WCTR 2013 RIO

SELECTED PROCEEDINGS

OVERALL ECONOMIC ASSESSMENT OF ELECTRIC MOBILITY

ULRIKE RAICH, GERD SAMMER, CHRISTOPH LINK, JULIANE STARK, INSTITUTE FOR TRANSPORT STUDIES, UNIVERSITY OF NATURAL RESOURCES AND LIFE SCIENCES, E-MAIL-ADDRESS: ULRIKE.RAICH@BOKU.AC.AT)

This is an abridged version of the paper presented at the conference. The full version is being submitted elsewhere. Details on the full paper can be obtained from the author.

ISBN: 978-85-285-0232-9

13th World Conference on Transport Research

www.wctr2013rio.com

15-18 JULY 2013

Rio de Janeiro, Brazil

unicast

OVERALL ECONOMIC ASSESSMENT OF ELECTRIC MOBILITY

Ulrike Raich, Gerd Sammer, Christoph Link, Juliane Stark, Institute for Transport Studies, University of Natural Resources and Life Sciences, Peter-Jordan-Straße 82, 1190 Vienna, Austria (Corresponding author Ulrike Raich. Tel.: +43-1-47654-5347; Fax: +43-1-47654-5344. E-Mail-address: Ulrike.Raich@boku.ac.at)

ABSTRACT

Electric mobility has a high acceptance among both, the population and political decision makers. However, it is rarely analyzed if this level of acceptance is justified in terms of the environmental and macroeconomic impacts of electric cars. Based on different assumptions of the market penetration of electric cars – gained by a stated-preference-survey based car market model – a cost-benefit- and a cost-effectiveness-analysis of electric mobility were conducted. A benefit surplus can be measured; that is for most parts due to environmental impacts.

Keywords: electric mobility, electric cars, macroeconomic assessment, cost-benefit-analysis

INTRODUCTION

The technical development of electric cars goes back to more than 130 years. It was pushed back by cars with internal combustion engines. Today, due to the challenges of climate change and the finiteness of fossil fuels, attention is drawn on electric mobility again.
Electric mobility is pushed in Europe by technological research promotion and economic incentives. Political background to this is to use the potential of electric propulsion in favour of a more sustainable and environmentally friendly transport system. As a result, dependency of mobility behaviour from fossil fuels is expected to decrease. According to national government plans electric cars shall step-by-step replace cars with internal combustion engines (Federal Government of Germany, 2009, Dorda, 2010). However, certain aspects of electric mobility are often unconsidered – this concern for example user needs and the overall assessments of electric mobility with regard to a macroeconomic perspective.
The research project "Smart Electric Mobility" (SEM, funded by The Austrian Climate and Energy Fund, funding programme New Energies 2020, 2009-2012) focused on the users' needs in terms of electric cars, users´ individual purchase and transport behaviour, deduced

the realistic future market penetration of electric cars and the assessment of macroeconomic aspects of electric mobility. The following describes the state of the art and own research with regard to the future market penetration of electric cars. Based on that electric cars are evaluated from a users' perspective and from an economic view.

FUTURE MARKET PENETRATION OF ELECTRIC CARS

Due to very low current sale figures of electric cars, hypothetical surveys with potential purchasers of electric cars are a promising approach. Today, the stated preference (SP) technique is widely used in travel behaviour research and an appropriate method to identify behavioural responses to choice decisions which are not revealed in the market (Axhausen & Sammer, 2001; Axhausen, 2003). In literature some stated preference studies can be found that reveal consumers' preferences with regard to the purchase of electric cars (e.g. Glerum et al. 2011, Dagsvik et al. 2002, Batley & Toner 2003, Achtnicht 2009). Often, the methodology applied is not disclosed in detail. Link et al. 2012 summarize some results of estimated market shares in literature (e.g. Berger 2009; Pfaffenbichler et al. 2009; Shell 2009):

Trend scenarios continue the current level of technological development. It is assumed that electric cars technology makes little or no progress, user costs hardly change, state subsidies for electric cars remain limited in amount and the fuel prices are rising in real terms or only weakly. As a result the new car market share of electric cars will remain in relatively small: from currently about 0.2% in Austria in 2011 (Statistik Austria 2011), it rises to a maximum of 1% in 2020 (Table I).

Table I: Trend scenarios for market development of electric cars 2020

New car share	Region	Scenario (condition) (excerpt)	Reference
< 1%	Austria	Low oil price, no electric car promotion	Haas et al. 2009
< 1%	FRG	Trend scenario	Shell 2009
0.4%	Austria	Basic szenario: Cost of electric cars come down by 4.7% p.a., cost of hybrid cars by 0.6 % p.a.	Pfaffenbichler et al. 2009

Several studies examine the impact of technological development of electric cars in terms of improving the technical characteristics of the vehicle (increasing the range, reducing the charging time, increase the maximum speed), and a reduction in user costs (running costs, purchase price, price for the battery lease). Depending on the scenario condition, the new car market share of electric cars increases significantly (Table II). The range of projected new car market share of electric cars varies between 3.3% (Shell 2009) for the market average up to 19% (Götz et al. 2011) for the sub-compact car segment.

Table II: Scenarios for the technological development 2020

New car share	Region	Scenario (condition) (excerpt)	Reference
3.3 %	FRG	alternative szenario (details unknown)	Shell 2009
5 %	Western Europe	Strong development of electric cars	Berger 2009
10 %	AUT	Basic szenario (table I) plus: Improving range and fuel efficiency of electric cars, loading points expansion, no state subsidies for electric cars	Pfaffenbichler et al. 2009
11.6 %	AUT	Basic szenario (table I) plus: Improving fuel efficiency of electric cars, no improving range efficiency, loading points expansion, state subsidies for electric cars	Pfaffenbichler et al. 2009
12 %	FRG	car segment medium sized, availability of all models provided	Götz et al. 2011
19 %	FRG	car segment small sized, availability of all models provided	Götz et al. 2011

Purchase premiums and higher fuel prices increase the new car market share of electric cars additionally. Götz et al. (2011) predicts for the year 2020 four percentage points more in the small car segment, if fuel price increases of 2.50 euros / liter. If fuel costs 3.00 euros / liter the new car market share of electric cars rise up to five percentage points more. Pfaffenbichler et al. (2009) investigate a scenario with a near doubling of fuel prices. Under this condition the new car market share of electric cars will rise to 24.7%. In the scenario with purchase premium of 10% of the purchase price, the new car market share of electric cars will increase by 3.3 percentage points (Pfaffenbichler et al. 2009).

Within the research project SEM the future market penetration of electric cars were investigated by a stated preference survey. The number of valid car purchase experiments is 1.850 conducted for 277 cars. Within each car purchase experiment the respondents were asked to choose between four alternatives: electric car, hybrid car, conventional car, and "none of these cars". The cars differ in up to seven characteristics (attributes): purchase price, range, CO_2 emission performance, engine power, time for charging/refueling, running costs (consumption, insurance, repair costs and taxes) per 100 km, running costs per year, lifetime costs (sum of purchase price and running costs for seven years). The possibility to reconsider the purchase decision was given. Based on the data of this stated preference survey a logistic transport model for individual purchase and transport behaviour was developed. The complex purchase demand model allows the estimation of the market share of electric cars in the new car market, depending on various factors.

METHOD OF ASSESSMENT

To assess the economic impacts of electric mobility, various evaluation scenarios were designed. The scenarios are described by several indicators like the technological development and several framework conditions (Link et al, 2012). In the different evaluation scenarios electric cars sales figures were forecasted; each of them is specified by given assumption concerning the technological development and the market availability of electric cars; some of the scenarios additionally include a buyer's premium for the purchase of electric cars or an intense increase of fuel prices (For a more detailed overview on the scenarios see Leitinger et al, 2011).
By varying the different indicators economic costs of electric mobility for the various evaluation scenarios can be shown. The results of the economic evaluation allow assessing measures described within the evaluation scenarios from an overall point of view. Recommendations to handle electric mobility can be derived. The analyses also demonstrate the effectiveness of greenhouse gas reduction measures with electric mobility; based on their results different approaches to limit GHG-emissions can be compared. Therefore the results are presented as:

- total amount of GHG-emissions saved,
- overall benefit-cost difference, and
- cost-effectiveness from a user's point of view.

All of these indicators are assessed for both,

- a reference scenario, and
- different evaluation scenarios.

While the first one describes a trend development in terms of both, the market penetration of electric cars as well as its impacts on mobility behaviour, the latter ones refer to a changed situation of an enhanced development of electric mobility. The resulting difference between a reference and an evaluation scenario represents the impact of the changed scenario settings.
Benefit-cost-analyses and cost-effectiveness-analyses are based on a value synthesis of different pecuniary and non-pecuniary cost and benefit elements; this includes various aspects of the mobility behaviour such as mileage, travel time and car purchase; further it refers to indicators such as emissions and energy consumption caused by mobility. It also takes into account the need for capital as well as environmental impacts; the selection of criteria for the assessment is based on the recommendations of the corresponding "Austrian guideline for cost-benefit-analysis to assess measures in road transport" (RVS 02.01.22) (BMVIT, 2002).
Within the analysis electric cars are assumed to correspond to conventional cars in terms of specific time costs, accident costs and costs due to traffic noise (Sammer, 2011a; Bickel et al, 2006; Helmers, 2010). A change from fossil fuel to electricity driven mobility is assumed to be a zero-sum game in terms of employment effects; thus those impacts were disregarded. The overall economic evaluation was carried out for Austria for the period between 2010 and 2025 in annual steps. Hybrid vehicles were not considered. Further assumptions concerns data on mobility behaviour in Austria including current (and future) mileage travelled, as well

as the future development of new passenger car sales figures (Herry, 2007; Snizek, 2010; BMVIT, 2009). In particular, the average yearly driving performance of electric cars was assumed to be below the average millage of conventional cars in Austria; depending on the range of electric cars within the scenarios It will account for 79% to 88% of the average driving performance of conventional cars. The Austrian standardized value of € 245 is taken as price of a ton of CO_2-emissions (Intraplan, 2006). Further traffic related emissions are valued according to the recommendations established by the "Austrian guideline for cost-benefit-analysis to assess measures in road transport" (RVS 02.01.22) (BMVIT, 2002). Home charging is considered to be the dominant charging possibility; average costs for installing a charging possibility at home are set to € 2,000; it will be fully financed by households on their own (Schuster, Leitinger, 2010).

EVALUATION SCENARIOS

The basic scenario refers to a mean technological development of electric cars. It is based on the following assumptions: electric cars of the compact class are available in the market in 2013, middle class vehicles starting in 2016. The range of electric cars will increase from 2010 to 2025 by 50%. The purchase price will decrease for 30 %. The base purchase price is 2.2 times the price of conventional cars. For these assumptions a share of electric cars on new cars market of 5.7% is predicted for 2025. This corresponds to a penetration of the Austrian vehicle fleet of slightly more than 2%. This is far below the expectations of the Austrian Federal Government in accordance with the "National Implementation Plan for Electric Mobility" (Dorda, 2010).
Several further scenarios are based on the same assumption concerning the technological development:

- Within the scenario of a low buyer`s premium of € 1,000 for electric car purchase the share of electric cars on new cars market is growing to 6.1%, while increases to 2.4% in total vehicle population in 2025.
- A high buyer`s premium of € 5000 has a higher impact. The percentage of electric cars on new cars market will almost be 8%, while its share on total vehicle population increases to 3.2% by the year 2025.
- Assuming a fossil fuel price increase by 50% affects the sales figures of electric cars. Their share on new cars market rises to 6.9%, within the total vehicle population to 2.6% by the year 2025.
- The scenario with a strong fossil fuel price increase of 150% reveals a higher market share: the share of electric cars on new cars market accounts for almost 11%; within the total vehicle population it rises to almost 4%. Thus, the aim of the Austrian federal government is almost reached.

For the sake of comparison also a scenario with a rough technological development was calculated. It includes a market availability of electric cars in the compact class starting in 2012, and within the medium sized cars from 2014 on. The range of electric cars doubles from 2010 to 2025, while the purchase price will decrease to 60% in 2025 compared to status quo. This scenario results for 2025 in a share of electric cars on new cars market of 13% and a share of below 5% of total vehicle fleet.

If technological development is almost absent, no buyer's premium for electric cars is paid, and fuel prices increase only slightly – in other words, the current situation maintains – electric cars remain a niche product.

The development of the new cars market share of the electric car until 2025 for several scenarios is shown in figure 1. Please note that new cars market share is presented and not the share in the vehicle fleet (this would be significant lower due to small replacement rates of vehicles). The high acceptance of electric cars that is shown in the quoted studies is not reflected by current sales figures. An overestimation of the market penetration can be laid back to methodological weaknesses of the research design applied: One major source of misjudgment could be the respondent's lack of awareness of travel behaviour restrictions caused by the purchase and use of electric cars.

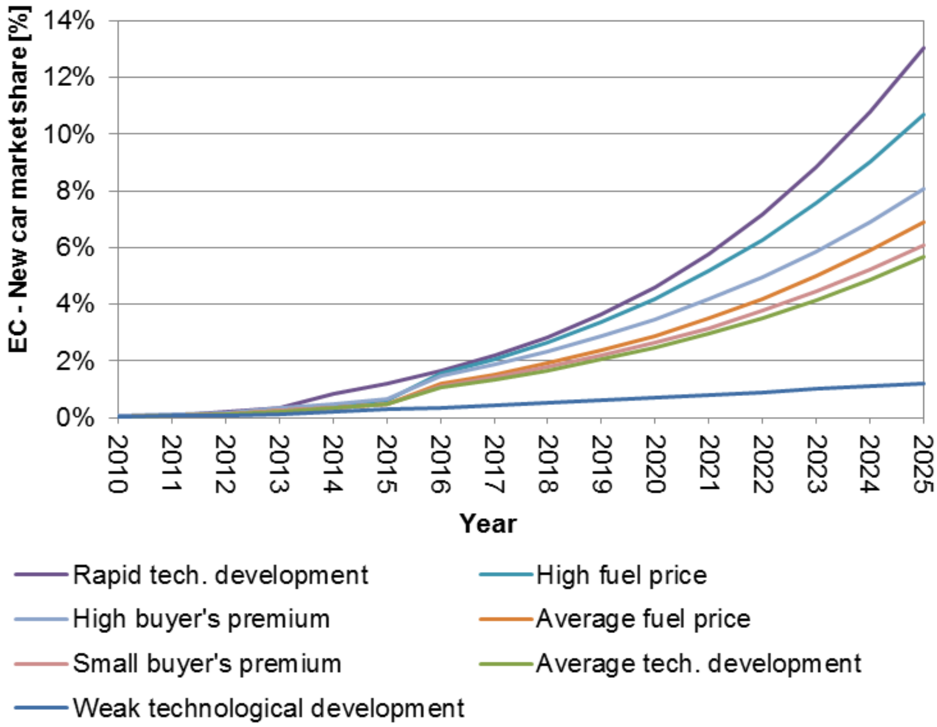

Figure 1: Electric cars' new market share of the electric car until 2025 under several conditions

Based on the results of the market penetration it could be derived, that expectations determined within the Austrian "National Electric Mobility Implementation Plan", regarding the development of electric cars can only be reached by a considerable acceleration of the technological development or a rough increase of fuel prices. This refers to an increase in fuel prices of 150% of current fuel price; this can be caused by both, financial policy measures such as a greenhouse gas emissions charge as well as increased production costs or fuel demand. Buyer's premium does not affect sales figures significantly, if it does not reach a considerable high of about € 5,000 per electric car. Such a promotion scheme is of course difficult to fund and to implement.

ELECTRIC MOBILITY FROM A USER'S PERSPECTIVE

To assess electric mobility, the knowledge of the users' needs is important. Main focus is on the revealing of purchase-relevant characteristics of electric cars; this is made under the consideration of the users' actual travel behaviour and car ownership. Therefore, an appropriate approach had to be developed allowing the modelling of purchase decisions under certain framework conditions.
As the questions of user needs in terms of electric mobility are very specific, an appropriate approach of data collection by use of interviews and GPS-records had to be developed and tested. A long term analysis was carried out with more than 30 car drivers in 2010.One central aspect within the research project SEM was the analysis of user needs in terms of electric cars. From the technological point of view electric cars offer restraints especially in terms of the driving range and charging time. In advance of a real-life purchase decision people would inform about these restrictions, reflect its impacts on their travel behaviour and draw their conclusions if applicable. This procedure often cannot be directly transferred to a survey situation. A discrepancy between the supposed behaviour in the survey and their real-life behaviour might follow. This can finally lead to an overestimation of the market potential. Within SEM a survey approach was developed that tries to make the respondents aware of the consequences of their hypothetical purchase decisions assuming that such a research design achieves more reliable estimates.

User costs consist of the purchase price, car operating costs, and costs for the charging infrastructure. As the longest car parking duration is reached for living and working places, these locations are the most important charging points for electric cars (Schuster, Leitinger, 2010). For the calculation, it was assumed that the charging structure at home will be fully financed by the users themselves and the cost of charging infrastructure in the workplace will be financed by employers.
According to this consideration, the mean value of user costs per vehicle-kilometer for conventional cars including taxes over the assessment period amounts for 0.38 € / km; if a fuel price increase of +50% is considered to 0.40 € / km, and with a high fuel price increase of +150% to 0.45 € / km. For electric cars, the effective cost vary between 0.35 € / km and 0.40 € / km in average; as the term “effective costs” suggests, these costs are based on the predicted vehicle fleet. They depend on the energy price level, the market penetration of electric cars in the categories analyzed, and the attributes of the purchased cars such as purchase price or energy consumption.
Within the scenarios, the market diffusion of electric cars per vehicle category differs. In all scenarios, the level of operating costs is initially very low, because only small cars with small equipment are available on the market. Depending on the scenario settings, cars in different vehicle categories (small cars, compact, middle, upper and special class) with more features enter the market. Purchase and usage of these electric vehicles affects the average operating costs changes.

RESULTS OF THE ANAYLSIS

Table I summarizes the difference of evaluation and reference scenarios in terms of benefit and cost components. Compared to the situation in the reference scenario, all evaluation scenarios provide a benefit surplus in terms of pollution and climate impacts. On the other side, investments for establishing the charging infrastructure will be expensive. Depending on the technological development assumed, vehicle operating costs are changing to a different degree.

As only charging infrastructure financed by private households is considered, and it is assumed, that each electric car needs an own home-charging facility, costs for establishing and operating private charging infrastructure is directly proportional to the penetration of electric cars. For conventional cars no investment costs were recognized as a private charging infrastructure is not needed. Thus, the corresponding costs are higher in scenarios with greater market penetration of electric cars.

Assuming an average technological development of electric cars, the analysis reveals a cost surplus regarding vehicle operating costs compared to the reference scenario. This is caused by the higher amount of money spend for electric cars purchases; although both, electric cars purchase price and energy consumption decreases as consequence of the technological development, the product of lower purchase price and higher market share results in higher absolute costs. The cost surplus is even higher, if a buyer's premium is considered; while the average purchase prices of electric cars is still higher, more electric cars are purchased. As a result the vehicle operating costs increase.

In case of an accelerated technological development, both, purchase costs per car decrease to a level above the comparable costs for conventional cars. However, purchase prices decrease in such an extent that they – in combination with the lower energy consumption – overcompensate the effect of additional electric car sales.

Vehicle operating costs are roughly affected by fuel costs. From an overall economic point of view it is essential, if the increase is driven by a governmental intervention or by the market. Increasing fuel prices due to a financial policy such as a greenhouse gas emission charge will cause public revenues since car users pay the costs or avoid them by adapting their mobility behaviour; while the savings do not become economically effective, the charge transfer is forwarded by the users to public authorities. Thus it is not relevant from an economic point of view as income and expenditure are equal. The last statement does not apply to increasing prices evoked by production costs or the demand for fuel.

We compared the hypothetic situation of a higher fuel price for both, a situation with and without electric mobility. In this situation, the reason for the fuel price increase is also highly relevant for the overall economic evaluation. If the fuel price level is an effect of the market, both fuel saving mobility behaviour as well as the purchase of low-consumption cars evoke a benefit surplus; this is due to the fact, that private costs are saved. In the situation of an increased fuel price caused by a policy measure, the cost saving is equivalent to an income loss of public budgets. Thus, costs are equal to a benefit.

The higher the share of electric cars, the greater the environmental benefit. Pollutant and climate costs increase with increasing mileage driven by conventional cars and inversely decrease with increasing market penetration and performance of electric cars. The benefits of electric vehicles gained from the climate component are higher than from the other emissions. However, it is important to note that this result is strongly influenced by the primary energy source used. It has to be taken into account that our results build on the Austrian average primary energy mix with its high share of environmentally friendly hydropower (Ökostrombericht, 2011). If the share of fossil energy sources on total energy production is higher, the cost benefit of electric mobility decreases.

Table III – Overall economic evaluation components [Mio. Euro] (TE - technological development of electric cars).

	costs for charging infrastructure[1]	**vehicle operating costs**[2]	**emission costs**	**climate cost**
	[Mio. €/(2010-2025)]			
Cost of evaluation scenarios to determine the effects of different technological development minus those of the reference scenario "update actual condition"				
average technological development of electric cars	-15,4	-47,0	27,3	61,2
strong technological development of electric cars	-35,7	11,0	69,0	169,3
Cost of evaluation scenarios to determine the effects of different buyer`s premium minus those of the reference scenario "no purchase bonus update actual condition"				
low buyer`s premium, average TE	-17,0	-50,8	29,8	66,9
high buyer`s premium, average TE	-24,7	-69,5	42,3	94,8
Cost of evaluation scenarios to determine the effects of different types of fuel price increases (increase of production costs or increase taxes on) minus those of the reference scenario moderate or severe fuel price increase				
moderate fuel price increase of product price, average TE	-19,0	0,6	33,9	76,1
strong fuel price increase of product price, average TE	-30,2	225,7	54,5	122,4
moderate fuel price increase due to taxes, average TE	-19,0	-28,1	33,9	76,1
strong fuel price increase due to taxes, average TE	-30,2	-45,2	54,5	122,4

[1] Investment costs including financing costs, re-investment, operating and maintenance costs for the creation of charging infrastructure;
[2] all vehicle user costs

From a macroeconomic perspective, the economic benefit of electric vehicles is clearly positive. For the most part this is a result of the reduction of exhaust emissions and greenhouse gases. In particular, the absolute overall economic benefit is high for both, a rapid technological development of electric vehicles as well as a high fuel price increases due to rising production costs or increasing demand.

Assuming an average technological development, which is supposed to be very likely, the overall economic benefits can be maximized primarily by higher fuel prices. If these revenues are earmarked to promote the research on electric cars, synergy effects might be achieved by accelerating the technological development.

There are clear differences in the various scenarios: The greatest advantage emerges from saving fuel costs if fuel costs increase and drivers switch to electric mobility. Also a high level of technological development of electric mobility brings high use. A buyer`s premium is less effective.

COST-EFFECTIVENESS OF REDUCING GREENHOUSE GASES BY ELECTRIC MOBILITY

The cost effectiveness of greenhouse gas reductions by electric mobility can be clearly shown, if the benefits derived from the saving of one ton of GHG-emissions are compared with other measures to limit GHG-emissions. As cost elements both, vehicle operating costs and costs for charging infrastructure are considered. They are set into relation to the amount of CO_2-emissions saved.

One benchmark for the cost-effectiveness can be the price of a certificate traded on the EU Emission Trading Scheme (EU ETS). Such a certificate allows emitting a ton of CO_2-emissions; if the benefit is higher than the corresponding price of currently approximately € 14 per ton CO_2-emissions electric mobility makes sense in an economic perspective. Another possibility is to compare the damage cost of a ton of CO_2-emissions. The benefits of GHG-emissions reduction by electric mobility have a value greater than the damage cost of about € 245 per ton of CO_2 emission in all the scenarios. Therefore, electric mobility is positive from a macroeconomic point of view.

COST EFFECTIVENESS PER KILOMETER TRAVELED USING ELECTRIC CARS

The total economic cost-effectiveness per kilometer traveled by electric cars shows the same result as before: rising demand for electric cars leads to a higher benefit of the electric car distance traveled. Depending on the scenario the overall economic benefits varies of 0.6 to 4.7 Euro-Cent/km when the scenario is compared to the reference case. This corresponds to a factor of almost 8. This leads to the same conclusion as before: under certain conditions electric mobility can be very efficient. This includes a significant acceleration of technological progress, and a strong increase in the fuel price. However, the comparison of the benefits of electric vehicles to the official mileage, the advantage of electric vehicles is low.

CONCLUSIONS

From a macroeconomic perspective, the benefits of electric cars are clearly positive: The benefit is mainly due to the reduction of exhaust emissions and greenhouse gases by a less number of trips made with conventional cars. The calculations of the benefits reveal a strong dependence of the technology development of electric vehicles respectively of the fuel price. Higher benefits due to electric mobility requires much more government funding and / or the implementation of a significant increase in the cost of car use as possible by a CO_2 charge or a road user tax for cars with internal combustion engines.

The ambitious objectives for market penetration of electric cars of the Austrian Federal Government in accordance with the "National Adoption Plan for Electric Mobility" can only be achieved with a currently unforeseeable acceleration of technological development or by an intense increase of fuel price. Lower operating costs below the level of conventional cars can only be gained with a high buyer`s premium of at least € 5,000 and / or heavy fuel price increases of more than 150 % compared to 2010.

LITERATUR

Achtnicht, M. (2009): German Car Buyers' Willingness to Pay to Reduce CO_2 Emissions, Zentrum für Europäische Wirtschaftsforschung, Mannheim.

Axhausen, K. and G. Sammer (2001): Hypothetische Märkte als Befragungsthema, In: Internationales Verkehrswesen, Nr. 6, Vol. 53, pp. 274-278, Deutsche Verkehrs-Verlags GmbH, Hamburg.

Axhausen, K. (2003): Befragungsmethoden für hypothetische Märkte, In: H.-D. K. G. Steierwald, Stadtverkehrsplanung. Heidelberg: Springer.

Batley, R. and J. Toner (2003): Hierarchical Elimanation-by-Aspects and Nested Logit Models of Stated Preferences for Alternative Fuel Vehicles, Association of European Transport Conference October 2003, Strassburg.

Roland Berger Consultants (Ed.) (2009): Powertrain 2020 - China's ambition to become market leader in E-Vehicles, URL: http://www.rolandberger.de/media/pdf/Roland_Berger_Powertrain_China_20090512.pdf (06.09.2012).

Bickel, P., N. Sieber, G. Arampatzis, R. Esposito, P. Fagiani, A. Hunt, C. Kelly, J. Laird, T. Odgaard and A. Ricci (2006): HEATCO - Developing Harmonised European Approaches for Transport Costing and Project Assessment, Sixth Framework Programme 2002 – 2006, FP6-2002-SSp-1/502481. Institut für Energiewirtschaft und Rationelle Energieanwendung, Universität Stuttgart.

Bundesministerium für Verkehr, Innovation und Technologie (Hrsg.) (2009): Verkehrsprognose Österreich 2025+. Wien.

Bundesregierung Deutschland (2009): Nationaler Entwicklungsplan Elektromobilität der Bundesregierung, Berlin.

Bundesministerium für Wirtschaft, Familie und Jugend (2011): Ökostrombericht 2011. Wien.

Dagsvik J., T. Wennemo, D. Wetterwald and R. Aaberge (2002): Potential demand for alternative fuel vehicles, Transport Research, Elsevier Science Ltd. Oslo.

Dorda, A. (2010): Nationaler Einführungsplan Elektromobilität Österreich. Strategie und Instrumente sowie prioritäre Anwender- und Einsatzbereiche. URL: http://www.bmvit.gv.at/innovation/downloads/einfuehrungsplan_elektromobilitaet.pdf (09.03.2011).

Forschungsgesellschaft für das Verkehrs- und Straßenwesen (2002): Nutzen-Kosten-Untersuchungen im Verkehrswesen, RVS 02.01.22. Wien.

Glerum, A., M. Thémans, and M. Bierlaire, (2011): Modeling demand for electric vehicles: the effect of car users' attitudes and perceptions, Second International Choice Modeling Conference July 2011, Lausanne.

Götz, K., G. Sunderer, B. Birzle-Harder and J. Deffner (2011): Attraktivität und Akzeptanz von Elektroautos. Arbeitspaket 1 des Projekts OPTUM: Optimierung der Umweltentlastungspotenziale von Elektrofahrzeugen: ISOE – Institut für sozial-ökologische Forschung, Frankfurt am Main.

Haas, R., M. Kloess, K. Könighofer, L. Canella, G. Jungmeier, P. Prenninger and A. Weichbold (2009): ELEKTRA. Entwicklung von Szenarien der Verbreitung von PKW mit teil- und voll-elektrifiziertem Antriebsstrang unter verschiedenen politischen Rahmenbedingungen. Technische Universität Wien, Wien.

Helmers, E. (2010): Bewertung der Umwelteffizienz moderner Autoantriebe - auf dem Weg vom Diesel-Pkw-Boom zu Elektroautos. In: Umweltwissenschaften und Schadstoff-Forschung, Nr. 22, pp. 564-578, Springer, Bundesanstalt für Straßenwesen (BASt), Bergisch Gladbach.

Herry, M. (2007): Verkehr in Zahlen. Bundesministerium für Verkehr, Innovation und Technologie. Wien.

Intraplan Consult GmbH, Verkehrswissenschaftliches Institut Stuttgart GmbH (2006): Standardisierte Bewertung von Verkehrswegeinvestitionen des öffentlichen Personennahverkehrs. Im Auftrag des Bundesministers für Verkehr, Bau und Stadtentwicklung. München und Stuttgart.

Leitinger, C., M. Litzlbauer, A. Schuster, G. Brauner, D. Simic, G. Hiller, T. Bäuml, C. Link, U. Raich, G. Sammer and J. Stark (2011): SMART-ELECTRIC-MOBILITY - Speichereinsatz für regenerative elektrische Mobilität und Netzstabilität (Endbericht), Klima-, Energiefonds (Neue Energien 2020 – 2. Ausschreibung), 209.

Link, C., U. Raich, G. Sammer and J. Stark (2012): Modeling Demand for Electric Cars - A Methodical Approach. In: Procedia: Social and Behavioral Sciences, 48/2012, pp. 1958-1970, Elsevier Ltd. Selection.

Pfaffenbichler, P. B. Emmerling, R. Jellinek and R. Krutak (2009): Pre-Feasibility-Studie zu „Markteinführung Elektromobilität in Österreich“, final report. Österreichische Energieagentur – Austrian Energy Agency (Ed.), Wien.

Sammer, G., D. Meth and C. Gruber (2008): Elektromobilität - Die Sicht der Nutzer. In: Elektrotechnik und Informationstechnik, 11/2008, pp. 393-399, Springer, Wien.

Sammer, G. and R. Klementschitz (2011a): Rankingmodell zur Evaluierung und Förderung von Umweltverbundmaßnahmen. Vorschlag eines Bewertungsverfahrens. Wien.

Sammer, G., J. Stark and C. Link (2011b): Das gesamtwirtschaftliche Bewertungsverfahren. In: Elektrotechnik & Informationstechnik, 1-2/2011, pp. 22-27, Springer, Wien.

Schuster, A. and C. Leitinger (2010): Wissenschaftliche Begleitforschung in der Elektromobilitäts-Region VLOTTE, TU Wien.

Shell Deutschland Oil GmbH (2009): Shell PKW-Szenarien bis 2030. Fakten, Trends und Handlungsoptionen für nachhaltige Auto-Mobilität, Hamburg: Shell Deutschland Oil GmbH.

Snizek+Partner Verkehrsplanung (2010): S1 Wiener Außenring Schnellstraße Schwechat-Süßenbrunn. Im Auftrag von Asfinag Bau Mangagement, Wien.

Statistik Austria (2011): Kfz-Zulassungen 2010. Wien. URL: http://www.statistik.at/web_de/statistiken/verkehr/strasse/kraftfahrzeuge_-_neuzulassungen/index.html (22.04.2011)