

## Wind Energy

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### Slide 2: *Wind Energy: What is Wind?*

- Winds are caused by the sun heating the earth's surface unevenly.
- Air above hot land rises.
- It is replaced by air from cooler areas.
- This movement of air is called wind.
- Winds are influenced by the rotation of the earth and by the surface type, called 'roughness'.
- There are large- and small-scale winds.
- They are also influenced by differences in temperature between land and sea.

### Slide 3: *Wind Energy: Wind Power*

- Winds travel at different speeds above the ground; winds are slowed down by contact/roughness of the earth.
- Roughness is very low for ice, water and deserts, but very high in cities and forests.
- Between 10 and 15 km above the earth they form strong jet streams, which can blow at 140 km/h.
- Some jet streams reach speeds of 450 km/h.
- Wind changes from day to day, depending on the weather and the seasons.
- However, all over the world there are patterns of wind direction and wind speeds that can be utilised for generating electricity.
- Some sites are better suited for wind farms than others.

### Slide 4: *Wind energy: Small-scale Wind Power*

- Wind energy was one of the first sources of energy to be used by early civilizations.
- Wind power was first utilised by sailing boats.
- Sailing ships move forward using the kinetic energy of the wind.
- The first machines to use wind were windmills.
- Windmills use the wind's kinetic energy to turn machinery.
- Early windmills were used to grind grain. The heavy sails of the windmill turned heavy millstones – that's where the name 'windmill' came from.

### **Slide 5: Wind energy: Small-scale Wind Turbines**

- There are a number of applications for small-scale wind turbines:
  - Residential (off-grid and grid-tied)
  - Telecommunication towers
  - Commercial (small businesses)
  - Farms
  - Rural communities
- Small-scale wind turbines, Vertical Axis Wind Turbines (VAWT) and Horizontal Axis Wind Turbines (HAWT), have capacities ranging from 50 W to 300 kW.
- They are typically installed in conjunction with battery storage systems.
- Due to wind energy resources being highly inconsistent in areas, batteries allow energy to be stored for when resources are unavailable and for a constant energy supply.
- The installation location is not as sensitive to performance as large-scale wind turbines and can therefore be installed in urban and rural areas, on and around building structures.
- VAWTs are more commonly used as small-scale technology in urban areas and cities, where the effect of surrounding obstructions and tall-standing buildings has a significant impact on wind behaviour.

Small wind turbines generally have a much lower energy output than large commercial wind turbines, but their size can differ significantly:

- So-called micro wind turbines may be as small as a 50-W generator and generate only about 300 kWh per year. They are used for boats, caravans and miniature refrigeration units, but also for fence-charging and other low-power uses.
- In comparison, household-size turbines reach diameters of 9 m, can have a rated power of 20 kW and produce about 20 000 kWh per year for homes, farms, ranches and small businesses.
- The biggest turbines described as small-scale wind turbines have a rated power of 50 kW. Small-scale wind turbines have been used to provide electricity to houses in remote areas that do not have access to electricity.

### **Slide 6: Large Wind Turbines: Using Wind to Generate Electricity**

- Since the 1980s to late 2000s there was rapid growth in wind turbine technology.
- Together with this increase in capacity came a cost reduction, which makes wind turbines one of the most cost-effective methods of electricity generation.
- Wind turbines turn generators to make electricity.
- They use two or three thin blades that look like aeroplane propellers.
- These blades can be up to 50 m long, or even longer.
- The larger the blades, the more energy from the wind are transformed into electricity.
- The wind turbines are fixed on top of tall towers.
- The blades are joined by a series of gears to a generator in the top of the tower.
- If the wind is blowing, the generator will turn and produce electricity.

### **Slide 7: Large Wind Turbines**

- Wind speed increases with height above the earth's surface due to surface drag or roughness.
- It is therefore better to build taller wind turbines to utilise the higher-speed winds above the earth's surface.

Annual energy production is determined by:

- Topography, the wake effect and other obstacles, such as trees.
- To avoid the wake effect, wind turbines are not placed behind one another, because turbulences are formed behind each turbine.

### **Slide 8: Wind Farms: Benefits and Concerns**

A wind farm consists of wind-powered devices using the kinetic energy of the wind to generate electricity.

#### **Benefits:**

- Windmills of all designs do not need any fuel to run them.
- They do not produce any pollution.
- Once the wind turbines have been built, their running costs are low.
- Turbines last up to 25 years before they get worn out and need replacing.
- The scrap metal value of these turbines pays for the decommissioning cost.
- Wind energy is a cheaper form of electricity.
- The wind is always blowing somewhere.

#### **Concerns:**

- Windturbines only work on windy days.
- They have to be shut down if the wind is blowing too strong.
- Only some parts of the country are windy enough for wind farms.
- Wind farms have to be built near the existing electricity grid (otherwise expensive power lines have to be built).
- Some people do not like wind farms because they can spoil the view and they can be noisy.

### **Slide 9: Wind Farms in South Africa: REIPPPP**

- The first bidding round of the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) started in 2011.
- To date, four bidding rounds have been completed.
- In bid window 1–4 (2011–2015) more than 2 000 MW of wind energy will be installed.
- New bid windows are ongoing.
- The following website is a map that provides the details of each REIPPPP project in South Africa.

<http://energy.org.za/knowledge-tools/map-of-sites>

The following details can be viewed on the website:

- **Name** of the project
- Type of **technology** being built
- The **capacity** of the power plant
- Current **status** of the project

| Bidding rounds | Capacity Allocated (MW) | Number of Projects |
|----------------|-------------------------|--------------------|
| Window 1       | 634                     | 8                  |
| Window 2       | 562.5                   | 7                  |
| Window 3       | 787                     | 7                  |
| Window 4       | 676                     | 5                  |
| Total          | 2 660 MW                | 27                 |

### **Slide 10: *Main aspects of a suitable windfarm***

Main aspects of a suitable wind farm:

1. Wind resource:
  - Wind speed throughout the year
  - Consistency and regularity of the wind
  - Dominant wind direction in the year; each site has a main wind direction and the wind turbines are placed according to the dominant wind on the site
2. Grid connection:
  - The distance to the existing grid and whether the grid is able to absorb the energy produced by the wind farm
3. Environmental aspects:
  - Noise
  - Electromagnetic interference
  - Aviation-related issues
  - Wildlife
  - Public attitudes and planning (visual impact)
4. Accessibility:
  - The accessibility of the site during construction must be taken into consideration.
  - Will the trucks transporting the turbines be able to reach the site and what is the distance that the turbines will have to travel?