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# Over Equipment in Wind Farms Maintaining Grid Connection Power

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**Abstract**

Over-equipment in wind farms maintaining grid connection power is a new sustainable procedure that is allowing the increase of energy producing in wind farms.In Portugal, one of the fundamental lines for the structural modernization of the country is the pursuit of an energy strategy focused on increasing electricity production through renewable energy.

In a wind farm the probability of all wind turbines running at full power and at the same time is very low. However, it is necessary to respect the maximum power of connection to the grid, which is established in the Production License issued by the General Direction of Energy and Geology. In this way a wind farm can be upgraded to 20% of its installed capacity, considering that not all wind turbines will be running at full power and at the same time. So, an additional power of 20% of the installed capacity can be used, increasing the profitability of the wind farm and the production of renewable energy. This energy produced by over-equipment is paid at 60 €/MWh. There is a measurement system to count that energy. The percentage of 20% has implicit statistical studies, which have been developed by the Portuguese Association of Renewable Energies.

The Portuguese legal regime applicable to the exercise of the activities of production, transportation, distribution and commercialization of electricity, namely concerning the concepts of production in ordinary regime and production in special regime, is established in Decree-Law number 215-B/2012, of October the 8th, which can be consulted through the internet site of the Last Resort Supplier [1]. This decree-law reinforced the legal regime applicable to the production of electricity under a special regime, namely through renewable energy sources.

Under these circumstances the power emitted by wind farms is monitored through dispatch centers and compared with the maximum power connected to the grid. If the power exceeds the connection power, the power emitted by the wind farms will be reduced to the limit allowed. In this way, the production of renewable energy became more profitable, because there is a surplus of energy that can be produced without exceeding the limit of maximum connection power to the network.

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## Introduction

The challenge of global warming and climate change is a remarkable opportunity for Portugal to invest in its endogenous resources, adopting measures whose objective is the autonomy and energy efficiency.

A huge effort has been made in the last decade to increase the renewable energy mix in this country. The total renewable production, including large hydro, reached 30,7 GWh in 2018 [2]. Figure 1 shows the evolution of renewable energy in Portugal from 2009 to 2018 [2]. The rectangles at the bottom of the graph represent the combined use of biomass, municipal solid waste and biogas. The next rectangles represent the wind energy production. In 2018 this production reached 12,7 GWh. The following small rectangles represent the production of photovoltaic energy, which presently is having a huge increase in Portugal. This great interest is mainly due to the fact of technology been having great cost reductions, due to scale effects. Portugal is a very sunny country with 1 700 hours of sunshine per year. The last graph rectangles represent hydro origin energy, including large hydro with a power greater than 10 MW. The energy produced in this segment was 13,6 GWh [2].

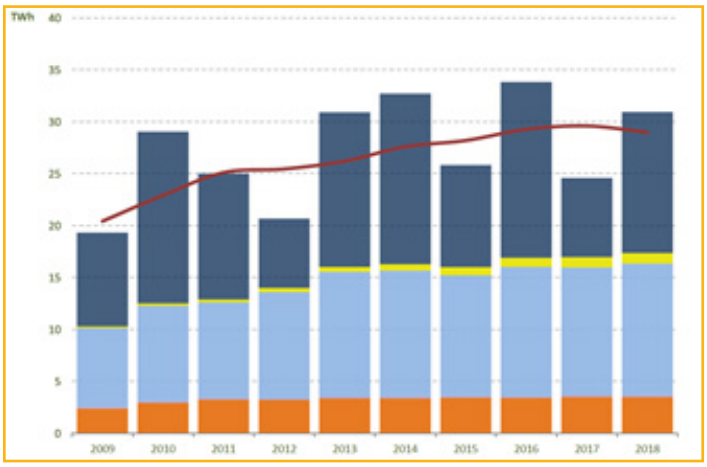


**Figure 1:** Evolution of renewable energy in Portugal [2].

Thus, it is evident the enormous importance that energy becoming from wind energy has been having in Portugal. The simplification of the procedure for the installation of over-equipment in wind power plants is one of the measures contributing to the increase of the production capacity of renewable energy, eliminating oil imports and reducing the use of the most polluting power plants. New concerns about environmental protection have made it necessary to focus more on environmental and energy policies to comply with international commitments, namely those relating to the limitation of greenhouse gas emissions.

The promotion of renewable energies, mostly wind power, has special importance for the international and European Union context, reminding the objectives and targets Portugal is committed to, that is gradually reducing external energy dependence and reducing the carbon intensity of its economy. Through the limited installation of new wind turbines, called over-equipment, to increase installed power in wind farms, it is possible to increase their installed capacity. Thus, there will be lower impacts on the environment and the territory than the installation of new wind farms, while rationalizing the use of existing public utility electricity infrastructures, such as rural and mountainous roads, as well as electric infrastructures.

The models of energy purchase contracts were approved by the Portuguese Direction of Energy and Geology, which gives investors a guarantee in the relationship between the producers and the Last Resort Supplier. The security of the energy purchase is an essential factor in the evaluation of project financing. Some banks request loan assignments with scope of guarantee on the future remuneration of energy production. The guarantee of purchase of the production under special regime becomes an added value, which nullifies the investment risk. On the other hand, renewable energies have a special contribution to the security of energy supply of the country [3].

Special regime power production is always ensured by the network Operators, both transport and distribution, except in the cases where it is necessary to interrupt the energy supplies due to constraints in the network. But when these events occur interrupted producers are economically compensated by those who have not been interrupted [4].

Limiting global warming involves creating 120 to 160 thousand jobs in key sectors such as energy, transport, building, food and forestry, and investing in the energy transition sector. Withal it is necessary to control the most polluting sectors of the economy, dedicating one day a week to the professional training of workers in

those sectors [5].

"Both Climate Change Adaptation and Disaster Risk Reduction aim to reduce the negative impacts of climate change and disasters on the natural environment, human society and economies by anticipating risks and uncertainties, and overcoming vulnerabilities." [6]. Achieving the 2013 goals and targets of international agreements will only be possible through a collaborative effort from all sectors of society across all governance levels, both public and private [6].

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"As urban areas continue to grow their impact on the climate increases. Cities occupy only 2% of the world´s landmass but they consume over 2/3 of the world´s energy and are responsible for more than 70% of global CO2 emissions." [9].

For the reasons explained above, the production of electricity through the using of a steady blowing wind has been of main importance in the production of renewable energy. Mainly from 2002, with the publication of Decree-Law nº 339-C/2001, of December 29th, there has been a widespread installation of wind farms in Portugal. The aerogenerators have been placed on the highest mountains, where there is more wind. The Portuguese annual power usage is about 2300 hours. The possibility of over-equipping wind farms, which is detailed in this article, is another possibility of producing more energy from renewable sources, using the existing infrastructures. In this way, the investment in the installation of new aerogenerators is reduced, thus allowing a reduction in the investment in new machines. This allows a reduction in the price of the energy produced, which means a global gain for the investors and the electricity customers.

In 2013 new legislation was published (Decree-Law nº 35/2013, of February 28th). That legal framework allows the extension of the energy acquisition by the Last Resort Supplier by another period of 5 of 7 years after 2020. To get the benefit mentioned above the producers are paying a monthly compensation.

**Increasing Installed Power**

In Mainland Portugal there are 238 wind farms, being the power installed 5 302 MW. In Azores Islands there are 9 wind farms, corresponding to the installed power of 31 MW. In Madeira Islands there are 11 wind farms, whose power is 46 MW [2].

In Figure 2 it is presented a graph that shows the relationship between the wind speed and the power obtained by a wind turbine [10]. For a wind speed between 3,5 m/s and 14 m/s the wind turbine power output is less than the nominal power. For newer wind turbines there is already a small power output for wind speeds of 2,5 m/s. When the wind power is between 14 m/s and 25 m/s, the wind turbine can reach its nominal power. Above the wind speed of 25 m/s the blades of the wind turbine are blocked, because for this order of speed the gear can suffer malfunctions.

Most of the time the wind turbines will run at a speed up to 14 m/s, thus not reaching its nominal power.

In probabilistic terms, it is very unlikely that all turbines in a wind farm are all running at nominal power at the same time.

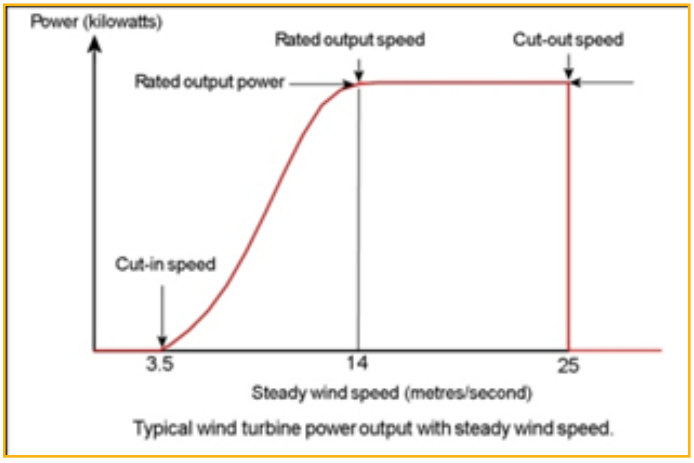


**Figure 2:** Typical turbine power output [10].

The accumulated experience and the new targets set for the wind-powered electricity production have advised over-capacity as an alternative form of investment, increasing the installed capacity of wind farms.

This established the possibility of over-equipping up to the limit of 20% of the power injection capacity in the public utility grid, previously assigned by the General Directorate of Energy and Geology.

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Therefore, over-equipment is not subject to environmental impact assessment in the following cases:

- When the over-equipment does not involve the installation of 20 or more wind turbines and the distance from another similar wind farm is not less than 2 km;
- When in over-sensitive areas over-equipment does not involve the installation of 10 or more wind turbines and the distances from another wind farm are not less than 2 km.

It should be recalled that the injection power attributed to the wind power plant remains unchanged despite over-capacity.

Following the working group formed by the entities APREN – Portuguese Association of Renewable Energy, the Global Technical Manager of the National Electric System, the Last Resort Supplier and the operators of the Transport System Operator and the Distribution System Operator, it was published the Decree-Law nº 94/2014, of June 24th, on the subject related to the over-equipping of wind farms.

The technical conditions of stability and security of the networks must be preserved.

However, it must be kept in mind that environmental impacts on the territory resulting from the installation of new wind turbines are reduced.

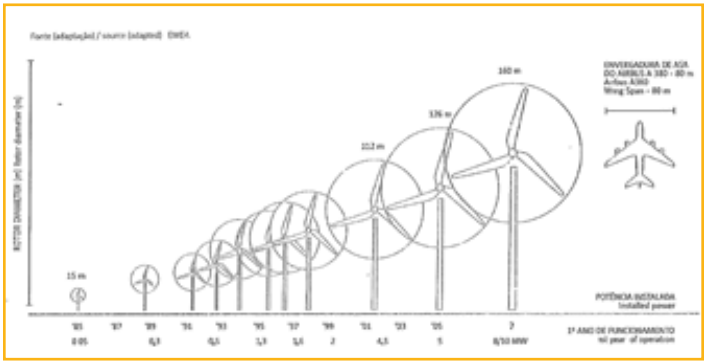

**Figure 3:** Evolution of wind turbine wingspan [11].

From the technological point of view, wind turbines have had a great evolution in recent years. According to the above Fig 3, the unit power of the wind turbines evolved from 300 kW in the early 90´s to about 7 500 kW presently. According to the same figure, the evolution of the rotor blades diameter can reach now over 120 meters, which is above the size of any commercial aircraft. The most commonly used modern wind turbine currently used has about 2 000 kW of nominal power, with a rotor of three blades 80 meters in diameter and a tower between 68 and 75 meters high [11].

In environmental terms, wind energy has enjoyed high public acceptance. In general, wind turbines are considered elegant, well framed in nature, symbolizing a less polluted future [12]. Concerning the birds, it has been shown that the mortality rate due to aerogenerators is very low and much lower than that resulting from other causes, such as car traffic or air navigation. A wind farm occupies only about 2% of the total area of leased land for this purpose. If the land is of agricultural ability, this activity may continue throughout the park lifetime [12].

**Over-Equipment Energy Counting**

A separate telemetering system should be installed to support the individualized billing of over-power. Thus, the cost of energy produced in this way is 60 €/MWh. For the main wind farm is applied a feed-in tariff. It was necessary to allocate a higher tariff at the beginning to promote the construction of wind farms in Portugal, thus making the investments profitable. As the wind farms became more widespread, the cost of the wind turbines has been reduced and so the feed-in tariff has been decreasing as well. It should also be reminded that the global telemetering system of the main electro-producer power plant will remain.

It will therefore be necessary to deduce from the energy measured in the main meter, the energy corresponding to over-equipment, because the prices are different. The energy produced by the over-power generators is dispatched by the Transport System Operator. Thus, if there is an excess of energy production in the network, not being balanced with consumption, that operator can send orders of power reduction concerning the wind turbines that are in over-equipment regime [13]. Wind farms are grouped by command centers, as that shown in Figure 3 [14].

Figure 4: Dispatch Center of EDP Renewables [14].

In O&M (Operation & Maintenance) office, it is ensured that the efficiency and operation of the wind turbines are the best possible, for example in carrying out preventive maintenance [14]. O&M control of the energy production (active and reactive) and the resolution of technical problems is carried out with the aid of the SCADA system installed in the control building of the wind farms, as exemplified in the figure below.

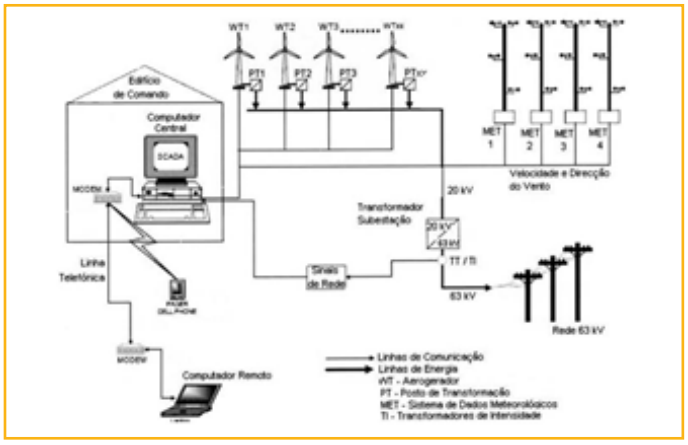


**Figure 5:** Windfarms Control [14].

Regarding the energy measurement for billing purposes, it must be followed what is mentioned in the Guide for Measurement, Reading and Availability of Data, which was approved by the Portuguese Regulator.

In this way, the wind turbines that have been installed under the over-equipping regime must have their own telemetering equipment. For each integration period of 15 minutes, the telemetering of the main wind farm must be deduced from the telemetering concerning the over-equipment aerogenerators.

**Price of Over Power Energy**

The investment made for the over-equipment is reduced because the main electrical and road infrastructures have already been carried out. Besides, the price of the aerogenerators has been successively reduced, while the power has increased.

Thus, the purchase price of energy may be close to that practiced in the Iberian Energy Market (OMIE). This price was fixed at 60 €/MWh. In this way, both the customers and the producers benefit from the over-equipment process. The over equipped power is also dispatchable by the Transmission System Operator, which is an added value for this new concept.

**Possibility of Legal Separation Of Over- Equipment**

The investment made in new wind turbines may be carried out by a legal entity other than the owner of the main wind farm. This possibility is included in the Portuguese Regulation nº 102/2015, of April 7th.

The owner of the over-equipment shall be held by the holder of the production license of the main wind farm. In other cases, both holders shall be held, directly or indirectly, by the same legal entity. In this way, the investment project of the wind turbines under over-equipment procedure becomes easier.

Thus, a project finance can be carried out only for the over-equipment. Sometimes the guarantees given to banks are of added importance. Some banks require assignments with scope of guarantee, to ensure that monthly income will always be deposited in a certain established bank account.

**Electronic Billing**

To simplify the operational process, an electronic self-billing process has been developed. Thus, every month the Distribution Network Operator provides the values of the energies affected to the over-equipment and to the main wind farm. Using these energies, the billing amounts allocated to the over-equipment and the main park are calculated. The simulations of the economic calculations made are then available on the internet site. Producers access this site and approve the simulations, or they can reject them if something is not right, which is very unusual.


**Figure 6:** Website for simulations´ approval.

The approval of the simulation will trigger the emission of the electronic self-billing. This automatic procedure is of most importance for the producers, because they have some difficulties in having all the data in the very beginning of each month. Small differences can be regulated using credit or debit electronic invoices as well. The producers are very pleased with electronic billing and they overpraise the digital platform developed.

## Conclusion

The process of over-equipping windfarms makes them more profitable, being neutral for consumers, since the price of energy is identical to that practiced in the market. Statistically, the percentage of all wind turbines running at full power and at the same time is very rare. According to statistical studies carried out by several entities, over-capacity can reach 20% of the installed power. It should be noted that the power of connection to the utility grid, established by the General Direction of Energy and Geology, will never be exceeded. If the power emitted by the wind farm exceeds this limit, the dispatch center will reduce the power emitted. Until now, we have never detected that the limit of the connection power has been exceeded, with a tolerance of 3%.

## References

**1.** Site www.edpsu.pt.

2. "Rapid Statistics No. 170", Directorate General for Energy and Geology, Portugal, 6th March of 2019, page 4.

3. Patrícia Pereira da Silva (2007) "The Electricity Sector in the European Union, Evolution and Perspectives", Coimbra University Press.

4. "High Altitude Wind Power Reviewed", in Energy, Environment and Policy, June 2016. http://euanmearns.com/high-altitude-wind-power- reviewed.

5. "ECCA - European Climate Change Adaptation Conference 2019", 28th till 31st May, Lisbon – Centro Cultural de Belém.

6. Mário Pulquério-ECCA-European Climate Change Adaptation Conference 2019", 28th till 31st May, Lisbon.

7. Diogo de Gurmão Sorensen, European Commission, Directorate-General for Research and Innovation, 28th till 31st May, Lisbon.

8. João Pedro Matos Fernandes, Portugal´s Minister of Environment and Energy Transaction, 28th May 2019, Lisbon.

9. Fernando Medina, Mayor of Lisbon, 31st May 2019, Lisbon.

10. Wind power Program–Wind turbine power output variation with steady wind speed in http://www.wind-power-program.com/turbine_characteristics.htm.

11. Energias Renováveis–Renewable Energies, António Lobo Gonçalves, Scientific Consultant, ISBN 978-989-96529-0-3.

12. António Brito & Luis Neves, "The innovative process in the interruption of wind power in Portugal", The 3rd International Conference on Power and Renewable Energy, 2018, Berlin.

13. Dispatch Center of EDP Renewables, Oporto, Portugal.

14. Tiago Filipe Coelho Durães-"Legal Framework and Economic Study of Wind Farms"- Polytechnic Institute of Bragança.