Turbine Life Cycle Engineering

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Life Cycle Engineering

- ✓ Where it all begins?
- ✓ All resources are limited, including ability of the earth and atmosphere to clean itself
- ✓ Major water and atmosphere pollutants, e.g., CO_2, NO_x, and SO_x
- ✓ CO_2 emissions in the energy production process (in particular the wind energy equipment production)
- ✓ Water contamination by industry, e.g., waste disposal, etc.
- ✓ Waste and disposal of contaminants and resources, e.g., electronics, mercury, cellulose (paper)

Sustainable Development

Main goal

- ✓ Meeting our needs without negative impact on the ability of future generations to meet their needs

- ✓ Most disputes evolve around who is going to pay for making the world clean and healthy
- ✓ Is it natural to be sustainable (responsible, no debt, …)

Sustainability Chain in Wind Energy

Energy usage and environmental impact perspective

- ✓ Extraction of natural resources, e.g., iron ore, chemicals, cellulose
- ✓ Transportation of natural resources
- ✓ Production of raw materials, e.g., iron, fiber glass
- ✓ Fabrication and machining – material processing
- ✓ Assembly of subsystems
- ✓ Transportation
- ✓ Final assembly
- ✓ Service (operations and maintenance)
- ✓ Product end of life

Sustainable Manufacturing

- ✓ Sustainability is of paramount importance in wind energy industry due to high material (energy) content, e.g., gearbox, tower, cables
- ✓ Sustainability has not been sufficiently addressed at this time by the wind energy industry due to the wind energy "rush"
- ✓ Now is the very last opportunity (somewhat late) to address turbine life-cycle engineering issues in wind industry

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The Four-Criteria Dilemma

- ✓ Maximization of turbine performance
- ✓ Maximization of turbine life-cycle
- ✓ Minimization of energy used to built a turbine
- ✓ Minimization of environmental impacts

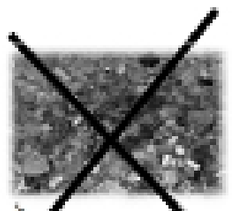
Emerging solution: Predictive engineering

Source of Decreased Wind Turbine Life Time?

- ✓ Problem: Variable loads
- ✓ Key issue: Torque management is a viable solution to reduction of extreme stresses
- ✓ Solution: Anticipation of the extreme loads (wind conditions)
- ✓ Implementation: Predictive engineering

What to Do With an Old Wind Farm Equipment?

Restored 1949 VW Bug



- ✓ Reuse (most preferred)
- ✓ Remanufacture
- ✓ Recycle
- ✓ Disposal (should disappear)

Life cycle engineering

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Life Cycle Engineering

Best industrial practices

- ✓ Fuji-Xerox
- ✓ Caterpillar
- ✓ Appliance industry, e.g., washers

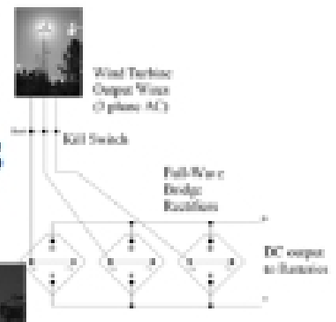
UI's "Wind Turbine Corporation"

Design, process, and mfg engineers:
- ✓ Kevin Langan
- ✓ Robbie Lovsnuen
- ✓ Dan Rogge
- ✓ Matt Zanker

UI engineering students

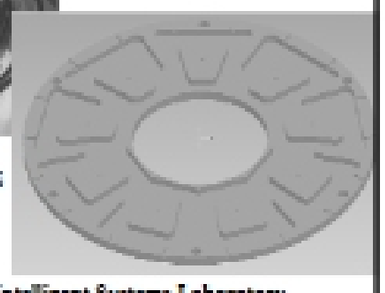
Turbine Components

Hub

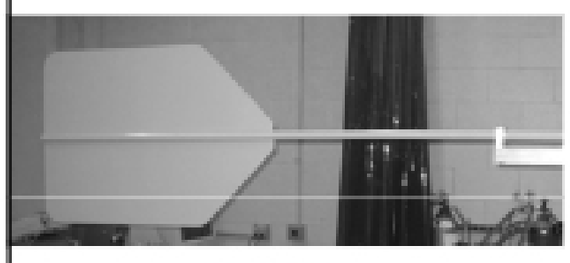


Coil manufacturing

Generator components designed for reuse and remanufacturing



Turbine Components



Vane

Rated power: 750 W
Total cost: $354

Yaw mechanism