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RESOR - **R**enewable **E**nergy **So**urces
as a Chance for Development for the
Rural Areas

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Module No 6:
Wind energy

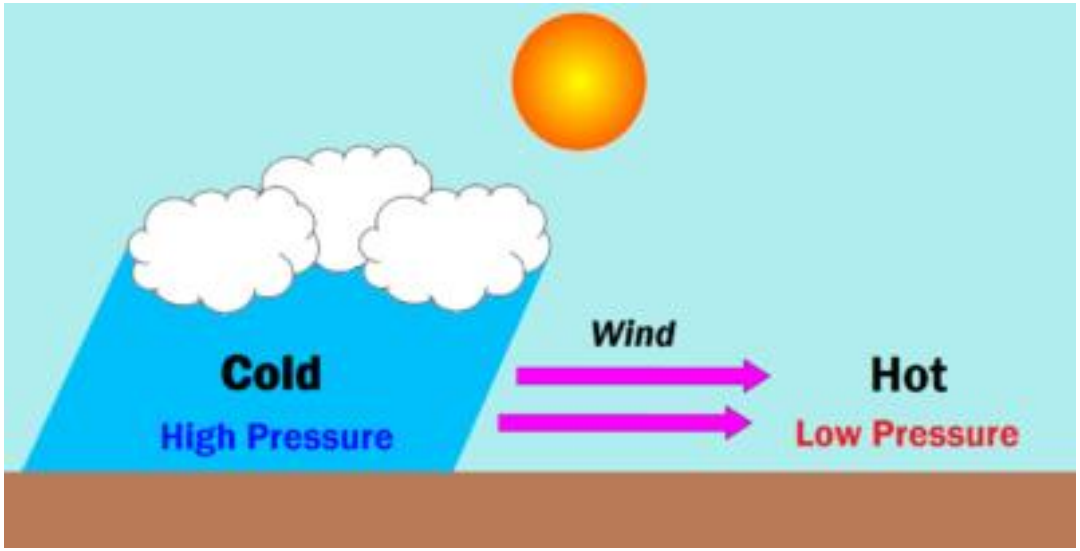
by BDIVE

What is wind?

Wind is the movement of air driven by the uneven heating of the surface by the Sun

Due to the heat dissipation of surfaces with different temperatures, air flows are generated

This air movement is renewable, since its driving force – the solar irradiation – is constant



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What is wind energy?

The kinetic energy of air flows called wind energy

The density of this energy increases along with the wind speed

The higher the wind speed, the more energy we can get from it → we can utilise more wind energy in a certain amount of time at higher altitude, where the average wind speed is higher

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Using wind energy

Energy of the wind has been used for hundreds of years. **Windmills** helped pumping water or grinding grain, convert the kinetic energy of the wind into **mechanical energy**

In the modern era, we build **wind turbines**, that convert the wind's energy into **electricity**

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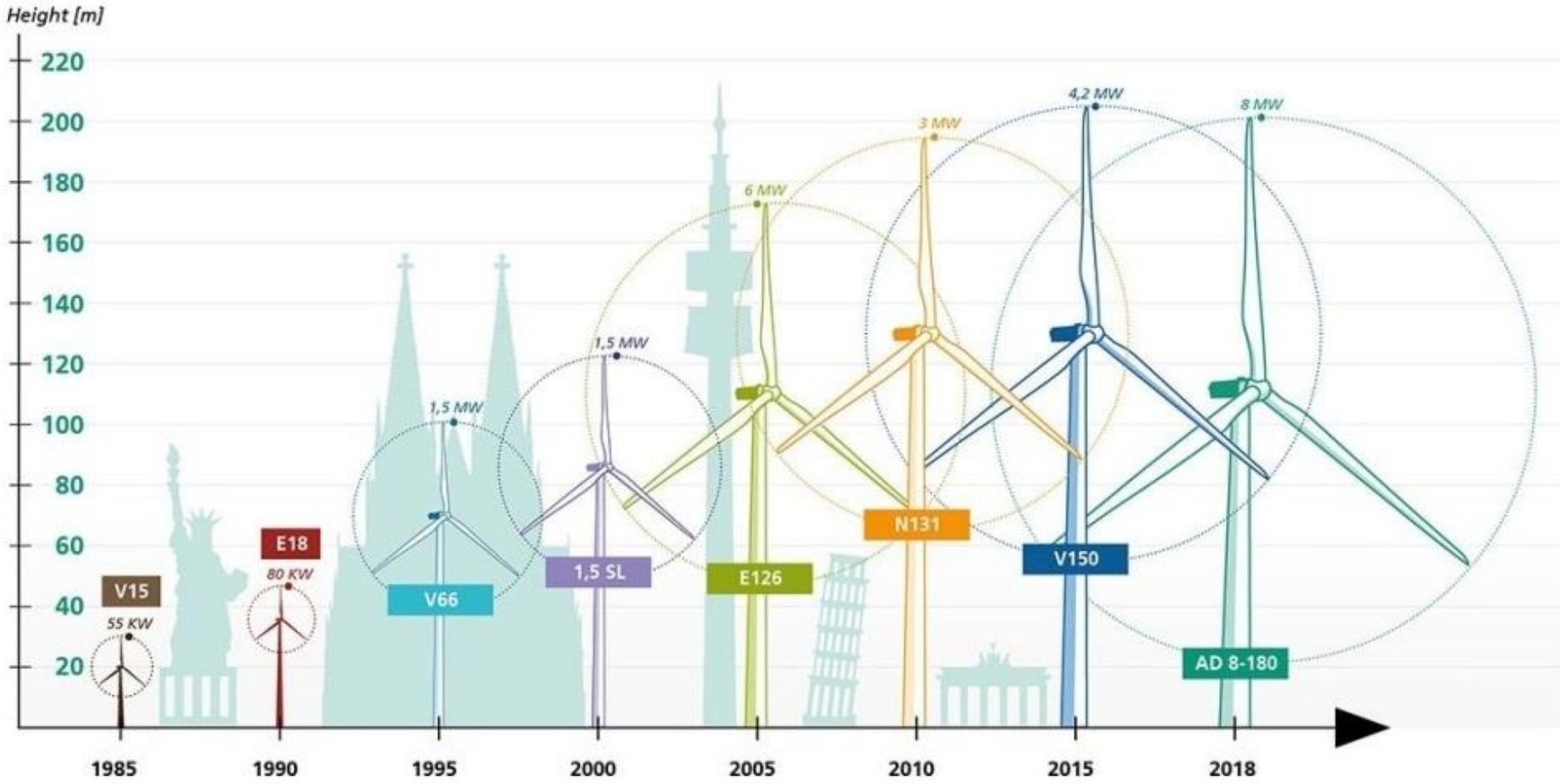
Using wind energy

Wind turbines can be installed as stand-alone applications, or **multiple turbines can be connected to one system** and to the grid. A large number of wind turbines can be built closely to form a wind plant or **wind farm**

The largest wind turbines of the last decades → increasing capacity



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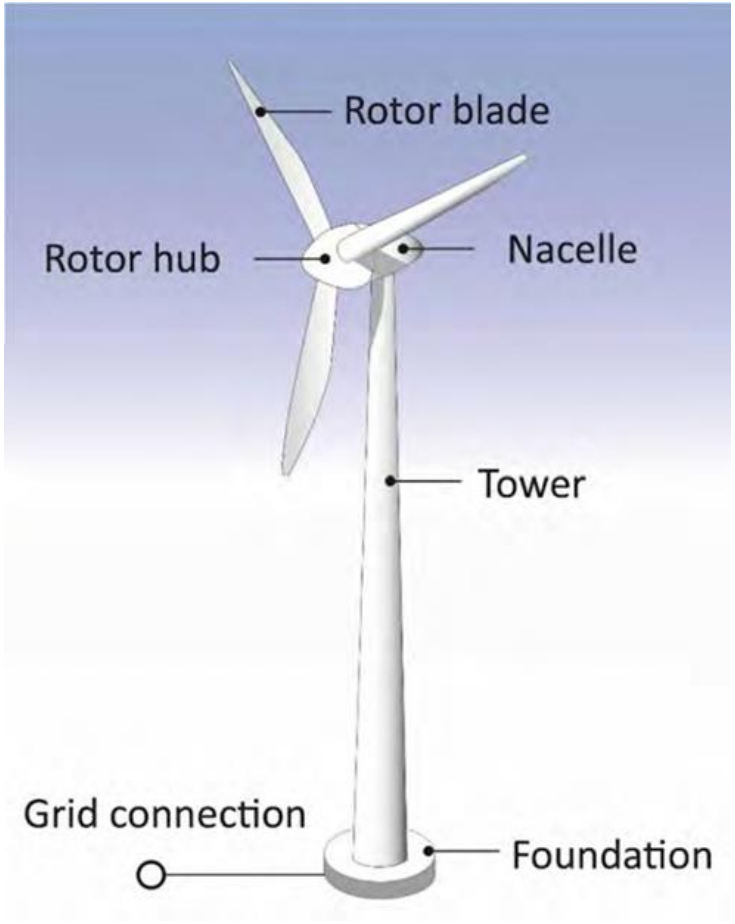
Components of a wind turbine

Wind turbines are designed with a vertical or horizontal axis, with 1-20 rotor blades, with or without gear box and with direct current or alternating current generator that converts mechanical energy into electricity

The primary components of a wind energy system are:

- Rotor blades
- Nacelle and controls
- Generator and electronics
- Tower components



RENAC

Components of a wind turbine

Rotor Blades

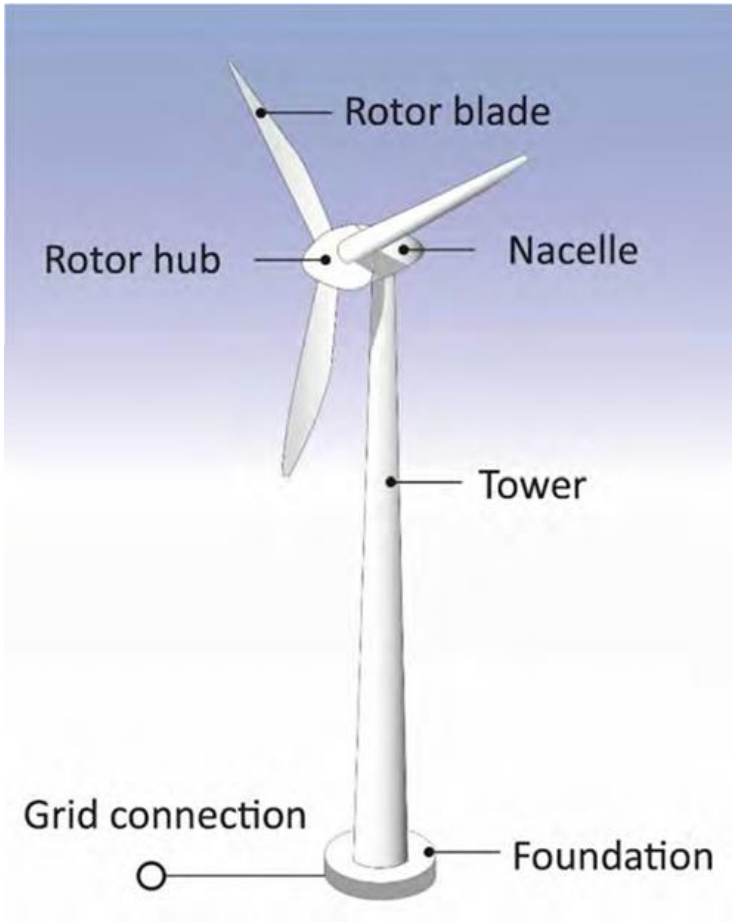
- Rotor blades capture the wind and convert its energy into the rotation of the hub. The hub directs the energy from the rotor blades to the generator
- The three-blade rotor is the most efficient one for power generation by large wind turbines

Nacelle

- The nacelle holds all the turbine machinery

Wind turbine towers

- Wind turbine towers are made of concrete, metal, wood or a combination of these materials.
- Most large wind turbines are built with tubular steel towers, which are manufactured in sections.



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Siting wind turbines

Because of the high initial cost of wind systems, it is imperative that the best site be used rather than just a good one. Three main questions should be answered when a site analysis is made:

- (1) Is there sufficient wind for the machine to produce usable power at least 50% of the time?
- (2) What effects will surface terrain have on the wind profile?
- (3) What barriers might affect the free flow of the wind?

Wind turbine blades being moved to site, Tararua wind farm

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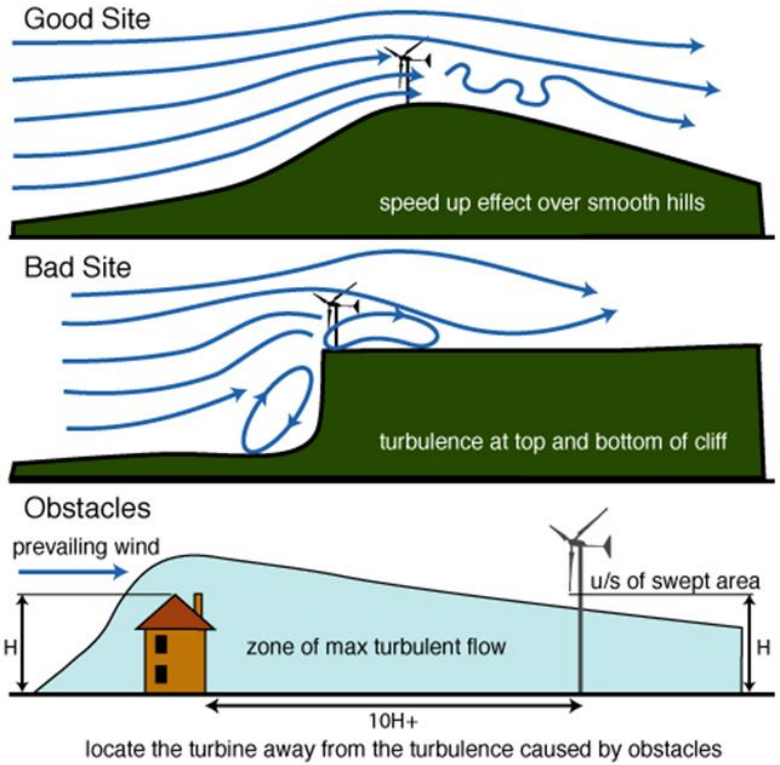
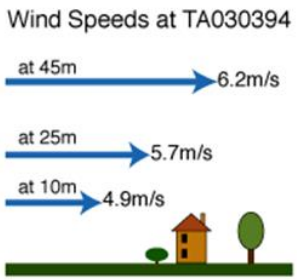
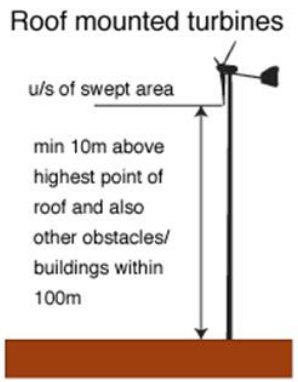
New Zealand Wind Energy Association

Siting wind turbines

The installation of a wind farm must always be preceded by a preliminary wind measurement in the designated area. It can be made by an anemometer, which is a device used for measuring wind speed and direction. In order for wind speeds to be comparable from location to location, the effect of the terrain needs to be considered, especially in regard to height. Other considerations are the presence of trees, and both natural canyons and artificial canyons (urban buildings).







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Limitations and advantages of using wind energy

Cost-effectiveness

By the end of the 2010s, on-shore wind technology offers the cheapest solution for power generation among all renewable or non-renewable energy sources in most region of the world with a global average of 0,06 USD/kWh LCOE (IRENA, 2020). That means, a wind energy investment is very cost-effective, and can be cheaper than any other solution for power generation in rural areas.

Moreover, costs of wind power technologies are expected to continue to decline till 2030 by 25% (IRENA, 2020).

Maintenance

Wind turbines require minimal maintenance throughout their 25-year lifetime. Continuous personal presence is not required, unlike in most power plants. Wind turbines generally require preventative maintenance checkups two to three times per year. Maintenance workers on wind farms lubricate moving parts – such as gearboxes and bearings – check connections within the system, and resolve any major issues that may develop.

Limitations and advantages of using wind energy

Environmental impacts

Wind turbines are able to operate in harmony with the environment on arable lands, pastures and abandoned areas, using the land in a multifunctional way. However, their installation in areas under environmental protection is not recommended (in most cases prohibited). Prior to installation, landscape effects, noise, bird migration and ecological corridors, soil load, etc. must be taken into account.

Weather dependency

The amount of wind energy is depend of the weather both in short and long term. Since energy storage is not a possibe solution in every rural areas, expecially for a longer period, owners need to find an alternative solution for power generation in the windless periods.

The number of windy and stormy days per year can vary, and it is important for farmers to be ready for even weeks without enough wind.

Altough, wind turbines with the newest technology in a windy site can generate electicity almost anytime.

Limitations and advantages of using wind energy

Forecast

The daily and weekly wind speed forecast has improved a lot in recent years. Free data on estimated wind speed is available in most EU countries for the next couple of days. Still, wind turbine owners have to face a slight uncertainty in the daily amount and dispersion of power generation.

Siting

The installation of wind turbines may have technical limitations. For example, due to the accessibility of the site or the soil structure which makes construction impossible.

The location of the farm or other agricultural area may also cause connection problems to the national electricity grid.

In addition, there may be environmental or nature barriers to the installation.

Small-scale wind turbines

The biggest turbines described as small-scale wind turbines have a rated power of 50 kW, and they:

- provide electricity for homes, farms, ranches and small businesses
- have much lower energy output than large commercial wind turbines
- both vertical or horizontal axis type can work

How much electricity they can provide?

Diameter: 9 meter
Rated power: 20 kW

Average wind speed: 5 m/s → 28000 kWh/year electricity
Average wind speed: 8 m/s → 72000 kWh/year electricity

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Economics of small-scale wind energy systems

Smaller wind turbines are easier to build but often have longer payback time → the LCOE is higher

> (LCOE: ratio between all the discounted costs over the lifetime of the plant divided by a discounted sum of the actual energy amounts delivered)

Lower altitude → lower average wind speeds → less power after each installed kW capacity

A small-scale wind power investment can be a cheaper solution for a farm, that is separated from the national electricity grid by a long distance.

In most EU countries, in windy places, the payback time of such small-scale wind investments can be much shorter than their lifetime, but purchase and installation costs along with the country's current electricity prices are always need to be analyzed.

Case Study – Community Wind Energy Project in the village of Vép (HU)

Vép: Hungarian village in Western Hungary

Measurements:
172 days are windy in a year, of which 68 days are stormy. The prevailing wind is northerly.

Before the decision of the investment, a survey had been take place among the villagers about their attitude on wind energy

600 kW capacity wind turbine was built near the village in 2005, that is still working.
The turbine generates an average of 1.2 million kWh of electricity in a year, that saves 5–6 million HUF per year for the village.
The municipality owns a 20% stake in the investment.

Table 4.1 *Parameters of the first turbine in Vép*

Type	Enercon E-40 turbine, without torque converter, rev can be varied, blade angle can be varied
Nominal performance	600 kW
Expected yield in Vép	1.2 million kWh/year
Diameter of the rotor	44 m
Surface of the rotor	1520 m^2
Axle height	78 m
Blade	Three-bladed
Material of blades	Epoxi resin, with built-in lightning rod, and demister heating
Direction of rotation	Clockwise
Rev	It can be varied, 18-34 rotations per minute
Blade angle regulation	All blades are equipped with separate blade angle regulator engine
Generator	Direct driver synchronous generator with Enercon Rings
Voltage	440 V
Intake from the network	Through a 20 kV transformer
Braking system	3 engines to vary the blade angle, rotor emergency brake, rotor fastener
Following of the wind direction	Active following of the wind direction with an engine
Starting wind speed	2.5 m/s (9 km/h)
Nominal wind speed	12 m/s (90 km/h)
Safety standstill	25 m/s (90 km/h)
Tower	Tapered steel structure
Tower mass	90 t

Case Study – Farming the wind in New Zealand

In New Zealand, farmers have been asked. what were the benefits of building wind turbines on their land?

For many farmers, harnessing the wind enables them to improve the viability and productivity of their farms. Not only the wind farm generates income, it also increases the capital value of the land. Rent and royalties are received for having the turbines and the power they generate. Wind turbines provide a guaranteed annuity, which can increase the financial viability of a farm. For a private farmer, it could be their superannuation plan.

The wind turbines provide other adventages.

- the turbines are also excellent tourist attractions → farm tours
- the wind power investment also provided them a proper road instead of their old tracks
- sheep like to snuggle up to the towers which give shade and shield them from driving wind and rain

New Zealand Wind Energy Association

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