The **Betz Limit** (also known as the Betz criterion) represents the **theoretical maximum efficiency for a wind turbine**, formulated by German physicist Albert Betz in 1919.

Betz Limit defines the **maximum possible efficiency** of a wind turbine. It states that a turbine cannot capture all the kinetic energy of the wind.

Maximum Efficiency Value:

$C_{p}^{max} = \frac{16}{27} \approx 0.593$

This means a wind turbine can convert **at most 59.3% (or a power coefficient fraction of 16/27)** of the wind's energy into mechanical energy. The rest of the energy must remain in the air so it can continue to flow past the turbine.

Physical Reasoning:

For a wind turbine to be 100% efficient, it would need to stop the wind completely. This is not possible because air must keep moving to pass through the turbine.

In reality, maximum power is obtained when the wind slows down to about **one-third of its original speed** at the turbine.

Real-World Performance:

The Betz limit is a theoretical value and does not include real losses like drag and air turbulence. In practice, modern wind turbines achieve about **35%–45% efficiency** (around 0.4 power coefficient), which is lower than the Betz limit.

Universal Application:

The **16/27 rule** (Betz limit) applies to any turbine working in a free-flowing fluid, like wind, tidal, or river currents. It means no turbine can extract more than about **59.3% of the available energy** from the flow

Why Can’t We Capture 100%?

To understand this, consider the flow of air through the rotor:

1. **Too Fast:** If the air passes through the turbine with very little change in speed, we extract very little energy.
2. **Too Slow:** If the turbine extracts too much energy, the air slows down significantly. This “slow air” then acts as a bottleneck, backing up behind the turbine and forcing the oncoming wind to flow *around* the blades instead of *through* them.

The **16/27** ratio represents the perfect balance where the wind is slowed down to exactly **one-third** of its original upstream velocity.