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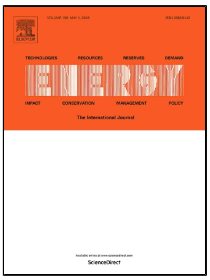

The Future of Energy Storage Shaped by Electric Vehicles: A Perspective from China

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The Future of Energy Storage Shaped by Electric Vehicles:

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Abstract

With the growth of Electric Vehicles (EVs) in China, the mass production of EV batteries will not only drive down the costs of energy storage, but also increase the uptake of EVs. Together, this provides the means by which energy storage can be implemented in a cost-efficient way. Here we identify and compare four basic pathways - *Smart Charging*, *Vehicle to Grid*, *Battery Swap* and *Repurposing Retired Batteries* - that can realize the storage potential from EVs. A potential capacity and cost comparison is conducted for each pathway, and it is concluded that EVs can achieve large scale energy storage effectively addressing the issue of intra-day power imbalance caused by the high penetration of variable renewable energy. It also indicates that the cost of *Vehicle to Grid* pathway is likely to be accepted by EV customers after 2025, and *Repurposing Retired Batteries* pathway shows diminishing cost competitiveness compared with the other pathways. The potential pathway combinations and corresponding scale of initial capital investments are further analyzed. Finally, we realize the EV storage capacity would not be significantly reduced by the introduction of the sharing economy and autonomous driving, particularly under the *Battery Swap* and *Repurposing Retired Batteries* pathways.

1. Introduction

Energy storage provides an essential component for the large-scale use of variable renewable energy (VRE). But its high cost has restricted the scope for application, and this in turn has formed a bottleneck for the high penetration of VRE. The global road transport sector is now beginning to invest in vehicle electrification, as this presents an important opportunity to address transport environment and energy issues. Although electric vehicles (EVs) directly impact on the transport sector they could also provide the means to transform the energy system through their potential for energy storage. A systematic analysis of EV energy storage potential and its role among other energy storage alternatives is central to understanding the potential impacts of such an energy transition in the future.

Across the globe, the road transport sector is experiencing a transition resulting from the increased use of EVs, as a result of the introduction of a range of hybrid and pure electric vehicles. Countries, such as the Netherlands, Germany, United Kingdom, Norway, India have already announced their plans to phase out the internal combustion engine vehicles (ICEV)[1,2]. In 2010, there were only 16,800 electric cars globally, but this figure has reached 2 million by the end of 2016[3]. China is leading this global EV development with more than 1.3 million EVs already running on its roads[4,5,6]. As the largest global market for both ICEVs and EVs, the Chinese government has recently launched a policy on New Energy Vehicle (NEV) production quotas for car manufacturers[7], and a timetable for banning ICEV sales is also under consideration[8]. All these policies will shift the scale and nature of vehicle production to EVs. Over the last three