What is vertical-axis wind turbine?

A Vertical Axis Wind Turbine (VAWT) is a type of wind turbine in which the main rotor shaft is vertical (perpendicular to the ground). The generator, nacelle, and other main components are placed near the ground, so a large tower is not required and maintenance becomes easier.

It can capture wind from any direction, so no yaw mechanism is needed.

Classify and describe different types of vertical-axis wind turbines.

Vertical Axis Wind Turbines (VAWTs) are classified into two main types based on the aerodynamic force used:

1. Lift-Type VAWT (Darrieus Turbine):

- Operates on lift force generated by wind passing over the blades.
- Has curved or straight blades (eggbeater or H-rotor shape).
- High efficiency and suitable for electricity generation.
- Not self-starting; requires external starting mechanism.

2. Drag-Type VAWT (Savonius Turbine):

- Operates on drag force where wind pushes the blades.
- Consists of S-shaped scoops or buckets.
- Simple design, self-starting, works at low wind speeds.
- Low efficiency compared to lift-type turbines.

Classification and Detailed Description of Vertical Axis Wind Turbines

Vertical Axis Wind Turbines (VAWTs) can be classified into two main categories based on the primary aerodynamic force they use to rotate: **lift-type** and **drag-type**.

1. Lift-Type Vertical Axis Wind Turbines The most common example of this type is the **Darrieus Wind Turbine**.

- **Description:** Named after the French engineer Georges Darrieus, this turbine features long, thin, C-shaped blades that connect to the top and bottom of a vertical axle. Because of this distinct shape, it is frequently referred to as an **“eggbeater windmill”**. They are typically constructed with two or three blades.
- **Operating Characteristics:** Darrieus turbines have a tip speed ratio greater than 1, meaning their rotation velocity exceeds the wind speed, making them excellent and efficient electricity generators.
- **Drawbacks:** Their main disadvantage is a very low starting torque, which prevents them from starting on their own; they usually require a small motor or a supplementary Savonius rotor to initiate rotation. They also generate large torque ripples and cyclic stress on the tower, contributing to poorer reliability, and they often require guy wires at the top for support.

2. Drag-Type Vertical Axis Wind Turbines The primary example of this category is the **Savonius Wind Turbine**.

- **Description:** Recognized as one of the simplest turbine designs, it typically consists of two to three “scoops”. When viewed from above, the cross-section of a two-scoop Savonius turbine forms an **S-shape**.
- **Operating Characteristics:** It relies on a drag action to convert wind energy into torque, where the wind pushes against the open, concave face of the scoops. Because it works well even at low wind speeds, it does not require a tower or an expensive support structure, reducing initial setup costs. It is also quiet, easy to build, and excels at self-starting in areas with highly turbulent or changing winds.
- **Drawbacks:** Because it is a drag-based design, the scoop system is only about half as efficient as conventional lift-type turbines, resulting in less power generation. Due to their high reliability rather than power output, Savonius turbines are most commonly used for applications like ventilation systems and anemometers