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Will current electric vehicle policy lead to cost-effective electrification of passenger car transport?

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ABSTRACT

Encouraged by the falling cost of batteries, electric vehicle (EV) policy today focuses on expediting electrification, paying comparatively little attention to the cost of the particular type of EVs and charging infrastructure deployed. This paper argues that, due to its strong influence on EV innovation paths, EV policy could be better designed if it paid more attention to cost and technology development risk. In particular, using a model that estimates the incremental cost of different EV and infrastructure mixes over the whole passenger car fleet, we find that EV policy with a strong bias towards long-range battery electric vehicles (BEVs) risks leading to higher costs of electrification in the medium term, possibly exceeding the ability of governments to sustain the necessary incentives until battery cost drops sufficiently. We also find that promoting a balanced mix of BEVs and plug-in hybrid electric vehicles (PHEVs) may set the electrification of passenger cars on a lower risk, lower cost path. Examining EV policy in the UK and in California, we find that it is generally not incompatible with achieving balanced mixes of BEVs and PHEVs. However some fine tuning would allow to better balance medium term risks and long term goals.

1. Introduction

1.1. Government support to electric vehicles

Road transport accounted for 21% of global energy consumption and 17% of global CO_2 emissions in 2013 (IEA, 2015c). Carbon emissions from road transport have been growing steadily and will continue to do so if road transport is not progressively decoupled from fossil fuels (EIA, 2014). In particular, stabilizing global temperature increase to below 2 °C relative to pre-industrial levels will require a combination of improved fuel efficiency and deployment of alternative fuels in road transport, particularly advanced biofuels, electricity and, to a lesser extent, hydrogen (IEA, 2015a; Kahn Ribeiro et al., 2012). Scenarios may differ as a multitude of energy technology pathways are possible (IPCC, 2014), however it is generally accepted that electric vehicles (EVs) will have a major role to play, especially in large markets such as the US, Europe, China and India. Electrification of passenger car transport also has the added benefit of reducing emissions of local air pollutants in urban areas, the impacts of which on public health are of growing concern in both developed and developing countries (OECD, 2014).

For the reasons noted, electrification of passenger car transport is receiving strong support from several national governments worldwide which seek not only to meet their environmental protection goals but also to develop national value chains in this emerging industry (Lutsey, 2015). Alongside aspirational targets set by several governments, electrification is increasingly being driven by regulation. Most notably, the California Zero Emission Vehicle mandate sets mandatory targets for EV sales; this type of regulation is increasingly being adopted across the US and Canada. In the European Union the Directive on the deployment of alternative fuel infrastructure (European Union, 2014) mandates that Member States develop national policy frameworks for future EV charging infrastructure rollout.

In order to achieve their targets, both aspirational and legally-binding, national and local governments are deploying sets of incentives to EV adoption, including purchase grants, tax exemptions, non-monetary incentives such as free parking and access to restricted lanes, and financial support for the development of extensive charging infrastructure (IEA, 2013; Lutsey, 2015). Incentives are necessary to overcome the substantial cost gap currently existing between EVs and conventional internal combustion engine vehicles (ICEVs) and the first mover disadvantage that characterises the development of alternative fuel infrastructures (NRC, 2015). For their part, automotive OEMs are producing an increasingly diverse range of EV models in order to comply with mandates and standards while gaining competitiveness. Although fleet penetration on a global level is still low, the market

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share of electric vehicles is growing fast (IEA, 2015b). In some countries, such as Norway and the Netherlands, the market share of EVs has reached substantial levels, while the US, Japan and China lead the way in terms of the absolute size of their EV stocks, and several new markets are starting to develop (IEA, 2015b).

Despite some early success stories and the growing momentum behind the EV transition, rapidly reaching a high level of EV penetration globally will be challenging, because of strong economic, institutional and behavioural barriers, together with the inherently slow turnover rate of passenger car stocks (Element Energy, 2013; NRC, 2015; Struben and Sterman, 2008). For this reason, in today's policy discourse much emphasis is placed on identifying those mixes of policy instruments that are most effective at accelerating the deployment of EVs and related charging infrastructure (Lutsey, 2015). Comparatively little attention is devoted to clearly articulating a vision of future self-sustained electrification of passenger car transport that does not solely rely on the cost of EV batteries rapidly falling. However, considering that the current high levels of government incentives cannot be sustained indefinitely, we argue that policy should also be designed taking account of the need to guide the EV transition towards low cost and low technology risk pathways.

1.2. Aim and objectives

The aim of our work is to assess whether today's EV policy is conducive to a future cost-effective use of this technology, considering the policy objectives it aims to achieve, particularly carbon emission reduction. We do so by exploring the incremental costs of future mixes of EVs and charging infrastructures that are broadly compatible with today's policy and market trends, and that can provide similar carbon emission reductions. We use the results of our cost analysis as a basis for discussion of key features and possible implications of current EV policy, and to identify opportunities for making it more robust under uncertainty.

In Section 2 we discuss the effect that deployment policy has on EV innovation pathways, including the possibility of technological lock-ins. Section 3 presents the methods used in the study and their limitations. Section 4 describes the current policy framework and deployment targets for the UK and California, the case studies chosen. Section 5 presents the results of the two case studies and discusses their policy implications. Section 6 concludes the paper.

2. EV deployment policy and its effect on innovation

Due to the specific characteristics of each market, the widely differing underlying taxation of conventional vehicles and fuels, and the lack of generally accepted best practices, different approaches have so far been used. As a result, different patterns of deployment of EVs and charging infrastructure have begun to emerge in the most active countries and regions, i.e.: China, Europe, Japan and the U.S. (IEA, 2013, 2015b; Lutsey, 2015). In particular, different ratios of pure battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) and of rapid charging and slow charging infrastructure can be observed across leading countries (IEA, 2013, 2015b). BEVs operate solely on electricity while PHEVs can operate on both battery power and an internal combustion engine, especially once the battery is depleted; the internal combustion engine and electric components of the powertrain can be arranged either in parallel or in series; the latter are also referred to as range extended electric vehicles (RE-EVs). In this paper we will use the term PHEVs for both types, unless otherwise specified. The term slow chargers is here used to indicate charging points of 3–7 kW power; rapid chargers supply power of the order of 40–50 kW. Figs. 1 and 2 provide and illustration of the different patterns of EV and charging infrastructure deployment observed today (IEA, 2016).

Evidence shows that incentives strongly influence the overall rate of EV uptake and the relative market shares of BEVs and PHEVs (Mock and Yang, 2014). In Norway for example BEVs receive generous support, whereas PHEVs have only recently become eligible for some, hence the rapid rate of uptake of BEVs. In the Netherlands incentives for BEVs and PHEVs have been similar, hence the dominance of PHEVs that offer better functionality. In California, where BEVs qualify for higher incentives than PHEVs, their market shares are comparable (Brook Lyndhurst, 2015). Hence, government incentives to EV purchase, combined with the underlying taxation of conventional fuels and vehicles, determine the type of EVs that are most competitive and also the market segments in which the value they offer relative to ICEVs is highest. This in turn influences the EV types and models that automotive OEMs will commercialise in order to achieve highest possible sales.

Moreover, public charging infrastructure is a strong enabler of BEV adoption (Sierzchula et al., 2014), so some countries are building extensive networks of public chargers, be they rapid or slow, that anticipates possible user needs (Brook Lyndhurst, 2015; NRC, 2015). The particular type, density and location of charging points aim to reduce range anxiety and increase the perceived utility of BEVs to a level comparable to ICEVs. However, it is difficult to anticipate how well this will work in practice and the extent to which the infrastructure will

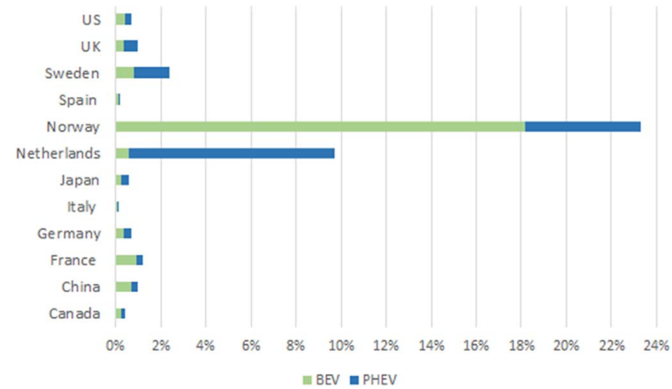

Fig. 1. Market share of EVs in selected countries in 2015, broken down by BEVs and PHEVs.
Source: adapted from (IEA, 2016).

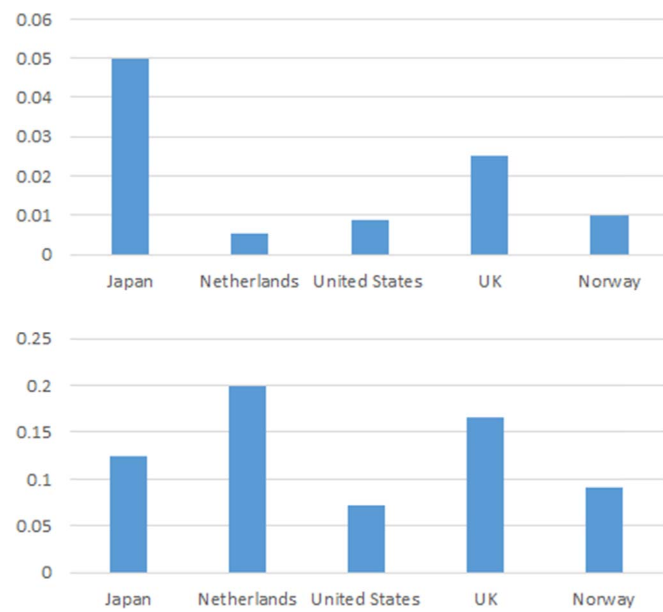

Fig. 2. Charging point/EV ratio in selected countries in 2015, respectively for fast (top) and slow chargers (bottom).
Source: adapted from (IEA, 2016).

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