PROMOTE GREEN MANUFACTURING INDUSTRIES "MADE IN AFRICA"

Observatoire Europe-Afrique 2030

"Value Chain"

Data Sheet n°4

Wind farm

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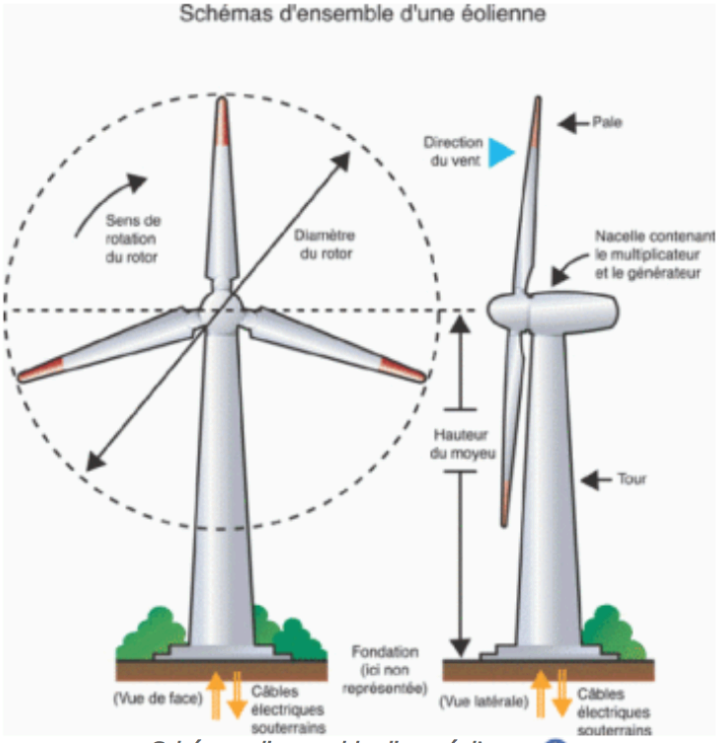
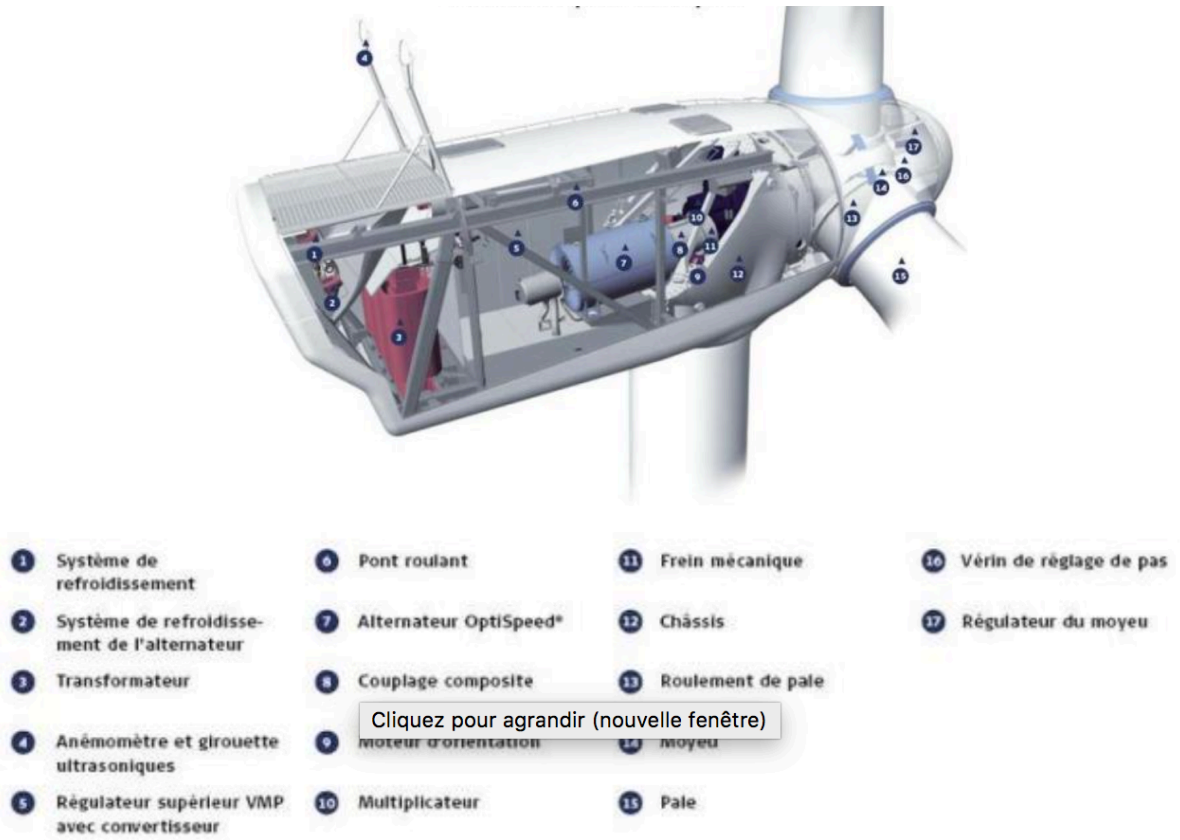
1. Components of a wind turbine

A wind power plant, or wind farm, is an industrial facility of several wind turbines producing electricity.



Cross-sectional view of a wind turbine



The propeller converts part of the wind's kinetic energy into mechanical torque. It is composed of blades carried by a hub. Most of today's industrial wind turbines are equipped with three blades. When the wind speed exceeds the rated power, a control system controls and degrades the efficiency of the propeller so that it captures only the power that is strictly necessary. The blades are made from composite materials.

The nacelle is the cockpit at the top of the mast. It can be rotated so that the angle between the propeller axis and the wind direction is zero on average. The generator assembly is installed there. It contains all the machinery that transforms the slow rotation of the blades into electricity. This machinery is used to supervise the wind turbine: direct the blades according to the strength of the wind, stop the wind turbine. The basket can be steered in the axis of the wind and is held there by a motorized slewing loop.

The **generator assembly**, integrated into the nacelle, performs two functions: To transform the mechanical torque of the rotating hub into electricity thanks to an electromechanical generator, and to adapt the electric current supplied by the generator to the standards of the network in which the machine delivers its energy so that coupling (synchronization of the frequencies of the machine and the network) is possible. The characteristics of the energy source (variable wind and variable powers) must be adapted to the needs of the electrical network (fixed frequency, constant voltage amplitude, variable power demand).

There are two main families of wind turbines:

- **Direct-coupled wind turbines** (multi-drive wind turbines and direct-to-grid coupling): a speed multiplier is placed between the propeller shaft and the electromechanical generator shaft. It increases the propeller rotation speed from 50 rpm to 1,500 rpm, the nominal rotation speed of the best value asynchronous generators. However, this technology forces the propeller to operate at a constant rotational speed (at +/- 2%), which does not allow the best use of wind energy.
- **Indirect wind turbines (**direct drive wind turbines and grid coupling by electronic converter): the propeller hub is connected directly to the rotor of the electromechanical generator (synchronous generator). As the wind speed varies, so does the output frequency of the current delivered by the alternator. To ensure coupling with the power distribution network (fixed frequency and voltage amplitude), a rectifier converter (associated with an inverter) must be installed.

Mast (or tower)
It carries the nacelle and allows the propeller axis to be placed at a height higher than that of its radius. The masts are generally tubular, truncated conical in construction. They are made by combining elements for internal bolting of flanges. The diameter of the base of a tower is 5 m and gradually decreases to about 3 m at the top. The towers have 3 or 4 sections. As a general rule, the height of the mast is equal to the diameter of the propeller. For very windy sites, masts can be built twice as high as the diameter of the propeller in order to get stronger winds. The mast can hold some of the electrical and electronic components, in combination with the nacelle.

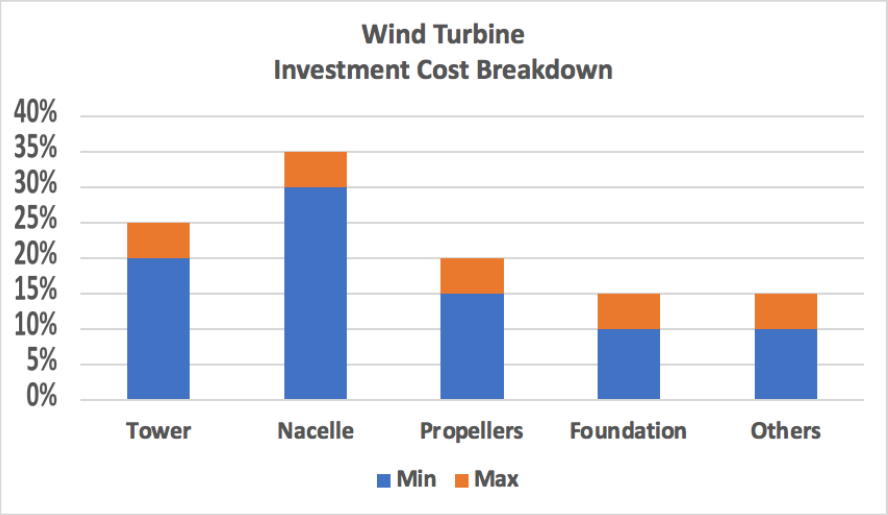
The tower rests on **foundations**, which for onshore wind turbines consist of a concrete foundation on which the entire structure is fixed, having to be able to withstand storms and extreme winds. Nearly 500 tons of concrete are needed for the foundations of a 3 MW wind turbine.

On the ground, a **dispersion booth** allows the current produced at the nacelle to be injected into the electrical network. The most common industrial wind turbines today are three-bladed wind turbines, driving an asynchronous generator.

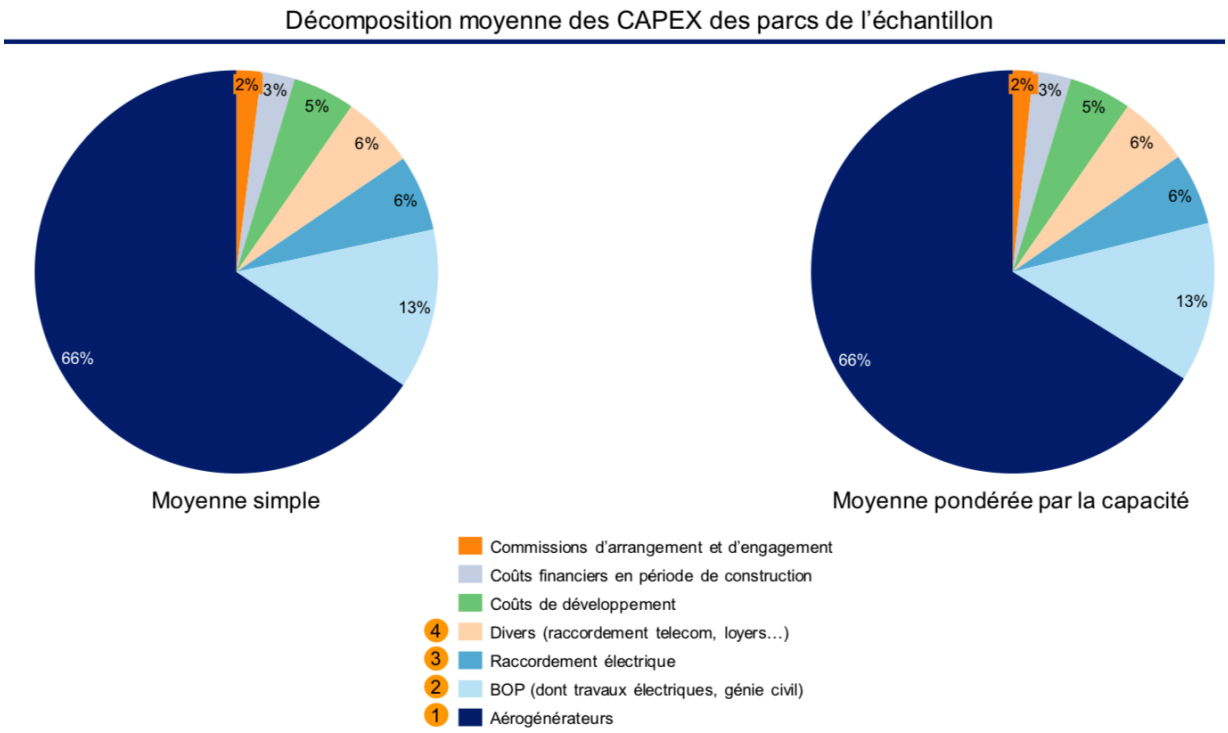
2. Investment cost of a wind turbine

The average investment cost is around €1.4 million/MW installed, with the following breakdown:

- Manufacture and assembly of wind turbines: 66%
- Civil engineering and other infrastructure: 13%
- Grid connection: 6%
- The rest is made up of miscellaneous costs and finance charges during the construction period



The unit cost of turbines depends little on their characteristics (height, in particular). There is no scale effect on wind turbine costs. The unit cost does not decrease with the number of wind turbines installed. The investment costs analysed are proportional to the installed capacity: on average €1.4 million/MW.

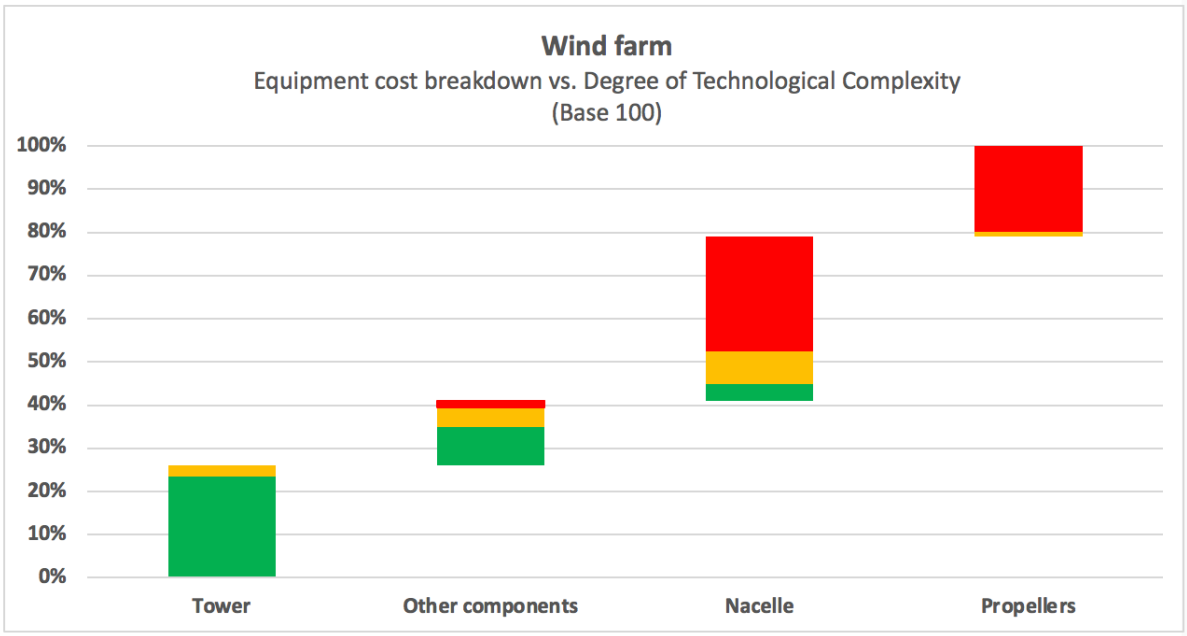


High-rise wind turbines with larger blade sizes produce more electricity. However, their cost per MW is not higher.

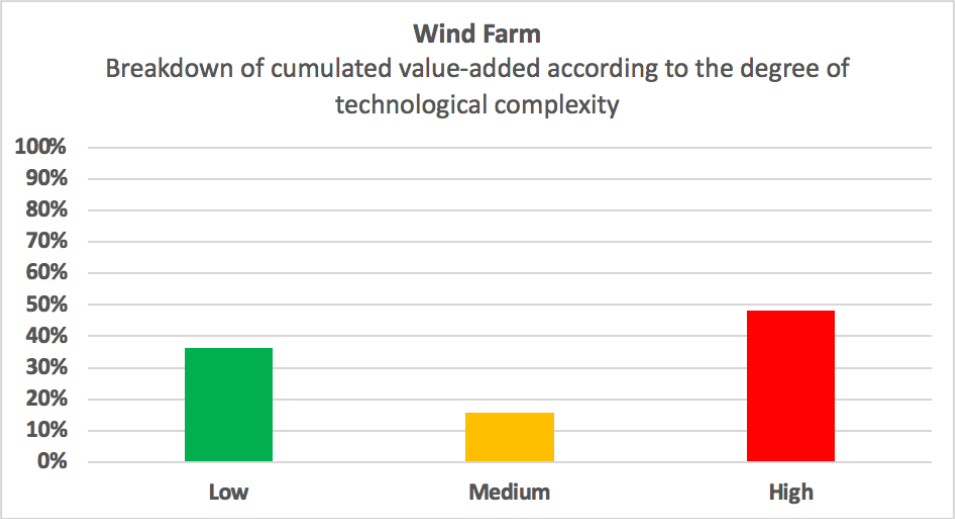
These distributions can vary depending on factors such as the size of the turbine and the specific requirements of the project. The costs associated with transport, installation and connection to the grid must also be considered.

As a reminder, the cost of an industrial wind turbine blade is approximately $100,000 to $125,000 each for a 1.5 MW turbine (blade 34 m to 38 m long) and between $250,000 and $300,000 each for a 3 MW turbine (blades 47 m long).

3. Value Chain



Source: Europe-Africa Observatory 2030. These data were estimated from bibliographic information. They are orders of magnitude.



Source: Europe-Africa Observatory 2030. These data were estimated from bibliographic information. They are orders of magnitude.

4. Sources of information

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