FACT SHEET NO.: 7 / 2 **PERFORMED BY: PRO**

A GENERAL INFORMATION

A 1	**Category**	**Research and Innovation**
A 2	**Subcategory**	**Technology - transport infrastructure / system**
A 3	**Transport policy measure (TPM)**	**Technological improvements regarding e-mobility charging systems**
A 4	**Description of TPM**	The TPM 'Technological improvements regarding e-mobility charging systems' covers the development of charging systems for electric road vehicles. Technological improvements on charging systems are expected to increase the efficiency, reliability and uniformity of charging E-mobility transport. Public and governmental investments will directly lead to more research effort concerning E-mobility charging systems and indirectly, on the long run, result in a rise of the number of efficient E-mobility charging stations. Increasing the amount of efficient E-mobility charging systems is of general importance for widespread acceptance of electric vehicles. Therefore, governments and the European Union try to increase the number of charging stations. At first, the increase of charging systems will focus on urban areas (with a comparably high population density). Improvements on E-mobility charging systems will have effects on private passenger road vehicles, public transport vehicles (buses and coaches) as well as for road freight vehicles. However, long-haul trucks propulsions are expected to remain on internal combustion engines (ICE) for the foreseeable future. [1] This impact assessment focusses on the influences of improvements of e-mobility charging system for private and light commercial road vehicles.
A 5	**Implementation examples**	Standardised charging interface: A mandate for European standardisation bodies will be set in 2010 to develop a standard by 2011 within the framework of Directive 98/34EC. The aim of this directive is to standardise charging infrastructure in order to ensure interoperability and connectivity between the electricity supply point and the charger of the electric vehicle. Smart charging and the possibility for users to take advantage of the use of electricity during "off peak hours" needs to be considered in standardisation. [5] The European automobile manufacturers have defined joint specifications to connect electrically chargeable vehicles to the electricity grid in a safe and user-friendly way. These recommendations should enable the relevant EU standardisation bodies to make rapid progress with defining a common interface between the electricity infrastructure and vehicles throughout Europe. [14] Unfortunately, until now an universal charging solution has not been defined.
A 6	**Objectives of TPM**	The objective is to improve the efficiency, reliability and uniformity of E-mobility charging systems in order to accelerate the expansion of electric vehicles, which means: - Reduce the charging time of E-Mobility charging systems - Improve the reliability of charging systems - Infrastructure must be compatible with vehicles produced by various manufacturers or the development of one matching charging system for all types of vehicles - 'Smart charging' i.e. Bidirectional charging systems (vehicle to grid) instead of unidirectional [4] Combined with these technical improvements, governments will increase the number of charging stations in order to: - Increase travel distance by expanding the network of charging stations - Boost the attraction and acceptance of electric cars [2]
A 7	**Key changes concerning:**	
A 7.1	- Choice of transport mode / Multimodality:	No key changes can be expected, because the impact of better charging systems can not solely improve the attractiveness of electric vehicles.
A 7.2	- Origin and/or destination of trip:	Will be adjusted according to the availability of charging systems, which at first will be placed at densed areas within the city center. [1]
A 7.3	- Trip frequency:	Increasing number of trips with electric vehicles possible due to faster charging
A 7.4	- Choice of route:	According to the availability of charging systems
A 7.5	- Timing (day, hour):	Charging times have to be adjusted to grid capacity i.e. charging will take place outside peak energy demand times. Timing becomes more important with an increasing share of electric vehicles. Preffered charging times are during low energy consumption, for instance at night. Later on, with the development of smart grids, a surplus of energy in the battery of electric cars can be used to supply energy to households in order to prevent power grids from overloading. [2]
A 7.6	- Occupancy rate / Loading factor:	No changes
A 7.7	- Energy efficiency / Energy usage:	Further development necessary to fasten charging times without limiting the durability of electric vehicles batteries. Increased energy efficiency is expected to be reached through development of new charging systems. [3]
A 8	**Main source**	[1], [2], [3], [4], [5]

B IMPACTS

B 1 OVERVIEW ON IMPACTS

		AFFECTED SEGMENTS															Geographical level		Source	
		Passengers					Transport operators													
		Road	Rail	Air	Public transport	Slow modes	Road	Rail	IWW	Air	Maritime	Public transport	Employees in transport	Residents	Economy	Public bodies	Society	1st level	2nd level	Source of assessment	Spatial level of source
B 1.1	**Summary**																				

- The electric car user will benefit from the technical improvements and increasing number of charging stations. An extensive network of charging stations offers electric car users the possibility to make longer trips without changing batteries. Other technical improvements concerning electric vehicles, like batteries which offers an increased driving range, will reinforce the possibility to make longer trips.
- Industries which deliver traditional equipment for gas stations can suffer losses (turn over and employment) due to rising demands for E-mobility charging station and decreasing demand for petrol pumps. But a rising demand for E-mobility charging systems offer opportunities for new enterprises and will lead to a whole new market (for the traditional petrol station industry). [11]
- In the beginning, charging systems will be located at urban areas, whereas rural/peripheral areas will be neglected. This spatial difference will increase inequality between urban and rural areas and is contrary to the cohesion policy of the European Union, which aims to decrease difference between urban and peripheral areas.
- The reduction of air pollutions is beneficial for residents living near busy motorways, the society and the climate at all. In general, the level of air pollutants depends on the production of the electric energy, which depends on the energy mix used (nevertheless the electricity mix also varies widely depending on geography, time of day and season). [7]
- Further effects strongly depend on the electric vehicle as such, and not particulary to the charging systems.
- Uncontrolled charging can significantly increase peak load and thus lead to a high cost burden. If uncontrolled EV (Electric Vehicle) charging is added to the system, this can have a strong negative effect on the grid system, which is not designed (capacity wise) for enormous amounts of electric vehicles. This will require substantial investments of public bodies in power grids [10]

B 1.2	**Summary: Income groups**	- Growing social disparities between urban and rural areas and its inhabitants. Strong economic regions (cities) will become more attractive compared to rural areas.
B 1.3	**Summary: Age groups**	
B 1.4	**Summary: Disabled people**	
B 1.5	**Summary: Gender groups**	
B 1.6	**Summary: Ethnic groups**	

B 2 TRAFFIC IMPACTS

		AFFECTED SEGMENTS															Geographical level		Source	
		Passengers					Transport operators													
		Road	Rail	Air	Public transport	Slow modes	Road	Rail	IWW	Air	Maritime	Public transport	Employees in transport	Residents	Economy	Public bodies	Society	1st level	2nd level	Source of assessment	Spatial level of source
B 2.1	Travel or transport time	↘																R	N	S	I
B 2.2	Risk of congestion																				
B 2.3	Vehicle mileage	↗																R	N	E	
B 2.4	Service and comfort	↗																R	N	S	I

B 2.I	**Overall impacts on social groups**	
B 2.II	**Implementation phase**	- The shift to electric vehicles can only be expected when electric vehicles will increase their attractiveness significantly (driving range, price, reliability). The solely improvement of charging possibilities is not sufficient to generate a shift from combustion engines to electric cars. - Furthermore, research determined that only fuel consumption or environmental friendliness of cars is not important to consumers when purchasing a new car. [13]
B 2.III	**Operation phase**	
B 2.IV	**Summary / comments concerning the main impacts**	- If new technological improvements lead to a shorter charging time (and thus a shorter travel time), without effecting the durability of batteries, it will improve the reputation of electric vehicles and lead to a rise of the number of electric vehicles. [2] - Service and comfort improvements through faster charging systems. [1] - Vehicle milage for electric vehicles increases according to the number of charging possibilities.
B 2.V	**Quantification of impacts**	

B 3	ECONOMIC IMPACTS	AFFECTED SEGMENTS																Geographical level		Source	
		Passengers					Transport operators														
		Road	Rail	Air	Public transport	Slow modes	Road	Rail	IWW	Air	Maritime	Public transport	**Employees in transport**	**Residents**	**Economy**	**Public bodies**	**Society**	1st level	2nd level	Source of assessment	Spatial level of source
B 3.1	Transport costs																				
B 3.2	Private income / commercial turn over												↗					N	R	S	I
B 3.3	Revenues in the transport sector																				
B 3.4	Sectoral competitiveness						↗											N	I	E	
B 3.5	Spatial competitiveness																↗	R	N	E	
B 3.6	Housing expenditures																				
B 3.7	Insurance costs																				
B 3.8	Health service costs																				
B 3.9	Public authorities & adm. burdens on businesses															↘		N	R	S	I
B 3.10	Public income (e.g.: taxes, charges)															↘		N		E	
B 3.11	Third countries and international relations																				
B 3.I	**Overall impacts on social groups**																				
B 3.II	**Implementation phase**																				
B 3.III	**Operation phase**																				
B 3.IV	**Summary / comments concerning the main impacts**	- Uncontrolled charging demand can significantly increase peak load and thus lead to a high cost burden. If uncontrolled EV (Electric Vehicle) charging is added to the system, this can have a strong negative effect on the grid system, which (capacity) is not designed for enormous amounts of electric vehicles. This will require substantial investments in power grids by public bodies. [10] - The implementation of bidirectional charging systems can ease the pressure of power grids during peak demands. In order to use this technology, public bodies are forced to invest in 'smart grids', which can handle the bidirectional energy flows. [6] - Mainly rural areas, which are not equipped with E-Mobility charging systems due to efficiency reasons (lower demand) face proper disadvantages compared to urban areas with a high population density. This will lead to increasing spatial competition between urban and peripheral areas and growing disparities between economically strong (mostly suburban) and weak regions (mostly rural and sparsely populated areas). - Sectoral competitiveness between transport operators / producers using traditional vehicles and ones using electric vehicles will increase. Electric vehicles will become more favorable compared to traditional petrol and diesel vehicles. - 3rd level impact: Energy efficient vehicles will require less fuel. This will lead to reduced public income for public bodies, because these receive excise taxes on petrol.																		
B 3.V	**Quantification of impacts**																				

B 4	SOCIAL IMPACTS	AFFECTED SEGMENTS																Geographical level		Source	
		Passengers					Transport operators														
		Road	Rail	Air	Public transport	Slow modes	Road	Rail	IWW	Air	Maritime	Public transport	**Employees in transport**	**Residents**	**Economy**	**Public bodies**	**Society**	1st level	2nd level	Source of assessment	Spatial level of source
B 4.1	Health (incl. well-being)																				
B 4.2	Safety																				
B 4.3	Crime, terrorism and security																				
B 4.4	Accessibility of transport systems	↗																R	N	S	I
B 4.5	Social inclusion, equality & opportunities																↘	R	N	E	
B 4.6	Standards and rights (related to job quality)																				
B 4.7	Employment and labour markets														→			N	I	S	N
B 4.8	Cultural heritage / culture																				
B 4.I	**Overall impacts on social groups**	- Growing social disparities between (sub-)urban and rural areas and its inhabitants. Strong economic regions will become more attractive compared to rural / sparsely populated areas, which will be excluded from the possibility to participate.																			
B 4.II	**Implementation phase**																				
B 4.III	**Operation phase**																				
B 4.IV	**Summary / comments concerning the main impacts**	- Increasing funds fostering E-mobility charging systems will lead to more employment for companies involved in electric vehicles or charging systems. Due to the strengthened research and innovation industry (through governmental funding), a positive effect on the labour market is expected. Nevertheless, this depends on whether the rise of electric vehicle demand affects the traditional petrol and gas industry. [11] - Governments will stimulate the placement of charing stations which will lead to two main effects : 1. Social inequality will grow between urban and peripheral areas (charging stations will be mainly placed in areas with a high population density).[1] 2. The electric car user will benefit and will have more charging opportunities and increase the driving range (not because of better battery performance, but because of the possibility to charge countrywide in short time). [1]																		
B 4.V	**Quantification of impacts**																				

B 5	ENVIRONMENTAL IMPACTS	AFFECTED SEGMENTS																Geographical level		Source	
		Passengers					Transport operators														
		Road	Rail	Air	Public transport	Slow modes	Road	Rail	IWW	Air	Maritime	Public transport	**Employees in transport**	**Residents**	**Economy**	**Public bodies**	**Society**	1st level	2nd level	Source of assessment	Spatial level of source
B 5.1	Air pollutants													↘			↘	L	N	S	I
B 5.2	Noise emissions													↘			↘	L	N	S	I
B 5.3	Visual quality of the landscape																↘	N	R	S	N
B 5.4	Land use																↗	N	R	S	N
B 5.5	Climate																↘	I		S	I
B 5.6	Renewable or non-renewable resources																↗	I		S	I
B 5.I	**Overall impacts on social groups**																				
B 5.II	**Implementation phase**																				
B 5.III	**Operation phase**																				
B 5.IV	**Summary / comments concerning the main impacts**	- **In general, the implementation of new technologies for charging systems will have an (both positive as negative) impact on the environment when it is combined with an increased usage of electric vehicles. Which means:** - The reduction of air pollutions and noise emissions is only on the local level (concerning residents) unambiguous. In general, the level of air pollutants depends on the production of the electric energy, which depends on the energy mix used (nevertheless the electricity mix also varies widely depending on geography, time of day and season). Hence, the emission of CO2 of a electric vehicle depends on the source of energy, which do not emit NOx and PM. Especially in urban areas with a high population density this reduced emissions have a strong impact. [7] Overall, the energy is at least partly produced by renewable energy sources, which result is a reduction of air pollutants positively affecting the climate. - Negative local environmental impacts are expected by the large-scale production of lithium for the lithium-ion batteries, because parts of the battery are extremely toxic.[7] - Depending on the source of energy, the energy production can also have a negative effect on land use (coal) and produce radioactive waste (nuclear power plants). [8] - Reduced oil consumption strengthens the energy security [9] - A widespread use of electric vehicles (> 10 % market share) will lead to a significant increase of energy demand. The current power grids will have to be expanded to meet the higher demand. Expansion of power grids will cause a negative impact on the visual quality of the landscape and demand extra land use [12].																		
B 5.V	**Quantification of impacts**	- Total CO2 emissions: Conventional ICE (Internal Combustion Engines) car: 145-215 g/km; Electric Vehicle (depending on the source of energy): 8-140g/km. CO2 in g/km/NEDC WTW (NEDC: New European Driving Cycle; WTW: Well-to-Wheel) [1] - The difference of well-to-wheel (energy consumption from feedstock to energy transimission) GHG emissions of electric (EV) and plug-in hybrid vehicles (PHEV) and their benefits compared to average conventional vehicles (CV) strongly depends on the considered energy mix assumptions, the benefit ranges from -38% (coal based energy production) to +81%. [7]																		

C REFERENCES

C 1	**Other TPMs of this subcategory**	GALILEO
C 2	**References**	**International** [1] European Commission (2011): European Green Cars Initiative: public-private partnership multi-annual roadmap and long-term strategy, Luxembourg: Publications Office of the European Union [3] European Commission (2010): Challenges for European Market for Electric Vehicles, Brussels: Policy Department Economic and Scientific Policy [4] European Commission (2010): European Green Cars initiative: European Roadmap Electrification of Road Transport, Luxembourg: Publications Office of the European Union [5] European Commission (2011): 2010-2013 Action Plan for European Standardisation, Luxembourg: Publications Office of the European Union [6] CE Delft (2011): Impact analysis for market uptake scenarios and policy implications, Delft: CE -publications [7] Hacker et al (2009): Environmental impacts and impact on the electricity market of a large scale introduction of electric cars in Europe - Critical Review of Literature, ETC/ACC Technical Paper 2009/4 [8] Althaus, Gauch (2010): Vergleichende Ökobilanz individueller Mobilität: Elektromobilität versus konventionelle Mobilität mit Bio- und fossilen Treibstoffen, Life Cycle Assessment and Modelling Group, Technologie und Gesellschaft, Empa, Dübendorf [10] CE Delft (2011): Impacts of Electric Vehicles, Delft: CE-Publications [14] ACEA (2010): Auto manufacturers agree on specifications to connect electrically chargeable vehicles to the electricity grid, available at: http://www.acea.be/index.php/news/news_detail/auto_manufacturers_agree_on_specifications_to_connect_electrically_chargeab **National** [2] German Federal Government (2009): German Federal Government's National Electromobility Development Plan [9] Bickert, Kuckshinrichs (2011); Electromobility as a technical concept in an ecological mobility sector? An analysis of costs; 9th International Conference of the European Society for Ecological Economics (ESEE 2011): Advancing Ecological Economics - Theory and Practice June 14–17, 2011, Boğaziçi University, Istanbul, Turkey [11] Draper, M., et al. (2008): Economic Impact of Electric Vehicle Adoption in the United States, California: U.C. Berkeley [12] Nationale Plattform Elektromobilität (2010): Zwischenbericht der Arbeitsgruppe 3 - Lade-Infrastruktur und Netzintegration, Berlin: Gemeinsame Geschäftsstelle Elektromobilität der Bundesregierung (GGEMO) [13] ADAC (2012): ADAC Pkw-Monitor: Was entscheidet beim Autokauf? Berlin: ADAC/Auto-Reporter.NET