FACT SHEET NO.: 7 / 1 **PERFORMED BY: ISI**

A GENERAL INFORMATION

A 1	**Category**	**Research and Innovation**
A 2	**Subcategory**	**Technology - vehicle**
A 3	**Transport policy measure (TPM)**	**H2 Fuel Cell Vehicles (H2-FCV)**
A 4	**Description of TPM**	Development and market introduction of road vehicles propelled by hydrogen (H2) as energy carrier by converting the H2 in fuel cells into electric energy that drive electric motors is covered by the 'H2 Fuel Cell Vehicles' TPM. Similar as with battery electric vehicles (BEV) the H2-FCV provide the opportunity of road transport to eliminate emissions of local air pollutants and significantly reduce noise emissions. If hydrogen is produced from electricity that in turn is produced from renewable electricity sources H2-FCVs also constitute an option for carbon-free transport. The latter would also reduce fossil energy consumption, thus reducing fossil energy imports and increasing energy security of the EU. However, besides surplus hydrogen from industrial processes the cheapest source of H2 would be from fossil gas, such that pure market forces would lead to usage of hydrogen still based on carbon, i.e. still causing CO2 emissions. Obstacles for market introduction of H2-FCV include the high cost of vehicles, in particular caused by the cost of the hydrogen fuel cell (HFC) and the lack of sufficient refuelling infrastructure for H2. Therefore a TPM 'H2 Fuel Cell Vehicles' involves a bundle of measures to foster R&D as well as to set the right incentives for market introduction at the right point of time.
A 5	**Implementation examples**	At the end of 2007 1.000 fuel cell cars were operated globally. The number of H2 fuelling stations at the end of 2008 amounted to 200 [1]. In the 1990s roadmaps existed in which car manufacturers like Daimler and Toyota had announced to commercialise H2-FCVs by 2004. This date of market introduction was later shifted to 2009 with a target of an annual production of 100.000 H2-FCVs in 2014 by Daimler. In 2013 the large scale production of H2-FCVs was postponed again to the year 2017. This shifting agenda reveals that there exist significant barriers to market ramp-up of H2-FCVs. Until the end of 2012 any of such vehicles in use, i.e. cars and buses, were or are part of a demonstration project or a field test. Examples are: (1) The municipality of London developed a Hydrogen Action Plan in 2009 according to which 150 H2-FCVs and 6 H2 refeulling stations should be deployed until the end of 2012 [9]. The targets have not been fully met, but moderate progress has been made. (2) Industry and the European Commission have jointly set-up the Fuel Cells and Hydrogen Joint Technology Initiative (JTI) which prepared and was converted into the Fuel Cells and Hydrogen Joint Undertaking (FCH-JU) [2]. For the period 2008 to 2013 the JTI/JU disposed of a budget of 1 billion Euro to implement R&D and demonstration projects for both stationary and mobile application of HFC. For the period 2014 to 2020 the FCH-JU estimates to increase the budget for HFC deployment to about 18 billion Euro, of which up to 14 billion Euro should be provided by the industry and about 12 billion Euro should go to transport projects. A variety of projects is currently funded e.g. adding hydrogen supplies to existing fuel stations in Oslo (H2MOVES), putting 26 HFC buses into operation (CHIC) or testing HFC in mail delivery fleets (MOBYPOST) [6]. (3) Activities to deploy hydrogen fuelling infrastructure from the year 2015 onwards are bundled in two national H2-mobility groupings in Germany and the UK. Final remark: application of HFC is also discussed and feasible for stationary applications, as well as for other modes than road. **However, this TPM focussed on road mode.**
A 6	**Objectives of TPM**	Fostering and deployment of H2-FCVs in the European transport system to reduce (urban) air pollution and noise, increase energy security, reduce fossil fuel dependency, reduce GHG emissions of transport and increase competitiveness and leadership of the European industry.
A 7	**Key changes concerning:**	
A 7.1	- Choice of transport mode / Multimodality:	Modal-shift is not objective of the TPM. However, limited modal-shift may occur if relative cost of modes is altered by introducing H2-FCV.
A 7.2	- Origin and/or destination of trip:	No change
A 7.3	- Trip frequency:	No change
A 7.4	- Choice of route:	Potential change during phases of limited spatial coverage of H2 fuelling stations to reach one of the few stations. Otherwise no change.
A 7.5	- Timing (day, hour):	No change
A 7.6	- Occupancy rate / Loading factor:	No change
A 7.7	- Energy efficiency / Energy usage:	HFC may slightly improve energy efficiency as compared with fossil fuel driven vehicles. More important is that they enable to reduce fossil fuel consumption in transport and to increase the share of renewable fuel / low carbon fuel in transport.
A 8	**Main source**	[1], [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**																	**R**	**I**	**E**	**I,R**

B 1.1	**Summary**	H2-FCVs provide environmental benefits (reduced pollution, noise, GHG), potentially stimulate the economy through developing a competitive future technology reducing dependency on and imports of fossil fuels. However, as early markets probably have to be developed through public procurement government at different levels has to provide extra funding for the development of the market.
B 1.2	**Summary: Income groups**	Similar as for electromobility it can be assumed that support for H2-FCVs is favoring higher income groups that can afford the additional cost at the time of introducing the cars. Such an inequality can partly be compensated if also public transport benefits e.g. by H2 FCV buses.
B 1.3	**Summary: Age groups**	None (apart from very limited intergenerational equity, if H2-FCV public funding would increase long-term public debt).
B 1.4	**Summary: Disabled people**	None
B 1.5	**Summary: Gender groups**	None
B 1.6	**Summary: Ethnic groups**	None

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**	**E**	**N,R**
B 2.2	Risk of congestion	→			→		→					→						**R**	**N**	**E**	**N,R**
B 2.3	Vehicle mileage	→			→		→					→						**R**	**N**	**E**	**N,R**
B 2.4	Service and comfort	↘			↗													**R**	**L**	**E**	**N,R**

B 2.I	**Overall impacts on social groups**	Usage of H2-FCVs buses could improve comfort (H2-FCV buses emit less noise compared with conventional buses) and image of H2-FCVs (clean and innovative) providing benefits for disadvantaged groups relying more on public transport.
B 2.II	**Implementation phase**	During implementation comfort for private users is reduced due to limited network density of fuelling stations.
B 2.III	**Operation phase**	Similar use as with todays fossil fuel based vehicles after a certain density of fuelling network is achieved.
B 2.IV	**Summary / comments concerning the main impacts**	No main impacts on traffic expected, assuming that variable cost of H2-FCVs will be similar as for fossil fuel based cars, which depends also on taxation of the different fuels.
B 2.V	**Quantification of impacts**	In the very long-term it is expected that the car market would be dominated by H2-FCVs (70%) as they do not face a range limit as it is expected to prevail for battery electric vehicles, which would be the long-term competitor of H2-FCV cars [6].

B 3	ECONOMIC IMPACTS	Passengers: Road	Passengers: Rail	Passengers: Air	Passengers: Public transport	Passengers: Slow modes	Transport operators: Road	Transport operators: Rail	Transport operators: IWW	Transport operators: Air	Transport operators: Maritime	Transport operators: Public transport	Employees in transport	Residents	Economy	Public bodies	Society	Geographical level: 1st level	Geographical level: 2nd level	Source: Source of assessment	Source: Spatial level of source
B 3.1	Transport costs	↗			→		↗					→						N	R	E	
B 3.2	Private income / commercial turn over	↘			→								↗	↗	↗	↘	↗	N	I	E	
B 3.3	Revenues in the transport sector											↗							R	E	
B 3.4	Sectoral competitiveness				↗								↗		→			N	I	E	
B 3.5	Spatial competitiveness																				
B 3.6	Housing expenditures													↗				R		E	
B 3.7	Insurance costs	↘																			
B 3.8	Health service costs												↘	↘		↘	↘	N	I	E	
B 3.9	Public authorities & adm. burdens on businesses						↗					↗						N	I	E	
B 3.10	Public income (e.g.: taxes, charges)															↘		N		E	
B 3.11	Third countries and international relations												↗		↗		↗	I	N	E	

B 3.I	**Overall impacts on social groups**	Most relevant are the indirect economic impacts of this TPM H2-FCV. These include stimulation of investment into R&D, construction and new manufacturing machinery. This increases employment rather of high-skilled employees in affected sectors. Macro-economic impacts emerge from reduced imports of fossil fuels, reduced fossil fuel tax revenues and potential lead market gains driving competitiveness and exports. Reduced adverse environmental impacts can improve general health and quality of life of urban/road residents, the latter usually benefitting disadvantaged social groups.
B 3.II	**Implementation phase**	Increase of R&D expenditures to innovate H2-FCV as well as increased investment into new vehicle manufacturing sites and H2 fuelling infrastructure. However, for economic assessments the net effects should be conisdered (i.e. stimulated/induced investment minus avoided investment e.g. to improve fossil fuel based vehicles).
B 3.III	**Operation phase**	Transport cost increases during implementation will disappear after some years of technological learning, leading to reduced vehicle costs (i.e. fuel cell cost, H2 storage cost). Effect of reduced fossil fuel imports and improved environmental quality should remain. Scarcity of rare earths and precious metals may play a role, when global deployment of H2-FCV should take place.
B 3.IV	**Summary / comments concerning the main impacts**	H2-FCV constitute a most promising option for transport energy supply in a post-fossil era. Leaders in the technology would benefit from economic benefits in terms of competitiveness. However, H2-FCV are a technology requiring a coordinated transition to the new technology paradigm affecting fuel supply, vehicle technology, vehicle manufacturing and maintenance, tax and incentive systems.
B 3.V	**Quantification of impacts**	Micro-economic impact assessment relate to the cost of H2-FCV in relation to their competitors, in particular road vehicles using internal combustion engines fuelled by fossil fuel, but also other kind of electric vehicles (BEV, HEV, PHEV). Industry studies expect cost parity of H2-FCVs between 2020 and 2025 [4]. Macro-economic analysis of hydrogen introduction based on renewable energy conclude that European GDP (EU25) could be increased by about overall 0.5% compared to a baseline [1].

B 4	SOCIAL IMPACTS	Passengers: Road	Passengers: Rail	Passengers: Air	Passengers: Public transport	Passengers: Slow modes	Transport operators: Road	Transport operators: Rail	Transport operators: IWW	Transport operators: Air	Transport operators: Maritime	Transport operators: Public transport	Employees in transport	Residents	Economy	Public bodies	Society	Geographical level: 1st level	Geographical level: 2nd level	Source: Source of assessment	Source: Spatial level of source
B 4.1	Health (incl. well-being)	↗			↗	↗								↗			↗	R	L	E	
B 4.2	Safety																				
B 4.3	Crime, terrorism and security														↗		↗	I	N	E	
B 4.4	Accessibility of transport systems	→			→	→											→	R	L	E	
B 4.5	Social inclusion, equality & opportunities													↗				R	L	E	
B 4.6	Standards and rights (related to job quality)																				
B 4.7	Employment and labour markets														↗			N		E	
B 4.8	Cultural heritage / culture																				

B 4.I	**Overall impacts on social groups**	Impacts on social groups are largely positive, and include job opportunities and reduced environmental impacts of transport. Trade-offs between alternative uses of public funds could provide a reason of potential disbenefit of the TPM. Migratory pressure on disadvantaged income groups could increase through improved attractiveness of their neighborhoods along roads due to reduced air pollution and less noise emissions making these neighborhoods also attractive for higher income groups.
B 4.II	**Implementation phase**	Possibly larger benefits for better-off and high skilled persons due to job opportunities in R&D and project management.
B 4.III	**Operation phase**	Benefits also for transport users (e.g. less noise and pollution during travel) and residents (same reasons). Significant increase of national content of transport energy supply i.e. fossil energy imports will be replaced by renewable energy.
B 4.IV	**Summary / comments concerning the main impacts**	In general rather positive social impacts on whole spectrum of social groups, though differing over time. During deployment phase rather high income groups would benefit from job opportunities and support schemes, while during operation phase ratzer lower income groups could benefit from environmental improvements of road transport. However, the potential trade-off between public spending on H2-FCV introduction and alternative uses e.g. of funding of social policy (e.g. improving the school system, etc.) should be taken into account.
B 4.V	**Quantification of impacts**	No comprehensive quantification available. Concerning employment studies indicate a potential gain of between 400.000 and 800.000 additional jobs in Europe (EU25) until 2030 in moderate to positive scenarios [1].

B 5	ENVIRONMENTAL IMPACTS	Passengers: Road	Passengers: Rail	Passengers: Air	Passengers: Public transport	Passengers: Slow modes	Transport operators: Road	Transport operators: Rail	Transport operators: IWW	Transport operators: Air	Transport operators: Maritime	Transport operators: Public transport	Employees in transport	Residents	Economy	Public bodies	Society	Geographical level: 1st level	Geographical level: 2nd level	Source: Source of assessment	Source: Spatial level of source
B 5.1	Air pollutants													↑			↑	L	R	E	
B 5.2	Noise emissions													↗			↗	L			
B 5.3	Visual quality of the landscape																				
B 5.4	Land use																				
B 5.5	Climate																↑	I	N	E	
B 5.6	Renewable or non-renewable resources																↑↘	I	N	E	

B 5.I	**Overall impacts on social groups**	Improved local environmental impacts, in particular less noise and air pollution, provide the largest incentive to foster H2-FCVs for the benefit of disadvantaged social groups, i.e. low income groups, that most often lives alongside bigger roads in urban areas. Risk of such a policy is that such neighborhoods get more attractive for better-off groups as well, such that migratory pressure on disadvantaged groups could increase.
B 5.II	**Implementation phase**	Construction of/at filling stations as well as of manufacturing sites may cause limited discomfort of residents.
B 5.III	**Operation phase**	Reduced use of fossil fuels, mitigation of climate impacts and reduced local pollution constitute the positive side, while potential increase of demand of scarce resources plus impacts during their extraction and processing would be on the negative side.
B 5.IV	**Summary / comments concerning the main impacts**	Overall the environmental impacts are expected to be strongly positive.
B 5.V	**Quantification of impacts**	Transport CO2 could be reduced by 4% in Europe compared to baseline. Use of platinum in Europe could increase by about 150% until 2030 as compared to 2010 [7].

C REFERENCES

C 1	**Other TPMs of this subcategory**	Electromobility - road
C 2	**References**	**International** [1] Ball M., Wietschel M. (eds.) (2009): The Hydrogen Economy: Opportunity and Challenges. Cambridge University Press, Cambridge. [2] FCH JU - Fuel Cells and Hydrogen Joint Undertaking (2012), http://www.fch-ju.eu/, Predecessor: European Fuel Cells and Hydrogen Joint Technology Initiative (JTI) [3] NEW IG - New Energy World Industrial Grouping (2012), http://www.new-ig.eu/ [4] McKinsey (2010): A portfolio of power-trains for Europe: a fact-based analysis. [5] Zachmann G., Holtermann M., Radeke J., Tam M., Huberty M., Naumenko D., Ndoye Faye A. (2012): The great transformation: decarbonising Europe's energy and transport systems. Bruegel Blueprint 16, Brussels. [6] NEW IG - New Energy World Industrial Grouping (2011): Fuel Cell and Hydrogen technologies in Europe: Financial and technology outlook on the European sector ambition 2014- 2020. [7] Schade W. (2008): Impact on resource use and emissions of transport by using renewable energy and hydrogen as transport fuel. In: Hartard S., Schaffer A., Giegrich J. (eds.) (2008): Ressourceneffizienz im Kontext der Nachhaltigkeitsdebatte, Nomos, Baden-Baden. **National** [8] Wells P. (2013): Converging transport policy, industrial policy and environmental policy: the implications for localities and social equity. Forthcoming. **Regional / Local** [9] Greater London Authority (2009): London Hydrogen Action Plan 2010 - 2012. [10] Elementary Energy Limited (2012): Post-2014 London Hydrogen Activity: Options Assessment. Study on behalf of the London Hydrogen Partnership.