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Interplay between electricity and transport sectors – Integrating the Swiss car fleet and electricity system

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ABSTRACT

Electric vehicles are seen as a future mobility option to respond to long term energy and environmental problems. The 2050 Swiss energy strategy envisages 30–75% introduction of electric cars by 2050, which is designed to support the goal of decarbonising the energy sector. While the Swiss government has decided to phase out nuclear electricity, deployment of electric cars can affect electricity supply and emission trajectories. Therefore, potential interactions between the electricity and transport sectors must be considered in assessing the future role of electric mobility. We analyse a set of scenarios using the Swiss TIMES energy system model with high temporal resolution. We generate insights into cross-sectoral trade-offs between electricity supply and electrification/decarbonisa tion of car fleets. E-mobility supports decarbonisation of car fleet even if electricity is supplied from large gas power plants or relatively low cost sources of imported electricity. However, domestic renewable based electricity generation is expected to be too limited to support e-mobility. Stringent abatement targets without centralised gas power plants render e-mobility less attractive, with natural gas hybrids becoming cost effective. Thus the cost effectiveness of electric mobility depends on policy decisions in the electricity sector. The substitution of fossil fuels with electricity in transport has the potential to reduce revenues from fuel taxation. Therefore it is necessary to ensure consistency between electricity sector and transport energy policies.

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1. Background

Electric vehicles are seen by many as a promising future mobility option that responds to today's energy-economic-environmental problems, such as increasing energy prices, climate change, inefficient resource usage, air and noise pollution in urban areas, and so on (Høyer, 2008; THELMA; Arar, 2010; Srivastava et al., 2010; Delang and Cheng, 2012; Fulton et al., 2009; Ernst et al., 2011; Brand et al., 2012; Dijk et al., 2013; Raslavičius et al., 2015; Seixas et al., 2015; Jenn et al., 2015). Unlike alternative mobility options to address the aforementioned issues, e.g., hydrogen vehicles, which may require an entirely new infrastructure, the advantage of electric mobility is in largely making use of the *existing* electric infrastructure (Horst et al., 2009; Electrosuisse, 2015), although some upgrading and expansion may be necessary (Srivastava et al., 2010). Another potential benefit of electric mobility is in the possibility of exploiting the electric storage batteries in electric vehicles for managing the balance between electricity supply and demand. That is, electric mobility is also seen as a solution for

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Nomenclature

Aviation (D) domestic aviation
Aviation (I) international aviation
BAU business as usual scenario
BEV battery electric vehicle
CHF Swiss Franc
CHP combined heat and power generation
CO_2 carbon dioxide
CROSSTEM cross-border Swiss TIMES electricity model
ESD energy service demand
ETS emission trading scheme
EU European Union
FC fuel cell
GDP gross domestic product
GTCC gas turbine combine cycle plant
HGV heavy goods vehicle
Hydro (D) dam storage hydro power
Hydro (P) pumped hydro power
Hydro (R) run of river hydro power
ICE internal combustion engine
INT intermediate season
kW kilowatt
kWh kilowatt-hour
LC low carbon scenario
LGV light goods vehicle
MARKAL market allocation—modelling framework
PJ Peta Joule (10^{15} J)
PHEV plug-in hybrid electric vehicle
Rail (F) rail—freight transportation
Rail (P) rail—passenger transportation
RES reference energy system
Rp Rappen (cent)
SMR steam methane reformer
STEM Swiss TIMES energy system model
STEM-E Swiss TIMES electricity model
SUM summer season
TIMES The Integrated MARKAL EFOM System—modelling framework
t-km tonne kilometre
V2G vehicle to grid
vkm vehicle kilometre
WE weekends
WIN winter season
WK weekdays

supporting a high share of intermittent renewables (e.g., solar and wind); managing base load type power plant through off peak charging, and to buffer the electric grid (i.e., vehicle to grid–V2G) for system balancing (Lund and Kempton, 2008; Horst et al., 2009; Budischak et al., 2013; Borba et al., 2012).

The current Swiss energy system is highly dependent on imported transport (and heating) fuels (BFE, 2010), and is thus incompatible with long-term climate change mitigation efforts. The 2050 Swiss energy strategy envisages 30–75% electric cars by 2050 (Prognos, 2012). This is designed to support the goal of decarbonising[1] the transport sector, given that the car fleet alone accounts for 53% of transport sector energy demand (or 66% excluding international aviation and 18% of total final energy consumption) (BFE, 2010). However, the well-to-wheel CO_2 emissions (and primary energy use) depend on the primary sources of electricity supply. The current Swiss electricity is nearly decarbonised, with nuclear power contributing around 40%. However, the government has also decided to phase out this low-carbon source of electricity after the Fukushima Daiichi

[1] Energy-related CO_2 emissions in Switzerland were 44 million tons in 2010. About 40% of the CO_2 were from the transport sector while the electricity sector account for less than 10% (FOEN, 2012).

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