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Energy Supply Chain Overviews

July 31	AI Data Centers Overview
August 21	Battery Storage
Sept 4	Natural Gas: Upstream

Coming Soon – Geothermal, Natural Gas: Upstream and Midstream, RNG for Biodigesters, Solar, and AI Data Centers: Structural, Power & Cooling

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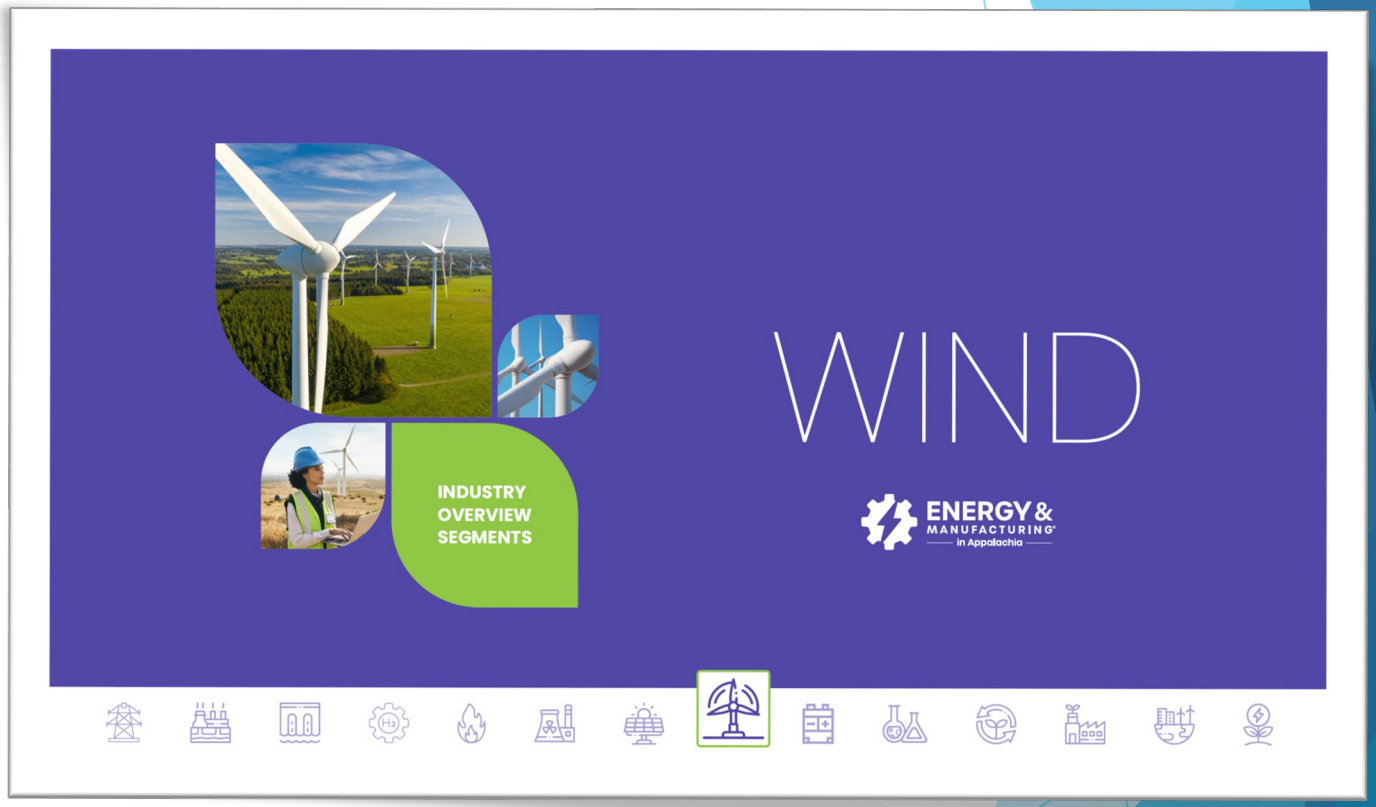
Today's Agenda

- Industry Segment Overview
- Market Size & Growth
- Wind Turbine Components
- Industry Resources
- Challenges & Next Steps
- Questions & Answers



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Wind Energy – Electricity Generation

- Accounts for approximately 8% of global electricity generation (2024)

- Percentage of total electricity from wind
  - United Kingdom 30%
  - Germany 28%
  - Sweden 24%
  - United States 10%

China produced 13% of total electricity (1Q 2025)

Rank (2024)	Country	Wind Generation (TWh)	Share of Country's Electricity (%)
1	China	991.6	9.8
2	United States	453.5	10.3
3	Germany	133.4	28
4	Brazil	107.8	14.5
5	United Kingdom	84.3	30
6	India	81.6	4
7	Spain	62.9	22.4
8	Canada	45.1	7.2
9	France	43.2	7.7
10	Sweden	40.8	23.6

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Wind Energy – United States

- 10% of electricity generation in 2024 (453 TWh)
- Installed capacity ~155,000 MW (2025)
  - Natural Gas 567,000 MW, Coal 201,000 MW, Solar 134,000 MW, Nuclear 99,000 MW
- Top Producing States by installed capacity
  - Texas 40,500 MW
  - Iowa 12,200 MW
  - Oklahoma 11,500 MW
  - Kansas 8,200 MW

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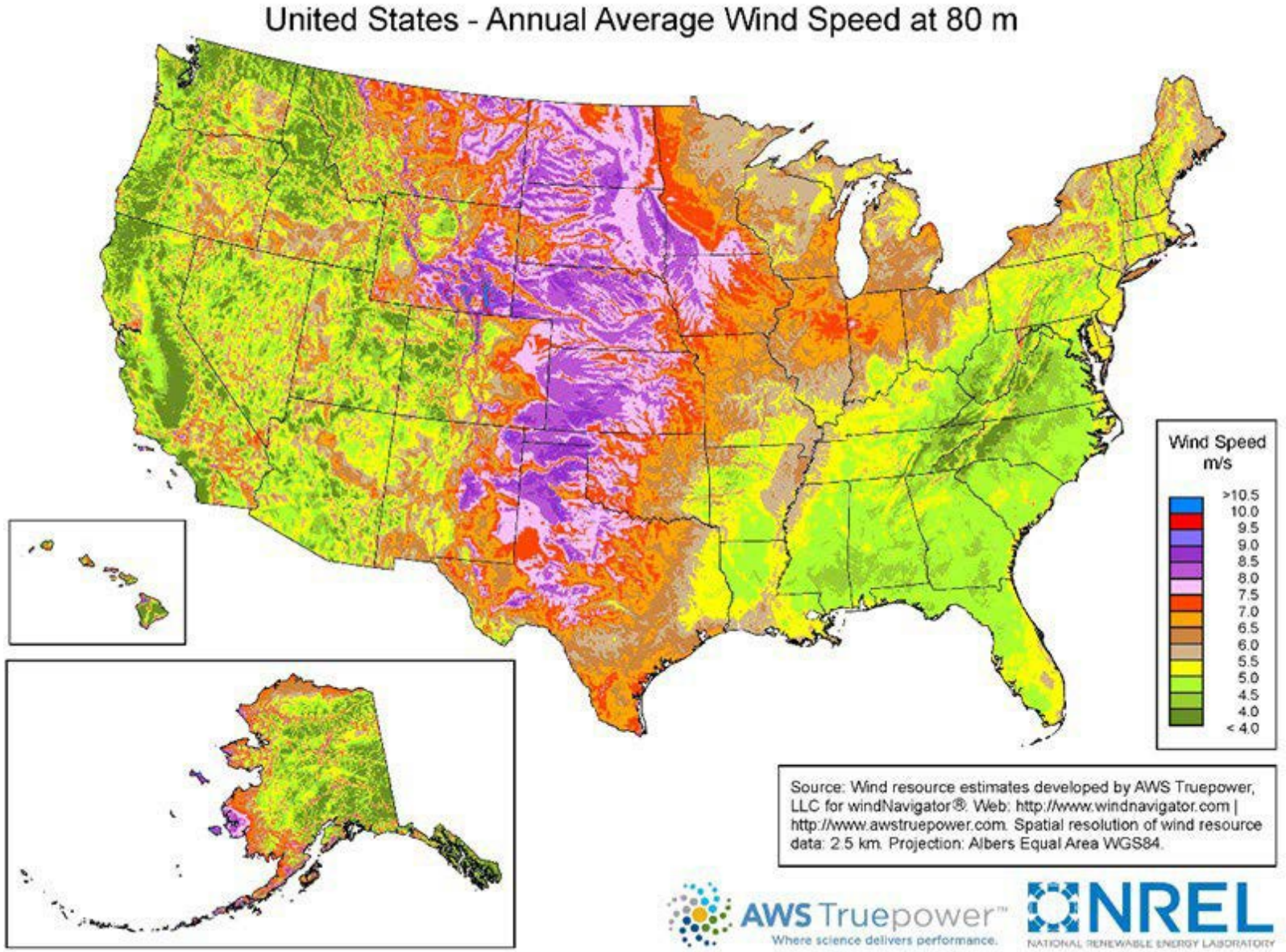

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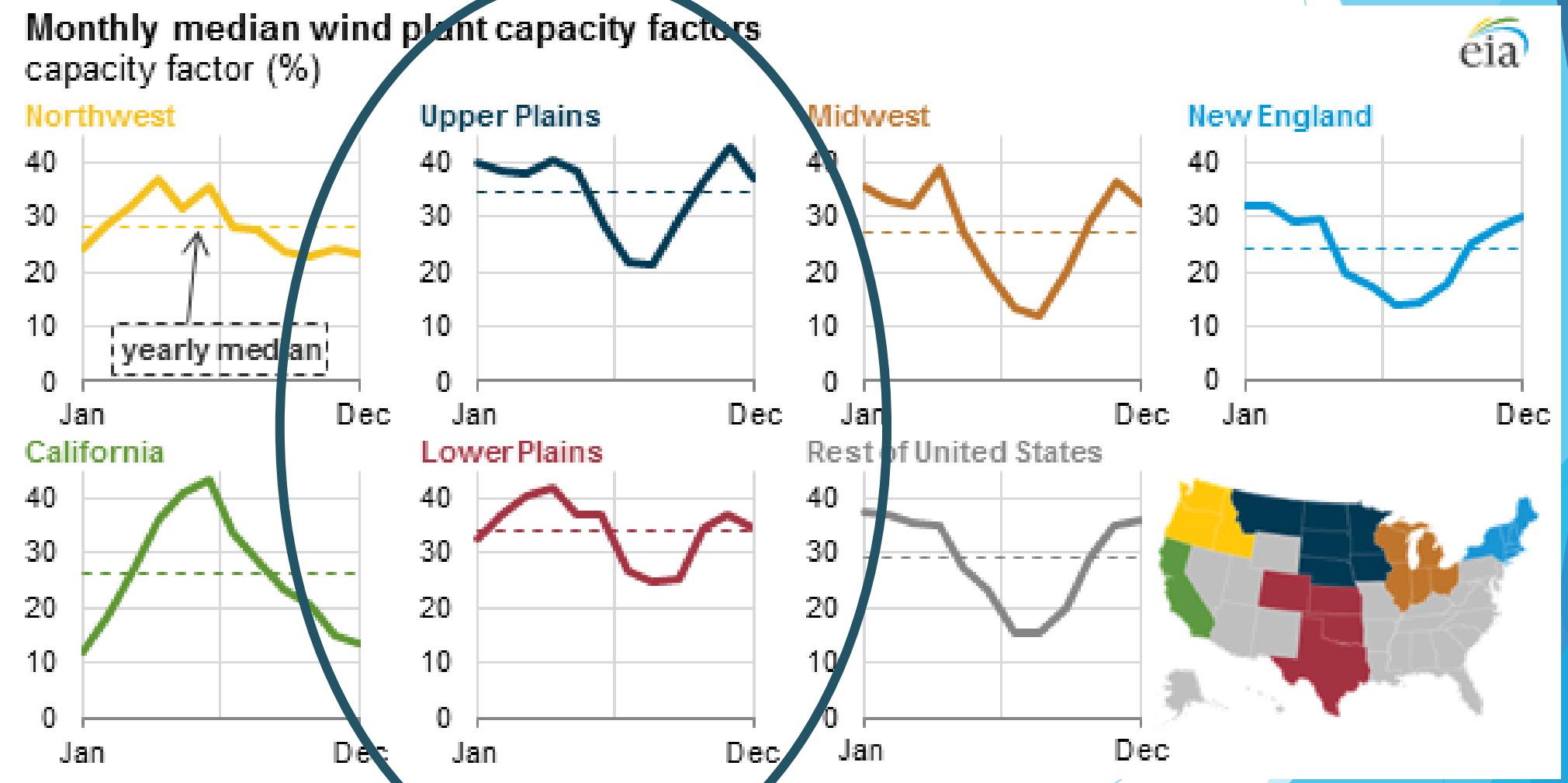
Wind Energy – United States



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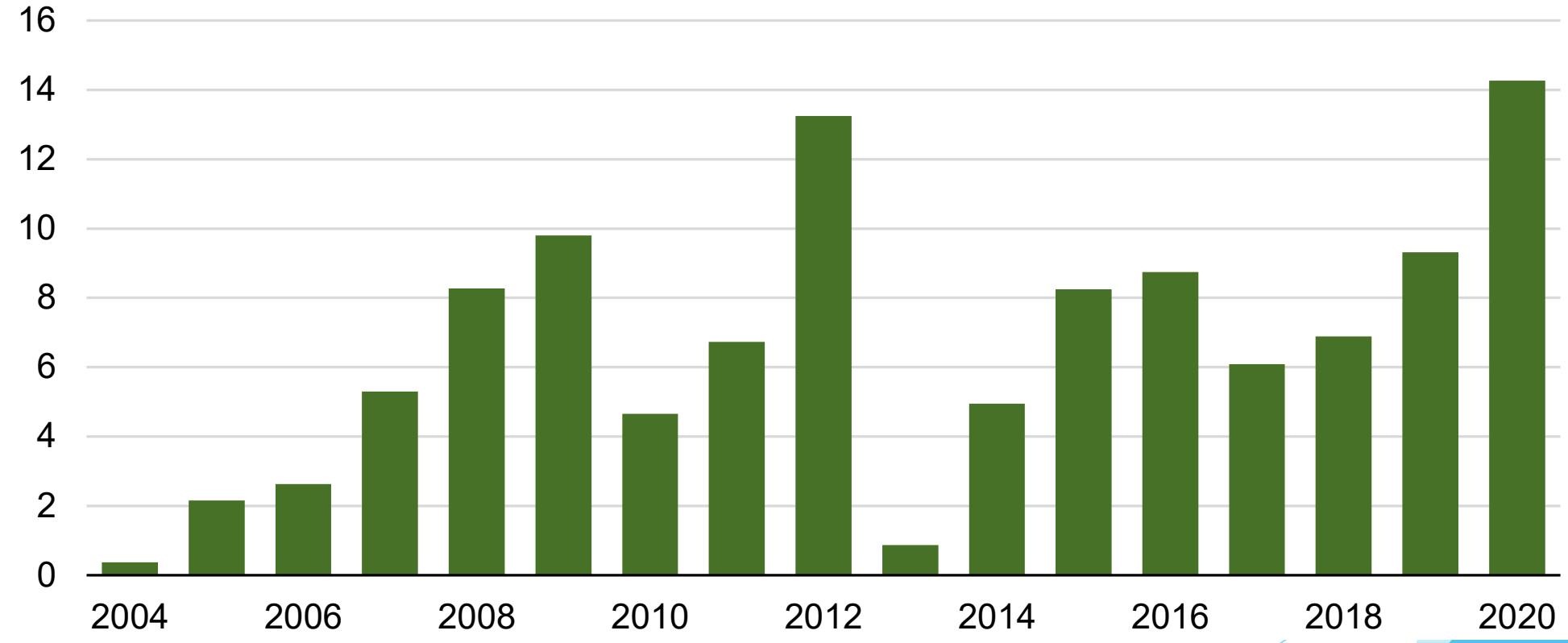
Market Growth

Annual U.S. wind turbine electricity generating capacity additions (2004–2020)
gigawatts



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Turbine Supply Chain Analysis

Component	Estimated Domestic Content (%)
Nacelle Assembly	Over 80%
Towers	80 - 85%
Blades & Hubs	50 - 70%
Overall Components	**Approximately 70 - 72%**

Compared to 2007 approximately 25% of supply chain was domestically produced

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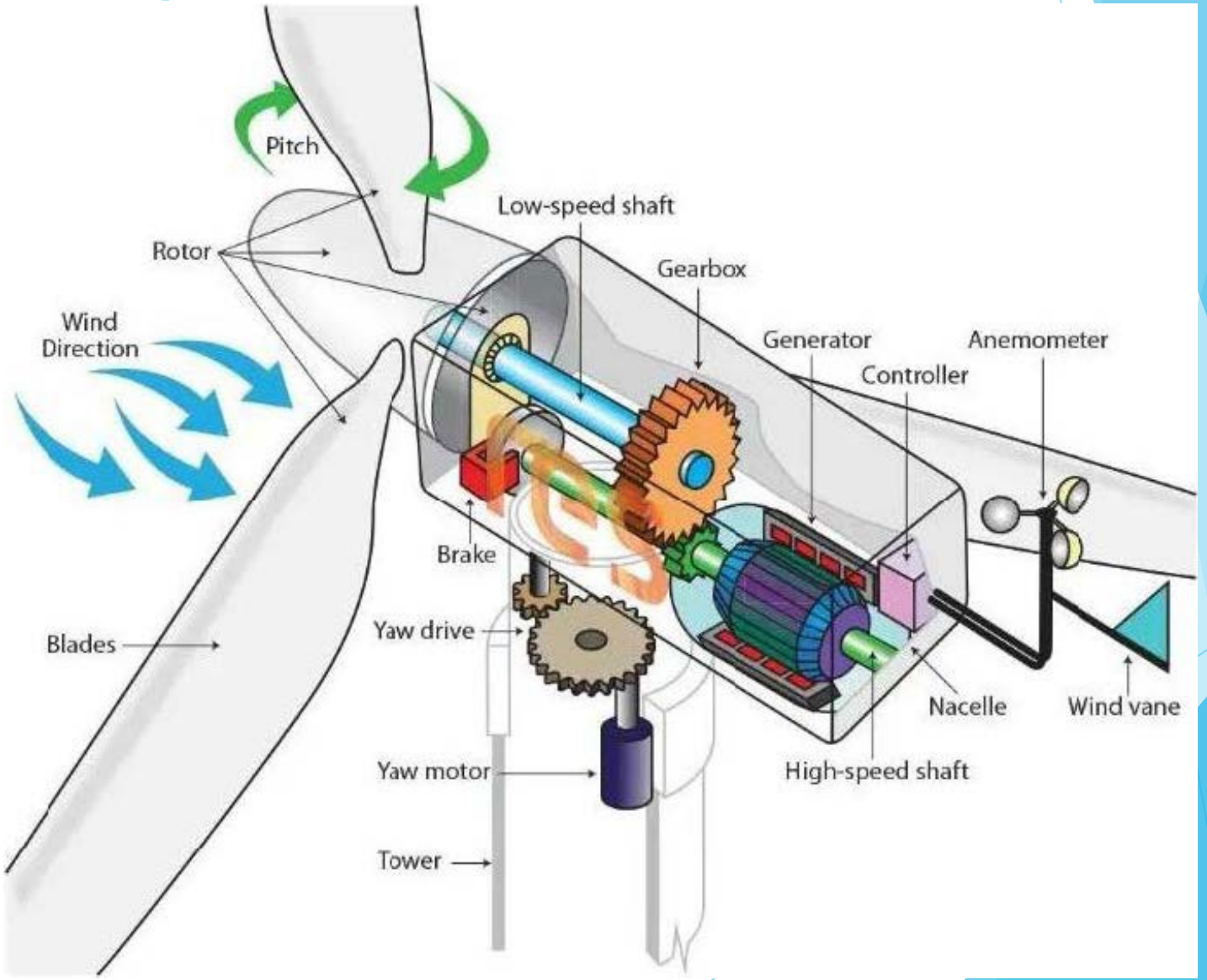
Wind Turbine Components



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Components of Typical Onshore Wind Turbine

COMPONENT	NAICS		DESCRIPTION	USE
Bearings	332991	Ball and roller bearings	A number of bearings are required for the shafts, gearbox, yaw mechanism, generator, and other rotating parts.	A four-point contact ball bearing joins the nacelle and the tower, allowing the nacelle to slew about in order to face upwind and extract the maximum amount of energy from the wind. The main shaft rotates on large tapered roller bearings, or in some cases a large spherical bearing.
Blade Externder	331511	Iron foundries	These steel components serve as a means to support the rotor blades and secure them to the hub.	Typically weighing over a ton, each blade extender is mounted to a four-point ball bearing, which is then mounted to the hub. The structure of the extenders allows each blade maximize rotation while connected to the pitch mechanism.
Brakes	33613	Power Transmission Equip.	Mechanical brakes are used as auxiliary devices to insure that the rotors, gears and generator have stopped during maintenance of periods of inclement weather.	The yaw mechanism typically halts any blade rotation by turning the rotors perpendicular to the wind direction. Should the rotors continue to turn, many turbines are equipped with either hydraulic or spring activated brake systems to prevent undesired rotation or fatigue on the turbine.
Cooling system	333412	Axial fans	A large fan drives air to convectively cool the generator and gearbox and exhausts waste heat from the nacelle assembly. Ducting directs cool air to the generator.	Most wind turbines have cooling and dehumidifying units set to maintain conditions within the nacelle at levels such that rust and corrosion is largely prevented.

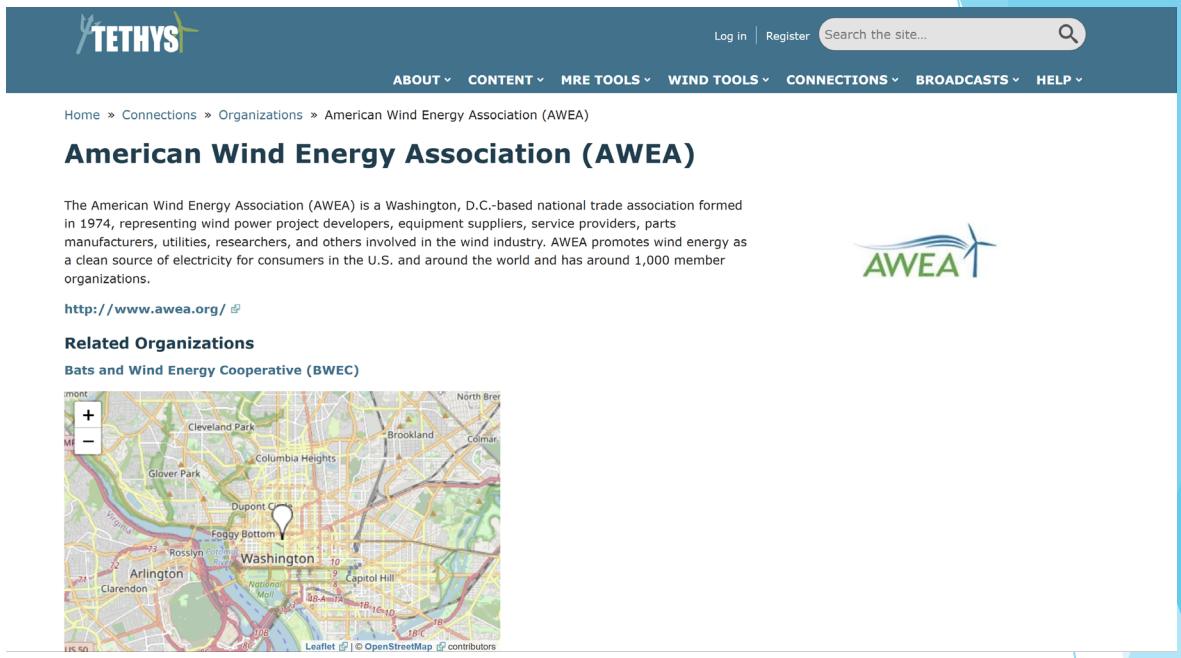
Industry Resources

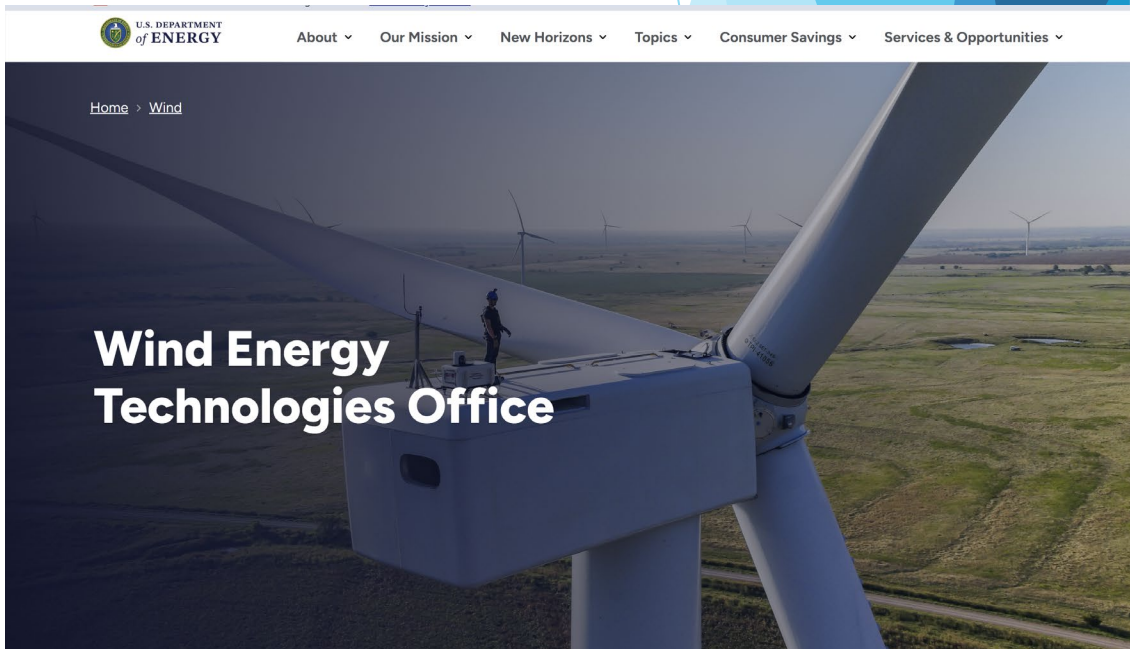
Policy & Advocacy Organization

- American Clean Power Association
- Wind Energy Foundation
- Clean Power State Alliance

Funding, Research, Developers

- U.S. DOE Office of Wind Energy
- NextEra Energy Resources
- GE Vernova





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Challenges & Next Steps

- Wind is used to generate electricity
- Technology constrained
- A marathon not a sprint
- Need strong and consistent speeds
- Capacity factor – 34-36%
  - Nuclear 92-93%, Natural Gas 45-60%, Coal 34-36%

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Questions?

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