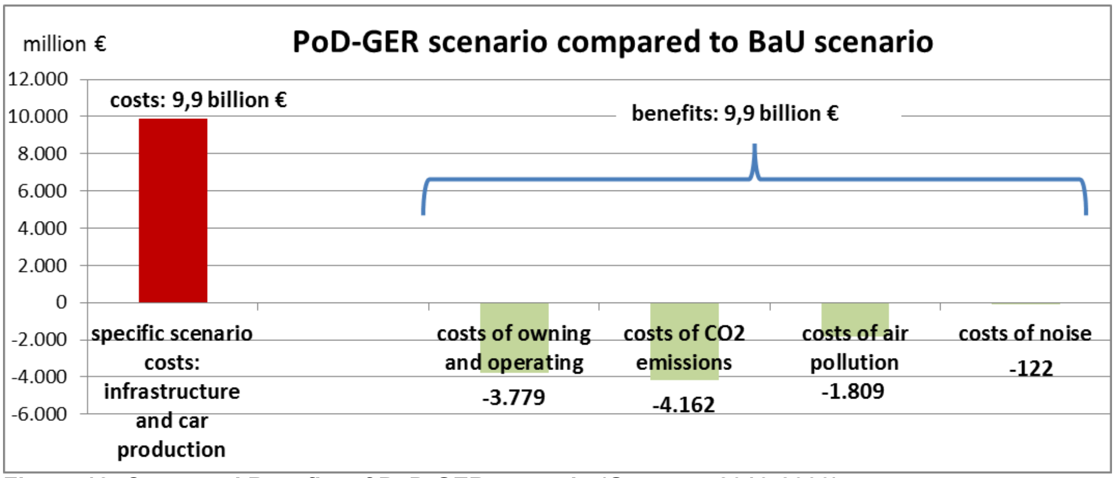

Figure 12: Costs and Benefits of PoD-GER scenario (Germany 2010-2030)

Wider economic aspects of electromobility in Germany

The results of the wider economic analysis are shown in the next figure. The structural changes in car purchases and vehicle stock will cause a higher value added and higher employment (PoD-GER scenario compared to BaU scenario). The most benefitting industry is the sector “generation of electricity” with 66,000 additional person-years and additional value added of more than 8 billion €. On the other hand the petroleum sectors loose sales and by this employment decreases by 60,000 person-years, value added decreases by more than 4 billion € (manufacturing and trade).

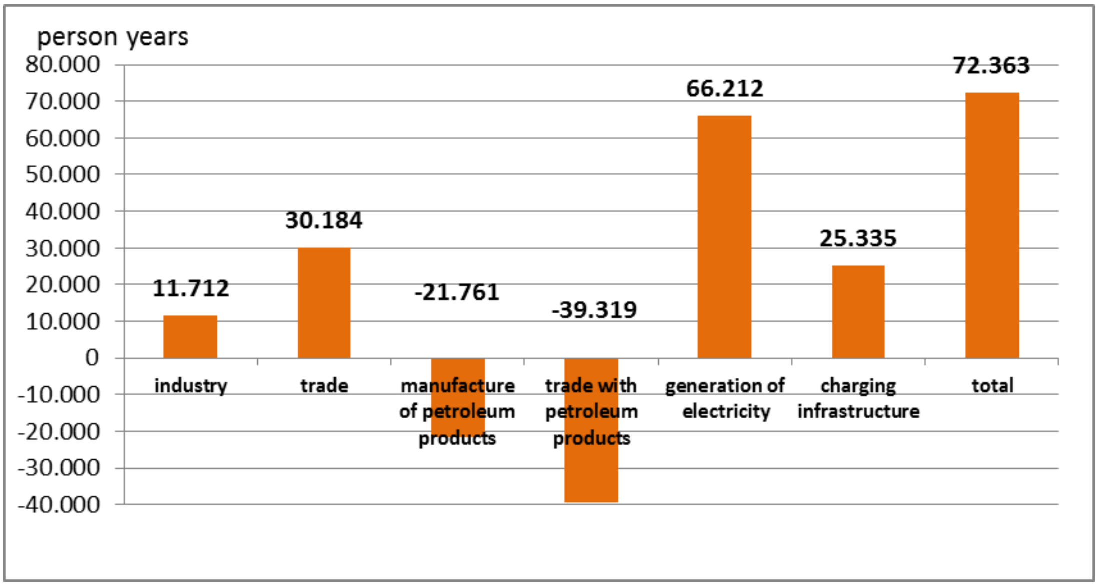

Figure 13: Wider economic impact in Germany, effect on employment (2010-2030)

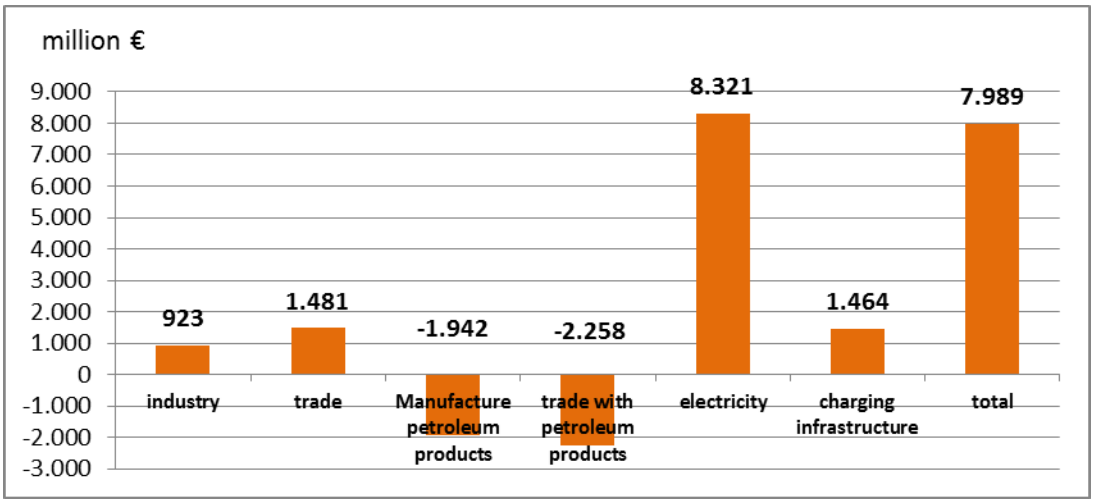

Figure 14: Wider economic impact in Germany, effect on value added (2010-2030)

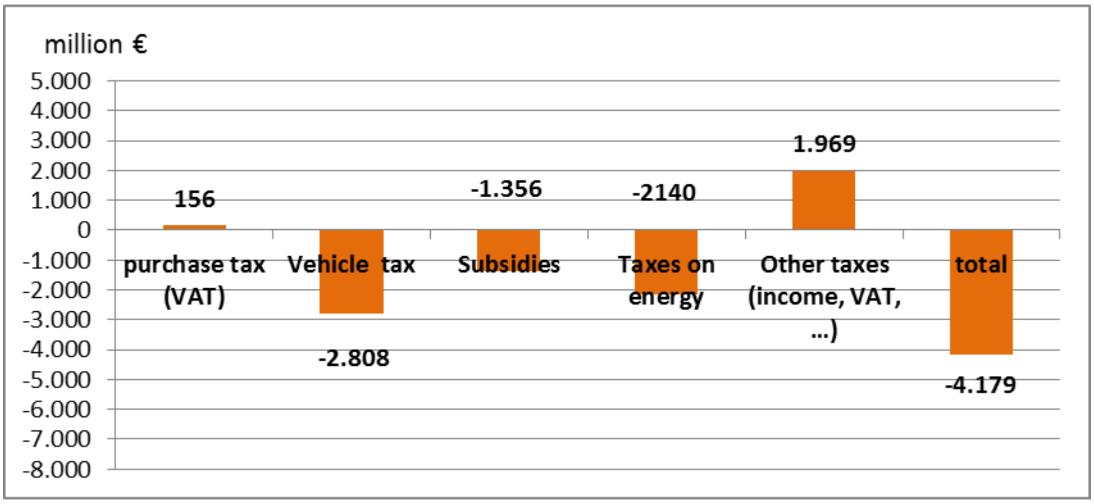

Figure 15: Wider economic impact in Germany, fiscal effect (2010-2030)

Due to the incentives assumed in the scenario PoD-GER losses in tax income can be regarded. Compared to scenario BaU, tax income in scenario PoD-GER is about 4.7 billion lower over the whole period.

5. SUMMARY AND CONCLUSION

In this paper, feasible deployment paths of electrified vehicles (EV) were analysed up to 2030. Different scenario storylines were developed following research questions on the timing and dimension of EV market penetration under current policies (BaU scenario) and on the influence of additional national and EU-wide policies (PoD).

One of the main drivers is the EU regulation on CO_2 targets for passenger cars. A tightening to 75 g CO_2/km in 2030 as assumed in the BaU scenario results in a significant market penetration of EV in Germany and in EU28. In combination with increasing efficiencies of conventional powertrains, this leads to a reduction in energy consumption and well-to-wheel CO_2 emissions of the passenger car stock in Germany and EU28 of around a third (2030 vs. 2010).

A further tightening to 60 g CO_2/km in 2030 as assumed in the EU28 PoD-EU scenario results in a slightly faster and more pronounced market penetration of EV in EU28. WTW CO_2 emissions and energy consumption of the EU28 passenger car stock are slightly reduced (< 5% in 2030 compared to the BaU scenario).

The calculation of benefit-cost-ratio in PoD-EU scenario shows that stronger limitations are not efficient. Costs exceed benefits, thus benefit-cost ration is less than 1.

In Germany, under the taxation system as of today and in combination with relatively high electricity prices, customers are not yet truly encouraged to purchase EV. In the new vehicle market under the BaU scenario, electrified powertrains reach market shares of around 65% in 2030, with two thirds being G-HEV and D-HEV. The share of BEV stays low. In stock, the share of electrified powertrains is around 35% in 2030 (1/3 of which are PHEV, REEV and BEV). Together with increased efficiencies of conventional powertrains and increasing shares of renewables in electricity production, total energy consumption and well-to-wheel CO_2 emissions of the German passenger car fleet are decreasing by around 30% in 2030 compared to 2010.

The German cost-benefit-analysis shows that there is a way to reach the German governmental goal of 1 million EVs in 2020 by balanced costs and benefits. Furthermore there will be economical advantages in PoD-GER scenario by having positive effects on employment and value added. On the other hand – given financial incentives lead to fiscal losses. Political decision makers have to weigh up wether those fiscal losses are feasible.

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NOTES

[1] In contrast to total costs of ownership (TCO), relevant costs of ownership (RCO) contain only those costs, which are relevant for the purchase decision like purchase costs, energy costs, incentives or taxes. Not included are for example replacement costs for tires or brakes as well as the changing of oil.

[2] So-called ”EEG-Umlage”, part of the electricity price, in 2015 6,17 €ct/kwh

[3] In relative terms compared to the BaU scenario

[4] vkm = vehicle kilometres

[5] The German Government’s Climate Action Programme 2020 assumes a reduction of 0.7 million tonnes CO_2 by reaching the one million vehicle goal in 2020. Basis of this achievement is the reference scenario of 600,000 electric vehicles in 2020. In comparison, the estimation within the eMAP business-as-usual scenario accounts for a more conservative deployment of approx. 90,000 vehicles in 2020.