

Alternative Power Generation – Wind Electric Systems



STUDY FOR FE

🌀 Fundamentals

- Wind energy converts **kinetic energy** of air movement into **mechanical energy** via rotor blades, and then into **electrical energy** using a generator.
- **Clean and renewable** — zero fuel cost, zero emissions during operation.

⚙️ Power Conversion Flow

Rotor → Generator → Rectifier → DC Link → Inverter → Transformer → Grid

- **Rotor:** Captures wind's kinetic energy.
- **Generator:** Converts mechanical power to variable-frequency AC.
- **Rectifier:** Converts AC to DC.
- **DC Link:** Smooths and stabilizes DC voltage (capacitors + controls).
- **Inverter:** Converts DC back to synchronized 50/60 Hz AC.

📖 Wind Speed Operation

- **Cut-in speed:** 3–5 m/s → turbine starts producing power.
- **Rated speed:** 11–16 m/s → turbine delivers full rated output.
- **Cut-out speed:** ~25 m/s → turbine shuts down to prevent damage.

📄 Relevant NEC® Articles

NEC Article	Scope / Purpose
694	Wind Electric Systems – wiring, grounding, disconnects
705	Interconnected Power Sources (grid-tied systems)
710	Stand-Alone Systems
250	Grounding and Bonding

- **NEC 694.31(B)** – Conductors and OCPDs sized $\geq 125\%$ of continuous current.
- **NEC 694.30(C)** – Use flexible, wet-rated, sunlight-resistant cables for tower movement.
- **NEC 694.40(B)** – Each turbine tower requires a **grounding electrode system** bonded to the metallic structure.
- **NEC 694.40(C)** – Lightning protection must be **bonded** to the same grounding system to avoid flashover.
- **NEC 694.22(A)** – Disconnecting means must be **readily accessible, manually operable, and clearly labeled**.