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All plug-in electric vehicles are not the same: Predictors of preference for a plug-in hybrid versus a battery-electric vehicle

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ABSTRACT

This study analyzes data from a survey of drivers ($n = 1080$) administered in late 2013 to assess factors that influence potential car buyers to consider two different types of plug-in electric vehicles (PEVs) in the United States: plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs). The results indicate distinct profiles of respondents preferring PHEVs, which have a gasoline backup engine, versus battery BEVs, which rely solely on a battery for power. Respondents interested in selecting a PHEV consider it more for its economic benefits, such as reduced gasoline and maintenance expenditures. Respondents preferring a BEV are drawn to its environmental and technological appeal. The absence of range anxiety for PHEV is a major factor influencing potential PEV buyers.

1. Introduction and background

The advancement of electric vehicle technologies represents one of the most notable developments for surface transportation in the 21st century (Sierzchula, 2014). The increasing availability and use of plug-in electric vehicles (PEVs), the growing worldwide investment in related technological development and industrial production, and calls for a permanent alternative to the internal combustion engine (ICE), all suggest that PEVs will be long-term components of the future of transportation (Sperling, 2018a,b). Electrification of surface transportation is motivated by both environmental and energy-security objectives. Broad diffusion of PEVs could contribute to the sustainability of transportation by decreasing reliance on petroleum in transport, with the associated benefits of lowering urban air pollution and greenhouse gas emissions from the transportation sector and reducing economic vulnerability (Lane and Beeler, 2017). Additionally, PEVs can encourage industrial development by enhancing the competitiveness of national and regional automotive industries, including their supply chains (Lane et al., 2013).

The global stock of PEVs in use has grown from virtually zero in 2010 to more than two million in 2016 (IEA, 2017). In 2017, approximately 200,000 new PEVs were sold in the United States, equating to a 26% increase over 2016 and a 72% increase over 2015

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([InsideEVs.com, 2018](#)). The United States Environmental Protection Agency lists 13 battery electric vehicle (BEV) models and 18 plug-in hybrid electric vehicle (PHEV) models¹ ([US EPA Fuel Economy Guide, 2017](#)). Many manufacturers and dealers, especially in metropolitan areas, now offer at least one PEV model, and an increasing number of consumers have a basic knowledge of PEVs in contrast to when these vehicles first appeared on the mass market in the early 2010s.

Although PEV sales are growing rapidly in the United States and globally, they account for a small share of total new vehicle sales (see [IEA, 2017](#) for PEV penetration rates in different countries). Questions remain about how PEVs can penetrate the mass market ([National Research Council, 2015](#)). Much of the existing research and popular literature points to various factors that encourage or hinder the uptake of PEVs. However, limited attention has been paid to ascertaining whether potential car buyers have distinct preferences for PEVs with different performance and functional characteristics. BEVs are subject to a much more limited range on a single charge than PHEVs, which can travel longer distances and whose ICEs refuel in the same manner as conventional vehicles. The greater similarity of PHEVs to existing conventional vehicles suggests the possibility that these different types of PEVs may not diffuse in the same way. With expanded offerings in recent years of PHEVs and BEVs, research into how appeal to PEVs might vary across different forms of PEVs is especially warranted.

In this paper, we analyze data from a survey of 1080 drivers across urban areas in the United States that was designed to capture potential car buyers' attitudes and preferences regarding different types of PEV technologies. In our analysis, we specifically examine whether individuals who are likely to purchase a vehicle in the near future – here defined as the next two years – indicating a preference for PHEVs are distinct in their profiles from those individuals who indicate a preference for BEVs. In doing so, we contribute to existing scholarship by offering a more nuanced discussion about which aspects of alternative vehicle technologies are most compelling and deterring to different types of consumers.

1.1. Overview of prior literature

There is a large literature on the factors that are related to interest in, and adoption of, alternative-fueled vehicles, in particular PEVs. There are clear demographic factors that associate positively with PEV adoption. In a survey of U.S. urban residents, [Carley et al. \(2013\)](#) found that younger, affluent, and educated individuals are more likely to purchase a PEV. Perceived ease-of-use (e.g., perceptions regarding vehicle range) and lifestyle compatibility (e.g., availability of charging infrastructure) are also factors shown to influence PEV adoption, particularly as they address key perceived shortcomings of the technology ([Petschnig et al., 2014](#), [Moons and De Pelsmacker, 2012](#); [Jansson, 2011](#); [Graham-Rowe et al., 2012](#); [Caperello and Kurani, 2012](#)). Direct prior experience with alternative-fueled vehicles, such as a conventional hybrid, also tends to encourage interest in PEVs ([Axsen and Kurani, 2013](#), [Carley et al., 2013](#); [Skippon and Garwood, 2011](#); [Moons and De Pelsmacker, 2012](#); [Caperello and Kurani, 2012](#)). Relatedly, social interaction, through which individuals hear about trusted peers' experience with vehicle technologies, also shapes car buying preferences ([Mau et al., 2008](#); [Axsen and Kurani, 2012](#)). Individuals may also be drawn to alternative vehicles as their use may serve as a medium through which to convey pro-environmental attitudes or enthusiasm for new technologies ([Axsen and Kurani, 2011](#)). Finally, PEV adoption may also be related to other lifestyle choices, including financial management, activity and fitness, and having a strong sense of community ([Heffner et al., 2008](#)).

Previous literature has also emphasized the importance of policy, such as rebates or tax incentives that minimize the cost of purchasing a PEV, in influencing consumer interest in PEVs ([National Research Council, 2015](#)). Other types of influential policy measures include free public charging stations, expedited permitting and rebates for the installation of home vehicle charging infrastructure, prioritized parking access in urban areas, and free access to high-occupancy vehicle or toll lanes ([Gallagher and Muehlegger, 2011](#); [Lane et al., 2013](#); [Lutsey et al., 2015](#); [Clark-Sutton et al., 2016](#); [Coffman et al., 2016](#); [Langbroek et al., 2016](#); [Liao et al., 2016](#); [Deshazo et al., 2017](#)). Lastly, preferences for certain vehicle attributes may impact one's interest in buying a PEV (e.g., [Moons and De Pelsmacker, 2012](#)). Individuals that prioritize high fuel economy or environmental performance will be more likely to purchase a PEV than those that prioritize towing capacity, for example. A complication to the study of consumer preferences is the possibility that consumers may have a relatively poor understanding of fuel economy, and their calculations of vehicle operating costs and tradeoffs among choices are fraught with error ([Dumortier et al., 2015](#); [Rezvani et al., 2015](#)). Particularly relevant to this research, [Axsen et al. \(2015\)](#) surveyed 1754 Canadian consumers and found that PHEVs are preferred to BEVs, irrespective of the driving range of the vehicle. This is surprising and the authors hypothesize that this is either due to the difficulty for “buyers with little or no previous PEV [battery electric vehicle] experience...to place a value on a unit of electric-powered driving range” or their research design capturing a too narrow band of electric driving ranges. In general, they find that the choice of a PHEV is associated with pro-environmental and technology oriented lifestyles, while willingness-to-pay (WTP) for charging infrastructure is valued more highly for BEV than a PHEV, further suggesting difference in appeal to the two types of PEVs related to range.

1.2. Knowledge gaps and contributions of this study

Previous research suggests that PEV purchase decisions are complex and multifaceted ([National Research Council, 2015](#)). The

¹ PEVs can generally be divided into two categories: (1) plug-in battery-electric vehicles (BEVs) and (2) plug-in hybrid electric vehicles (PHEVs). BEVs, such as the Nissan Leaf or the Tesla Model S, rely solely on a battery for power that recharges through an electric socket. PHEVs, such as the Chevrolet Volt and the Toyota Prius Prime, rely on a battery and a gasoline engine that works either as a backup to the electric motor or in tandem with it. The Volt is sometimes called a range-extended BEV but for simplicity in this article we call it a PHEV.

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