



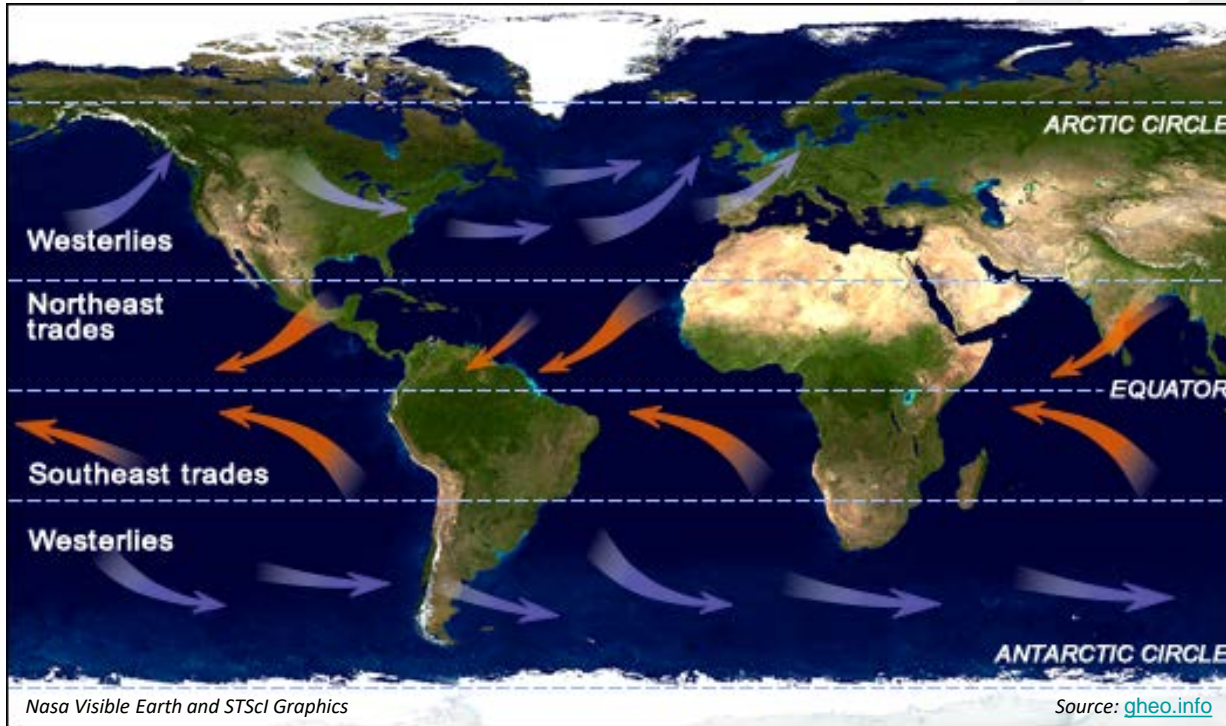
CENTRE FOR RENEWABLE &  
SUSTAINABLE ENERGY STUDIES

# • Wind Energy



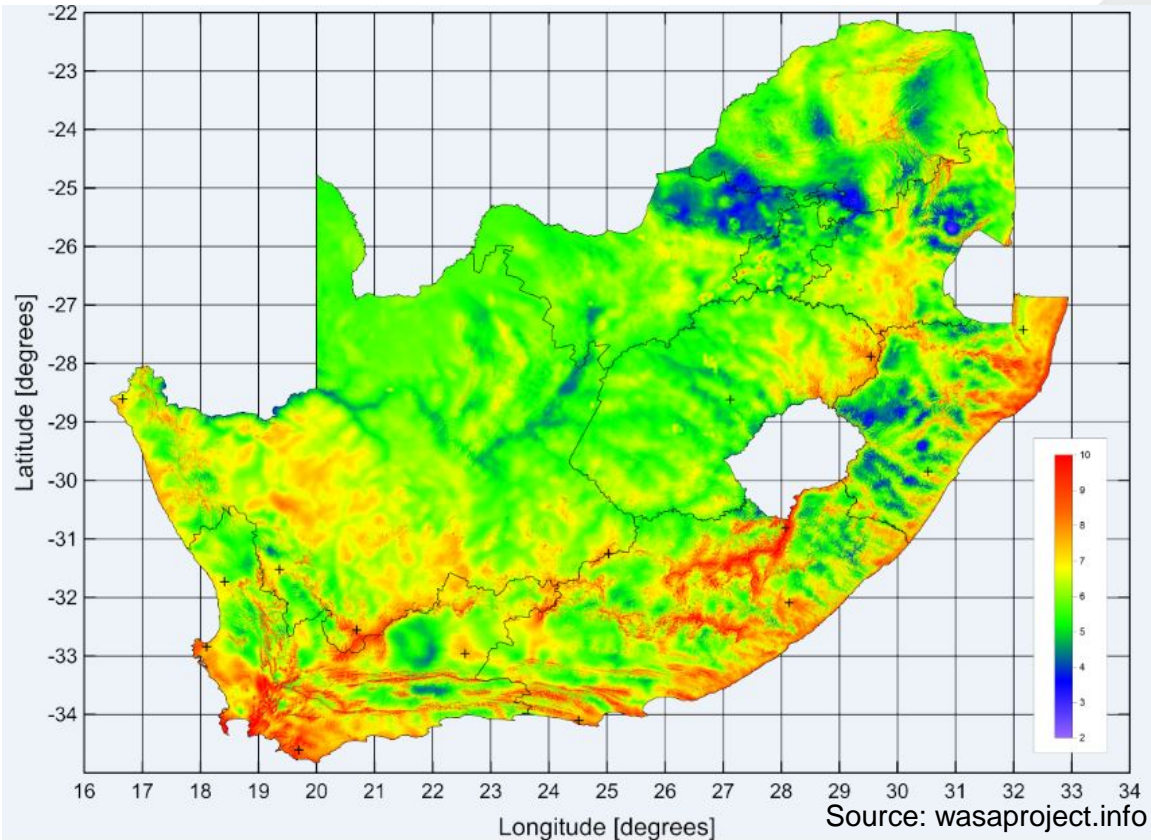
# Wind Energy: What is Wind?

**Winds are caused by air flowing from high pressure to low pressure. Its direction is influenced by the earth's rotation.**



- **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.

## Wind Energy: Wind Power



SAWEP 2, WASA 3 Interim WRF-5km based High Resolution Wind Resource map for South Africa (mean wind speed [ $\text{ms}^{-1}$ ] @ 100 m a.g.l. Oct 2017

- **Winds** travel at **different speeds** above the ground; winds are slowed down by friction/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, winds form strong **jet streams**, which can blow up to 140 km/h.
- Some jet streams reach speeds of 450 km/h.
- **Winds change** 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 utilized for **generating electricity**.
- Some sites are better suited for wind farms than others.

## Wind Energy: Small-scale Wind Power

Wind Turbine



Sailing Ship



Wind Mill



- Wind energy was one of the first sources of energy to be used by early civilizations.
- **Wind power** was first utilized 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 big sails of the windmills turned heavy millstones – that's where the name 'windmill' came from.
- The use of wind mills evolved to **wind turbines** generating electricity.

## Wind Energy: Small-scale Wind Turbines



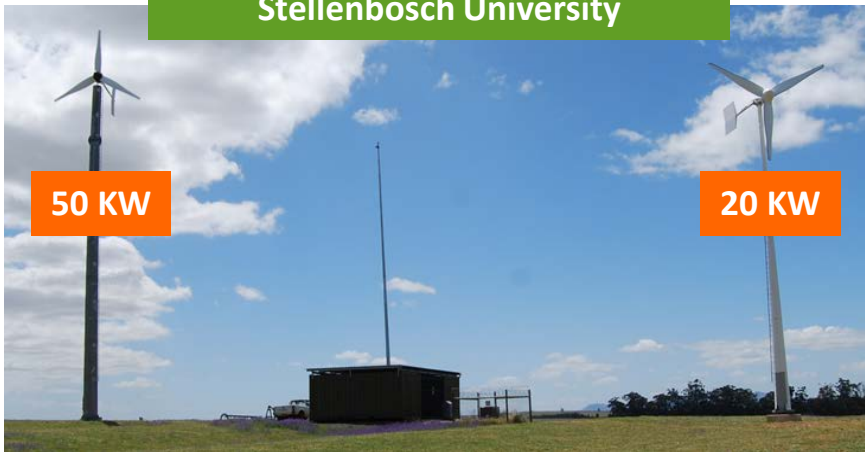
- There are a number of applications for **small-scale** wind turbines:
  - Residential (**off-grid & grid-tied**)
  - **Telecommunication** towers
  - **Commercial** (small businesses)
  - **Farms**
  - **Rural** communities
- Small-scale wind turbines, **Vertical Axis Wind Turbines** (VAWT) and **Horizontal 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**.



## Wind Energy: Small-scale Wind Turbines



Small wind turbine at Mariendahl, Stellenbosch University



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.
- **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 still classified 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.

## Large Wind Turbines: Using Wind to Generate Electricity



- From the 1980s to the 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.

## Large Wind Turbines: Using Wind to Generate Electricity



- 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.

The annual energy production from a wind turbine is determined by:

- **Topography**, the **wake effect** and other obstacles, such as trees.
- **The wake effect** is the aggregated influence on the energy production of the wind farm, which results from the changes in wind speed caused by the **impact** of the turbines on each other.
- To avoid the **wake effect**, wind turbines are not placed behind one another, because **turbulences** are formed behind each turbine.



## Wind Farms: Benefits and Concerns

Dorper Wind Farm 97 MW



Gouda Wind Farm 135 MW



### Benefits:

- Wind turbines of all designs **do not need any fuel** to run them.
- **No 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.

## Wind Farms: Benefits and Concerns



### Concerns:

- Wind turbines only work on **windy days**.
- They have to be shut down if the wind is blowing **too strongly**.
- 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**.

# Wind Farms in South Africa: REIPPPP

## Wind Energy

Bidding rounds	Capacity allocated (MW)	Number of projects
Window 1	651.59	8
Window 2	571.26	7
Window 3	787	7
Window 4	676.42	5
Window 4b	686.3	7
<b>Total</b>	<b>3372.57</b>	<b>34</b>

- 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 which more than 3 000 MW of wind energy was installed. New bid windows are ongoing.
- Refer to the map on this website for details of each REIPPPP project in South Africa:  
[www.eskom.co.za/Whatweredoing/Pages/RE\\_IPP\\_Procurement\\_Programme.aspx](http://www.eskom.co.za/Whatweredoing/Pages/RE_IPP_Procurement_Programme.aspx)
- The following details can be viewed on the website: Name of the project, type of technology being built, capacity of the power plant, project status.



# 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?



Wind Farms

**Cookhouse Wind Farm 135 MW**



**Jeffreys Bay Wind Farm 138 MW**



**Hopefield Wind Farm 66 MW**



## References

Slide 2: <http://gheo.info/earth-wind-map/earth-wind-map-awesome-amazing-space-wind-patterns-on-earth/>

Slide 3: [http://www.wasaproject.info/docs/WASA\\_Resource\\_Map\\_Dec\\_2018\\_public1.png](http://www.wasaproject.info/docs/WASA_Resource_Map_Dec_2018_public1.png)

Slide 4: Wind mill [online] <https://www.pexels.com/photo/brown-and-black-wooden-wind-mill-1036148> ,Wind turbine [online] <https://www.pexels.com/photo/alternative-energy-blade-blue-clouds-414928> [www.pexels.com/photo/sea-landscape-water-ocean-37859](http://www.pexels.com/photo/sea-landscape-water-ocean-37859) (White and brown galleon ship)

Slide 5: Wind turbine [online] <https://pixabay.com/de/photos/wind-macht-turbine-windm%C3%BChle-strom-3106627/>

