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Assessment of wind and solar PV local complementarity for the hybridization of the wind power plants installed in Portugal

António Couto *, Ana Estanqueiro

LNEG - Laboratório Nacional de Energia e Geologia, Renewable Energy and Energy Efficiency Unit, Lisbon, Portugal

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ABSTRACT

To decarbonize electrical power systems, it is essential to incorporate a high share of variable renewable energy sources while minimizing their costs. An important step towards this goal includes exploring the potential for the so-called hybrid renewable power plants through the combination of (existing) wind and solar power parks. Although that is not the usual approach in their design, hybrid power plants should take advantage of existing synergies, as generation complementarity among the renewable generation technologies, and benefit from using existing infrastructures and the same grid connection point.

This investigation assesses the potential of existing Portuguese wind parks for hybridization with solar power photovoltaic generation. Correlation and energy metrics for assessing the complementarity at hourly and daily periods are applied to quantify existing synergies.

Results show a high potential for hybrid power plants: levels of complementarity between wind and solar resources are globally high thus allowing to increase the share of variable renewable energy sources with minimal energy curtailment, when compared with scenarios of overplanting additional wind power capacity. The highest and most consistent levels of complementarity are found in the interior regions of central and northern Portugal.

The research shows that Portugal has privileged weather conditions that allow the concept of hybrid power plants to be largely explored and extended on a large and efficient scale. This outcome, which may be replicated for other countries, is an important contribution to increasing the penetration of renewable energy in electrical power systems while minimizing the overall costs of renewable energy.

1. Introduction

A transition to a low-carbon society is a key commitment of the European Union (EU) in the present and coming years. The role of the EU in leading this transition effort worldwide is embodied in the recent National Energy and Climate Plans (NECPs) (National Energy and Climate Plans, 2020). According to them, the main contributions in terms of electricity supply in Europe are expected to come from solar and wind power generation.

These two clean energy power systems are already economically competitive with conventional forms of power generation. However, both their primary resources present an intermittent behaviour being dependent on the weather conditions. Since wind and solar photovoltaic (PV) generators are not fully dispatchable and controllable as conventional thermal or hydropower plants, the variability and poor predictability of their generation profiles can significantly hinder effective power system management.

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Both technologies require flexibility (and added reserves) especially in periods with severe power ramp events (Couto et al., 2021). The additional requirements to operate and maintain a stable and robust power system with high shares of variable renewable energy systems (vRES) increase its overall operational costs, which may, in turn, reduce the environmental and societal benefits of these resources (Viviescaset al., 2017). Thus, exploring new options to integrate a higher share of vRES while minimizing the costs and minimizing the environmental impact is crucial for our future, as a sustainable society.

One promising option is to assess and explore vRES generation complementarity using two or more technologies. The goal is to take advantage of the lack of temporal correlation (negative correlation) between their primary resources: in this case, wind speed and solar

* Corresponding author.
E-mail addresses: antonio.couto@lneg.pt (A. Couto), ana.estanqueiro@lneg.pt (A. Estanqueiro).

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