Energy Policy 56 (2013) 51–62

Contents lists available at SciVerse ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Fuel electricity and plug-in electric vehicles in a low carbon fuel standard

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HIGHLIGHTS

- The challenge for fuel electricity usage is vehicle demand, not fuel supply.
- LCFS will have a limited role in reducing fuel electricity carbon intensity.
- Carbon intensity will depend on regional, temporal and methodological factors.
- Policy design influences incentives between fuels and among electricity providers.

ARTICLE INFO

Article history:
Received 13 December 2011
Accepted 3 May 2012
Available online 15 June 2012

Keywords:
Greenhouse gases
Policy
Incentives

ABSTRACT

Electricity is unique among the alternative fuels in a low carbon fuel standard (LCFS) policy, in that demand from vehicles is the major barrier to its usage, not supply. This paper presents a policy discussion and policy recommendations on a number of topics related to the regulation and incentives for fuel electricity within the LCFS. In the near-term, the LCFS will have a limited role in incentivizing the use of electricity and lowering the carbon intensity of electricity, and electricity will play a small role in meeting LCFS targets. Calculating a carbon intensity value for electricity is a complex process, requiring many decisions and trade-offs to be made, including allocation methods, system boundaries, temporal resolution and how to treat electricity demand for vehicle charging. These choices along with other regulatory decisions about who can obtain LCFS credits will influence the incentives for providing electricity and charging infrastructure relative to other low-carbon fuels as well as across different electricity providers. The paper discusses how fuel electricity would fit into an LCFS, identifying those special characteristics that could reduce the effectiveness of the policy. It also provides specific recommendations to enable better policy design that appropriately incentivizes the use of low-carbon fuels.

1. Introduction

Electricity is one of the alternative fuels that are widely touted to help reduce greenhouse gas (GHG) emissions from the transportation sector (EPRI and NRDC, 2007; Samaras and Meisterling, 2008; NRC, 2009; Yang and McCollum, 2009; IEA, 2010). The low carbon fuel standard (LCFS), which regulates and incentivizes reductions in the carbon intensity (CI) of transportation fuels, is one of the key policies being discussed to reduce transportation GHG emissions. However, electricity has a number of important differences from other alternative, low-carbon fuels that can be used in the LCFS, and these differences require careful consideration from policymakers and regulators.

The purpose of this paper is to explore how fuel electricity will fit into an LCFS and present key issues of interest regarding policy incentives and regulatory decisions. This discussion is used to inform specific policy recommendations in order to ensure the policy adequately incentivizes electricity as a low-carbon fuel. Calculations based upon regional and national data are used to provide quantitative context for this policy discussion.

Three sets of issues are discussed in this paper. The first is the value of electricity credits and the role electricity could play in LCFS compliance. The second relates to the determination of the

Abbreviations: AEO, Annual Energy Outlook; BEV, Battery Electric Vehicle; CARB, California Air Resources Board; CI, Carbon Intensity; CPUC, California Public Utilities Commission; EER, Energy Efficiency Ratio; eGRID, Emissions & Generation Resource Integrated Database; EIA, Energy Information Agency; EPA, Environmental Protection Agency; FCV, Fuel Cell Vehicle; GHG, Greenhouse Gases; GREET, The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation model; ICE, Internal Combustion Engine; kWh, Kilowatt Hour; LCFS, Low Carbon Fuel Standard; LSE, Load Serving Entity; MJ, Megajoule; NERC, North American Electricity Reliability Corporation; PCA, Power Control Area; PEV, Plug-In Electric Vehicles; PHEV, Plug-In Hybrid Electric Vehicle; REC, Renewable Energy Credit (or Certificate); RPS, Renewable Portfolio Standard; ZEV, Zero Emission Vehicle

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0301-4215/$ - see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.enpol.2012.05.006

CI value for electricity and the factors that influence that value. The third highlights several key questions about electricity providers in an LCFS policy.

While the focus of this paper is an analysis of electricity within the LCFS, this focus is not meant to imply that electricity is the best way to meet an LCFS policy. Regulated parties must comply with the CI targets set forth by the regulation, and this analysis does not address the question of which fuel(s) should be used to reduce GHG emissions or comply with an LCFS policy. Regulated parties are free to choose whichever fuels they prefer and are not obligated to produce, supply or purchase fuel electricity. Instead, accurately and appropriately setting a regulatory CI value for electricity, including accounting for relative vehicle efficiency, will allow the market to decide which fuels and vehicle technologies will be used to comply with an LCFS.

Throughout this paper, the term "plug-in electric vehicles" (PEVs) is used to describe vehicles that use grid electricity to charge. PEVs can include plug-in hybrid electric vehicles (PHEVs), which can run on gasoline or electricity, and battery electric vehicles (BEVs), which run entirely on electricity. The term "fuel electricity" is used to differentiate electricity that is used as a transportation fuel from electricity that is used in more conventional applications.

2. Background and review of relevant concepts

2.1. Low carbon fuel standard

An LCFS is a policy that regulates the carbon content of transportation fuels in order to reduce GHG emissions associated with transportation activities. It is an important tool that develops a quantitative performance metric for transportation fuels based upon the fuel's CI in order to incentivize reductions in GHG emissions (Farrell and Sperling, 2007; Sperling and Yeh, 2010). All fuels are given a regulatory CI value (grams of GHG per megajoule of fuel, or gCO_2e/MJ) accounting for the entire fuel production cycle in order to provide a fuel-neutral metric that can incentivize lower carbon fuels based upon their expected emission reductions relative to the gasoline baseline.

An LCFS policy has been implemented in California and is being discussed/proposed in several other jurisdictions (CARB, 2009a; NESCAUM, 2009; Andress and Nguyen, 2010; ORDEQ, 2010; TIAX, 2011). This analysis focuses on a hypothetical national LCFS policy, although many of its findings are also relevant to implementation at a regional level.

Under the LCFS policy, major oil providers and importers are the regulated parties that are required to reduce the CI of their fuel mix by the target amount. They can do so by reducing the emissions from the fuels they produce, changing their fuel mix, and/or purchasing credits on the trading market. Because electricity is not a traditional transportation fuel, electricity providers are not regulated parties in the LCFS. Fuel electricity providers may choose to participate in the credit trading market, where regulated parties purchase credits to aid in meeting their compliance target.

2.2. Electricity carbon intensity

There are numerous studies that have estimated or calculated the CI of electricity used to charge PEVs and assess their GHG impacts (e.g., (EPRI and NRDC, 2007; Hadley and Tsvetkova, 2008; Samaras and Meisterling, 2008; NRC, 2009; McCarthy and Yang, 2010). Each of these analyses uses a different method for estimating the mix of power plants used to generate electricity to charge vehicles. This is due to the fact that there is no standardized method for calculating the CI of electricity for charging electric vehicles. The results of these analyses are quite variable because they were performed for different regions and different periods of time into the future and used different methodological approaches. But given the central importance of the CI value for the functioning of the LCFS, it is critical to understand how these regional, temporal and methodological factors can influence the calculation of electricity emissions.

2.3. Energy efficiency ratio (EER)

The energy efficiency ratio (EER) is an important tool for ensuring that fuels that lead to carbon reductions in transportation are appropriately incentivized in the LCFS. The EER is an adjustment factor that reduces the regulatory CI of a fuel based upon the vehicle's improved efficiency (e.g., if a vehicle is three times as efficient as a baseline gasoline vehicle, then the CI of that vehicle's fuel would be reduced by a factor of three). Electricity is a fuel that would not be adequately incentivized without the use of an EER, because the carbon savings are not reflected in the CI of electricity. The average CI for US average electricity in 2005 was nearly double that of gasoline on an energy basis (181 vs 93 gCO_2e/MJ), and its use would be disincentivized under the LCFS. However, using electricity as a transportation fuel would lower GHG emissions relative to a conventional vehicle running on gasoline because of the much higher vehicle efficiency (Kromer and Heywood, 2007; Plotkin and Singh, 2009), so an EER is used to lower the CI of electricity. In the California LCFS, the EER represents the relative efficiencies of drivetrains using the different fuels (compared on a miles-per-MJ basis) (CARB, 2009a, b). Fig. 1 shows that the value of the multiplier has a big impact on the regulated CI of electricity. An EER of 4 would make any electricity source favorable to gasoline, while for a multiplier of 3, all electricity sources except coal-steam power would be favorable to gasoline. An EER of 1, i.e., no efficiency adjustment, would effectively disincentivize the use of most electricity under the LCFS.

California chose a value of 3.0 for electricity based upon a comparison of equivalent gasoline and electric vehicles and adjusting for future fuel economy regulations (CARB, 2009a, b). Oregon did the same but proposed a declining value from 4.1 in 2012 to 3.1 by 2022 (ORDEQ, 2010). More recent data from EPA testing of the Nissan Leaf and Chevy Volt and current comparable gasoline vehicles yield EERs of 3.3 and 3.7 (Lutsey, 2011), which also leads to a value of around 3 when required near-term gasoline fuel economy improvements are factored in.

Note that for the remainder of the paper, all subsequent calculations and discussions of electricity CI will use an assumed EER value of 3.

3. Electricity and PEVs in the LCFS: Incentives and impacts

This section explores the incentives that the LCFS provides to fuel electricity as well as the potential contribution of electricity to LCFS compliance. Calculations and quantitative scenarios are used to help provide context for these discussions.

Because the principal goal of the LCFS is to incentivize the use of low-carbon fuels in the transportation sector, the emphasis of this section is to explore to what extent the LCFS incentivizes the use and CI reductions in fuel electricity, quantify the incentives it does provide and examine the potential for using electricity to achieve LCFS compliance. This discussion is not meant to identify ways for the LCFS to promote electricity over other fuels, but rather is meant to identify the barriers that prevent the LCFS from providing the equivalent incentives to electricity as with more conventional liquid low-carbon fuels.