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Travel intensity and climate policy: The influence of different mobility futures on the diffusion of battery integrated vehicles ☆

Thomas Longden

Fondazione Eni Enrico Mattei, Euro-Mediterranean Center for Climate Change, Corso Magenta, 63, 20123 Milano, Italy

HIGHLIGHTS

- Travel intensity of GDP at the national level shows signs of stability over an extended period.
- Different mobility futures imply notably different optimal vehicle fleet compositions.
- As climate policy becomes more stringent, investments in battery related technologies increase substantially.
- The model results show that the Electric Vehicles Initiative goal of a 2% share of vehicles in 2020 could be achieved.
- Cost reductions and the removal of barriers to diffusion will need to continue for the EVI goal to be achieved.

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ABSTRACT

The importance of a focus on mobility and the kilometres travelled using light duty vehicles is reflected in the persistence of strong demand for personal mobility and emissions that tend to be linked with population and economic growth. Simulation results using the WITCH model show that changes in the kilometres driven per year using light duty vehicles have a notable impact on investments related to the development of battery related technologies. As a result, different mobility futures have notably different optimal vehicle fleet compositions. As climate policy becomes more stringent, achieving abatement with increased mobility implies large investments in battery related technologies in comparison to the 2010 level. The model results also show that the Electric Vehicles Initiative goal of a 2% share of vehicles in 2020 could be achieved with climate policy in place. However, notable cost reductions and the removal of barriers to diffusion will need to continue for the EVI goal to be achieved.

1. Introduction

Transport is a sector that has shown little evidence of decoupling emissions from population and economic growth. Demand for mobility and a continued reliance on fossil fuels are amongst the reasons that this has prevailed (Knowles, 2006; Frändberg and Vilhelmson, 2011). Mobility demand (in terms of vehicle kilometres travelled) has been found to be relatively inelastic with respect to changes in the cost of travel due to the value of the activity at the destination and demand tends to increase with improved infrastructure (Metz, 2008). The persistence of mobility demand can be seen in recent trends across sectors. For example, in the period between 1980 and 2009 per capita emissions associated with manufacturing industries and construction decreased globally by 19%, while per capita emissions related to the transport sector rose by 17%. Focusing on per capita emissions associated with road transport shows an increase in emissions of 29.5% for the same period. While similar trends persist for the OECD, data for the non-OECD shows increases in per capita emissions of 14%, 63% and 95% for these same sectors (IEA, 2010). In the case of the USA, a 17% increase in per capita emissions related to road transport between 1980 and 2005 (IEA, 2010) has coincided with an increase in vehicle kilometres of 28% and a 29% improvement in fuel efficiency for light duty vehicles, buses, trucks and motorcycles (BTS, 2012).

The importance of a focus on mobility and fuel use attributed to light duty vehicles is reflected in the persistence of stable travel trends and strong demand for personal mobility. In accordance with this, the report titled 'Transport Outlook 2012: Seamless Transport for Greener Growth' and produced by the OECD and ITF noted that within modelling for the period between 2010 and 2050 "passenger mobility in the OECD is dominated by light-duty

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E-mail address: thomas.longden@feem.it

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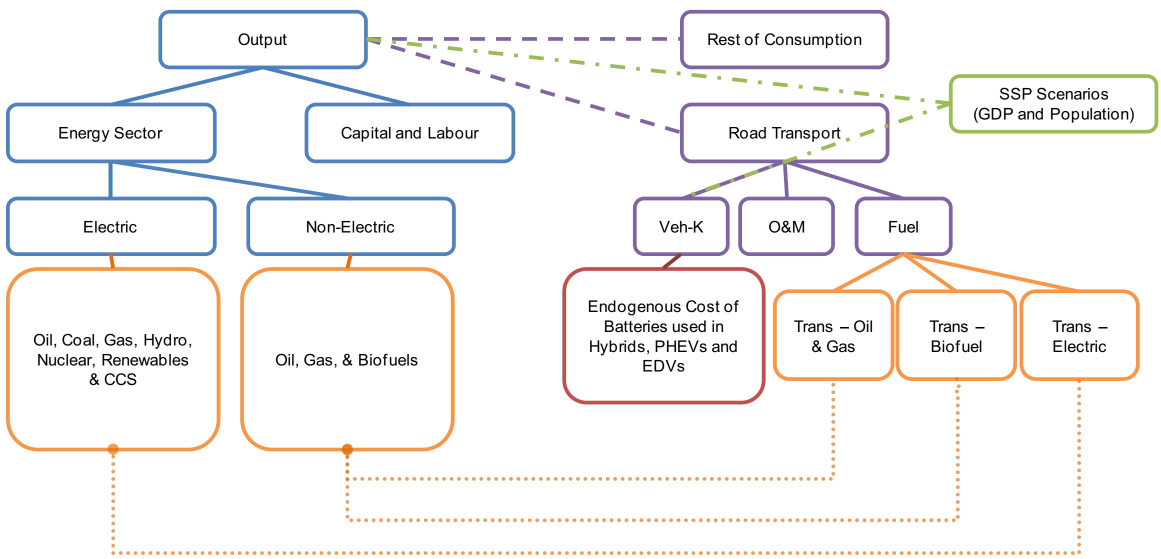

Fig. 1. The WITCH LDV transport module. *Note*: Transport cost is modeled as part of consumption. Biofuel consumption in the transportation sector competes with biomass use in electricity production. Demand for Oil & Gas competes with demand coming from both the electric and non-electric sectors. Demand for electricity coming from the transport sector has to be met by the electric component of the energy sector and can be sourced from any available option.

vehicles (cars and light trucks), and this dominance declines only to the extent that air travel takes up a greater share of total passenger-km" (OECD/ITF, 2012: 20). In addition, the IEA MoMo model forecasts that the 2050 level of total kilometres driven by light duty vehicles will be 1.4 times higher than the 2005 level for the OECD, 7.4 times higher for the non-OECD and 2.5 times higher at the global level (Fulton et al., 2009).

It is on this basis that a review of travel scenarios focusing on the amount of kilometres travelled has been conducted using the integrated assessment model (IAM), WITCH (Bosetti et al., 2006, 2007, 2009; Bosetti and Longden, 2013). WITCH – World Induced Technical Change Hybrid model – is a regional integrated assessment model that provides normative information on the optimal responses of world economies to climate policies. Within the model, key macroeconomic variables are represented through a top-down inter-temporal optimal growth economic framework. This is combined with a bottom-up compact modelling of the energy sector, which details energy production and provides the energy input for the economic module and the resulting emission input for the climate module. Further information about the model is available at the website www.witchmodel.org.

Recent work, Bosetti and Longden (2013), has been conducted to expand the model to include a light duty vehicle (LDV) transport sector and provide representations of the future of personal travel. Bosetti and Longden (2013) also reviews the structure of the light duty vehicle (LDV) transport sector that exists in WITCH and investigates the importance of electrification for cost effective climate policy. Fig. 1 shows the LDV transport module within the WITCH model structure. The model separates consumption in transport from the rest of consumption, which allows for the direct modelling of the costs involved in switching between vehicles and fuels for a given demand of mobility. Investments in vehicle capital and supplementary costs decrease the level of consumption. This means that increased LDV travel (in terms of kilometres travelled per vehicle) as well as the costs of the vehicle and fuel expenditure directly impact utility through the corresponding effect of decreasing consumption on other goods and services. Technological change is endogenous in the model and takes the form of a two factor learning curve which impacts the costs of batteries for battery integrated vehicles (BIVs). A Leontief production function provides the fixed proportions of operation and maintenance (O&M) costs, fuel and investment cost required for each technological type. Fuel demand and fuel type depend upon the vehicle chosen. The LDV transport sector's demand for fuels (oil, biofuels and electricity) compete with the energy sector demand, as shown in Fig. 1 with dotted lines between the two sectors. Note that details of the model in comparison to other IAMs can be accessed via Pietzcker et al. (2014).

The assumption of constant travel patterns has been used within the WITCH model up until now with travel patterns over time having remained fixed based on constant kilometres travelled per year for each vehicle. The application of the WITCH model within this paper is focused on a review of how changes in travel patterns may impact innovations related to BIVs, the demand for fuels and total emissions across macro-economic regions. Within this paper, travel intensity levels (as a function of GDP) are combined with three different projections of GDP pathways between 2005 and 2100. These GDP pathways are sourced from the Shared Socioeconomic Pathways (SSPs) Database.[1] As demonstrated in Fig. 1, the application of SSP data on GDP and population impact the WITCH model by changing output, the number of LDVs (Veh-K) and the kilometres driven by these vehicles per year.

The paper is set out as follows. Section 2 initially reviews historical travel trends in a range of countries (Section 2.1) and then utilises the travel intensity of GDP to establish scenarios for review within the WITCH model (Section 2.2). Section 2.3 then focuses on the modelling of long term LDV transport sector projections within the WITCH model. Section 3 reviews the results of the simulations for a range of mobility and climate policy scenarios at the global level and discusses the WITCH estimates in contrast to recent BIV sales. Section 4 discusses the global policy implications of the modelling results. Section 5 then concludes the paper with a discussion of the main results.

2. Analysis of travel trends

Having introduced the paper within the introduction, this initial section reviews the development of travel trends that will be implemented within WITCH. Section 2.1 discusses the

[1] For further information on the SSPs refer to the SSP Database and SSP (2012).