PERSPEKTIVEN FÜR UMWELT & GESELLSCHAFT umweltbundesamt

DEFINE-Deliverables

4.1 Dataset on vehicle technology development (conventional and electric vehicles) up to 2030
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DEFINE
Development of an Evaluation Framework for the Introduction of Electromobility

Electromobility+

1 DATASET ON VEHICLE TECHNOLOGY DEVELOPMENT (CONVENTIONAL AND ELECTRIC VEHICLES) UP TO 2030 (DELIVERABLE 4.1)

1.1 General remarks on scenario building within the DEFINE framework

A scenario workshop including almost all consortium partners[1] was held at UBA Wien on April 10th 2013. The goal of the workshop was to achieve a better understanding of the models used within the DEFINE framework and to clarify the scenario building process and the required parameter exchange between the partners/models. It was decided to analyse two scenarios as part of the DEFINE project.

The basis of the project will be the BAU[2] scenario covering current framework conditions and laws/regulations. The second scenario will be the electromobility$^+$ scenario (EM$^+$), which considers further policy measures for a faster market penetration of electric vehicles. Potential measures for the market support of xEVs[3] were discussed during the scenario workshop at UBA Wien and a list of policy measures was provided, in order of priority. This list will be the basis for the development of the EM$^+$ scenario.

1.2 Balancing the system boundaries

Balancing the boundaries within the DEFINE modelling framework was discussed at both meetings[4] and with all consortium partners. The time frame for the project's analyses was discussed at the scenario workshop in April 2013. The bottom-up approaches for market penetration modelling (carried out by UBA Wien and the Oeko-Institute) are based on a conjoint analysis[5] of the preferences of new car buyers. As the required empirical data was collected in 2011 and 2012, these approaches are not suitable for reliable long term market penetration scenarios and even the application for 2030 is controversial from a scientific point of view. Economic and electricity market modelling is mainly affected by strong xEV usage and a time frame until 2050 was proposed.

It was agreed to set the modelling time frame from 2010 to 2030 to allow for reliable market penetration modelling. Consortium partners who wish to use their modelling framework for electromobility scenarios until 2050 have to establish their own scenario projections until 2050. Nevertheless, it would make sense to coordinate with each other if more than one project partner decided to use scenario modelling from 2030 onwards.

Different modelling and project setups in Austria, Poland and Germany require different balancing scopes regarding transport modes. The balancing scope was limited to the passenger traffic sector at the kick-off meeting in June 2012. The Austrian partners proposed the modelling of transport mode choices in

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[1] CASE did not participate at the scenario workshop.

[2] BAU: business as usual

[3] xEV – electric vehicle; BEV – battery electric vehicle; PHEV – plug-in hybrid vehicle; REEV – extended range electric vehicle

[4] A kick-off meeting was held in June 2012.

[5] conjoint analysis = discrete-choice-experiment modelling

their project description. This is not included in the proposal of the German project partners. Therefore, different transport modes and changes in the modal split have been modelled for Austria. The scope for Germany only includes passenger cars; changes in transport demand and modal split are not modelled.

1.3 Scenario building

Several parameters and assumptions have to be coordinated among all partners in order to use the same input data for all modelling steps within the DEFINE framework. It should be clear to all consortium partners that parameters have to be coordinated with the consortium, but all the models involved will use input data of a different quality and at a different aggregation level. Therefore, the input data will differ between the used models and differences will remain in place even after the scenario parameter process.

1.3.1 Framework conditions

Framework conditions are general, exogenous parameters required for modelling that affect the mobility and electricity generation sector without being influenced directly by mobility policy measures. These conditions should not be changed when developing mobility sector scenarios since they will heavily change the modelling output without any applied policy measure.

The main parameters which will be discussed are: primary energy carrier prices, population development and GDP development from 2010 to 2030.

Prices for primary energy carriers and CO_2 allowances within the EU ETS are a necessary parameter for economic modelling within the DEFINE framework and are taken from the Austrian Monitoring Mechanism Report[6].

	coal	crude oil	natural gas	exchange rate	EUA
	$\$_{2010}$/tonne	*$\$_{2010}$/bbl*	*$\$_{2010}$/mmBtu*	*\$/€*	*€$_{2010}$/tonne CO_2*
2010	99.2	78.1	7.1	1.33	13
2020	109	118.1	10.4	1.30	20
2030	116	134.5	11.9	1.30	30

Table 1: Assumptions for primary energy carrier prices and European Unit Amount (EUA)

Assumptions for population and GDP development until 2030 have to be made for all of the analyzed countries. This data will provide input for economic modelling and will also affect the transport demand scenarios needed for the calculation of the CO_2 emission effect of electromobility.

6 Umweltbundesamt: Grundlage für den Monitoring Mechanism 2013 und das Klimaschutzgesetz, Synthesebericht 2013. 2013.

The framework conditions relating to population and GDP in Austria are also the same as those applicable in the Austrian Monitoring Mechanism Report. Different assumptions for population and GDP development are used in diverse studies on future energy and transport sector scenarios in Germany. Oeko-Institute will use the modelling results from Renewability II[7] for transport demand projections for cars until 2030. Socio-economic input parameters of Renewability II are based on energy sector scenarios[8] for the German energy system concept of the German government. As for population development/growth, variation of the population forecast from the German Federal Statistics Office[9] has been used and a 1 % p.a. GDP growth until 2030 has been assumed.

	Austria			Germany	
	population	GDP	households	population	GDP
	million	*billion €$_{2010}$*	*million*	*million*	*billion €$_{2010}$*
2010	8.38	286	3.62	81.5	2,098
2020	8.73	340	3.86	80.5	2,229
2030	9.03	410	4.05	79.1	2,418

Table 2: Assumptions for socio-economic parameters

1.3.2 Technical characteristics and costs of cars

Performance and the technical characteristics of cars have to be assumed for all steps of the DEFINE modelling framework. The most accurate description of cars and the costs for new cars are necessary parameters for the conjoint analysis used in xEV market penetration modelling. Therefore, this aggregation level is used for the discussion presented in this short paper.

UBA Wien and Oeko-Institute use slightly different categories and aggregation levels for new car market simulations. Both of them split passenger cars into three size classes[10] – small, medium, large. In addition, four (Germany) or five (Austria) different propulsion systems for cars are considered in the car market simulation and CO_2 emission balance – petrol, diesel, HEV[11], PHEV/REEV and BEV. Other propulsion systems such as natural gas and liquefied petroleum gas systems are not covered by the models developed within the scope of this project since their market share is considered to remain rather small and their effect will remain negligible when modelling emissions from electric vehicles.

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[7] Zimmer, W. et al.: Renewability II – Szenario für einen anspruchsvollen Klimaschutzbeitrag des Verkehrs, 2013 (to be published).

[8] Schlesinger, M. et al.: Energieszenarien für ein Energiekonzept der Bundesregierung, 2010.

[9] Statistisches Bundesamt (Destatis): 12. Koordinierte Bevökerungsvorausberechnung, 2009.

[10] The categories used for splitting the passenger cars into size classes correspond to the respective KBA segments: small – Mini, Kleinwagen; medium – Kompaktklasse, Vans; large – Mittelklasse, Obere Mittelklasse, Oberklasse, Sportwagen, Geländewagen.

[11] HEV – hybrid electric vehicle

Average cars the can realistically be expected to be produced in the listed size classes and with the mentioned propulsion technologies have to be assumed for the new car market simulation years to enable xEV market penetration modelling. The German market penetration model from Oeko-Institute will be used for the modelling years 2020 and 2030, the Austrian model from UBA Wien will simulate the new car market up to 2030. Therefore, car performance and the costs for cars will have to be determined at least for 2020 and 2030.

Internal combustion engine (ICE) cars

A definition of conventional cars is needed for xEV market penetration modelling and for the calculation of the CO_2 effects of electromobility. The following characteristics of conventional cars are needed for a conjoint analysis:

- power of the propulsion system
- specific CO_2 emissions (NEDC)
- purchase price
- fuel costs

Specific CO_2 emissions, as well as the purchase price and the fuel costs of conventional cars heavily depend on the required average specific CO_2 emissions from new cars registered in the EU as set out by the European CO_2 Emission Regulation[12]. Therefore, these parameters strongly interact with the specific CO_2 emission targets defined for 2020 and 2030 and will differ between the BAU and the EM^+ scenarios (see Table 3). These assumptions are based on the current Regulation 443/2009 (including amendments) as well as possible future EU policies.

	BAU scenario *g CO_2/km*	EM^+ scenario *g CO_2/km*
2015	130	130
2020	95	95
2030	72.5	60

Table 3: Assumptions for specific CO_2 emission targets according to Regulation (EC) No 443/2009 for new car registrations

Data from 2010[13] shows a non-uniform distribution of specific CO_2 emissions from newly registered cars within the EU. Specific CO_2 emissions of car registered in Austria and Germany were 2.6 % and 7.8 % higher than the average emissions in all EU countries. This effect can be attributed to more cars sold in the large car segment and to higher rates of motorisation compared to the EU average. No changes in these new car sales figures will be assumed for Austria

[12] EU Directive 443/2009 sets maximum levels for average specific CO_2 emissions from all new cars registered in the Community from 2012 onwards (2012 – 2019: 130 g CO_2/km, from 2020: 95 g CO_2/km).

[13] European Environment Agency (EEA): Monitoring the CO2 emissions from new passenger cars in the EU: summary of data for 2010, 2011.

and Germany and therefore the specific CO_2 emissions will be 2.6 % and 7.8 % higher than the EU average in 2020 and 2030 in both scenarios.

Car registration of xEVs will also have an effect on the specific CO_2 emissions from conventional cars due to the modalities defined in the CO_2 Regulation. Since the effect depends on the market penetration of xEVs and the detailed design of the EU Regulation, the exact deviation from the target value cannot be calculated. Nevertheless, a loosening effect of 5 g CO_2/km for ICE cars is assumed for 2020. This effect will increase to 10 g CO_2/km (BAU) and to 12.5 g CO_2/km (EM^+) in 2030. The assumptions for CO_2 average emissions from new ICE cars at type approval in Austria and Germany are summarised in Table 4 and Table 5.

Purchase prices for new cars are shown in Table 6 to Table 12. In the Austrian data, compliance costs for the EU CO_2 Regulation are not considered in the listed purchase prices. A feebate system for the sale of new car (see chapter 1.6) has already been established in Austria and will be tightened from now onwards in the EM^+ scenario. Such a kind of system will also be considered for Germany in the EM^+ scenario. Therefore, the CO_2 emission fees and rebates are included in the following tables, as well as the purchase price of new cars.

	xEV effect	mass	$e_{target,ICE}$	$e_{avg,ICE}$	mass	$e_{target,ICE}$[14]	$e_{avg,ICE}$
		EU			Austria		
	g CO_2/km	kg	g CO_2/km	g CO_2/km	kg	g CO_2/km	g CO_2/km
2010	-	1,365	-	140.3	1,410	-	144.0
2020	5	1,365	100.0	100.0	1,410	101.5	102.6
2030	10	1,365	82.5	82.5	1,410	84.0	84.7
		EU			Germany		
2010	-	1,365	-	140.3	1,433	-	151.2
2020	5	1,365	100.0	100.0	1,433	102.3	107.8
2030	10	1,365	82.5	82.5	1,433	84.8	88.9

Table 4: Assumptions for the development of specific CO2 emissions from conventional cars (BAU)

	xEV effect	mass	$e_{target;ICE}$	$E_{avg,ICE}$	mass	$e_{target,ICE}$	$e_{avg,ICE}$
		EU			Austria		
	g CO_2/km	kg	g CO_2/km	g CO_2/km	kg	g CO_2/km	g CO_2/km
2010	-	1,365	-	140.3	1,410	-	144.0
2020	5	1,365	100.0	100.0	1,410	101.5	102.6
2030	12.5	1,365	72.5	72.5	1,410	74.0	74.4
		EU			Germany		
2010	-	1,365	-	140.3	1,433	-	151.2
2020	5	1,365	100.0	100.0	1,433	102.3	107.8
2030	12.5	1,365	72.5	72.5	1,433	74.8	78.1

Table 5: Assumptions for the development of specific CO2 emissions from conventional cars (EM^+)

The data on conventional car-specific CO_2 emissions can be used to derive additional production costs for CO_2 emission reduction technologies (as compared to passenger cars sold in 2010) and to generate the purchasing price for new cars up until 2030. Furthermore, the CO_2 emissions assumed under the **N**ew **E**uropean **D**riving **C**ycle (NEDC) will be used to derive the average fuel consumption of conventional cars. A real-life fuel consumption factor of 1.2[15] will be applied to account for discrepancies between NEDC CO_2 emission val-

14 The emission targets are higher than the EU average in Austria and Germany due to the average mass of newly registered cars which is above EU average.

15 Mock, P.: Discrepancies between type-approval and “real-world” fuel-consumption and CO_2 values - Assessment for 2001 - 2011 European passenger cars, 2012.

ues and real-life emissions. Configurations and costs of conventional cars which are applied in the conjoint analysis are shown in Table 6 and Table 7.

The data for Germany has been taken from a database developed in the eMobil 2050 project[16]. This database uses CO_2 reduction potential estimates and potential costs for CO_2 reduction technologies. The original data has been taken from the literature, and this data and the methodology have been discussed and adjusted after an expert workshop with representatives from the automotive industry and the scientific world.

	motor	power	CO_2 emissions (NEDC)	purchase price	fuel consumption
	-	*kW*	*g CO_2/km*	*€$_{2010}$*	*l/100 km*
Austria – small					
2010	CV	51	128	14,000	5.50
2020	CV	51	100	14,000	4.30
2030	CV	51	80	14,000	3.40
Austria – mid-size					
2010	CV	84	143	24,500	5.45
2020	CV	84	122	24,500	4.64
2030	CV	84	97	24,500	3.70
Austria - large					
2010	CV	125	194	55,000	7.40
2020	CV	125	165	55,000	6.30
2030	CV	125	132	55,000	5.02
Germanys- small					
2010	gasoline	60	130	14,000	5.58
2020	gasoline	60	93	14,680	3.98
2030	gasoline	60	76	16,020	3.28
Germany – mid-size					
2010	gasoline	90	154	21,000	6.63
2020	gasoline	90	110	21,440	4.73
2030	gasoline	90	91	21,880	3.90
Germany – large					
2010	diesel	150	192	43,500	7.25
2020	diesel	150	137	43,910	5.17
2030	diesel	150	113	44,660	4.26

[16] Hülsmann, F. et al.: eMobil 2050: Perspectives of passenger car technologies up to 2050, in progress.

Table 6: Assumptions for technical characteristics and purchase prices of ICE cars (BAU)

	motor	power	CO_2 emissions (NEDC)	purchase price	fuel consumption
	-	*kW*	*g CO_2/km*	*€$_{2010}$*	*l/100 km*
ICE – small (Austria)					
2010	CV	51	128	14,000	5.50
2020	CV	51	100	14,300	4.30
2030	CV	51	80	15,000	3.40
ICE – mid-size (Austria)					
2010	CV	84	143	24,500	5.45
2020	CV	84	122	25,200	4.64
2030	CV	84	97	26,500	3.70
ICE – large (Austria)					
2010	CV	125	194	55,000	7.40
2020	CV	125	165	57,000	6.30
2030	CV	125	132	65,000	5.02
ICE – small (Germany)					
2010	gasoline	60	130	14,000	5.58
2020	gasoline	60	93	15,250	3.98
2030	gasoline	60	67	17,710	2.88
ICE – mid-size (Germany)					
2010	gasoline	90	154	21,000	6.63
2020	gasoline	90	110	22,070	4.73
2030	gasoline	90	80	23,090	3.43
ICE – large (Germany)					
2010	diesel	150	192	43,500	7.25
2020	diesel	150	137	44,610	5.17
2030	diesel	150	99	48,010	3.75

Table 7: Assumptions for technical characteristics and purchase prices of ICE cars (EM$^+$)

Electric vehicles (xEVs)

Assumptions for the technical configuration and costs of xEVs are needed at all modelling steps within the DEFINE framework. The main driver for xEV characteristics and costs continues to be the development of battery technology over the 2010 – 2030 time period. Fewer changes and improvements are expected for all drive train technologies.

The required battery capacity c for an electric car is defined by its electric driving range r and its electricity consumption while driving e_d.

$$c = r * e_d$$

Furthermore, the electric consumption depends on the vehicle mass which is also a function of the total battery capacity c_{tot}[17] and teh mass specific capacity. Therefore, assumptions for electric vehicle configurations, specific costs of the battery system[18] and the mass specific capacity[19] have to be made for the 2010 – 2030 time period. A German consultancy and expert council[20] has defined technology targets for 2020. Data and targets in the NPE's final reports have been defined for assumed battery developments in 2020. Assumptions for 2030 have been taken from the eMobil 2050 project (see Table 8).

	specific battery costs	mass specific capacity	depth of discharge[21]
	€/kWh	*kWh/kg*	*%*
2010	600	0.105	80 / 65
2020	280	0.105	85 / 70
2030	200	0.150	90 / 75

Table 8: Assumptions for battery technology development

Average technical configurations for PHEVs/REEVs and BEVs need to be included to be able to calculate the costs and the energy consumption for xEVs. The electrical range of BEVs is assumed to be 150 km in each scenario. PHEVs/REEVs are capable of running 50 km in all-electric mode.

The technical and the cost characteristics of xEVs are shown in Table 9 and Table 10. The German data is derived from the database of the eMobil 2050 project. Fuel costs needed for the bottom-up approach of the German xEV market penetration model are given as a combination of the specific consumer energy prices and the energy consumption when driving.

[17] $c_{tot} = c/\eta_{DoD}$; η_{DoD}: depth of discharge

[18] The specific costs of the battery system [€/kWh] are based on capacity c of the applied battery system.

[19] The mass specific capacity [kWh/kg] is based on the total capacity c_{tot}.

[20] Nationale Plattform Elektromobilität (NPE)

[21] The first value refers to BEVs, the second value to PHEVs.

	power	purchase price	fuel consumption (electricity)	available capacity
	kW	*€$_{2010}$*	*kWh/100 km*	*kWh*
BEV – small (Austria)				
2010	80	29,340	15	23
2020	80	23,251	13	19
2030	80	16,789	12	18
BEV – mid-size (Austria)				
2010	110	42,000	19	28.5
2020	110	33,284	16	24
2030	110	24,033	15	22.5
BEV – large (Austria)				
2010	125	100,000	24	36
2020	125	95,536	22	33
2030	125	89,620	20	30
BEV – small (Germany)				
2010	51	36,450	15.2	22.8
2020	51	23,540 / 21,400	13.8	19.4
2030	51	21,840 / 21,274	11.9	18.6
BEV – mid-size (Germany)				
2010	77	44,800	18.6	27.9
2020	77	30,260 / 28,120	15.7	23.8
2030	77	28,040 / 27,460	14.6	22.8
BEV – large (Germany)				
2010	-	-	-	-
2020	-	-	-	-
2030	-	-	-	-

Table 9: Assumptions for technical and cost characteristics of BEVs (BAU/EM+)

	power	CO_2 emissions	purchase price	fuel consumption (electricity)	fuel consumption (gasoline)	available capacity
	kW	*g CO_2/km*	*€$_{2010}$*	*kWh/100 km*	*l/100 km*	*kWh*
PHEV/REEV –small (Austria)						
2010	100	16	30,000	15	4.68	7.6
2020	100	14	26,742	12	3.97	6.1
2030	100	11	22,767	11	3.17	5.5
PHEV/REEV – mid-size (Austria)						
2010	125	18	39,000	19	5.12	9.3
2020	125	15	34,765	15	4.35	7.5
2030	125	12	29,597	14	3.47	6.8
PHEV/REEV – large (Austria)						
2010	175	24	58,884	21	6.75	10.7
2020	175	20	56,256	19	5.75	9.2
2030	175	16	52,772	16	4.60	7.9
PHEV/REEV –small (Germany)						
2010	60	28	31,170	15.2	6.04	7.6
2020	60	24	21,700	13.9	5.54	6.9
2030	60	22	21,030	12.4	4.79	6.2
PHEV/REEV – mid-size (Germany)						
2010	90	33	37,760	18.6	7.16	9.3
2020	90	28	28,810	17.0	6.56	8.5
2030	90	25	27,810	15.2	5.50	7.6
PHEV/REEV – large (Germany)						
2010	150	37	61,620	25.0	8.18	12.5
2020	150	28	53,080	21.2	6.29	10.6
2030	150	28	50,930	20.5	6.22	10.4

Table 10: Assumptions for technical and cost characteristics of PHEVs (BAU)

	power	CO_2 emissions	purchase price	fuel consumption (electricity)	fuel consumption (gasoline)	available capacity
	kW	*g CO_2/km*	*€$_{2010}$*	*kWh/100 km*	*l/100 km*	*kWh*
PHEV –small (Austria)						
2010	100	16	30,000	15	4.68	7.6
2020	100	14	26,000	12	3.97	6.1
2030	100	11	21,500	11	3.17	5.5
PHEV – mid-size (Austria)						
2010	125	18	39,000	19	5.12	9.3
2020	125	15	34,000	15	4.35	7.5
2030	125	12	28,000	14	3.47	6.8
PHEV – large (Austria)						
2010	175	24	58,884	21	6.75	10.7
2020	175	20	56,000	19	5.75	9.2
2030	175	16	53,000	16	4.60	7.9
PHEV –small (Germany)						
2010	60	28	31,170	15.2	6.04	7.6
2020	60	24	20,630	12.9	5.15	6.4
2030	60	21	21,010	12.4	4.43	6.2
PHEV – mid-size (Germany)						
2010	90	33	37,760	18.6	7.16	9.3
2020	90	28	27,740	15.8	6.11	7.9
2030	90	22	28,080	15.2	4.83	7.6
PHEV – large (Germany)						
2010	150	37	61,620	25.0	8.18	12.5
2020	150	28	52,010	21.2	6.29	10.6
2030	150	25	51,410	20.1	5.49	10.1

Table 11: Assumptions for technical and cost characteristics of PHEVs (EM+)

	power	CO_2 emissions (NEDC)	purchase price	fuel consumption (electricity)	fuel consumption (gasoline)
	kW	*g CO_2/km*	*€$_{2010}$*	*kWh/100 km*	*l/100 km*
HEV –small (Austria)					
2010	75	110	20,000	-	4.68
2020	75	93	19,000	-	3.97
2030	75	74	18,000	-	3.17
HEV – mid-size (Austria)					
2010	100	120	27,000	-	5.12
2020	100	102	25,500	-	4.35
2030	100	81	24,000	-	3.47
HEV – large (Austria)					
2010	165	158	55,000	-	6.75
2020	165	135	54,000	-	5.75
2030	165	108	53,000	-	4.60

Table 12: Assumptions for technical and cost characteristics of HEVs (BAU/EM+)

1.4 Consumer energy prices

Scenario assumptions for car user specific energy prices are needed at several modelling steps within the DEFINE framework. Energy prices are a relevant parameter in the decision making process of new car buyers and have been used in the bottom-up market development approach for Germany and Austria. Energy prices are also essential parameters for economic modelling and have to be split into production costs and taxes to enable the modelling of state income effects.

Austria

The development of fuel end consumer prices has been taken from the Austrian Monitoring Mechanism Report[22]. The last time the mineral oil tax was adjusted in Austria was in 2011. Then the tax on gasoline was raised by 4 cent and for diesel by 5 cent.

The difference between the fuel prices in the BAU and the EM^+ emerge solely from the increases in the mineral oil tax in Austria assumed for the years 2015 and 2019. It is assumed that in 2015 the mineral oil tax will be raised by 5 cent for gasoline and for diesel. In 2019 a second increase by 2 cents on the 2030 level (real) is assumed.

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22 Umweltbundesamt: Grundlage für den Monitoring Mechanism 2013 und das Klimaschutzgesetz, Synthesebericht 2013. 2013.

By raising the mineral oil tax it is intended to reduce motorised individual transport and to achieve a shift towards eco-modes (cycling, public transport, walking).

	real terms				nominal terms	
	end consumer price				end consumer price	mineral oil tax
	€2010/l				*€/l*	*€2010/l*
gasoline – BAU						
2010	1.373				1.373	0.485
2020	1.478				1.855	0.592
2030	1.474				2.322	0.721
gasoline – EM+						
2010	1.373				1.374	0.482
2020	1.574				1.975	0.592
2030	1.550				2.442	0.721
diesel – BAU						
2010	1.301				1.301	0.397
2020	1.428				1.792	0.471
2030	1.441				2.271	0.574
diesel – EM+						
2010	1.301				1.301	0.397
2020	1.524				1.912	0.507
2030	1.518				2.391	0.590
electricity - BAU/EM+ [€/kWh] VAT energy fee						
2010	0.195	0.032	0.021	28%		
2020	0.250	0.042	0.026	27%		
2030	0.323	0.054	0.031	26%		

Table 13: Assumptions for end consumer energy prices in Austria

Germany

The development of liquid fuel prices in Germany has been derived from the energy sector scenarios used for the energy system development strategy of the German government[23]. This data has been used as end consumer price for liquid fuels in the BAU scenario. The end consumer price of liquid fuels in Germany can be split into the following factors:

- production costs
- energy tax
- value added tax (VAT)
- miscellaneous costs

The energy tax is an absolute tax[24] and is not adjusted for inflation in the BAU scenario. Furthermore, the VAT level is held constant at 19 % over the time period 2010 – 2030. Using these assumptions, the liquid fuel prices are derived and can be split up into production/miscellaneous costs and taxes (see Table 14).

Changes to energy tax levels are assumed in the EM^+ scenario for xEV market penetration and CO_2 emission reduction support. The end consumer prices for gasoline are set at 1.70 $€_{2010}$/l in 2020 and 2.30 $€_{2010}$/l in 2030 to allow for derivation of new energy taxes. Furthermore, a 50-50 split into energy content and CO_2 emission based taxation is assumed. The following values have been used for deriving the new rates for taxation:

- energy content tax: 2020: 12.03 €/GJ 2030: 14.29 €/GJ
- CO_2 emission tax: 2020: 0.17 €/kg CO_2 2030: 0.20 €/kg CO_2

The change to the energy tax makes liquid fuel prices more expensive than in the BAU scenario[25] and electricity driven vehicles more attractive (given higher fuel costs of conventional vehicles (see Table 14)). The switch to a tax partially based on CO2 emissions makes especially diesel fuel more expensive and results in a similar end consumer price for diesel and gasoline[26].

Energy taxes on liquid fuels represent 30 – 45 % of the end consumer prices of liquid fuels (not included is the increase in VAT due to energy taxes). This kind of taxation does currently not apply for electricity even if a high share of the electricity end consumer price is made up by taxes and levies on electricity. The following cost factors are currently included in the household electricity prices:

- production costs
- electricity tax
- value added tax (VAT)
- miscellaneous costs

Since the electricity tax is rather small compared to the energy tax raised on liquid fuels, low electricity prices can be achieved and xEV market penetration

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[23] Schlesinger, M. et al.: Energieszenarien 2011, 2011.

[24] gasoline: 654.40 €/1000 l; diesel: 470,40 €/1000 l

[25] gasoline: 2020: + 8 %; 2030: + 30 % - diesel: 2020: + 27 %; 2030: + 48 %

[26] based on the energy content of both fuels.

strongly promoted by this taxation scheme. Currently, there is no indication that an extra tax might bhe introduced on electricity used for electric vehicles. In the long run, this taxation scheme would result in a smaller tax income for the state because of fewer energy taxes paid on conventional cars (being replaced by electric vehicles). Therefore, an extra energy tax on electricity for electric vehicles is assumed in 2030, based on the energy content tax described above. This assumption is used for both BAU and EM^+ scenario.

There is one more justification for higher end consumer prices for electricity used in xEVs (in comparison to households). The charging infrastructure for electric vehicles has yet to be built and needs extra investments from the utilities. Supplementary costs may be introduced by the utilities in the future for xEV charging infrastructure construction. However, this extra cost factor is accounted for by an increase in the electricity taxes on xEV usage in both scenarios. A final overview of specific end consumer energy prices is given in Table 14.

	real terms				nominal terms				
	end consumer price		VAT	energy / electricity tax	end consumer price		VAT	energy / electricity tax	tax share
	€2010/ l	€2010/ GJ	€2010/ GJ	€2010/ GJ	€/l	€/GJ	€/GJ	€/GJ	%
gasoline – BAU									
2010	1.47	45.60	7.28	20.26	1.47	45.60	7.28	20.26	60
2020	1.57	48.74	7.78	17.34	1.84	56.95	9.09	20.26	52
2030	1.77	54.64	8.72	14.84	2.41	74.59	11.91	20.26	43
gasoline – EM+									
2010	1.47	45.60	7.28	20.26	1.47	45.60	7.28	20.26	60
2020	1.70	52.62	8.40	20.59	1.99	61.48	9.82	24.06	55
2030	2.30	71.19	11.37	28.74	3.14	97.18	15.52	39.24	56
diesel – BAU									
2010	1.41	39.54	6.31	13.16	1.41	39.54	6.31	13.16	49
2020	1.52	42.62	6.81	11.26	1.78	49.80	7.95	13.16	42
2030	1.72	48.16	7.69	9.64	2.35	65.75	10.50	13.16	36
diesel – EM+									
2010	1.41	39.54	6.31	13.16	1.41	39.54	6.31	13.16	49
2020	1.93	54.07	8.63	20.88	2.26	63.17	10.09	24.40	55
2030	2.55	71.37	11.40	29.14	3.48	97.43	15.56	39.78	57
electricity - BAU/EM+									
2010	-	63.52	10.14	5.69	-	63.52	10.14	5.69	25
2020	-	68.23	10.89	4.87	-	79.72	12.73	5.69	23
2030	-	84.90	13.56	14.64	-	115.90	18.50	19.99	33

Table 14: Assumptions for end consumer energy prices in Germany

The specific energy prices are used for determining the energy costs of car usage in the xEV market penetration models in Germany. The energy prices of Table 14 have to be combined with the real life energy consumed by the new cars for new car market simulation. Since PHEVs use both liquid fuels and electricity, the share of electrically driven mileage has to be estimated. Large cars are usually used for longer distances and have a higher yearly mileage than mid-size and small cars. Thus, an electrically driven share of 66 %, 75 % and 80 % is assumed for large, mid-size and small cars.

1.5 Charging system and scenario analysis

Electricity dispatch models are run for Austria and Germany within the DEFINE modelling framework. Input data for these models are amongst others the power plant fleet, the energy prices (see section 1.3.1) and the load profiles for the simulation years. Additionally, information about the charging infrastructure, the load/usage profiles of xEVs and the charging strategies of the electricity providers are needed for dispatch modelling.

In the electricity sector (i.e. power plant fleet, energy prices, load profiles), input data is not supposed to change between the scenarios except for analysis purposes. This is to not mix up effects of electric vehicle usage with changes in electricity provision. The most user-friendly charging strategy for xEV users is immediate charging after connecting the car to the charging station. Since this charging strategy will result in increases in peak loads and high electricity production costs, it is not preferred by the utilities and questionable from a technical point of view. The utilities would prefer to shift the extra load from peak hours to low cost off-peak hours. The most extreme strategy of xEV load shifting is perfect foresight modelling (i.e. perfect foresight of xEV usage and electricity production capacities) of xEV charging. At least these two charging strategies are expected to be analysed for Austria and Germany. More charging strategies can be researched if the partners in Germany and Austria agree to do so. Furthermore, one more electricity dispatch modelling run without xEV usage for each simulation year is required for an investigation of the additional CO_2 emissions caused by xEV usage.

Information on the distribution and the maximal power of xEV charging points is required for electricity dispatch modelling. The standard maximal power for xEV charging points will be 3.7 kW until 2020 according to the German advisory body for electromobility (**N**ationale **P**lattform **E**lektromobilität)[27]. Faster and higher power charging stations up to 22 kW seem to be feasible but will not become the standard until 2020. Charging stations using maximal power up to 60 kW are more difficult to set up and will – if they are available - mainly be used by freight transport vehicles. Generally, NEP expects charging station developments to be adjusted and tailored to the requirements of the xEV market.

For the purpose of coordination between the simulation tools within the DEFINE framework, the range of different power levels at charging stations has been reduced to *low*, *medium*, *high*. Furthermore, assumptions for energetic losses during charging due to thermodynamic losses have to be made for the different power levels while charging. Table 15 shows the assumptions for modelling within the DEFINE framework, derived from several studies[28].

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[27] NPE: Zweiter Bericht der Nationalen Plattform Elektromobilität – Anhang, 2011.

[28] Kasten, P. et al: CO_2-Minderungspotenziale durch den Einsatz von elektrischen Fahrzeugen in Dienstwagenflotten, 2011. Thielman, A. et al: Technologie-Roadmap Energiespeicher für die Elektromobilität 2030, 2012.

	low		medium		high	
	max. power	efficiency	max. power	efficiency	max. power	efficiency
	kW	*%*	*kW*	*%*	*kW*	*%*
2010	3.7	80	11	80	50	75
2020	3.7	85	11	85	50	80
2030	3.7	90	11	90	60	85

Table 15: Assumptions for technical characteristics at xEV charging stations

Germany

The basis for German electricity dispatch modelling is provided by the framework conditions assumed in a study conducted for the planning of future developments of the German high-voltage grid[29]. The German power plant fleet of the DIW electricity dispatch model is adjusted to the assumptions of this study and additional cost data from previous studies[30] conducted by DIW will be included. Hourly load profiles are derived from original data[31] and adjusted to future load levels. Electric vehicle usage profiles will be provided by Oeko-Institute for the DIW model and by TU Wien for their electricity dispatch model.

Very few charging stations for xEVs currently exist in Germany. Most charging points were built as a part of demonstration projects for xEV technology and were financed by public funds. Private investment in charging stations will probably develop slowly given the insecure development of xEV usage and the costs of xEV charging. Home charging seems to be the preferred charging solution for first xEV car users, but ownership of private property is needed for the installation of home charging stations. Tailored solutions for different regions[32] and xEV users are expected, as are different regional charging infrastructure developments until 2030.

The assumptions for scenario analysis and the development of bottom-up xEV market penetration are summed up in Table 16. They reflect the expected charging infrastructure development discussed above and are the same for both the BAU and EM^+ scenarios. They do not imply the same number of charging stations or the same performance level, but reflect a general increase in the xEV charging infrastructure. High power level charging stations are assumed to be available only for long distance travelling and are accounted for by the number of impossible long distance trips in xEV market development modelling. These charging stations are not considered in electricity dispatch modelling given their low impact on charging patterns.

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[29] 50Hertz e al.: Kraftwerksliste Szenariorahmen NEP 2013, 2012.

[30] Schröder, A. et al.: Current and Prospective Costs for Electricity Generation - Background Paper for the Project "Modelling the Energy Transformation" and Other Modelling Exercises, 2012.

[31] ENTSO-E: Consumption Data. (https://www.entsoe.eu/data/data-portal/consumption/), 2013.

[32] Four Schaufensterregionen were selected for the special promotion and demonstration of electromobilty. Charging infrastructure will be available sooner in these regions than in other parts of Germany.

	home			
	private property	*public*	*work*	*others*
2020	low	medium	medium	-
2030	low	medium	medium	medium

Table 16: Assumptions for charging infrastructure development at different locations in Germany

Potential scenario variations for a sensitivity analysis of the effects on electricity dispatch resulting from xEV usage will be discussed between DIW and Oeko-Institute after having completed the first simulation runs. A potential analysis could include a variation of the German power plant fleet, different charging strategies[33] and charging infrastructures.

1.6 Other scenario measures/assumptions

Two political measures for xEV market support – stricter CO_2 emission regulation for new passenger cars and higher fuel taxes on carbon intensive fuels – were discussed in the previous chapters of this paper. The partners agreed at the scenario workshop to add one more measure for xEV market support. A so-called feebate[34] system has already been in place in Austria since 2008. Under this system, additional fees have to be paid if an acquired car surpasses a threshold CO_2 emission level.

Feebates are essentially a fee on inefficient technology and a rebate on efficient vehicles. A properly constructed feebate system has important features: First, in contrast to standards, it creates a continuous incentive for vehicle manufacturers to improve the environmental performance of their vehicles. That implies that it pays to further improve even the most efficient vehicles. Second, fuel efficiency is incorporated in the consumers' decision making process. Third, a benchmark, or so called pivot point, should ideally be set so that a balance between revenues and fees is achieved.

Austria

The fees in Austria are currently set at 25 – 75 €/(g CO_2/km) for each g CO_2/km above the threshold value of 160 g CO_2/km. In return, cars with alternative propulsion systems are granted a tax exemption up to 500 € to support market development (until 31.08.2012). Such a feebate system will be used for xEV market stimulation in Austria and Germany in the EM^+ scenario. Currently, the maximum level of support is around 300€ for low emission vehicles. The data for the current feebate system for Austria is shown in *Table 17*.

[33] The effect of a combination of immediate charging up to threshold value and load shifting to off-peak hours could be an interesting aspect of a sensitivity analysis.

[34] feebate: a blend of fee and rebate. Both fees and rebates are exempt from VAT.

CO_2 emission level	rebate/fee (as of 1 January 2013)
< 120 g CO_2/km	rebate maximum 300 €
160 g CO_2/km - 180 g CO_2/km	fee of 25€ for each g CO_2/km
180 g CO_2/km - 180 g CO_2/km	fee of 50€ for each g CO_2/km
> 220 g CO_2/km	fee of 75€ for each g CO_2/km

Table 17: Current feebate rates for Austria[35]

For the EM$^+$ scenario of the DEFINE project it is intended to set the pivot point for Austria at 105 g CO_2/km in 2015 and at 95 g CO_2/km in 2020 (according to the Austrian Monitoring Mechanism Report[36]).

[35] Bundesministerium für Finanzen Österreich: https://www.bmf.gv.at/steuern/fahrzeuge/normverbrauchsabgabe.html, acess date: August 22 2013.

[36] Umweltbundesamt: Grundlage für den Monitoring Mechanism 2013 und das Klimaschutzgesetz, Synthesebericht 2013. 2013.

Germany

A feebate system has yet not been established in Germany and does not seem to be the most likely measure in Germany. Nevertheless, a feebate system is applied in the EM^+ scenario for xEV market support. The assumed fees are based on the EU CO_2 Emissions Regulation No 443/2009.

Therefore, the CO_2 emission threshold level is set so as to comply with the current mass-based approach of the EU CO_2 Regulation. The current slope factor (a: 0.0333) and the average mass of new cars from 2010 have been used in the calculation of additional fees. The amount of the fees has also been adapted to the CO_2 regulation and has been set at 95 € per g CO_2/km above the threshold value. Assumptions for new cars are in line with Table 5 and Table 7. Hence, the CO_2 emissions from conventional cars are 7.8 % above the threshold value of the feebate system (see Table 18).

	mass	$e_{threshold}$	e_{avg}	fee	
	kg	*g CO_2/km*	*g CO_2/km*	*€*	*$€_{2010}$*
small – gasoline					
2020	1,066	90.03	97.03	664	569
2030	1,066	62.53	67.39	462	338
mid-size – gasoline					
2020	1,332	98.91	106.59	730	625
2030	1,332	71.41	76.96	527	386
large - diesel					
2020	1,680	110.49	119.08	815	698
2030	1,680	82.99	89.44	613	449

Table 18: Assumption for feebate system fees in Germany (EM+)

The income gained through this kind of taxation is partially used to support alternative propulsion system market developments within the feebate system. Both BEVs and PHEVs are granted a rebate on their sales price until 2030. The assumed sales price reduction for PHEVs is half the BEV price (see Table 19).

	BEV		PHEV	
	€	*$€_{2010}$*	*€*	*$€_{2010}$*
2020	2,500	2,140	1,250	1,070
2030	750	549	375	275

Table 19: Assumptions for feebate system rebates in Germany (EM+)

Additional measures (mobility management and awareness raising)

In the EM^+ scenario additional measures such as mobility management and awareness raising measures will be implemented for Austria. They include all measures designed to raise awareness of environmentally friendly alliance. For Austria, these measures can be modelled within the DEFINE framework via a factor analysis.

1.7 Specific Measures in Austria for the BAU and EM+-Scenario

BAU - Measures

In this scenario all measures are considered that are already implemented. Specifically the following measures are relevant in the transport sector:

1) A rise in the mineral oil tax is considered: in the year 2011 by 4 cents for petrol and by 5 cents for diesel fuel.
2) Various measures to boost electromonility are considered: subsidies for research and development; the measures discussed in the Masterplan for Electromobility Austria, measures to increase the awareness of electromobility, measures for mobility management such as the Masterplan for Foot Traffic Austria.
3) Revision of the feebate system (NOVA tax):
   Here the feebates are changed so that higher CO2 emissions lead to higher taxes when buying a new vehicle. Or, more specifically, if CO2 emissions are between 180g/km and 220g/km, then 50 Euros per additional gram of CO2 have to be paid. If the emissions are above 2020 g/km, 75 Euros/gram have to be paid.

Due to our study design all of the measures can be modelled within the simulations of the choice experiment by changing the attributes of the choice experiment accordingly.

EM+ measures

In this scenario the following measures are considered:

1) Increase of mineral oil tax from 2015 and 2019 onwards
   On 01.01.2015 the mineral oil tax will be increased by 5 cents for gasoline and diesel fuels, and from 01.01.2019 onwards further by 5 cents.
2) Reform of the NoVA (feebate) system
   Setting the pivot point at 105g/km from 01.01.2015 onwards; at 95g/km from 01.01.2020 onwards.
3) Service station expansion
   From
   2015 low
   2020 medium
   2030 high
4) Awareness raising: 15% more environmentally aware people

5) Priorisation of urban transport
6) Priorisation of public transport through speed limits, season ticket for commuters.

The following incentives (offered to customers when buying an EV) are taken into account:

2015: investment subsidy for electric loading stations and an offer of an oebb (Austrian Railways) season ticket

2020: season ticket and park and ride ticket

2030: investment subsidy, oebb season ticket and park and ride ticket for one year

2 POLICY SIMULATIONS (DEVELOPMENT OF VEHICLE STOCK UP TO 2030 DELIVERABLE 4.3)

To analyse the effect of the two scenarios BAU and EMOB+ on vehicle stock, energy demand and GHG emissions we proceed as follows: As a first step, the market shares for the different technologies have to be calculated, using the multi-nominal logit model (estimated in WP3), a common method to approach this type of problem (Train, 2009; Axsen et al. 2009). As a second step, the market shares are used as input to determine the technology diffusion curves of the different technologies used in the TEEM Model (Transport Energy and Emission Model) of Umweltbundesamt. The TEEM Model is then used to calculate the vehicle stock of passenger cars in Austria (deliverable 4.3), the direct emissions from the vehicles (CO_2 and NOx, particulate matter) (Deliverable 5.1), the energy demand (Deliverable 4.4) and the upstream emissions according to the well-to-tank approach.

2.1 Attributes to measure passenger car demand

To form our BAU scenario, the vehicle and mode choice attributes were set according to current and expected market developments. Second, we used the estimated vehicle demand model and mode choice demand model from WP 3 to calculate choice probabilities per person and alternative, while keeping individual specific variables constant. By summing the individual choice probabilities over the sample and averaging them a mean choice probability can be obtained, which can be interpreted as vehicle share or as modal split respectively. It should be noted, however, that the calculated vehicle shares and the modal split cannot be seen as real life shares, as they are derived from a choice experiment. Nevertheless, they are helpful for conducting policy analysis. We repeated this procedure for the Elektromobility+-scenario.

2.1.1 Attributes in the BAU scenario

The vehicles are the same as in the choice experiment; however, we reduced the vehicle segments from seven to four for the sake of simplicity and comparability with the German scenarios.

Table 20: vehicle segments for simulations

Segments	Segments for Simulations
minicar	Segment small
compact car	Segment medium
middle class	
mid-range car	Segment large
executive car	
people carrier/family van	
SUV	

The BAU scenario expects for the conventional vehicles (CV) no considerable price changes up to 2030. For electrified vehicles, price reductions from -2% up to -28% are expected compared to the starting values in 2013. Most reductions are expected for the small segments.

	2015		
conventional vehicle	**Segment 1**	**Segment 2**	**Segment 3**
purchase price [€]	14,000	24,500	55,000
power [PS]	69	114	170
fuel costs [€/km]	0.07	0.07	0.1
maintenance costs [€/km]	0.06	0.06	0.06
range [km]	> 500	> 500	> 500
service station availability [%]	100	100	100
	2020		
conventional vehicle	**Segment 1**	**Segment 2**	**Segment 3**
purchase price [€]	14,000	24,500	55,000
power [PS]	69	114	170
fuel costs [€/km]	0.08	0.08	0.11
maintenance costs [€/km]	0.06	0.06	0.06
range [km]	> 500	> 500	> 500
service station availability [%]	100	100	100
	2030		
conventional vehicle	**Segment 1**	**Segment 2**	**Segment 3**
purchase price [€]	14,000	24,500	55,000
power [PS]	69	114	170
fuel costs [€/km]	0.08	0.08	0.12
maintenance costs [€/km]	0.06	0.06	0.06
range [km]	> 500	> 500	> 500
service station availability [%]	100	100	100

Table 21: attributes of the conventional vehicle in the BAU scenario (2015-2030)

The average fuel prices for CV and HEV (diesel and petrol) (inflation effects are taken into account) are 1.58 € in 2015 ; 1.80€ in 2020 and 2.30€ in 2030. Prices per km are shown in and in **Error! Reference source not found.**.

2015			
hybrid vehicle	**Segment 1**	**Segment 2**	**Segment 3**
purchase price [€]	20,000	27,000	55,000
power [PS]	136	170	238
fuel costs [€/km]	0.07	0.07	0.1
maintenance costs [€/km]	0.06	0.06	0.06
range [km]	> 500	> 500	> 500
service station availability [%]	100	100	100
2020			
hybrid vehicle	**Segment 1**	**Segment 2**	**Segment 3**
purchase price [€]	19,000	25,500	54,000
power [PS]	136	170	238
fuel costs [€/km]	0.07	0.08	0.1
maintenance costs [€/km]	0.06	0.06	0.06
range [km]	> 500	> 500	> 500
service station availability [%]	100	100	100
2030			
hybrid vehicle	**Segment 1**	**Segment 2**	**Segment 3**
purchase price [€]	18,000	24,000	53,000
power [PS]	136	170	238
fuel costs [€/km]	0.07	0.08	0.11
maintenance costs [€/km]	0.06	0.06	0.06
range [km]	> 500	> 500	> 500
service station availability [%]	100	100	100

Table 22: attributes of the hybrid vehicle in the BAU scenario (2015-2030)

For electrified vehicles (EV and PHEV) (Table 24 & Table 25), prices are expected to range between 0.22 €/kWh in 2013; 0.28 €/kWh in 2020 and 0.32kWh in 2030. To meet the assumed CO2 emission targets (e.g. 95 g CO2/km in 2020), which will be achieved by a higher efficiency of the vehicles, PHEV fuel prices will decrease by 5%.

Table 23: Assumptions for specific CO_2 emission targets of the EU Regulation and new car registrations

	BAU scenario	EM^+ scenario
	g CO_2/km	*g CO_2/km*
2015	130	130
2020	95	95

2030	72.5	60

Table 24: attributes of the plug-in hybrid vehicle in the BAU scenario (2015-2030)

2015			
plug-in hybrid vehicle	**Segment 1**	**Segment 2**	**Segment 3**
purchase price [€]	30,000	39,000	58,884
power [PS]	136	170	238
fuel costs [€/km]	0.039	0.057	0.059
maintenance costs [€/km]	0.06	0.06	0.06
range [km]	> 500	> 500	> 500
service station availability [%]	100	100	100
2020			
plug-in hybrid vehicle	**Segment 1**	**Segment 2**	**Segment 3**
purchase price [€]	26,742	34,765	56,256
power [PS]	136	170	238
fuel costs [€/km]	0.04	0.05	0.065
maintenance costs [€/km]	0.06	0.06	0.06
range [km]	> 500	> 500	> 500
service station availability [%]	100	100	100
2030			
plug-in hybrid vehicle	**Segment 1**	**Segment 2**	**Segment 3**
purchase price [€]	22,767	29,597	52,772
power [PS]	136	170	238
fuel costs [€/km]	0.039	0.059	0.062
maintenance costs [€/km]	0.06	0.06	0.06
range [km]	> 500	> 500	> 500
service station availability [%]	100	100	100

In the BAU scenario no real changes in the attributes power, maintenance costs and range are assumed. Therefore the assumed EV range is 150 km throughout. Further, the share of people who are environmentally conscious is also kept constant and no real changes are assumed in the BAU scenario.

Table 25: attributes of the electric vehicle in the BAU scenario (2015-2030)

2015			
electric vehicle	**Segment 1**	**Segment 2**	**Segment 3**
purchase price [€]	26,295	37,642	97,768
power [PS]	109	150	170

fuel costs [€/km]	0.03	0.04	0.05
maintenance costs [€/km]	0.06	0.06	0.06
range [km]	> 500	> 500	> 500
service station availability [%]	100	100	100
2020			
electric vehicle	**Segment 1**	**Segment 2**	**Segment 3**
purchase price [€]	23,251	33,284	95,536
power [PS]	109	150	170
fuel costs [€/km]	0.04	0.05	0.06
maintenance costs [€/km]	0.06	0.06	0.06
range [km]	150	150	150
service station availability [%]	100	100	100
2030			
electric vehicle	**Segment 1**	**Segment 2**	**Segment 3**
purchase price [€]	16,789	24,033	89,620
power [PS]	109	150	170
fuel costs [€/km]	0.04	0.05	0.06
maintenance costs [€/km]	0.06	0.06	0.06
range [km]	150	150	150
service station availability	low [private hubs]	low [private hubs]	low [private hubs]

In the BAU scenario the service station availability for electric vehicles is assumed to be low, which means that loading stations are available only from selected hubs (private garage or parking slot). Additional incentives when purchasing an electric vehicle such as the offer of a park and ride ticket, a public transport subsidy or an investment subsidy are not foreseen in the BAU scenario.

2.1.2 Attributes in EMob+-Scenario

In the Emob+- Scenario the attributes are manipulated to reflect a progressive development of electric or electrified vehicles.

Table 26: attributes of the conventional vehicle in the EMOB+– Scenario (2015-2030)

2015			
conventional vehicle	**Segment 1**	**Segment 2**	**Segment 3**
purchase price [€]	14,000	24,500	55,000
power [PS]	69	114	170
fuel costs [€/km]	0.08	0.08	0.11
maintenance costs [€/km]	0.06	0.06	0.06

range [km]	> 500	> 500	> 500
service station availability [%]	100	100	100

2020

conventional vehicle	Segment 1	Segment 2	Segment 3
purchase price [€]	14,300	25,200	57,000
power [PS]	69	114	170
fuel costs [€/km]	0.08	0.08	0.11
maintenance costs [€/km]	0.06	0.06	0.06
range [km]	> 500	> 500	> 500
service station availability [%]	100	100	100

2030

conventional vehicle	Segment 1	Segment 2	Segment 3
purchase price [€]	15,000	26,500	65,000
power [PS]	69	114	170
fuel costs [€/km]	0.08	0.09	0.12
maintenance costs [€/km]	0.06	0.06	0.06
range [km]	> 500	> 500	> 500
service station availability [%]	100	100	100

Table 27: attributes of the hybrid vehicle in the EMOB+– Scenario (2015-2030)

2015

hybrid vehicle	Segment 1	Segment 2	Segment 3
purchase price [€]	30,000	39,000	58,884
power [PS]	102	136	224
fuel costs [€/km]	0.1	0.08	0.08
maintenance costs [€/km]	0.06	0.06	0.06
range [km]	> 500	> 500	> 500
service station availability [%]	100	100	100

2020

hybrid vehicle	Segment 1	Segment 2	Segment 3
purchase price [€]	19,000	25,500	54,000
power [PS]	102	136	224
fuel costs [€/km]	0.07	0.07	0.1
maintenance costs [€/km]	0.06	0.06	0.06
range [km]	> 500	> 500	> 500
service station availability [%]	100	100	100

2030

hybrid vehicle	Segment 1	Segment 2	Segment 3
purchase price [€]	18,000	24,000	53,000
power [PS]	102	136	224
fuel costs [€/km]	0.07	0.08	0.11
maintenance costs [€/km]	0.06	0.06	0.06
range [km]	> 500	> 500	> 500
service station availability [%]	100	100	100

Table 28: attributes of the plug-in hybrid-vehicle in the EMOB+– Scenario (2015-2030)

2015			
plug-in hybrid vehicle	**Segment 1**	**Segment 2**	**Segment 3**
purchase price [€]	30,000	39,000	58,884
power [PS]	136	170	238
fuel costs [€/km]	0.046	0.058	0.066
maintenance costs [€/km]	0.06	0.06	0.06
range [km]	> 500	> 500	> 500
service station availability [%]	100	100	100
2020			
plug-in hybrid vehicle	**Segment 1**	**Segment 2**	**Segment 3**
purchase price [€]	26,000	34,000	56,000
power [PS]	136	170	238
fuel costs [€/km]	0.046	0.058	0.073
maintenance costs [€/km]	0.06	0.06	0.06
range [km]	> 500	> 500	> 500
service station availability [%]	100	100	100
2030			
plug-in hybrid vehicle	**Segment 1**	**Segment 2**	**Segment 3**
purchase price [€]	21,500	28,000	53,000
power [PS]	136	170	238
fuel costs [€/km]	0.048	0.06	0.069
maintenance costs [€/km]	0.06	0.06	0.06
range [km]	> 500	> 500	> 500
service station availability [%]	100	100	100

Table 29: attributes of the electric vehicle in the EMOB+– Scenario (2015-2030)

	2015		
electric vehicle	**Segment 1**	**Segment 2**	**Segment 3**
purchase price [€]	11,626	16,642	47,768
power [PS]	109	150	170
fuel costs [€/km]	0.03	0.04	0.06
maintenance costs [€/km]	0.06	0.06	0.06
range [km]	150	150	150
service station availability [%]	low [private hubs]	low [private hubs]	low [private hubs]
	2020		
electric vehicle	**Segment 1**	**Segment 2**	**Segment 3**
purchase price [€]	23,251	33,284	95,536
power [PS]	109	150	170
fuel costs [€/km]	0.04	0.05	0.06
maintenance costs [€/km]	0.06	0.06	0.06
range [km]	150	150	150
service station availability [%]	medium	medium	medium
	2030		
electric vehicle	**Segment 1**	**Segment 2**	**Segment 3**
purchase price [€]	16,789	24,033	89,620
power [PS]	109	150	170
fuel costs [€/km]	0.04	0.05	0.06
maintenance costs [€/km]	0.04	0.05	0.06
range [km]	150	150	150
service station availability	high	high	high

Incentives:

2015	investment subsidy and season ticket for public transport in Austria
2020	season ticket for public transport and park and ride ticket
2030	investment subsidy and season ticket for public transport in Austria

2.2 THE TEEM MODEL

Energy and emission calculations were carried out using the Transport, Energy and Emission Model (TEEM) of the Environment Agency Austria. The model was developed with the aim to calculate specific emissions and energy inputs of the Austrian fleet by propulsion system and passenger car segment. The TEEM is based on the results and background data from the GLOBEMI model from the University of Technology of Graz (HAUSBERGER & SCHWINGSHACKL 2010), which are published each year in the Austrian air emission inventory (OLI).

At a more detailed level, TEEM breaks the stock of vehicles down into seven vehicle segments and nine propulsion concepts. The advantage of this detailed breakdown is that it allows for a segment-specific perspective which also accounts for alternative fuel vehicles and permits a higher level of accuracy in the emissions and energy calculations for the vehicle fleet than an approach which is based e.g. on the engine size.

2.2.1 TEEM input data

The input data requirements for TEEM emissions and energy calculations are as follows:

market development input data:

- segment-specific new registrations, from Statistics Austria (updated annually)
- segment-specific mileage (in vehicle kilometres), from Eurotax (updated annually)
- overall mileage (in km), from the Austrian air emissions inventory OLI (updated annually)[37]
- Austrian vehicle stock, from the Austrian air emissions inventory OLI (updated annually)[10]
- market shares by vehicle segment and propulsion system. The project includes the calculation of these market shares using a discrete choice experiment followed by the estimation of a model demonstrating the demand for new car purchases (see report from the Institute for Advanced Studies) (= maximum potential).
- assumptions about market diffusion
- assumptions about the technical vehicle range

[37] The underlying calculations were carried out using the GLOBEMI model of the University of Technology of Graz. For a detailed description of the method see HAUSBERGER (1997) and HAUSBERGER & SCHWINGSHACKL (2010).

input data for emission and energy calculations:

- Direct emissions are derived from our own calculations using the Handbook of Emission Factors (HBEFA 3.1) and performing a segment-specific adaptation/calibration of the values obtained. That is to say that the segment-specific emission factors come as close as possible to the real emission factors of the new car fleet and that the latest state-of-the-art technology is considered.
- upstream emissions are calculated on the basis of the life cycle analysis (LCA) method, using the GEMIS 4.6 computer model. The underlying life cy The underlying life cycle calculations were, amongst others, carried out as part of the *Zukunft Auto* (future of the car) project, which was created in co-operation with BMVIT and A3PS. They are used as input data for the EEA model (UMWELTBUNDESAMT 2012).

Market development was analysed for two scenarios:

In the Business as Usual (BAU) scenario only the measures and incentives planned at the present time are considered.

In the second scenario, Electromobility Plus (EMOB+), additional measures such as a tighter reform of the Austrian car registration tax (NOVA) and an expansion of the charging point infrastructure are included. The measures for the Emob+ scenario were selected together with the Öko-Institut (Institute for Applied Ecology) in Germany because the aim was to demonstrate common, transnational and political plausibility in the assumed scenarios.

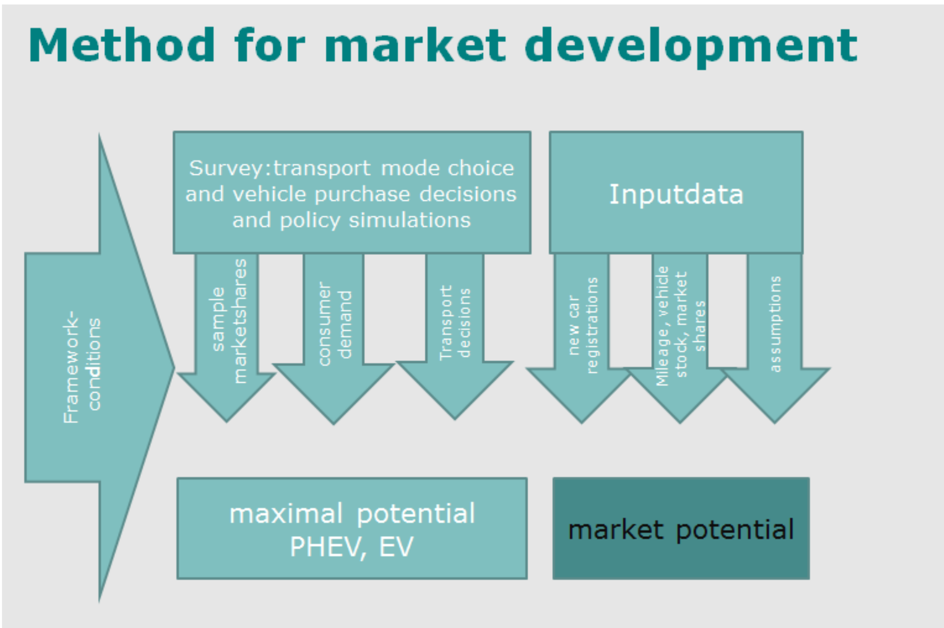


Figure 1: Method for market developments

3 SCENARIOS FOR POTENTIAL USER GROUPS AND MARKET POTENTIAL OF ELECTRIC VEHICLES FOR AUSTRIA UP TO 2030 (DELIVERABLE 4.2)

3.1 Electric vehicles: user groups

3.1.1 Drivers behind choice preferences

The fact that attitudes and values play an important role in shaping the choice preferences of individual consumers is undisputed in research. Therefore, it seems plausible to assume that changes in the values of consumers would lead to changes in their consumption behaviour. However, recent research has shown that this is not so straightforward (EC, 2014).

Another recognised fact is that consumers are heavily influenced by other people (e.g. by their peers) and social norms: in addition, social pressure can override objective information. Therefore, measures with the objective of changing choice preferences so that choices are made in favour of the environment (e.g. purchase of electric vehicles) should pay attention to the fact that different attitudes may lead to different responses and that the availability of information is not the only key to changes in behaviour. Rather, non-regulatory policies need to be targeted at specific attitudinal groups.

As a consequence, governments should base their policy modelling on models that split the population into different attitudinal groups to be able to ex-post evaluate policy changes according to these groups. To give an example: In the UK, several government departments have constructed segmentation models of the population to identify attitudinal groups (e.g. early adopters of new technologies).

Hence, this section deals with the identification of different groups from our sample and with the interpretation of their attitudes.

3.1.2 Identification of user groups from the sample

In this section, we describe how the user groups are identified on the basis of the collected data (WP3). After identifying and transforming the variables, we carried out a cluster analysis. Cluster analysis is an appropriate method to structure the data. The aim of cluster analysis is to group heterogeneous individual units (in our case individuals) into a homogenous group.

Cluster analysis is used in various scientific fields for clustering and classification (Everitt, 2013). For example, in anthropology it is used to identify homogenous cultural regions, whereas in psychology it is used to identify personality types. It needs to be stressed that cluster analysis is solely an instrument to identify groups within given structures, and that it therefore it sheds new light on structures - which could not be discovered otherwise.

The procedure is as follows:

1. Identification and selection of the considered units and attributes
2. Calculation of similarities, based on a grouping algorithm (k-means)
3. Checking for validity and significance

We perform our cluster analysis by using mobility and household specific attributes for the individuals.

attribute	characteristic
region	urban
	suburban
	rural
household type	single
	couples without children
	single parent
	families
	flat sharers
age group	<24
	25-34
	35-49
	50-64
	>65
activity status	full-time employed
	part-time employed
education	low
	medium
	high
	academic
gender	male
	female
commuter allowance	none
	below 100€
	above 100€ below 200€
	above 200€
car-sharing activities	yes, regularly
	yes, occasionally
	no, never
driving distance per year	less than 5.000 km per year
	medium ddistance
	a lot 20ts -30ts and more
distance travelled on a typical week day	short (1km)
	medium (1-6km)
	long (7-15km)
	very long (16-550km)
main transport mode for the most frequently travelled route	on foot
	MIT (vehicle or motorbike)
	PT (bus, speed train, train, tram)

purpose of the trip	work
	education
	private
	Free time
probability of buying an EV	small
	medium
	high
probability of buying an HEV	small
	medium
	high
probability of buying an CV	small
	medium
	high
probability of buying an PHEV	small
	medium
	high

Table 30: attributes for cluster analysis

Before the analysis, we transformed the data into classes and standardized the variables, because of the different scales and levels. We applied z standardization, which rescales each variable so that it has a mean of zero and a standard deviation of 1. We also checked for correlations between the variables to avoid similarity.

As a next step we applied the most popular partitioning method, the k-means method on the data. The k-means algorithm minimizes the squared sums within a group and maximizes them between different groups. Before applying this algorithm one has to specify the cluster groups a priori. Therefore, we used a formal stopping rule to decide how many clusters should be formed. The Calinski and Harabasz rule provides a distinct clustering statistic, which is characterised by large pseudo-F values.

Doing this for different k-means cluster results in the 6 cluster model produces the best distinct clustering, as it has the largest pseudo-F statistic.

number of clusters	Calinski/Harabasz pseudo-F
4	614.1
5	599.07
6	**641.81**
7	623.76
8	558.42

Table 31: various pseudo F-statistics for different clusters

Finally, we checked if all sixteen attributes contributed equally to the cluster membership, by applying a discriminant analysis. The results in Table 32 show that 93 % are well explained by the variables; only 7% of the sample are not explained by the variables.

True clugroup6	Classified 1	2	3	4	5	6	Total
1	809	17	10	22	69	0	927
	87.27	1.83	1.08	2.37	7.44	0.00	100.00
2	20	769	0	16	110	0	915
	2.19	84.04	0.00	1.75	12.02	0.00	100.00
3	2	0	954	24	3	1	984
	0.20	0.00	96.95	2.44	0.30	0.10	100.00
4	0	4	1	664	34	0	703
	0.00	0.57	0.14	94.45	4.84	0.00	100.00
5	47	11	7	8	2,006	0	2,079
	2.26	0.53	0.34	0.38	96.49	0.00	100.00
6	0	0	0	0	0	161	161
	0.00	0.00	0.00	0.00	0.00	100.00	100.00
Total	878	801	972	734	2,222	162	5,769
	15.22	13.88	16.85	12.72	38.52	2.81	100.00

Table 32: results of the discriminant analysis

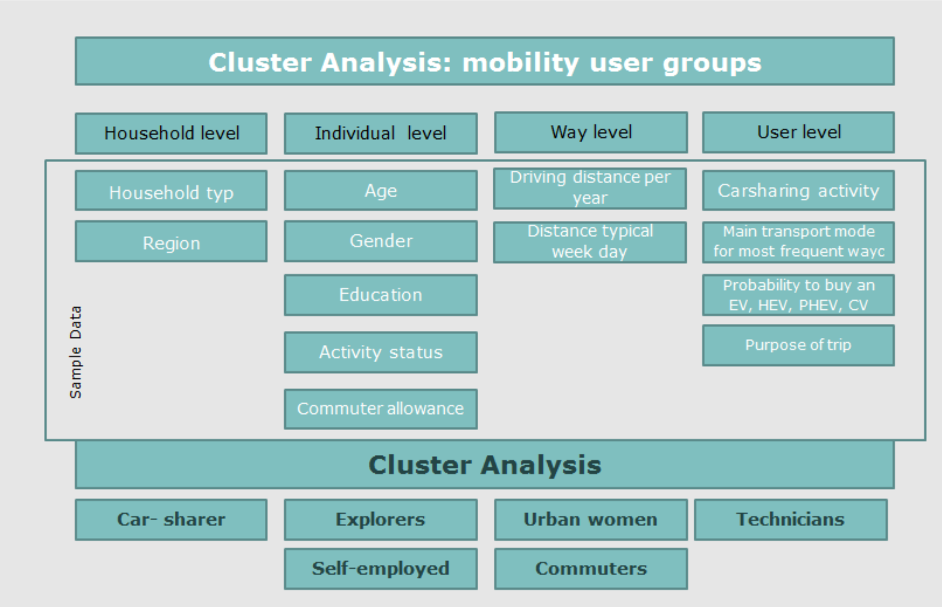


Figure 2: Schematic representation of the approach.

3.1.2.1 Cluster Analysis results

The following six user groups are identified from the data:

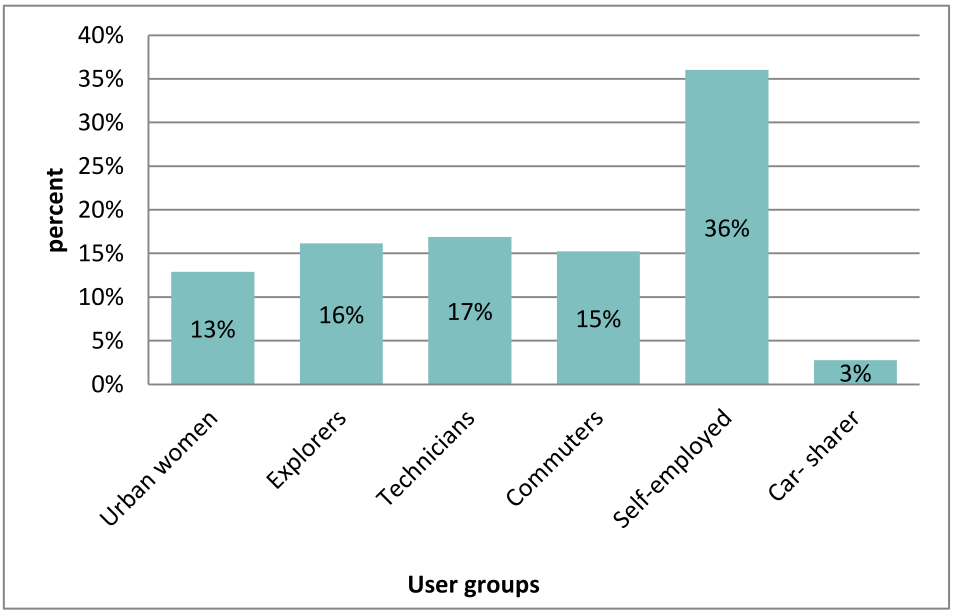


Figure 3: percentage distribution of user groups in sample

As shown above, the user groups are not equally distributed across the data. The group with the largest share is the self-employed group, holding a share of 36%. The smallest group is the one of the car-sharers.

Urban Women:

This group mostly consists of middle-aged women (35-49-year-olds), most of whom (63%) live in an urban area. They do not commute; therefore, they do not receive a commuter allowance. They have the highest levels of education -

compared to the other groups (26% academics) – and a large portion of them live in “double income no kids” households.

They travel long distances on a frequent basis (7-15 km), and medium distances every year (5,000-10,000 km). Their main mode of transport is walking or cycling (41%); to work and for private purposes. They never use car-sharing opportunities. Most of them work full-time. The probability that they will buy an electric vehicle is high.

Explorers

The explorers are the group with the highest proportion of people who are most likely to buy an electric vehicle. They are evenly distributed across rural, urban and suburban regions and they drive very long distances regularly. Most of them do not receive a commuter allowance, which implies that a large proportion within this group is probably self-employed (79%).

They live in households consisting of two people, families and flat sharers. The number of men and women is almost equal in this group. They are middle-aged (36-49 years old). The main purpose of their trips is to drive to work, more often by car (88%) than by public transport. They never use car-sharing opportunities and they work full-time.

Technicians

Technicians are evenly distributed across urban, rural and suburban environments. They prefer no-nonsense solutions; therefore, a large proportion within this group would be willing to buy a plug-in hybrid electric vehicle (PHEV). For them, the probability of buying any other vehicle option has been found to be the lowest. So, they could be also called PHEV buyers.

They are 35-49 years old and mostly highly educated. They do not use car-sharing options. They live in two-people households and family households and they work full-time. The number of men is slightly higher than in the ‘explorers’ groups. They also drive long distances 15 -20,000 km per year and a small proportion (17%) receives a small commuter allowance (less than 100 euros per month). Besides the car, public transport is used by some for their most frequent routes (13%).

Commuters

This is the group of the classic commuters. They live in rural areas and are mainly male (63%). Most of them are middle-aged (35-49) and they live in households similar to those of the ‘technicians’ (couples, families and flat sharers). There are also some single parents in this group (3%).

All of them receive a form of commuter allowance (200 euros per month). They live mainly in rural areas; their level of education varies widely.

60 percent within this group use the car for the long distances to go to work (16-550 km). Men make up the higher share in this group. The do not use car-sharing options, or have ever heard about it. The probability of buying an alternative vehicle is low; rather, there is a high probability that they will buy conventional vehicles.

Self-Employed

A large proportion of the group of the self-employed live in rural and suburban areas. They live in households as couples, families and flat sharers. In this group the highest proportion of people aged 50-64 can be found. Most of them are in full-time employment. They do not receive commuter allowances, although they drive long distances every day and long distances is every year. They mainly use individual motorised transport (94%), rather than public transport (5%). The main purpose of their trips is to go to work.

Car-sharer

This group consists mainly of people living in the urban area (78%). Most of them live in “double-income-no-kids” households. There are more males than females in this group. They all use car-sharing options: regularly (22%) or occasionally (78%). They are highly educated and they drive distances of 7-15 km on a typical work day. They use all modes of transport: walking or cycling (17%), public transport (39%), motorised individual transport (45%).

There is a high probability that they will buy an electric vehicle and a plug-in electric vehicle.

Austria		mobility user groups					
Attributes	**Level**	**Urban women**	**Explorers**	**Technicians**	**Commuters**	**Self-employed**	**Car-Sharer**
Urbanisation	urban	63%	27%	29%	7%	19%	78%
	suburban	29%	36%	33%	29%	38%	17%
	rural	9%	38%	38%	64%	43%	6%
Hauseholdtype	single	18%	11%	12%	9%	10%	17%
	2 people no kids	47%	38%	35%	36%	32%	50%
	single parent	0%	1%	3%	3%	1%	0%
	families	20%	27%	25%	28%	30%	22%
	flat sharers	15%	23%	25%	25%	26%	11%
Gender	female	67%	50%	47%	37%	42%	33%
	male	33%	50%	53%	63%	58%	67%
Age	<24	8%	6%	4%	6%	3%	6%
	25-34	30%	21%	16%	26%	14%	39%
	35-49	32%	46%	48%	46%	49%	50%
	50-64	29%	27%	30%	22%	31%	6%
	>65	1%	1%	2%	0%	3%	0%
activity status	part-time employed	26%	22%	26%	9%	21%	33%
	full-time employed	74%	78%	74%	91%	79%	67%
education	low	1%	6%	10%	2%	10%	11%
	medium	20%	35%	35%	41%	44%	17%
	high	52%	49%	44%	47%	39%	50%
	academic	26%	10%	11%	10%	6%	22%
commuter allowance	none	97%	79%	74%	0%	90%	78%
	below 100€	3%	16%	17%	22%	10%	0%
	above 100€ below 200€	0%	5%	9%	60%	0%	17%
	above 200€	0%	0%	1%	18%	0%	5%
carsharing activities	yes, regularly	0%	0%	0%	0%	0%	22%
	yes, occasionally	0%	0%	0%	0%	0%	78%
	no, never	100%	100%	100%	100%	100%	0%
distance of typical week day	short (1km)	1%	0%	0%	0%	0%	0%
	medium (1-6km)	34%	2%	4%	0%	3%	6%
	long (7-15km)	53%	21%	20%	4%	20%	44%
	very long (16-550km)	12%	76%	76%	96%	77%	50%
driving distance per yea	less than 5.000 km per year	9%	3%	3%	1%	2%	6%
	medium distance	86%	72%	72%	62%	72%	78%
	a lot 20ts -30ts and more	5%	25%	25%	37%	26%	17%
main transport mode for most frequent way	by foot	41%	2%	4%	1%	0%	17%
	PT (bus, speed train, train, tram)	26%	11%	13%	12%	5%	39%
	MIT (vehicle or motorbike)	33%	88%	83%	87%	94%	45%
trip purpose	work	63%	83%	84%	94%	87%	94%
	education	1%	1%	0%	0%	2%	0%
	private	23%	12%	14%	5%	10%	0%
	freetime	13%	4%	2%	1%	1%	6%
probability to buy an EV	highest	***	**				***
	lowest			**			
probability to by an HEV	highest		**		**		
	lowest			**			
probability to by an CV	highest				**		**
	lowest			**			
probability to by an PHEV	highest			**			**
	lowest		**				

Table 33: Structure of the mobility groups for Austria

URBAN		mobility user groups					
Attributes	**Level**	**Urban women**	**Explorers**	**Technicians**	**Commuters**	**Self-employed**	**Car-Sharer**
Hauseholdtype	single	18%	20%	19%	10%	21%	14%
	2 people no kids	53%	36%	35%	13%	34%	43%
	single parent	0%	0%	0%	0%	0%	0%
	families	15%	21%	27%	54%	25%	28%
	flat sharers	14%	22%	18%	24%	21%	14%
Gender	female	65%	48%	40%	2%	29%	35%
	male	35%	52%	60%	98%	71%	65%
Age	<24	10%	10%	5%	2%	5%	7%
	25-34	33%	27%	18%	70%	22%	50%
	35-49	32%	41%	42%	29%	37%	42%
	50-64	23%	22%	34%	0%	30%	0%
	>65	2%	1%	1%	0%	6%	0%
activity status	part-time employed	26%	18%	14%	13%	12%	28%
	full-time employed	74%	82%	86%	87%	88%	72%
education	low	0%	2%	10%	0%	6%	0%
	medium	20%	28%	26%	8%	39%	7%
	high	52%	57%	43%	90%	39%	64%
	academic	28%	14%	21%	2%	16%	29%
commuter allowance	none	100%	89%	93%	0%	93%	94%
	below 100€	0%	8%	2%	3%	7%	0%
	above 100€ below 200€	0%	3%	4%	97%	0%	0%
	above 200€	0%	0%	0%	0%	0%	6%
carsharing activities	yes, regularly	0%	0%	0%	0%	0%	29%
	yes, occasionally	0%	0%	0%	0%	0%	71%
	no, never	100%	100%	100%	100%	100%	0%
distance of typical week day	short (1km)	0%	0%	0%	0%	0%	0%
	medium (1-6km)	26%	2%	6%	0%	0%	7%
	long (7-15km)	61%	16%	29%	0%	7%	57%
	very long (16-550km)	13%	82%	64%	100%	93%	36%
driving distance per year	less than 5.000 km per year	4%	8%	8%	8%	3%	7%
	medium distance	93%	67%	69%	79%	68%	78%
	a lot 20ts -30ts and more	3%	24%	22%	13%	29%	14%
main transport mode for most frequent way	by foot	33%	1%	8%	0%	0%	22%
	PT (bus, speed train, train, tram)	37%	13%	28%	16%	3%	42%
	MIT (vehicle or motorbike)	29%	86%	64%	84%	97%	36%
trip purpose	work	72%	72%	90%	100%	85%	93%
	education	0%	0%	0%	0%	0%	0%
	private	19%	20%	7%	0%	12%	0%
	freetime	9%	8%	2%	0%	3%	7%

Table 34: Structure of the mobility groups for urban areas

SUBURBAN		mobility user groups					
Attributes	**Level**	**Urban women**	**Explorers**	**Technicians**	**Commuters**	**Self-employed**	**Car-Sharer**
Hauseholdtype	single	21%	10%	15%	12%	8%	0%
	2 people no kids	44%	49%	36%	30%	30%	100%
	single parent	0%	1%	3%	6%	1%	0%
	families	15%	21%	13%	28%	30%	0%
	flat sharers	20%	20%	33%	24%	31%	0%
Gender	female	70%	49%	49%	37%	42%	0%
	male	30%	51%	51%	63%	58%	100%
Age	<24	4%	10%	4%	9%	3%	0%
	25-34	20%	27%	12%	16%	9%	0%
	35-49	32%	41%	51%	60%	55%	100%
	50-64	44%	22%	33%	15%	32%	0%
	>65	0%	1%	0%	0%	0%	0%
activity status	part-time employed	11%	22%	31%	7%	19%	67%
	full-time employed	89%	78%	69%	93%	81%	33%
education	low	4%	7%	18%	6%	14%	67%
	medium	24%	38%	37%	50%	43%	33%
	high	45%	43%	39%	37%	40%	0%
	academic	27%	11%	7%	6%	3%	0%
commuter allowance	none	95%	85%	72%	0%	89%	33%
	below 100€	5%	11%	18%	4%	11%	0%
	above 100€ below 200€	0%	4%	10%	68%	0%	67%
	above 200€	0%	0%	0%	28%	0%	0%
carsharing activities	yes, regularly	0%	0%	0%	0%	0%	0%
	yes, occasionally	0%	0%	0%	0%	0%	100%
	no, never	100%	100%	100%	100%	100%	0%
distance of typical week day	short (1km)	4%	0%	0%	0%	0%	0%
	medium (1-6km)	41%	2%	3%	0%	4%	0%
	long (7-15km)	45%	27%	18%	7%	25%	0%
	very long (16-550km)	10%	71%	80%	93%	86%	100%
driving distance per year	less than 5.000 km per year	17%	1%	2%	0%	4%	0%
	medium distance	72%	72%	70%	55%	64%	67%
	a lot 20ts -30ts and more	11%	27%	28%	45%	32%	33%
main transport mode for most frequent way	by foot	61%	2%	3%	0%	0%	0%
	PT (bus, speed train, train, tram)	5%	12%	7%	14%	6%	0%
	MIT (vehicle or motorbike)	34%	86%	90%	86%	94%	100%
trip purpose	work	55%	91%	80%	94%	88%	100%
	education	3%	1%	0%	0%	2%	0%
	private	20%	6%	19%	2%	9%	0%
	freetime	22%	2%	1%	4%	1%	0%

Table 35: Structure of the mobility groups for suburban areas

RURAL		mobility user groups					
Attributes	Level	Urban women	Explorers	Technicians	Commuters	Self-employed	Car-Sharer
Hauseholdtype	single	11%	5%	3%	7%	8%	100%
	2 people no kids	14%	32%	35%	40%	34%	0%
	single parent	0%	3%	5%	3%	1%	0%
	families	75%	41%	33%	25%	32%	0%
	flat sharers	0%	20%	23%	25%	25%	0%
Gender	female	75%	57%	50%	40%	49%	100%
	male	25%	53%	50%	60%	51%	0%
Age	<24	2%	2%	2%	5%	3%	0%
	25-34	39%	22%	19%	25%	14%	0%
	35-49	36%	52%	50%	42%	49%	0%
	50-64	23%	30%	24%	28%	27%	100%
	>65	0%	2%	5%	0%	4%	0%
activity status	part-time employed	75%	29%	30%	10%	28%	0%
	full-time employed	25%	81%	70%	90%	72%	100%
education	low	0%	10%	4%	0%	9%	0%
	medium	13%	40%	41%	41%	47%	100%
	high	75%	52%	49%	47%	38%	0%
	academic	13%	7%	6%	12%	6%	0%
commuter allowance	none	88%	72%	61%	0%	89%	0%
	below 100€	13%	28%	26%	32%	11%	0%
	above 100€ below 200€	0%	9%	11%	53%	0%	100%
	above 200€	0%	0%	1%	15%	0%	0%
carsharing activities	yes, regularly	0%	0%	0%	0%	0%	0%
	yes, occasionally	0%	0%	0%	0%	0%	100%
	no, never	100%	109%	100%	100%	100%	0%
distance of typical week day	short (1km)	0%	0%	0%	0%	0%	0%
	medium (1-6km)	67%	3%	4%	0%	3%	0%
	long (7-15km)	20%	22%	15%	2%	22%	0%
	very long (16-550km)	13%	84%	82%	98%	74%	100%
driving distance per year	less than 5.000 km per year	13%	1%	1%	0%	1%	0%
	medium distance	88%	83%	76%	64%	80%	100%
	a lot 20ts -30ts and more	0%	26%	23%	36%	20%	0%
main transport mode for most frequent way	by foot	30%	2%	2%	2%	1%	0%
	PT (bus, speed train, train, tram)	14%	8%	7%	10%	6%	100%
	MIT (vehicle or motorbike)	56%	99%	90%	88%	93%	0%
trip purpose	work	27%	92%	84%	94%	87%	100%
	education	2%	2%	0%	0%	2%	0%
	private	64%	13%	14%	6%	10%	0%
	freetime	8%	2%	2%	0%	1%	0%

Table 36: Structure of the mobility groups for rural areas

The four tables show that the structure of the mobility groups varies depending on the area type. For example the “urban woman” type tends to choose public transport as her preferred transport mode (37%) when living in an urban area; in the suburbs her main transport mode for the most frequently travelled routes is walking or cycling (61%). In the rural area, motorised individual transport dominates. These differences are mainly due to the different regional structures.

By way of summary, the different mobility groups can help to design policy reforms according to people's behaviour and attitudes. For example: If a policy-maker intended to boost the market share of electric vehicles in the short-term, measures should be targeted at the car-sharing group and the group of "urban women", as the probability that they will buy electric vehicles is already high. And these groups would not have to change their behaviour or attitudes very much. On the other hand, if a policy maker intended to build structures for a change in the long-term, the measures should be aimed at the group of the self-employed and at the technicians. The self-employed are a group where there is a high potential when it comes to environmental considerations as they are the group where most of them use motorised individual transport and where long distances are driven every year.

The technicians and the explorers can play a major role in a transformation process as there is a high probability that they will buy alternative fuel vehicles.

Literature:

Everitt, Brian; Landau, Sabine; Leese, Morven; Stahl, Daniel (2013): Cluster Analysis. 5th Edition. Wiley, Kings College London, UK.

European Commission (2014): Influences on Consumer behaviour. Policy implications beyond nudging.

3.2 Scenarios describing the market potential of electric vehicles for Austria up to 2030 (deliverable 4.2)

As described in section 1.3, two scenarios are developed. The BAU scenario as the "Business as Usual" scenario and the EMOB+ scenario, which reflects a progressive development of electric or electrified vehicles.

This section describes the market opportunities gained for electric vehicles in both scenarios up to 2030 in detail. To obtain the market shares, we proceed as follows: As a first step, the market shares are calculated on the basis of a sample (estimated market shares) and as a second step, the estimated market shares are used as input for the calculation of the market shares which are valid for the Austrian vehicle fleet. To obtain distinct market shares for both scenarios and take into account the specific measures and framework conditions, the market shares are estimated after performing the policy simulations (section 2).

As can be seen from Figure 1, the survey data serves as input for the maximal potential of electric vehicles. This is because in the survey, alternative vehicles are an option to purchase in each vehicle category, whereas in real life this is not the case. Therefore, a higher market share tends to be derived. We have corrected this derivation by using different input data, such as data on new car registrations, market diffusion assumptions etc.

Figure 4 illustrates the market development for alternative fuel vehicles. In 2015, the stock of electric vehicles is expected to be around 500. In 2020 it is assumed that the stock will rise by up to 10% and in 2030 by up to 1% compared to 2015. Therefore, in 2030, more than 85,000 electric vehicles are expected to be part of the vehicle stock in the BAU scenario.

Plug-in hybrid (PHEVs) electric vehicles show a different picture: In 2015, there are expected to be nine times more than EVs. For 2030, around 800,000 PHEVs are expected.

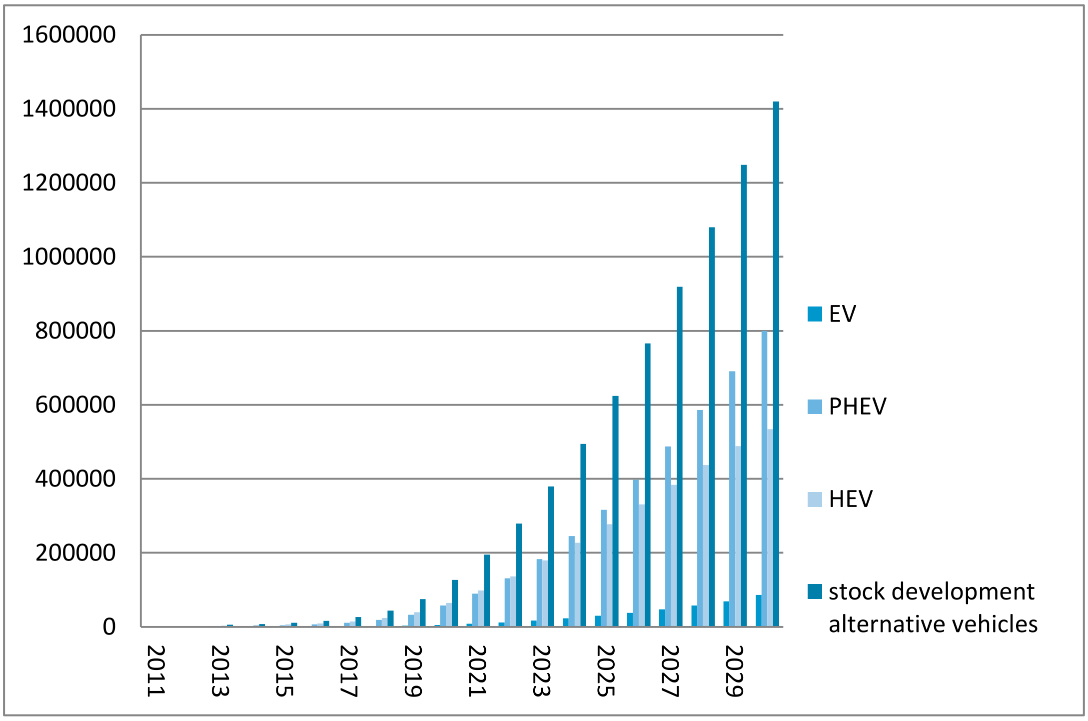
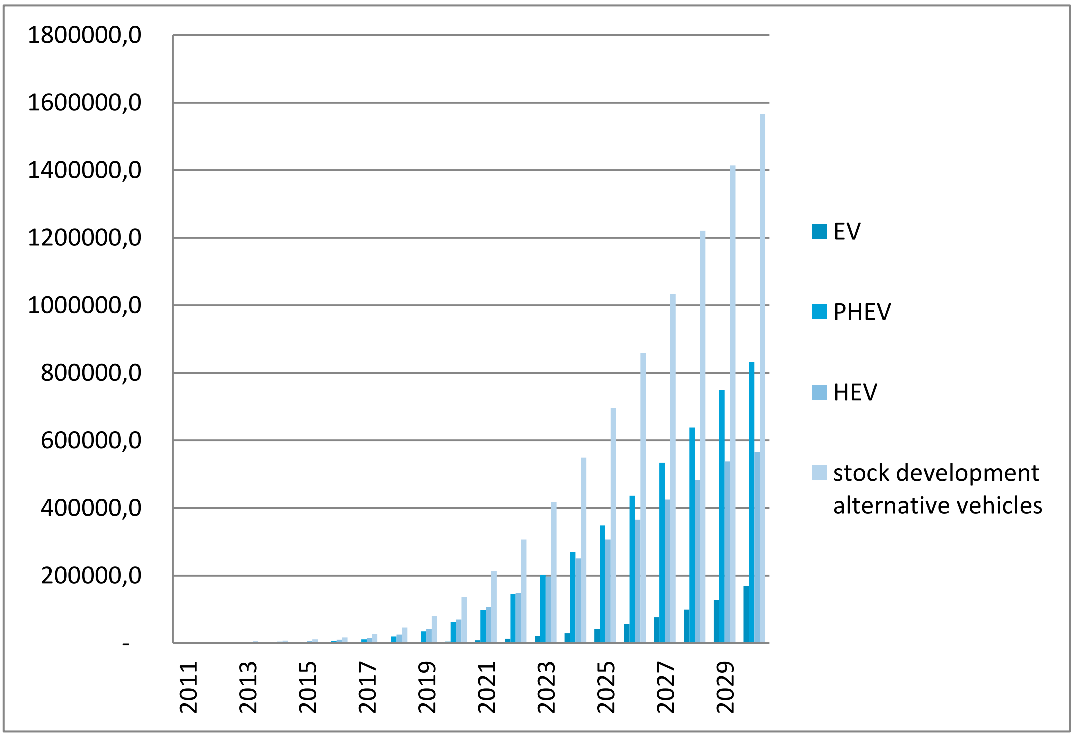


Figure 4: BAU scenario market development

Looking at the progressive scenario, some differences can be identified. In 2015, 550 electric vehicles are expected to be on the market, only 50 vehicles more than in the BAU scenario.

Figure 5: EM+ scenario market development



The calculated energy demand from the Environment Agency Agency (EEA) is mentioned in this paragraph. However, it should be noted that TU-Wien has also reported an additional energy demand for the scenarios triggered by electromobility, with differences arising because of the different systematic approaches.

The following graphs show the energy reduction potentials as described in the two scenarios. For direct emissions, emission factors are calculated using the HBEFA (Handbook on Emission Factos). For the upstream emissions, a well-to-tank approach is applied. The method and the factors used are described in Umweltbundesamt (2012a) and in Umweltbundesamt (2012b).

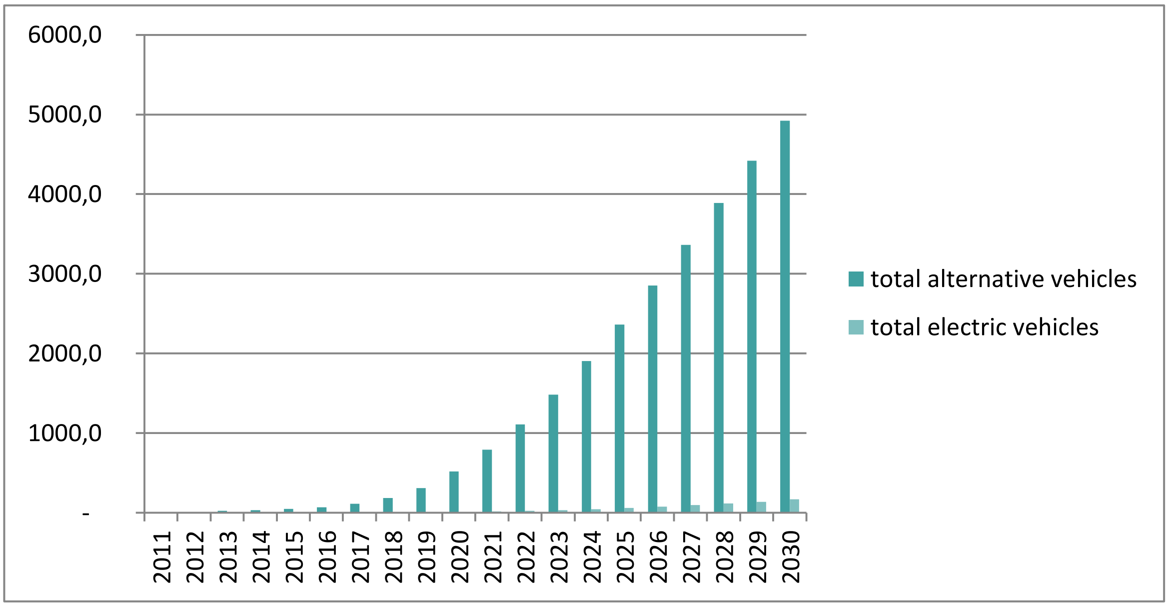


Figure 6: direct energy emission reductions (2011-2030) in GWh

Figure 6 shows that in the BAU scenario the share of energy reductions compared to the total energy reductions rises only slightly from 1% in 2011 to 3% in 2030. The main reductions in this scenario come from the hybrid vehicles introduced at the beginning but this effect decreases over time from 72% in the year 2013 to 49% in 2030. The opposite effect can be seen when looking at the plug-in vehicles in detail. Their share increases from 27% to 47% in 2030. HEVs remain the biggest contributors to the energy reduction potentials described in the BAU scenario.

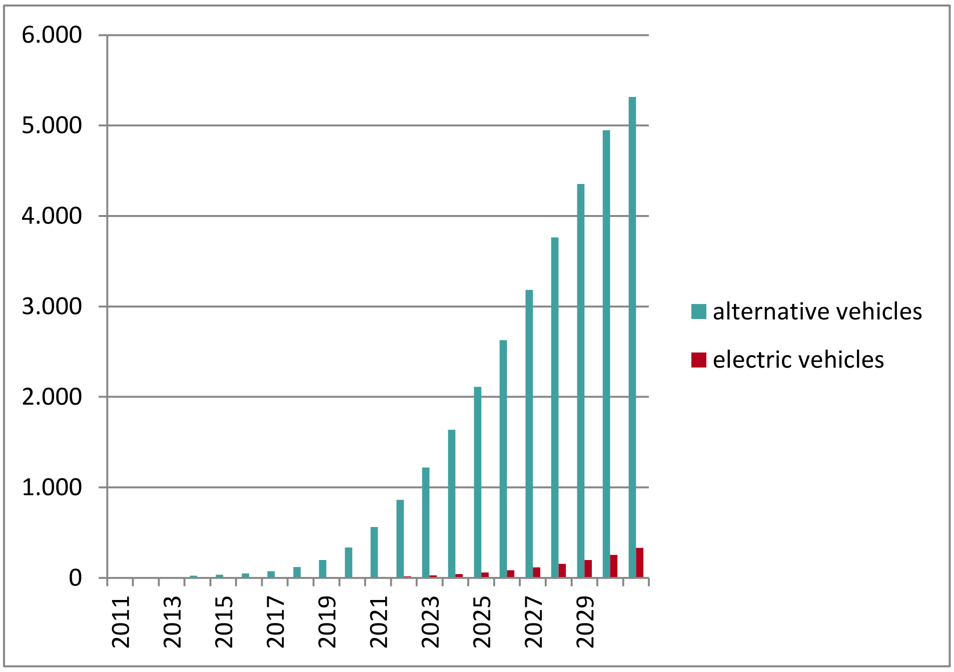


Figure 7: direct energy reduction potentials EMOB+ scenario in GWh

In the EMOB+ scenario the total energy savings are higher than in the BAU scenario. This is mainly due to the fact that in 2030 the energy savings resulting from the (higher) share of EVs have doubled (6%). HEVs remain the vehicles with the highest contributions to the reductions.

All in all, the energy reductions achieved in the year 2030 in the EMOB+ scenario are about 8% higher than in the BAU scenario.

Literature:

UMWELTBUNDESAMT (2012a): Lichtblau, G.; Pötscher, F.; Winter, R.: Ökobilanzierung von
alternativen Fahrzeugen. Elektrofahrzeuge im Vergleich. (in Vorbereitung).

Umweltbundesamt und Institut für Höhere Studien (2012b): Hanappi, T.; Lichtblau, G.; Müllbacher, S.; Ortner, R.; Plankensteiner, B.; Pötscher, F.; Reitzinger, S.; Schuh, U.; Stix, S: Elektromobilität in Österreich: Determinanten für die Kaufentscheidung von alternativ betriebenen Fahrzeugen: Ein diskretes Entscheidungsexperiment.

5 WORKSHOP 3: SCENARIO BUILDING AND DATA IMPLEMENTATION (DELIVERABLE 4.5)

DEFINE - SCENARIO WORKSHOP

Location:	Umweltbundesamt GmbH Spittelauer Lände 5 1090 Vienna
Room:	Sitzungszimmer (ground floor), Ingen-Housz-Gasse 3, 1090 Vienna
Date:	12th April, 2013
Time:	9 a.m – 5 p.m

Participants:

IHS
Markus Bliem, IHS Carinthia
Bianca Brandl
Michael Miess
Stefan Schmelzer

DIW
Christian von Hirschhausen,
Artem Korzhenevych, DIW econ
Clemens Gerbaulet

TU Vienna
Gerhard Totschnig
Markus Litzlbauer
Rusbeh Rezania

Öko-Institut
Peter Kasten

Umweltbundesamt (U)
Günther Lichtblau
Nikolaus Ibesich
Friedrich Pötscher
Sigrid Stix

Agenda

9:00 - 9:15 Welcome and coffee

9:15 - 9:45 Electromobility, targets and paths
(Keynote: Günther Lichtblau, U)

9:45 - 10:10 Scenario approach & presentation of BAU (Business as Usual) measures Austria (U)

10:10 - 10:30 Scenario approach & presentation of BAU Germany (ÖKO-Institute)

10:30 - 10:45 Coffee break

10:45 - 12:30 Presentation of scenario guideline (example Austria) and data requirements: Modelling the BAU within the DEFINE Framework (IHS)

12:30 - 14:00 Lunch break

14:00 - 15:30 Discussion:
Scenario electromobilit(moderated), (all participants)

15:30 -15:45 Coffee break

15:45 -16:15 Organisational Issues, Points of Intersection, open questions (IHS)

List of attendants:

Participants- attendance 12th April 2013 (9:00a.m -5p.m):

Institution	Name	Signature	Dinner @Rebhuhn Yes/No
IHS	Markus Bliem		NO
IHS	Bianca Brandl		NO
IHS	Michael Miess		YES
IHS	Stefan Schmelzer		Yes
DIW	Christian von Hirschhausen		
DIW-econ	Artem Korzhenevych		Yes
DIW	Clemens Gerbaulet		no
TU_Vienna	Gerhard Totschnig		No
TU_Vienna	Markus Litzlbauer		no
TU_Vienna	Rusbeh Rezania		yes
ÖKO-INST	Peter Kasten		Nein
U	Günther Lichtblau		no

U	**Nikolaus Ibesich**		NO
U	**Friedrich Pötscher**		NEIN
U	**Sigrid Stix**		
IHS	Julia Janke		

3/3

6 EMISSION REDUCTION POTENTIAL FOR GHG EMISSIONS AND AIR POLLUTANTS IN AUSTRIA UP TO 2030 (DELIVERABLE 5.1)

In this section the calculated ghg-emission and air pollutant reductions are presented. We specifically show CO2, NOx and particulate matter (PM) developments in both scenarios from a direct and upstream emission reduction perspective.

6.1 Direct and upstream emission reduction potentials in BAU

The following figures show the direct and upstream emission effects in the BAU scenario.

BAU	**2020**	**2025**	**2030**
CO2ttons/year	79	418	1,022
NOx ttons/year	13	61	126

Table 37: direct emission reductions in the BAU scenario

In the BAU scenario, there are enormous reduction potentials for the direct CO2 emissions. CO2 emissions will decline by more than 1 million tonnes in 2030. But the direct effects on the NOx emissions are also significant.

	BAU 2020	BAU 2025	BAU 2030
EV	2	10	27
PHEV	11	57	137
SUM	12	67	164

Table 38: upstream CO2 emission effects in the BAU scenario, in ttons/year

Table 38 shows the upstream effects of the BAU scenario. What can be seen is that the effects on CO2 are still positive even when the whole supply chain is considered.

6.2 Comparison BAU and EM+ scenario

Vehicle stock developments

Currently 3.038 electric vehicles are in the Austrian vehicle fleet. In the BAU scenario, which includes the measures currently in place, a total of about 886,000 electric passenger cars and plug-in vehicles are expected for 2030. If, in addition to the BAU measures, the measures assumed for the EM+ scenario are implemented, the stock of electric vehicles is expected to rise to about 1 million in 2030 (figure 2, right side).

Emission effects

In the BAU scenario, the direct CO_2 emission reductions expected to be achieved in 2030 amount to about 1 million tonnes (excluding HEVs). In the EM+ scenario, the direct CO_2 emission reductions expected to be achieved with additional measures amount to about 1.2 million tonnes (16 per cent greater than in the BAU scenario). Regarding the NOx emissions, the following reductions are expected: in the BAU127 tonnes and in the EM+ 143 tonnes.

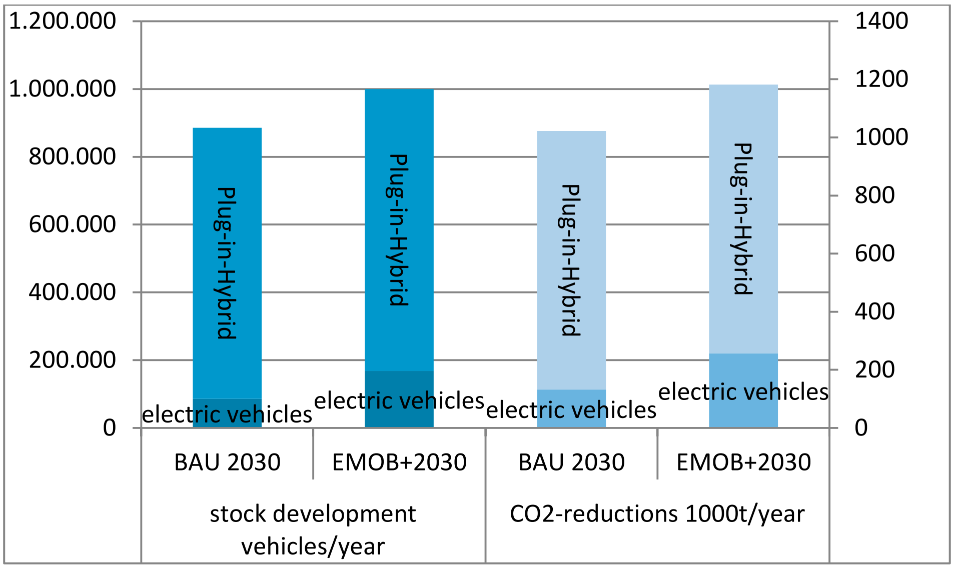


Figure 8: vehicle stock developments and emission reduction potentials