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Evaluating the impact of new renewable energy on the peak load - An ARDL approach for Portugal

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Abstract

The integration of intermittent renewable energy will lead to demand surplus, whenever the need for generation from combined-cycle plants increases. This paper focuses on Portugal, a country in which wind power is largely integrated, and which has recently made major investments in solar power. The results show that coal energy management does not contribute to smoothing out the intermittency problems of intermittent renewable energy. The results further demonstrate that the inclusion of intermittent renewable energy in the electricity system leads to a huge need for combined-cycle generation. Thus, this suggests that a differentiated price policy will only be effective if, instead of consumption, the focus is on net load.

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Keywords: Net load; Intermittent renewable energy; Combined-cycle plants; ARDL; Demand surplus

1. Introduction

The intermittent renewable energy sources (hereafter RES-I), namely wind and solar-photovoltaic, are characterized by intermittent and unpredictably generation with variable costs close to zero. However, the penetration of RES-I implies high initial investment costs. These costs are an obstacle to investors, and therefore generation by RES-I would have to be subsidized. The most common contracts used to finance wind power and solar energy are the feed-in tariffs, which provide RES-I with dispatch priority at a fixed price throughout the period of consumption/generation [1, 2].

This work intends to add to the literature by investigating changes in peak electricity periods when there is RES-I generation. To do this, four Autoregressive Distributed Lag (ARDL) models will be developed to compare the differences between electricity demand and electricity net load with generation from thermal sources. No comparable methodology was found in the literature. In order to analyze the

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intermittency problem of RES-I, it is crucial to define the notion of net load. Net load is defined in the literature as the total electricity demand minus the total renewable energy [3, 4], or minus wind power [5, 6]. In this paper, the electricity net load (hereafter ENL) is defined as the demand for electricity minus the supply from wind and solar power.

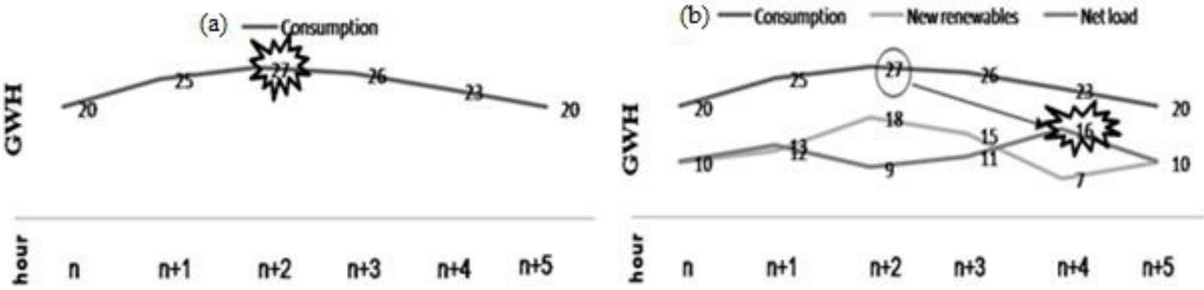

Figure 1 (a) Demand surplus before the integration of RES-I. (b) Demand surplus with integration of RES-I

With non-renewable sources, the variable costs vary with the price of raw materials. As such, when there is higher consumption, the demand for raw materials also increases, leading to an increase in its price. Thus, before the integration of RES-I, it was crucial to smooth the load diagram by decreasing consumption peaks. The consumption peak corresponds to the generation peak of the total thermal sources. Fig.1, (a) and (b) serve as examples of the demand surplus before the integration of RES-I, and illustrate the ENL concept, respectively.

Fig.1 (a) represents a situation of electricity demand in GWh over a period of 6 hours on a given day (values are merely illustrative). So, before the integration of RES-I, critical consumption would be in the period n+2, i.e. a consumption of 27 GWh. Considering the intermittent nature of resource availability, the peak-pricing concept has to be adapted to the new energy mix challenges.

Given that the RES-I are intermittent, the best scenario for accommodating these RES-I is making demand follow the availability of the natural resources. In this way, the higher costs of electricity may not be present in times of higher consumption. This will happen whenever the need for generation from thermal sources increases.

In Fig. 1 (b), there is a change regarding the period of peak consumption due to the RES-I, i.e. the peak period is not period n+2 (consumption = 27 GWh) but period n+4 (consumption = 23 GWh). This peak change is due to the greater need for electricity production by thermal sources during period n+4. Thus, it can be seen that, with the integration of RES-I, the most problematic moments are the peaks observed in the ENL, since it is at these times that renewable production is lower.

This paper seeks to answer the question: could intermittent electricity contribute to the reduction of demand surplus? The objectives are to identify the differences between the presence and absence of generation from combined-cycle gas turbine plants (hereafter CCGT) in relation to consumption and ENL. By clarifying the relationship, the impact of RES-I on the remaining generation sources will be identified. To do this, the paper focuses on Portugal, a country with substantial integration of wind power and one of the most isolated countries in Europe. The main outcome shows that the RES-I, by not following the increases of electricity demand, causes an increased need for generation by CCGT.

The paper is developed as follows: section 2 presents a review of the literature; section 3 is devoted to presenting the data and methodology used and the preliminary results; section 4 presents the main results, as well as the robustness checks and a discussion of the results; and section 5 presents the conclusions.

2. Literature Review