KEY OBSTACLES TO WIND ENERGY DEVELOPMENT: A STUDY WITH THE TOP 10 COUNTRIES IN NEWLY INSTALLED CAPACITY

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ABSTRACT

This article identifies and classifies the key obstacles to wind energy development, in order to better understand these barriers and provide guidelines to help public managers to develop and share new energy policies. The methodology used was a case study with documentary research, carried out through an analysis of the Global Wind Report - Annual Market Update, 2009 to 2013, published by Global Wind Energy Council – GWEC. The results showed a significant occurrence of technological and operational obstacles, especially concerning electricity grids. The results lead to the conclusion that the biggest issue for wind energy development is concentrated in technological and operational obstacles, especially concerning the management of transmission networks. In addition, the results indicate the possibility of countries, with common obstacles, to improve their energy policies in partnership, or share their successful expertises.

Key Words: *Wind Energy, Renewable Energy Management, Energy Policies*

1. Introduction

Power generation is indispensable for humankind, especially from a socioeconomic view. In the last decades, the world has achieved a great dependence on fossil fuels, but the increase in the complexity in fossil fuel transformation is driving changes in the world's energy mix (IEA 2014). Moreover, fossil fuels represent carbon-intensive energy inside a global scenario of increasing environmental concern, which demands low-carbon generation and demand-side technologies.

Aiming to reduce or even to eliminate issues related to energy, nations worldwide have been driving efforts to diversify their energy matrix by exploiting renewable energy (RE) sources, looking to combine profitability with environmental protection (REN21 2011). Among the RE sources, wind and solar energy have shown the biggest growth rates for power generation from 2005-09, which can be assumed to be a consequence of the rapid increase in technology to exploit these sources (EIA 2011), as well as the proven technological, economical and environment viability of its production (Dai et al. 2015).

Dai et al (2015) highlighted wind energy among the RE sources due to the verified technological and economical maturity associated with the environmental and social viability of its exploitation. Indeed, wind energy stands among other RE for its capacity to generating work positions (social advantage), for reducing production costs related to technologic improvements in recent years (economic advantage) and for being a zero carbon energy source (environmental advantage) (Simas and Pacca 2014).

Recognizing wind energy as a viable option to global power generation, and through the verification of the need to of its sustainable expansion, this paper indentify and classify key obstacles to wind energy development in the top 10 countries in newly installed wind power capacity presented in the 2013 Global Wind Report published by the Global Wind Energy Council (GWEC). The main contribution of this research is to support the ideas that nations can improve their energy policies jointly, and that successful management experiences can be shared.

Considering the presented arguments, this article is structured in six sections. Besides this introduction, section 2 presents a brief literature review of RE (emphasizing wind energy), while section 3 presents its global scenario. Section 4 accounts for the material and methods used and section 0 presents the results obtained. Finally, section 6 presents the conclusions.

2. Renewable energies: a brief summary

Directive 2009/28/EC defines RE sources as those from renewable non-fossil sources, namely wind, solar, aero thermal, geothermal, hydrothermal and ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas and biogas; a similar definition is found in REN21 (2010). The USEPA (2014) states that RE sources can restore themselves over short periods of time and do not diminish, while the USEIA (2015) points out that they are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time.

Currently, modern renewables are considered as the best alternatives to increase power generation (Cavaliero and Da Silva 2005, Alnatheer 2005, Huacuz 2005). Modern renewables, i.e. energy resources that can be transformed into modern energy services, like electricity, have an important role in the world energy matrix, once they introduce three major technological changes: energy savings, efficiency improvements, and replacement of fossil fuels.

This scenario contributes for a new energy world order, which is based on the self-sufficiency in power generation, combined with the diversification of energy sources (Pacheco, 2006). In this context, governments are looking for policies to promote the development and the establishment of these modern renewable sources (GWEC 2014a).

Participation in modern renewables has been increasing quickly and reaching a competitive edge (Fridleifsson 2001). According this situation, the European Renewable Energy Council (EREC) estimates that in 2030, the share of renewable electricity will account for 65-67%, and by 2050 renewable electricity will provide for 100% of the EU´s power demand in the "aggressive efficiency" scenario (EREC 2010, Kralova and Sjöblom 2010).

However, in 2012 RE was responsible only for 19% of the total energy consumed in the planet and, from this total share, approximately 10% were related to modern renewables, while 9% of the remainder coming from traditional biomass (REN21 2014). From this 10%, it is estimated that only 2% came from wind, solar, geothermal, biomass and biofuels, as shown in (REN21 2014). The gap between fossil fuel and RE sources is still significant; however, renewables participation in the total energy consumption is increasing, as demonstrated in Section 3.

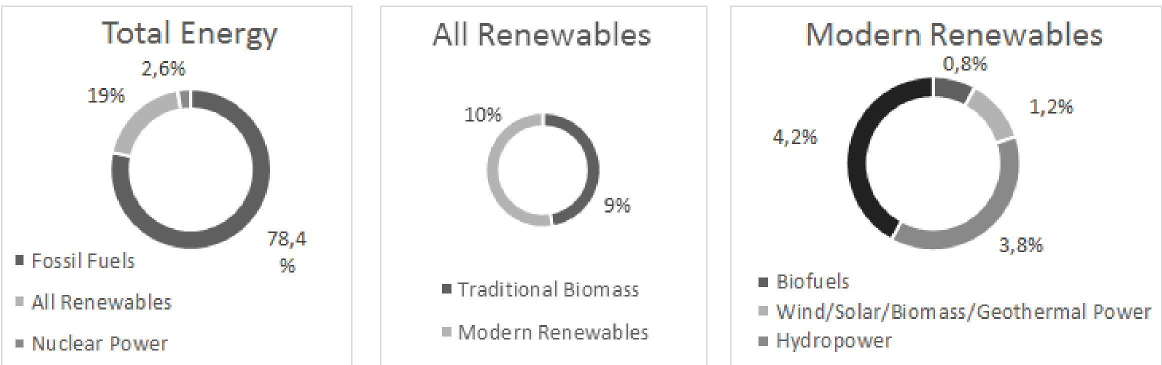

Figure 1: Estimated renewable energy share of global final energy consumption in 2012.
Source: adapted from REN21 (2014).

3. Wind power: the global scenario

Wind energy is a primary source of energy and it can be exploited for electricity generation through the conversion of translational kinetic energy into rotation kinetic energy through wind turbines (Amarante et al. 2001). The usage of wind energy is an ancient practice and it dates back to the development of agriculture, when methods to reduce the involvement of humans and animals became necessary and the first wind mills were developed. In the beginning of the industrialization era, wind mills were replaced by an energy generator and in

1981, in Denmark, the first wind generator for electricity was built (Reis, Jr., and Carvalho 2006).

Driven by political, industrial and scientific efforts, among modern renewables, wind power has obtained prominence in the global energy scenario and it is considered by many as a mature technology and a RE that is able to provide supply in a global scale, even considering its challenges (Huang and McElroy 2015, IEA 2014). This is highlighted in Figure 2, which shows that wind power is the major source for electricity generation among the modern renewables.

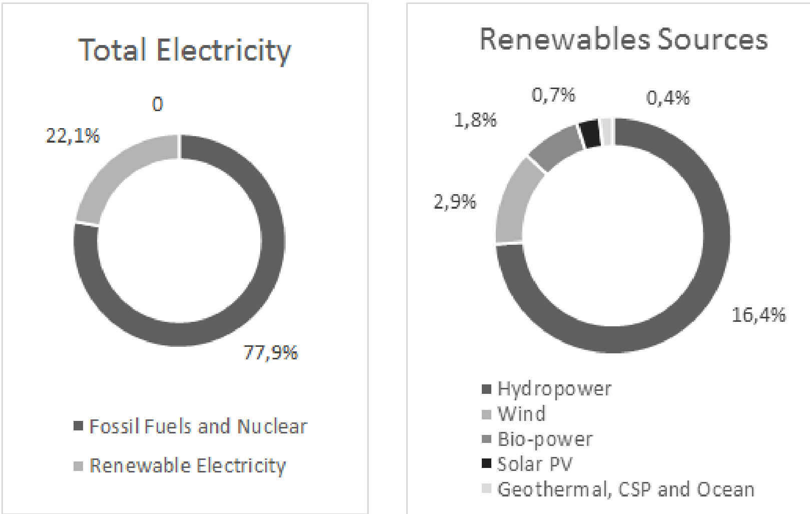

Figure 2: Estimated Renewable Energy Share of Global Electricity Production, End-2013.
Source: adapted from REN21 (2014).

By the end of 2013, the total installed capacity of wind power achieved 318 GW, from which more than 10% (about 35 GW) were added only in 2013. This data shows a strong correlation to the World Energy Outlook (WEO), which showed that wind power capacity increased from 17 GW in 2000 to 317 GW in 2013, i.e. a 25% growth rate per year (IEA 2014). The WEO predicts that, in the Current Policies Scenario, wind energy will reach 1043 GW of installed capacity in 2040 and it will account for over 6% of the global generation mix (IEA 2014).

Currently 103 countries are using wind power on a commercial basis (Huang and McElroy 2015). In 2013, according to GWEC (2014a), China had the biggest cumulative capacity, accounting for 28.7% of the share, followed by the United States of America (USA) with 19.2%, Germany (10.8%), Spain (7.2%), India (6.3%), United Kingdom (UK) with 3.3%, Italy (2.7%), France (2.6%), Canada (2.5%) and Denmark (1.5%) (GWEC 2014a).

Considering the incremental installed capacity in 2013, the same countries in cumulative capacity were observed, except for Spain, Italy, France and Denmark (which can be accounted for the reduction of investments observed in these countries). Considering a 2013 installed capacity rank, Spain, Italy, France and Denmark were replaced by Brazil, Poland, Sweden and Romania.

China is observed as a leader, accounting for 45.6% of the 35GW added in 2013, followed by Germany (9.2%), UK (5.3%), India (4.9%), Canada (4.5%), USA (3.1%), Brazil (2.7%), Poland (2.5%), Sweden (2.1%) and finally Romania (2.0%) (GWEC 2014a). These numbers demonstrate that Asia (China and India) are the leaders in the wind power generation, followed by North America (USA and Canada), Europe (Germany, UK, Spain, Italy, France, Denmark, Poland, Sweden and Romania) and Latin America, led by Brazil.

4. Research Method

This study is a applied research and, regarding its objectives, it is defined as descriptive and exploratory. A qualitative analysis was carried out, using a case study. To support this research, the available literature was investigated in relevant bibliographic databases.

This research was conducted in two stages: (i) bibliographical research, in which existing data were verified and the scope of the research was defined, with the aim of generating the theoretical basis and (ii) documental analysis. In the second stage, annual reports published by the Global Wind Energy Council from 2008 to 2013 were analyzed (GWEC 2009, 2010, 2011, 2012, 2013, 2014a).

In these reports key barriers and obstacles for wind development were verified, analyzed and classified in section 0. Ten countries were evaluated, which were selected based on their increase in wind power installed capacity in 2013, namely: China, Germany, UK, India, Canada, USA, Brazil, Poland, Sweden and Romania, as reported by GWEC (2014b).

Data analysis was made through descriptive tables, which were organized biennially (2008/2009; 2010/2011; 2012/2013) and presented in the columns the key-obstacles and its classification. Regarding the classification of the identified obstacles, three representative categories were defined, considering the definitions presented in Table 1.

Table 1: Classification of obstacles.

Nature	Challenges
a) Technological/Operational	Development and implementation of technologies and

	infrastructure. Wind projects management in financial, operational, marketing and technological aspects.
b) Market/Regulation	Definition, control and management of actions that monitor and promote energy market in financial, commercial, operational, legal and tax issues.
c) Political/Social	Legal framework, definition of incentives, promotion and social support for wind energy development.

5. Results

The key obstacles to wind energy development in the ten selected countries are identified and classified in *Table 2*, according to the classification of obstacles described in Table 1. This section presents the main results regarding the data analysis performed.

In all years, China presented technological/operational obstacles, mainly related to transmission networks and their management. Besides, political and social obstacles were observed in the last two biennia, demonstrating little political incentive, which resulted in project financing reductions and in projects approvals (mainly in terms of offshore generation). However, China has demonstrated efforts to confront market/regulatory issues, since its Renewable Energy Law guarantees wind and other renewable electricity sources priority access to the grid.

In Germany, in all years, market/regulatory obstacles were observed, related restriction in the height and distance between wind turbines. In addition, in the first biennium, barriers related to area restriction to wind farms were reported. In the first and in the last two years, technological/operational obstacles regarding the use of modern turbines, system optimization and grid expansion were revealed. Finally, in the last two years, political/social obstacles were linked to political uncertainty in the formulation of wind power laws.

In the UK, technological/operational obstacles were verified in all years, mainly in transmission network management. In the last two biennia project management delays were identified: planning of wind farms was delayed and high production costs were observed. It is important to point out that political/social obstacles were observed in all periods, which can be associated to a increasing social opposition to wind power, that is calling political attention; in the last biennium, political uncertainty was also observed regarding the Energy Bill, which can impact project finance and investor confidence in manufacturing.

In India, in the last two biennia, transmission network management was a relevant technological/operational obstacle. Market and regulatory obstacles were reported only in the last two years, and they were related to wind generation financing and net concessions. Finally, political and social obstacles were observed in the first couple of years, due to the absence of a national law on renewable energy, and in the third biennium, due to the reduction of fiscal benefits to producers, such as credit and tax reduction.

In Canada, in the last two biennia, market/regulatory obstacles were verified due to uncertainties in energy policies, carbon and electricity pricing. In this country, in all years, political/social obstacles gained prominence due to the lack of definition in wind power insertion in the national energy system, as well the referred uncertainties in energy policies that regulate electricity pricing.

Concerning the USA, in all analyzed periods of time, the political aspect was very significant and it is mainly linked to the instability in the federal Production Tax Credit (PTC), whose extension is expected to be approved. PTC is an inflation-adjusted per kilowatt-hours (kWh) tax credit for renewable electricity which can be extended for one or two years. This short term policy generates instability, making the promulgation of a legal incentive for renewables a major key point to assure stability in the sector in the long term.

In Brazil, in the first two biennia, a main political obstacle was reported the need of a new wind regulatory framework due to the expressive wind energy development. In 2012 and 2013, technological/operational and market/regulatory obstacles gained projection. In these years, the technological/operational obstacles were related to operation management aspects, such as infrastructural and logistical limitations in transporting wind components, as well as situations regarding the management of the transmission network and the market/regulatory issues are related to new rules that hamper machine and equipment financing.

In Poland, the first two years presented technological and operational barriers, more specifically issues related to the management of transmission networks. In this period, two market/regulatory obstacles can be highlighted, namely: (i) operational and financial regulations (associated to the difficult to construct wind farms in natural reserves) and (ii) the absence of clear regulations regarding cost allocation of transmission network expansion and optimization.

Lastly, the last two biennia presented market and regulatory obstacles. During 2010-2011 barriers to offshore wind energy were shown, while, during 2012-2013, barriers related to energy pricing were found. Political and social obstacles emerged during 2012-2013, as the absence of laws to promote stabilization in wind production.

In Sweden, in all years analyzed, the technological/operational obstacles were identified, mainly in the transmission network management scope. Finally, political/social obstacles emerged in the last two years analyzed, which are related to the little political incentive to offshore wind.

In Romania, technological and operation obstacles, as well as political and social obstacles, were present in the first two biennia, basically corresponding to transmission networks and their management and low political incentive, respectively. In the last two years, a market/regulatory obstacle showed problems in the new policy framework. A 2012 law determines that power producers have to sell power only to the wholesale market directly and also determines an outright ban on power purchase agreements, generating difficulties for project financing.

Table 2: Identification and classification of obstacles.

Countries	2008-2009	2010-2011	2012-2013
1) China	***(A)* Transmission networks:** optimization, expansion and integration issues. Physical constraints of grid capacity.	(*A)* **Transmission networks**: optimization, expansion and integration issues. Electricity grid infrastructure. ***(B)* Financing:** low investments that leads to a low competitive market. ***(B)* Network usage**: grid companies monopolies. ***(C)* Political incentive:** legal barriers, low number of projects approved, submission of projects to government's approval.	***(A)* Transmission networks**: optimization, expansion and integration issues. ***(B)* Financing*:*** low public and private credit offer. ***(B)* Network usage*:*** regulatory aspects that guarantee that renewable energy has priority in the transmission grid. ***(C)* Political incentive*:*** lack of coordination between different government agencies led to a minor development of offshore wind.
2) Germany	***(A)* Transmission networks**: optimization, expansion and integration issues. ***(B)* Operating regulations:** restrictions regarding height and distance between turbines. ***(B)* Operating regulations:** definition of specific areas to wind development, generating zones of exclusion**.**	***(B)* Operating regulations:** restrictions regarding height and distance between turbines.	***(A)* Transmission networks**: optimization, expansion and integration issues. ***(B)* Operating regulations:** restrictions regarding height and distance between turbines. ***(B)* Political incentive:** legislative uncertainties in formulation of laws of laws that support wind power development.

Countries	2008-2009	2010-2011	2012-2013
3) United Kingdom	***(A)* Transmission networks:** optimization, expansion and integration issues. ***(C)* Social incentive:** increasing opposition to wind power.	***(A)* Project management:** delays in planned actions and decision making. ***(A)* Transmission networks**: optimization, expansion and integration issues. ***(C)* Social incentive*:*** increasing social opposition to wind power.	***(A)* Operation management*:*** high operational costs in wind farms, mainly in offshore facilities. ***(A)* Project managements:** delays in planning and long governmental decision time. ***(A)* Transmission networks*:*** optimization, expansion and integration issues. ***(C)* Political incentives:** political uncertainties regarding support to production, affecting investor confidence. ***(C)* Social incentive:** increasing opposition to wind power.
4) India	***(A)* Transmission networks**: optimization, expansion and integration issues. ***(C)* Policy definitions*:*** absence of national policy for renewable energy.	***(A)* Transmission networks**: optimization, expansion and integration issues.	***(A)* Transmission networks**: optimization, expansion and integration issues. Transmission infrastructure need to be improved. ***(B)* Financing*:*** Great delays in wind farm operators payments. ***(B)* Financing*:*** high borrowing costs reduce the pace of wind energy expansion. ***(C)* Network usage*:*** instabilities to network connection.

Countries	2008-2009	2010-2011	2012-2013
5) Canada	***(C)* Political incentive:** political uncertainty in stimulating wind energy development.	***(A)* Transmission networks:** planning and construction of grids is needed. Transmission constraints prevent wind development in the country. ***(C)* Political incentive*:*** uncertainty of the wind energy share in the energy expansion of the country. ***(C)* Political incentive:** unclear policies to address climate chance. The lack of carbon pricing does not reflect the environmental aspect of wind energy and creates distortions in energy pricing.	***(C)* Political incentive*:*** uncertainty of the wind energy share in the energy expansion of the country. ***(C)* Political incentive:** unclear policies to address climate chance. The lack of carbon pricing does not reflect the environmental aspect of wind energy and creates distortions in energy pricing.
6) USA	***(C)* Political incentive:** regulatory uncertainties concerning the Production Tax Credit (PTC). ***(C)* Political incentive:** uncertainties regarding policies, such as the creation of a national electricity standard (RES).	***(C)* Political incentive:** regulatory uncertainties concerning the Production Tax Credit (PTC).	***(C)* Political incentive*:*** regulatory uncertainties concerning the Production Tax Credit (PTC).

Countries	2008-2009	2010-2011	2012-2013
7) Brazil	***(B)*** **Regulatory Framework:** a new regulatory framework is necessary due to the great development of wind in the country.	***(B)*** **Regulatory Framework:** a new regulatory Framework is needed due to the great development.	***(A)*** **Operation management**: logistical difficulties in transporting towers and other large wind components. ***(A)*** **Transmission networks:** optimization, expansion and integration issues. ***(B)*** **Financing:** new financing rules for machines and equipment. ***(B)*** **Physical guarantee:** current legislation increased the requirement from 50% to 90% probability of achieving stated generating power. ***(B)*** **Markets:** Postponement of energy auctions.
8) Poland	***(A)*** **Transmission networks**: optimization, expansion and integration issues. ***(B)*** **Operational regulation:** some areas with the best wind conditions are situated in nature reserve areas. ***(B)*** **Financial regulation:** absence of clear rules for determining and allocating costs between grid operators and power producers.	***(B)*** **Operation regulation:** restrictions regarding offshore wind farms installations.	***(B)*** **Pricing definition*:*** energy prices are defined in accordance with green certificates; which has presented growing reference values. ***(C)*** **Political incentive:** Absence of laws to guarantee stability in wind power generation.
9) Sweden	***(A)*** **Transmission networks**: optimization, expansion and integration issues.	***(A)*** **Transmission networks**: optimization, expansion and integration issues.	***(A)*** **Transmission networks**: optimization, expansion and integration issues. ***(C)*** **Political incentives:** little incentives in offshore production.

Countries	2008-2009	2010-2011	2012-2013
10)Romania	The country was not evaluated in these years.	***(A)*** **Transmission networks**: optimization, expansion and integration issues. ***(B)*** **Regulatory framework:** uncertainty in the legal framework ***(C)*** **Political incentive:** despite the great development and the target of 20% of renewables sources for total gross electricity produced in the country, only 1.5% of the produced energy in 2010 came from renewable sources,	***(B)*** **Regulatory framework:** a new law prohibits energy selling in specific situations. It generates limitations for contracts, which reflects as a barrier for investors.

6. Conclusions

Wind energy contribution is already noticeable in the renovation of global energy. This can be seen as a consequence of the need to reduce dependency on non-renewable sources allied with an increasing environmental awareness. Taking this into consideration and the large wind capacity available worldwide, it is clear that wind energy is a major player in power generation.

Efforts to improve and to support wind energy development need to be made, allowing a favorable political, methodological and technological environment. Aiming to contribute to this maturation, this study identified and classified the key obstacles to the development of wind energy, considering 10 countries that significantly increased their wind installed capacity in 2013.

The results of this study enable to conclude that major challenge to wind development in the selected countries is related to technological and operational issues, more specifically transmission, grid integration and their management. This particular issue was identified in different moments in all countries analyzed, except in the USA. It is possible to conclude that improvements in the transmission network is a major need worldwide; as well as to facilitate its optimization, expansion and integration to ensure that all of the energy produced in wind farms can be delivered at the right time and in the right quantity to all targeted places.

It was also possible to identify a great occurrence of political/social obstacles, specifically related to political incentives of the countries that failed in assuring the necessary legal framework to the development of wind energy. This issue was verified in all years in Canada and the USA. The same barrier was also present in different periods of time for all countries, excepting Brazil and India. Therefore, it is clear that there is a need to define energy policies that enable the sustainable development of the wind sector and which also comply with the interests of government, producers and society.

Finally, a very significant number of market/regulatory obstacles were identified. These challenges are mainly related to financing, operating regulations and pricing issues. It is possible to conclude that there is a global need to define regulatory frameworks which present, considering the specificities of each country, rules defining how wind energy shall be driven, maintained, expanded, and, mainly, how it will be paid.

The identification of the key obstacles in the selected countries offers the possibility to identify similarities regarding its occurrence, which may allow the conjoint development of energy policies. Even though there is a lack of a joint energy in the short and medium terms, the identification of similarities in barriers allows the nations to identify solutions and strategies to eliminate its own barriers.

The classification of the key obstacles is important while formulating these policies, since it allows for a better understanding of the problems and allows a comparison between them. This classification is considered by the authors as an important methodological contribution given in this paper.

Future studies may identify, among the nations that were analyzed, which of them continue in the top-10 regarding installed capacity. The key obstacles should also be reanalyzed in the future and their evolution should be verified in order to examine if the exiting barriers are still exiting or not. The processes involved in the solution of the related problems may also become a case of study in the future.

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