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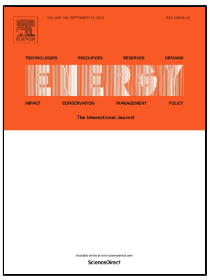

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Strategies for solar and wind integration by leveraging flexibility from electric vehicles: the Barbados case study

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ABSTRACT

Rapid deployment of large shares of Variable Renewable Energy (VRE) is driving a shift in economics and operational practices in power systems around the world, creating the need for a more flexible and decentralized power system. In this context, electric vehicles (EVs) are expected to play a significant role, as they can make use of large shares of renewables in the power system to decarbonize the transportation sector. It is important to carefully plan for EV integration to make sure that they facilitate the integration of VRE and capture the potential benefits for the power system. This paper assesses the different impacts on production costs that electric vehicles could have depending on different charging profiles and considering the value added from allowing the EVs to provide energy and ancillary services to the grid. This paper shows how smart charging strategies can 1) limit the total increase in production cost from charging EVs, 2) facilitate VRE integration into the system reducing curtailment 3) affect marginal cost of electricity and 4) reduce the investment needed for grid connected storage, using an innovative approach to calculate the contribution of EVs to system reliability based on the different charging scenario. Finally, the effects of adding a constraint to represent battery degradation due to operation are analysed. This analysis is carried out using as a case study the Caribbean island of Barbados, given the expected large shares of VRE in the future, however it suggests a general framework to assess the impact of EVs in power systems with high shares of VRE.

1. Introduction

The operation of electric power systems is being transformed by the increasing penetration of Renewable Energy Sources (RES-E), which have become highly attractive due to their increased competitiveness and environmental benefits. Among these technologies, wind, solar PV and run-of-the-river hydro are characterized by variability and limited predictability in generation ahead of dispatch time, and as such generally referenced to as Variable Renewable Energy (VRE). Variability in generation is creating new challenges in planning and operating electric power systems. Some of the implications are described in [1]. Here the authors divide the different VRE impacts based on the timescale studied. In the very short-term VRE can increase reserve requirement, as also described in [2] where the impacts of high shares of wind generation in electric power systems are assessed. From short to medium-term the impact becomes relevant for unit commitment, production costs and electricity prices. In this timescale, it is important to underline that, although VRE reduces the electricity generation cost, it might increase generation cost for thermal units by increasing cycling and reducing fuel efficiency [3]. Finally, in the long-term VRE might require new investments in flexibility options that can help to handle the increased variability in the residual load (load minus VRE generation). However, it is paramount that before investing in additional flexibility options, the flexibility already existing in the power systems should be unlocked through regulatory measures and improved market design, as discussed in [4].

Over the last two decades, many countries and international institutions joined their efforts to fight climate change, with efforts being facilitated by the rapid increase in competitiveness of renewable energy technologies. This global momentum culminated with the adoption of the Paris Agreement on December 2015 and its rapid ratification throughout 2016, where it was agreed to take the appropriate measures to limit the temperature increase of the planet in less than 2ºC, with efforts to limit it to less than 1.5ºC [5]. To reach this ambitious goal, renewable energy has been identified as the key solution for decarbonising the energy system, together with energy efficiency. Renewable energy deployment has accelerated significantly in particular in the power sector, due to the rapid cost reductions in solar and wind technologies [6]. However, to meet the objective of the Paris

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