Wind Energy Research Interests and Activities at NASA Ames Research Center

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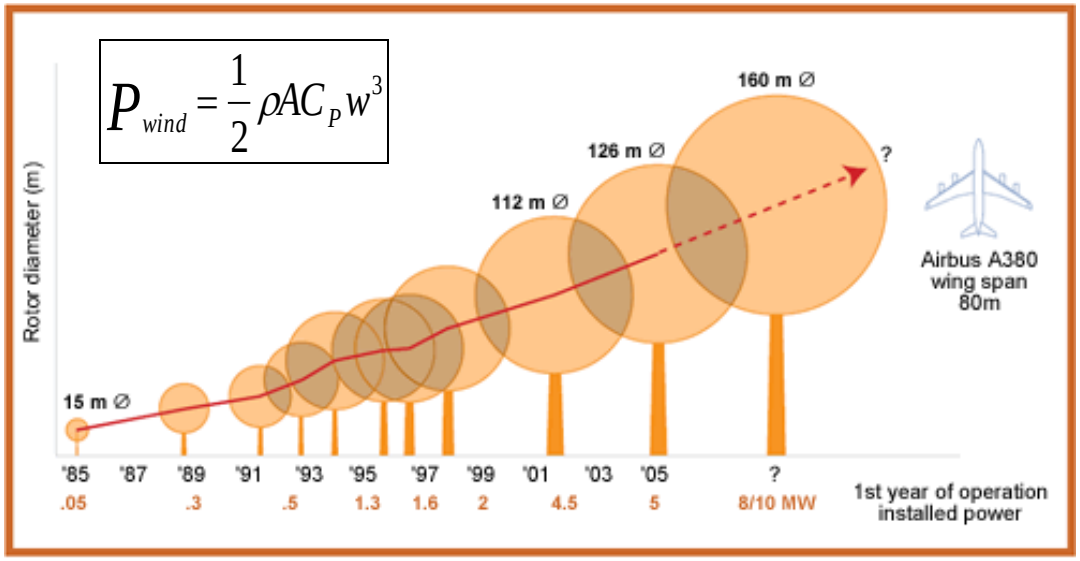
Decreasing Cost of Wind Energy

1979: 40 cents/kWh

2000: 8 - 10 cents/kWh

2010: 4 - 7 cents/kWh

$$P_{wind} = \frac{1}{2}\rho A C_P w^3$$



- Economies of Scale
  - Increased turbine size
  - Large wind farms
- Increased Energy Capture
  - Design and control
  - Manufacturing and materials
  - Site selection
  - Increased up time

Wind Industry Observations

Wind Industry Practices

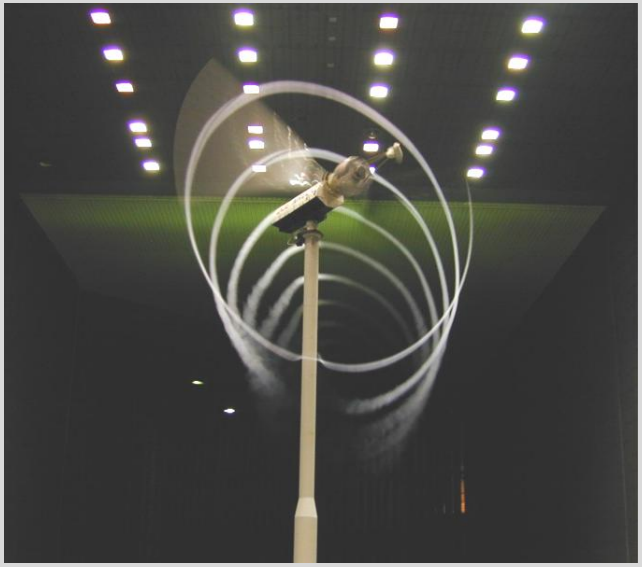
- Industry is relatively low-tech and very protective of IP
- Research funding is limited
- Very little vertical stratification
- New technologies need **quick** and **cost-effective** integration
- Solutions must make economic sense

Wind Industry Challenges

- Building large turbines (>5 MW)
- Operating & maintenance costs
- Turbine reliability
- Grid integration, transmission
- Community acceptance
- Wind farm development – regulations (environmental, FAA), forecasting, siting

Wind Energy Areas of Interest for Ames

- Intelligent controls
  - Load alleviating control
  - Off-nominal control
  - Aeroelastic tailoring for performance
  - Wind farm optimization
  - Advanced sensors and actuators
- System health monitoring
  - Structural, electrical prognostics
  - Prognostics integrated with controls
- Computer modeling (CFD, multi-body)
  - Turbine aerodynamics, aeromechanics, aeroelastic fluid-structure interactions
  - Turbine wakes, wake interactions
  - Atmospheric boundary layer
- Wind tunnel testing, model validation
- Blade and rotor design, optimization, and modeling



NREL Wind Turbine, NASA Ames, 2000

Collaborations, Interactions, and Relevance

- University of Wyoming - $50K Reimbursable Space Act Agreement
  - Adaptive control for load minimization and performance, system health management
- National Renewable Energy Laboratory
  - Control of utility-scale wind turbines, wind tunnel test of subscale wind turbine
- Lawrence Livermore National Laboratory
  - Exchange of ideas for future collaborations
- Private company interested in licensing adaptive control algorithms

Mission Support and Benefits to NASA

- Collaborations support NASA's Strategic Goal 3, specifically 3.4, “Facilitate the transfer of NASA technology and engage in partnerships with other government agencies, industry, and international entities to generate US commercial activity and other public benefits.”
- Wind turbine research and development provides a non-safety critical environment with the potential to field test new aerospace technologies, and bring them to a higher TRL.
- Wind energy is an engaging subject, encompassing multiple disciplines that has successfully attracted many students to the STEM fields.

Potential 10 MW Wind Turbine Collaboration

Collaboration Objectives

- Work as an integrated multi-disciplinary team to design and build a revolutionary, economically viable 10 MW wind turbine
- Game-changing system design to increase performance, safety, and reliability using
  - Lightweight materials & novel structural concepts
  - Innovative actuation & sensing
  - Intelligent control integrated with system health management
- Optimize and validate design with extensive CFD modeling of atmospheric boundary layer to determine wind inflow, rotor wakes, turbine wake interactions & turbine loads
- Couple design with fabrication, transportation, installation, & maintenance solutions

Potential Collaboration Partners

- NASA Ames Research Center
- National Renewable Energy Laboratory
- Lawrence Livermore National Lab.
- Aeros Aeronautical Systems Corp.
- University of Wyoming