University of Lisbon | Faculty of Science

Master's Degree on Energy and Environment Engineering

Energy Systems| 2019/20

Sizing of wind generators for the island project

Students:

Miguel da Fonte, no. 49724

José Grosso, no. 49921

Ricardo Duarte, no. 49915

Teacher:

Miguel Brito

Content

Objectives

The main goal of this work is to design a wind farm located on an imaginary island, using the meteorological data available.

Introduction

Many countries have already started to invest on renewable energies. One of the main growing renewable energies is the wind energy. To do the sizing of a wind farm we used different type of data, such as the daily wind speed onshore and offshore for the year of 2008, a turbine of 2 MW, we had to choose which type of turbine we were going to use taking into account the respective specifications. We also had to consider the area of the island for calculations.

Assumptions and calculations

Wind speed correction

Using the available data, we did a correction for height=10m where we used the typical *Hassan* values for z_0, displayed in the following equation (1):

$$\frac{u(z)}{u(z_R)} = \frac{\ln\left(\frac{z}{z_0}\right)}{\ln\left(\frac{z_R}{z_0}\right)} \quad (1)$$

We obtained the following results for monthly wind speed:

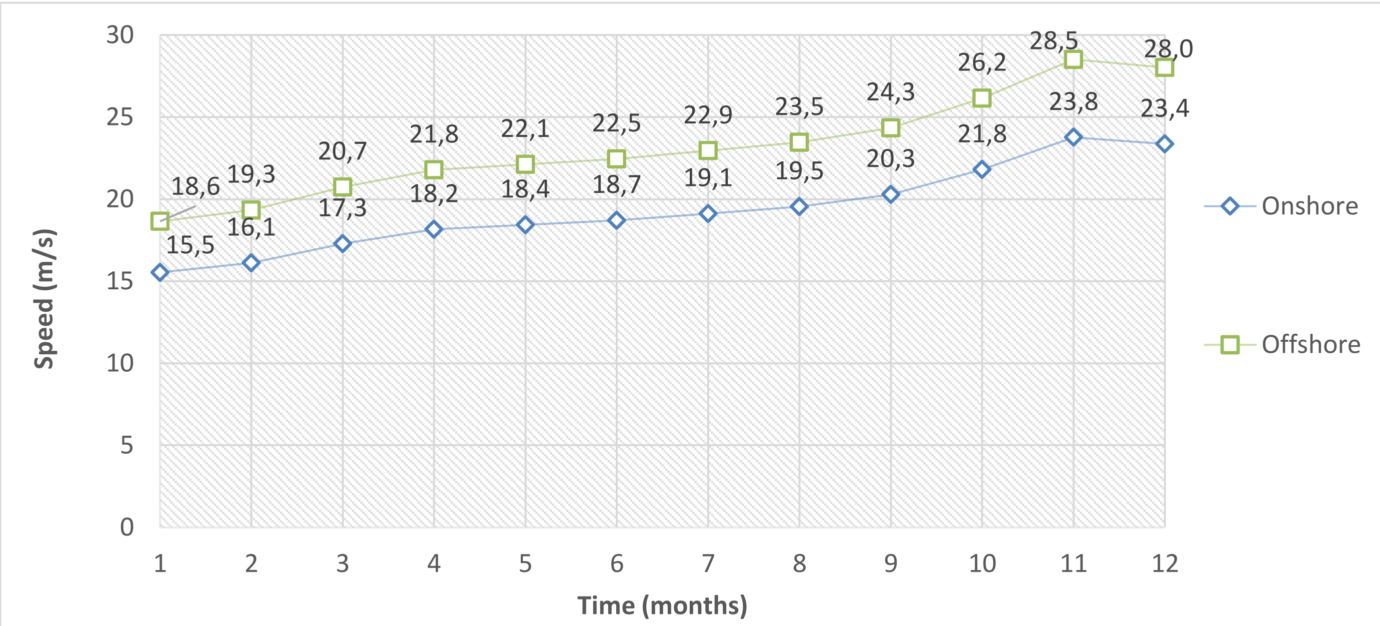

Figure 1-Monthly average wind speed (h=10m correction).

Turbines

We used the same model of the turbine for both onshore and offshore installations, the turbine specifications are listed in the table below:

Model	Gamesa
Type	G90
Capacity (kW)	2000
Rotor diameter (m)	90
Power Production (GWh/year)	3.763
Capacity factor (%)	21,5

Table 1-Turbine especifications.

To calculate the position and spacing between turbines we considered a space of 10 times the blade diameter in the wind direction and 5 times the diameter for perpendicular direction. We determined the available area by considering the island to be square shaped, therefore having a length of 22 km in each side. Based on these assumptions we obtained the following results:

Vertical spacing (m)	**Horizontal spacing (m)**
900	450
Max number of turbines (onshore)	**Min number of turbines (offshore)**
75	99
Power density (onshore) [kW/m²]	**Power density (offshore) [kW/m²]**
0,298	0,398

Table 2-Turbine occupation.

Power curve

Considering data from the *Siemens* website we obtained the following power curve for the turbine:

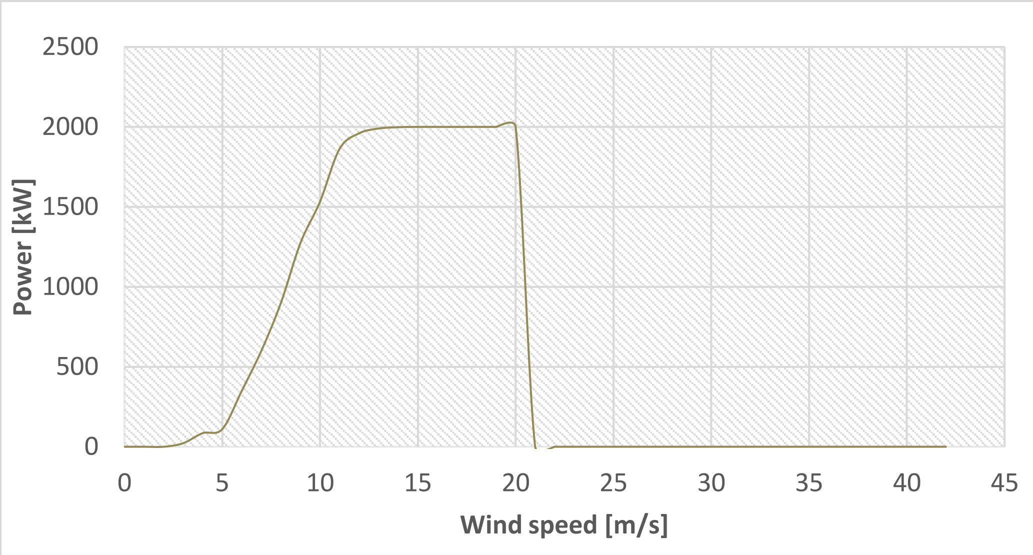

Figure 2-Turbine's power curve.

Energy production

We gathered the final results for annual energy for both onshore and offshore, for this result we counted the number of hours that each range of speed occurred in the measurements and multiplied that number of hours by the correspondent power of the power curve to obtain the energy generated.

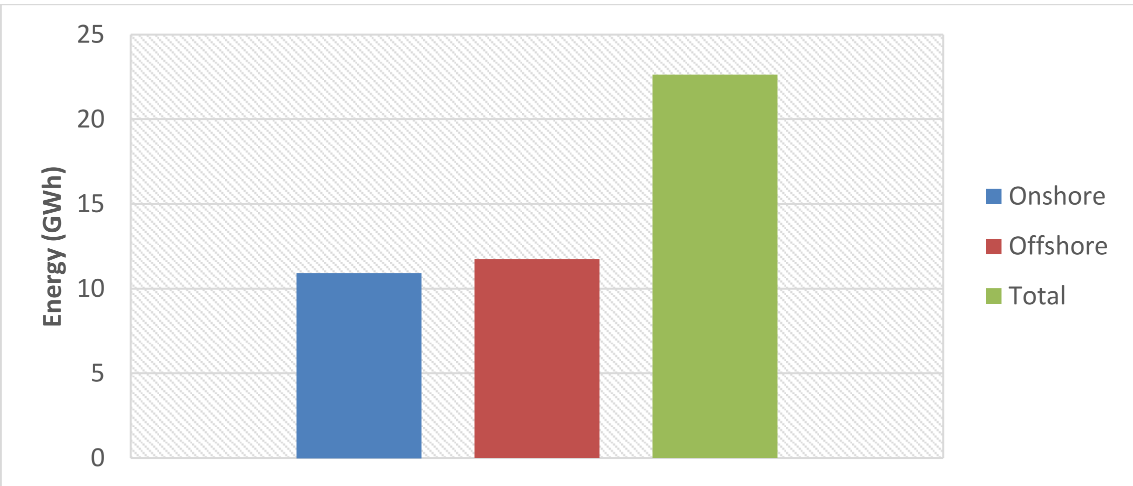

Figure 3-Energy production per turbine.

Costs

We considered different costs for onshore and offshore, for offshore we considered a price of 5890€/kW based on an article about wind energy installation, for offshore energy we considered the double of this cost. To calculate the cost of installation we used the following equation:

$$\frac{Cost\left[\frac{€}{kW}\right] \times Power\ [kW]}{Turbine\ expected\ lifetime\ [years] \times Annual\ energy\ production\ [kWh]} \quad (2)$$

Results

Considering all the assumptions and calculations and considering an occupation of around 25% of all the available area we obtained the following results:

	Number of turbines	Installed power (kW)	Annual energy production (GWh)	Cost (€/kWh)
Onshore	18	36000	196,45	0,0540
Offshore	24	48000	281,28	0,1006
Total	42	84000	477,72	0,0814

Table 3-Final results.

Environmental, social and economic impacts regarding the installation of the turbines

The installation of wind turbines causes environmental, social and economic impacts when installing:

- The economic impacts of wind energy provide benefits to neighboring communities, giving job opportunities, new sources of revenue for farmers and ranchers.
- The social impacts are the increase of health over time, in other words people nearby the wind turbines would not be exposed to many wastes and emissions.
- The main impacts are environmental, including the potential to reduce the habitat for wildlife, namely birds and bats through its spinning turbines. Also, offshore wind turbines can have similar impacts on marine birds,

although the bird's deaths associated with onshore wind are much more impactful.

Advantages and Disadvantages of wind energy

Compared to solar panels, the main advantage of wind energy is that wind turbines release less CO_2 to the atmosphere, consume less energy, and produce more energy overall.

The disadvantage of the wind energy is that the wind energy is not constant over time, due to periods when there is no wind, the installation is expensive (wind turbines are expensive), wind turbines can cause harm to wildlife and they create visual pollution to the nearby houses. Other significant disadvantage of wind is that the power includes initial cost and technology immaturity.

References

https://www.meridianenergy.co.nz/who-we-are/our-power-stations/wind

http://esa.ipb.pt/~jpmc/ArquivoEA/Eolica_ed2p1.pdf

https://wind-data.ch/tools/powercalc.php?type=ak&a=6&k=2&v=5&d=1.225&turbine=23&p%5B0%5D=0&p%5B1%5D=0&p%5B2%5D=21&p%5B3%5D=85&p%5B4%5D=197&p%5B5%5D=364&p%5B6%5D=595&p%5B7%5D=901&p%5B8%5D=1275&p%5B9%5D=1649&p%5B10%5D=1899&p%5B11%5D=1971&p%5B12%5D=1991&p%5B13%5D=1998&p%5B14%5D=2000&p%5B15%5D=2000&p%5B16%5D=2000&p%5B17%5D=2000&p%5B18%5D=2000&p%5B19%5D=2000&p%5B20%5D=2000&p%5B21%5D=1906&p%5B22%5D=1681&p%5B23%5D=1455&p%5B24%5D=1230&p%5B25%5D=0&p%5B26%5D=0&p%5B27%5D=0&p%5B28%5D=0&p%5B29%5D=0&abfrage=+Calculate+production+

https://www.cm-pombal.pt/2020/03/04/camara-de-pombal-da-parecer-positivo-a-localizacao-de-novo-parque-eolico/?fbclid=IwAR1OzE_HuEf2dl4nDx1grTtsap2K_qx3dvaP93qlE6PwPBZRC0havRgG4hg

https://www.dinheirovivo.pt/economia/windfloat-governo-da-apoio-de-10-milhoes-a-parque-eolico-offshore/