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Wind power idle capacity in a panel of European countries

Rui Flora [a], António Cardoso Marques [a,b,*,1], José Alberto Fuinhas [a,b]

[a] University of Beira Interior, Portugal
[b] NECE, Portugal

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ABSTRACT

In renewables, namely wind power, the evidence of discrepancy between the installed and the used capacity needs to be studied in depth. The wind idle capacity is analysed, through panel data techniques, for a set of 18 European countries for the time span 1998–2011. Notwithstanding the so-called common policy guidelines within the countries, contemporaneous effects among countries were not proven. Socio-economic factors should be considered in order to understand the phenomenon of wind idle capacity. Policy measures that stimulate additional wind capacity are also contributing towards increasing the phenomenon of idleness. This fact should be taken into consideration by policymakers, who must refocus their policies towards enhancing technological efficiencies. Both the substitution effect and the lobbying effect are found for conventional sources, which could be smoothing larger idle capacity inefficiencies.

1. Introduction

Renewable energy has been widely adopted as part of the European strategy both to meet long-term targets for reducing energy dependence and to reduce greenhouse gas emissions (e.g. Ref. [1]). Wind power has been one of the main vehicles in accomplishing these goals. The intrinsic characteristic of intermittency of renewables is notorious in wind power. Indeed, evidence of divergence between the installed and used wind capacity could be leading to economic inefficiencies that deserve to be given particular focus in the literature.

Working upon traditionally established concepts, most of which come from the field of industrial economics such as installed or excess capacity, is a sensitive issue when pursued from a different viewpoint. In particular, focussing on industries such as wind power, where the non-used capacity of production surpasses the lack of market demand, is even more exciting. This complexity therefore deserves brief clarification. Commonly, installed capacity is defined as the set of resources that are available to firms producing goods or services. This could be part of a strategy to mitigate the effects of demand uncertainty or it could even be a market competition strategy.

For wind power players, none of these strategies is, in fact, attractive. Lack of demand, or demand uncertainty, are far from being severe problems to these players. Indeed, they have priority in the dispatch of the electricity to the grid. Therefore, it is worthwhile noting that the electricity generated from renewables has priority access to the grid as a result of EU Directive [1], and consequently market demand is not a constraint in using installed capacity. This framework, jointly with the guaranteed prices over long-term contracts, makes the second strategy pointless. This means that unused wind power installed capacity is a consequence of the absence of wind, which is the main production input, rather than lack of electricity demand or competition behaviour strategy. Moreover, another specificity of electricity is the great difficulty (if it is even possible) of storage, unlike most other goods and services. In short, idle capacity rather than excess capacity is the object of analysis.

Once the specificities of wind power installed capacity have been clarified, two possible options arise to analyse this issue: (i) focus on the share of installed wind capacity, which is effectively used (capacity factor); and (ii) focus on the share of installed wind capacity, which is idle. Unlike other authors, such as Boccard [2] and Yang et al. [3], who follow option (i), our insight was towards option (ii). The motivations for this choice are threefold. First, the paper is focused on explaining the installed capacity in wind power that is not actually used. As such, it seems to us appropriate to work upon idle capacity instead of upon the capacity that is really used. Second, for the policymakers, guidance is more attractive in order to understand the factors that are enhancing idle capacity so that it

* Corresponding author. University of Beira Interior, Management and Economics Department, Estrada do Sineiro, 6200-209 Covilhã, Portugal. Tel.: +351 275 319 600; fax: +351 275 319 601.
E-mail addresses: amarques@ubi.pt, acardosomarques@gmail.com (A.C. Marques).
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can be avoided. Third, from the economic point of view, economic inefficiency concerns, i.e. the opportunity cost of investments. These investments are not even used over long periods. This inefficiency should be reduced or even eliminated. As stated above, the planned excess capacity is a well-known practice of strategic behaviour within the markets, which is vastly studied in the context of industrial economics. But the excess capacity is also economically inefficient. This inefficiency is of particular concern in capital intensive industries such as wind power, where the majority of costs are capital costs. In short, our option brings more readability to the results and enriches the debate and discussion.

Centred on a set of European countries, which have long been committed to environmental concerns, long-term energy goals and a large and well developed wind power industry, the main aim of this paper is to empirically appraise the factors that influence wind power idle capacity. It is already well-known that the degree of idleness is firstly determined by the availability of wind. Nevertheless, taking into account that the option towards wind power is also a consequence of policymakers' decisions, other factors arise in explaining the gap between the capacity that is installed and that which is actually used. Specifically, this paper attempts to answer the following tangled questions: (i) what role do socio-economic factors play in explaining wind power idle capacity?; (ii) how do conventional energy sources interact with idle capacity in wind power, even playing a backup role to renewables?; (iii) what is the contribution of the policymakers' measures in influencing this phenomenon of idle capacity? The panel was subject to a battery of diagnostic tests presented further ahead and, accordingly, the most suitable panel estimators were applied.

Results prove to be consistent and robust. They support the existence of a substitution and lobbying effect in conventional sources based on fossil fuels. Though it was not possible to measure the backup effect directly, results are consistent with the possibility that backup is actually present. In fact, hydro plants seem to be used to backup wind energy generation in idle periods. Additionally, the results suggest that policy measures may be having an unwanted effect, since they may be causing idle capacity in wind power. This finding is discussed thoroughly further ahead.

The remainder of this paper is organised as follows: Section 2 focuses on the literature review. Section 3 presents data and methodology. Section 4 discloses the results, and discussion is provided in Section 5. Finally, Section 6 concludes.

2. Renewable intermittency and idle capacity: theoretical background

In the literature, the main motivations towards the support for renewable energy sources are well known. They include: the reduction of CO_2 emissions, despite the literature's lack of consensus (e.g. Ref. [4]); reducing energy dependence; the promotion of local industry and employment [5] and energy demand growth [6]. However, some renewables imply intermittency in generation due to the lack of constant input that would allow output to be maximised. This issue is widely discussed in the literature [7–9] both theoretically and based on case studies. Nevertheless, the concept of intermittency raises problems, such as the non-use of installed capacity, which has been mentioned by Tarroja et al. [10] but deserves further research.

The literature concerning the effects of efficient allocation of wind farms is far from abundant. Caralis et al. [11] analysed the capacity factors in Greece and suggested that spatial dispersion of wind farms benefits the wind power capacity factor. They concluded that the accumulation of too many wind farms is not always the optimal solution because it may impair the efficiency of each individual wind farm. The higher the penetration level of wind power, the higher the role of spatial dispersion will be. In line with that, in China, according to [3], more than three quarters of wind installed capacity is idle, causing a capacity factor of 16.3% between 2007 and 2010. This may be signalling too much wind power capacity.

The reasons for the huge growth of wind power in China are summarised by Yang et al. [3] and Zhang and Li [12]: (i) the perception that China would benefit from large wind resources; (ii) the adoption of energy policies that promote incentives and subsidies for the installation of wind power; and (iii) the reduction of wind capital costs. Boccard [2] sustains that capacity factors depend on: (i) wind variability; and (ii) the shadowing phenomenon, which comes from wind farms compromising the distance between each one to save on land cost or grouping too many turbines in a limited area with high population density, reducing turbines individual performance.

The decision to install wind capacity could have been predominantly political. This would imply changes in the current balance of the different components within the national energy systems. Consequently, when the literature centres attention exclusively on the generating factors, economic and energy supply reasons, then it could be restricting a full understanding of the phenomenon. The focus of the analysis should be anchored not only on accepting the fact that idle capacity exists, but it should also be placed on the eve of that origin. In other words, policies directed at promoting a specific new energy source are not only influencing the global energy mix, but also depend and impact on other factors with different natures. A different approach could be to analyse the impact of excess electricity production on the energy system as a whole [13–16].

Socio-economic factors are frequently pointed out in the literature as being relevant to understanding the renewables path. The presence of a relationship between economic growth and renewables deployment is well-known, but also controversial. Marques et al. [17] argued that the effect of GDP on renewables depends on the share level of renewables. In their turn, Chang et al. [18] suggest that economic growth and renewables' growth are not directly related. Nonetheless, countries that are in an upward trajectory with high growth rates can support costs of investing efficiently in renewables. Developed countries have more economic capability to support retrofitting investments in renewable energy sources to reduce idleness.

Most of the literature has focused on the interconnection of renewable energy sources to minimise wind volatility effects. One of the best known examples is wind-hydro pumped storage systems. In low electricity demand periods, electricity generated from wind can be seized to pump water to an upper reservoir to be reused later to balance electricity supply [19,20]. The interconnection of hydro power plants with wind power in isolated areas has been assessed for Mexico [21] and for Greece [22]. Fossil-based power plants are, in general, indicated as a backup to offset the volatility of energy from renewables [23,24], namely natural gas and coal. The combined cycle natural gas power plants can backup renewables on quasi-standby, having start up times of only a few minutes as pointed out by Luickx et al. [25] and Purvins et al. [26]. In their turn, coal plants provide backup with different characteristics, requiring early planning due to their longer start-up time, which could take several hours to reach full power operation [26,27]. This planning ahead is often wrongly associated with the role of baseload. Since it is the cheaper fossil source, coal enables this partly scheduled backup while contributing to cutting average costs in electricity generation.

Nevertheless, traditional energy sources are usually influenced by a lobbying effect in the energy industry [28,29] suggest that, for OECD (Organisation for Economic Co-operation and Development) countries, established interests can lead to more stringent energy policies, in spite of renewables. These results may suggest that political decisions can protect traditional energy industries in detriment of renewables' deployment.

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