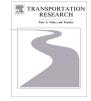
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Interplay between electricity and transport sectors – Integrating the Swiss car fleet and electricity system



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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-economicenvironmental 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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		(D) domestic 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
	CROSSTE	M 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
) 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
		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
	VVIX	weenays

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 decarbonising¹ 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 CO₂ 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 CO₂ emissions in Switzerland were 44 million tons in 2010. About 40% of the CO₂ were from the transport sector while the electricity sector account for less than 10% (FOEN, 2012).

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