SMART Wind Consortium

Mechanical Systems
Gaps & Opportunities Discussion

Mechanical Subgroup Meeting
November 13, 2014
NWTC
Boulder, Colorado, USA

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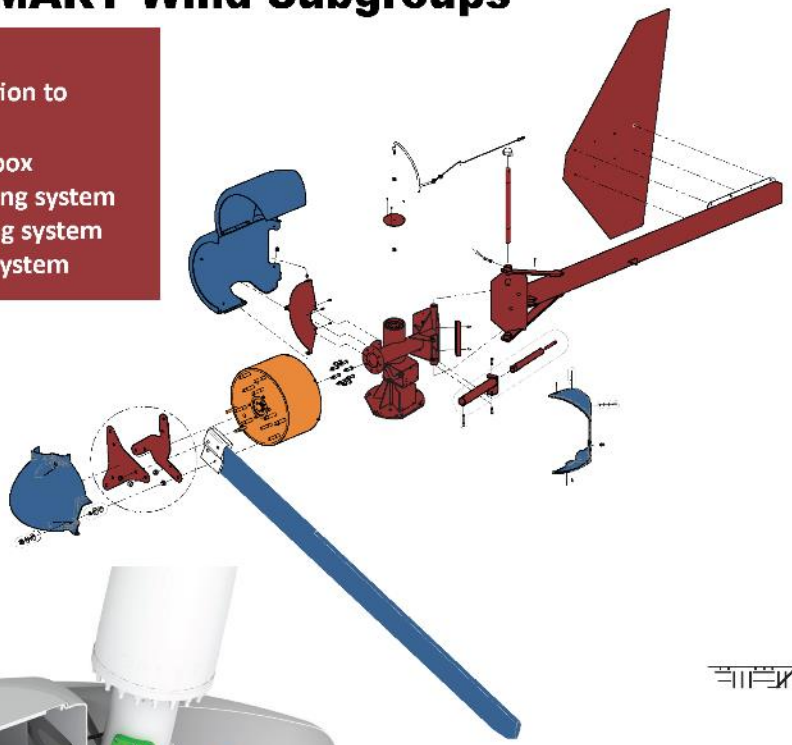
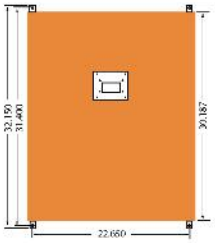
NIST
National Institute of Standards and Technology
U.S. Department of Commerce

SMART Wind Subgroups

Mechanical Systems

- Rotor, hub, mainshaft, mainframe; rotor connection to generator, generator support
- Tower top/bed plate, tower adapter
- Shafts
- Bearings
- Braking system
- Gearbox
- Pitching system
- Furling system
- Yaw system

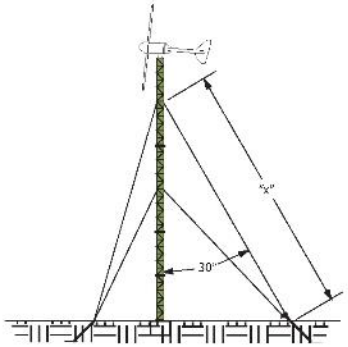


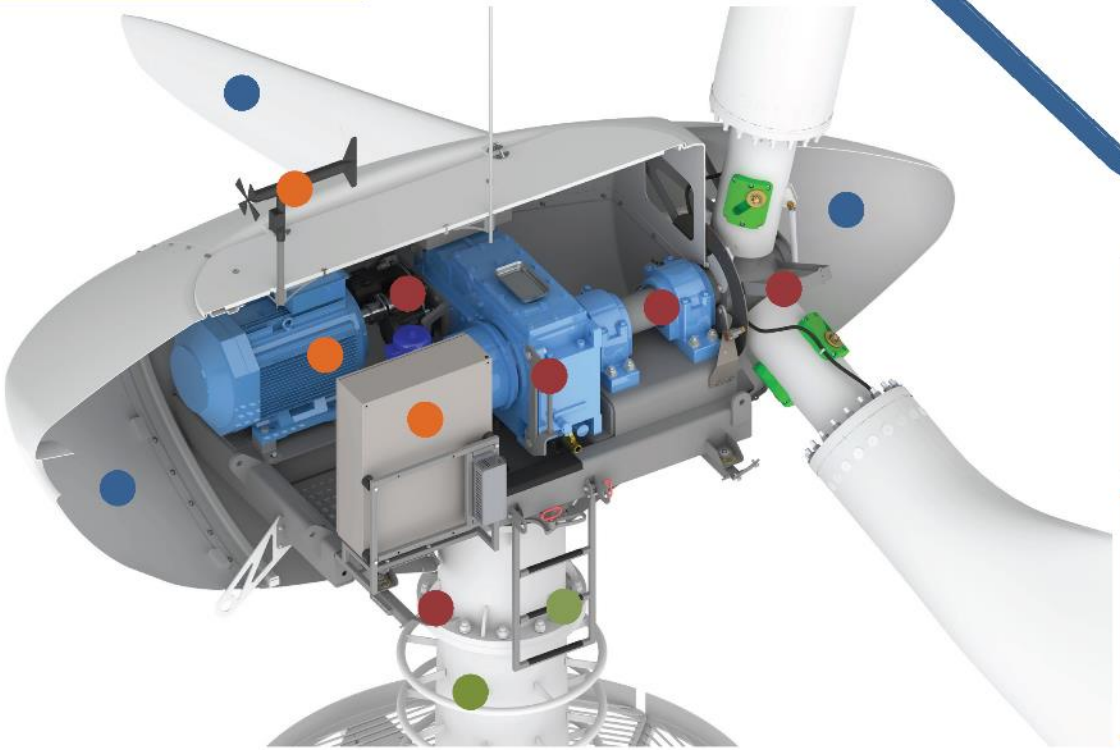


Inverter

Support Structures

- Tower
- Access ladder
- Foundation
- Achoring system
- Permitting





Composites

- Anything using fibre-reinforced or carbon resins including:
- Blade
- Nacelle housing
- Nosecone
- Tower

Electrical Systems

- Inverter
- Controller
- Alternator
- Power electronics
- Generator
- Magnets
- Bus bars
- Slip rings
- Interconnection
- System monitoring

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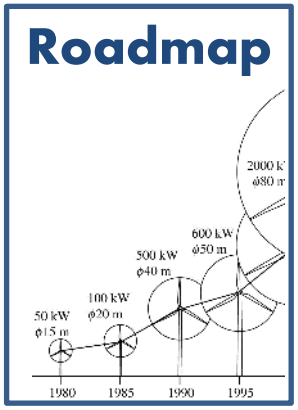
Reminder: Although we are trying to focus on issues through subgroups,

this is a complete wind turbine SYSTEM

Another reminder:

Use your notecards



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Mechanical Opportunities from OEM Steering Group

Aeronautica Windpower: opportunities with castings

Bergey Windpower: process improvements, automation

Black Island Wind Turbines: castings, small volume automation

Dakota Turbines: lean manufacturing techniques

Endurance Wind Power: Just-in-time, making parts less expensively

Eocycle Technologies: Low volume manufacturing is challenging

Northern Power Systems: reducing labor, flexibility, just-in-time

Pika Energy: opportunities with castings

Primus Windpower: US sourcing sometimes involves design change

Ventera Wind: opportunities with castings

Xzeres Wind: design changes an certification

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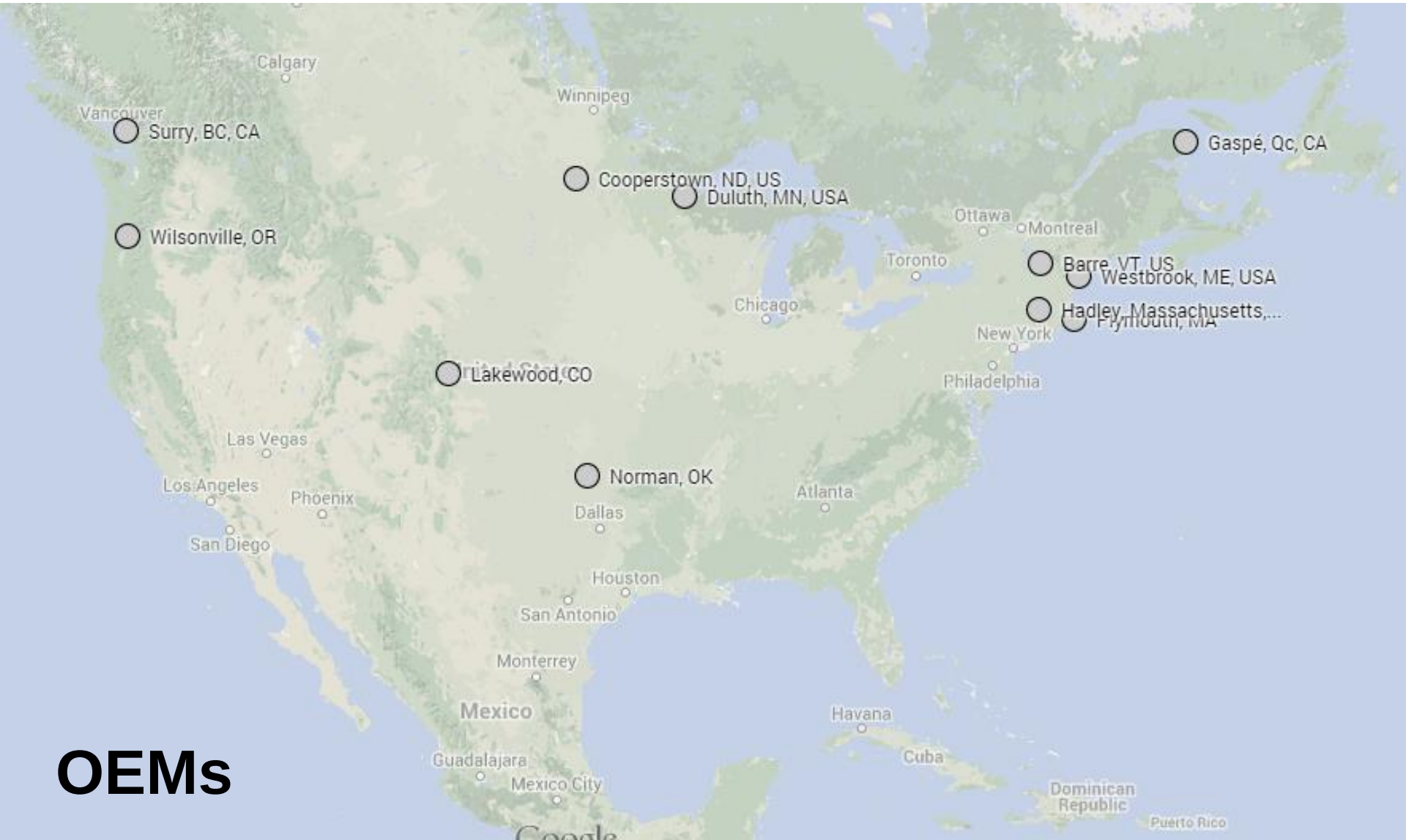

OEMs

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Global supply chain

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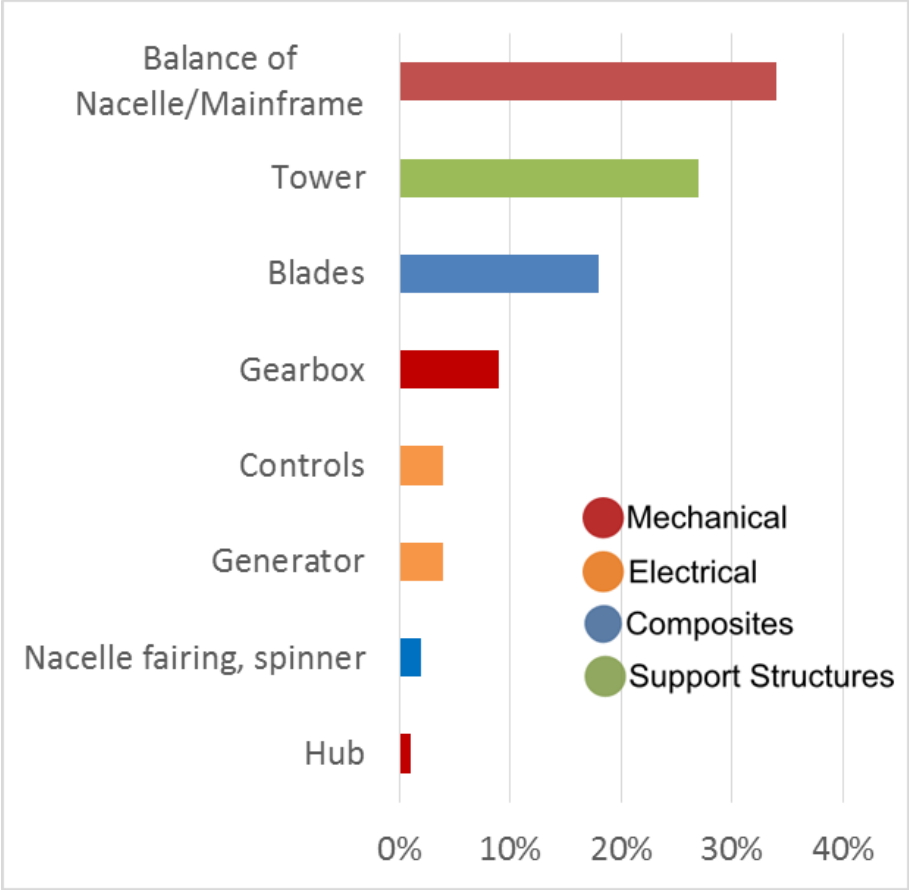
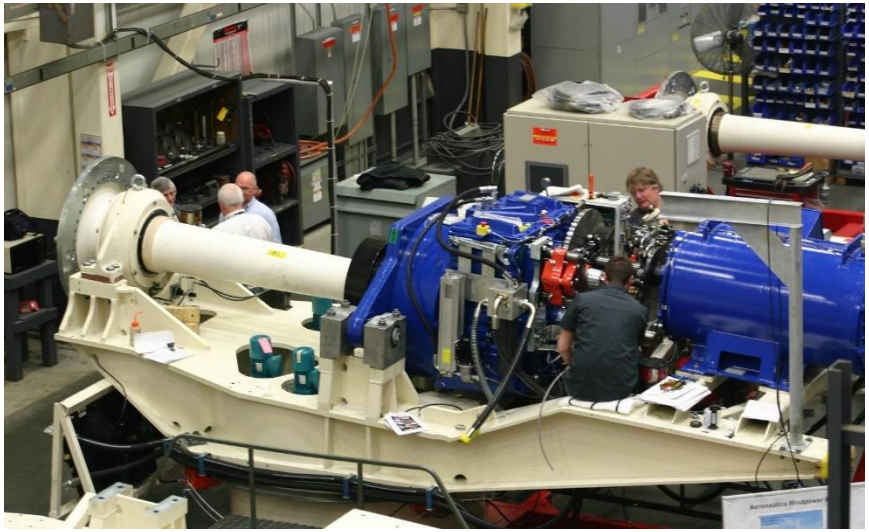
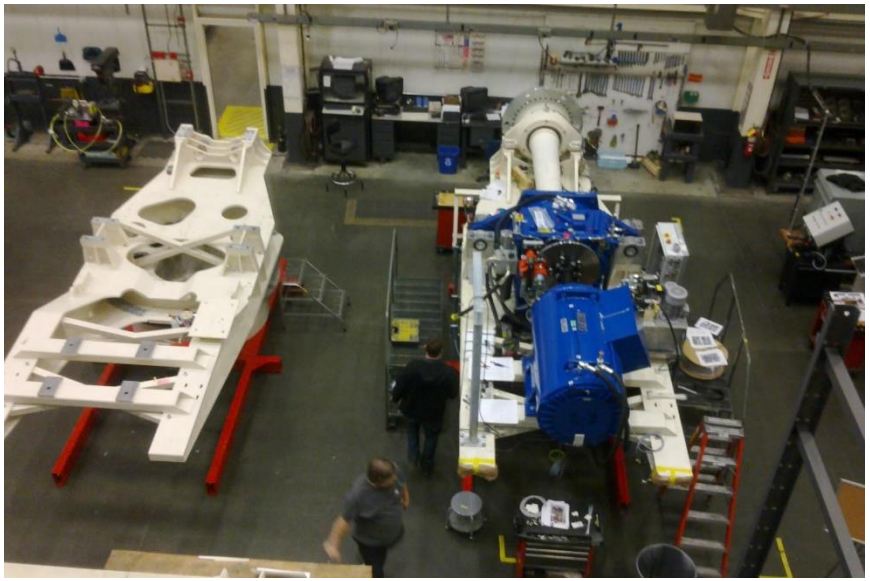
N. America Supply Chain

How do mechanical parts rank in % of BOM costs?

Aeronautica AW-54-750kW BOM







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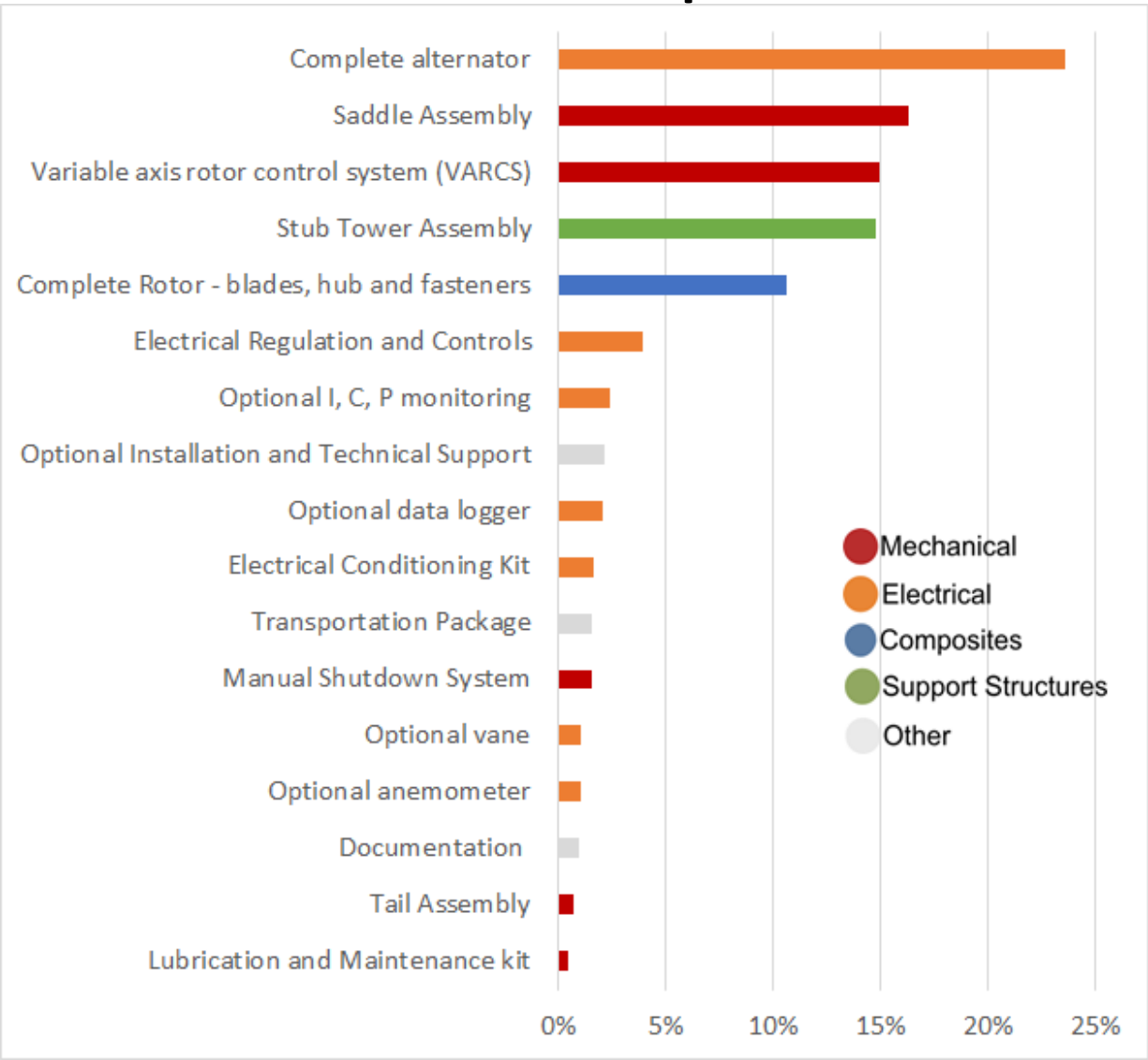
Black Island 48V HR3 Top Level BOM



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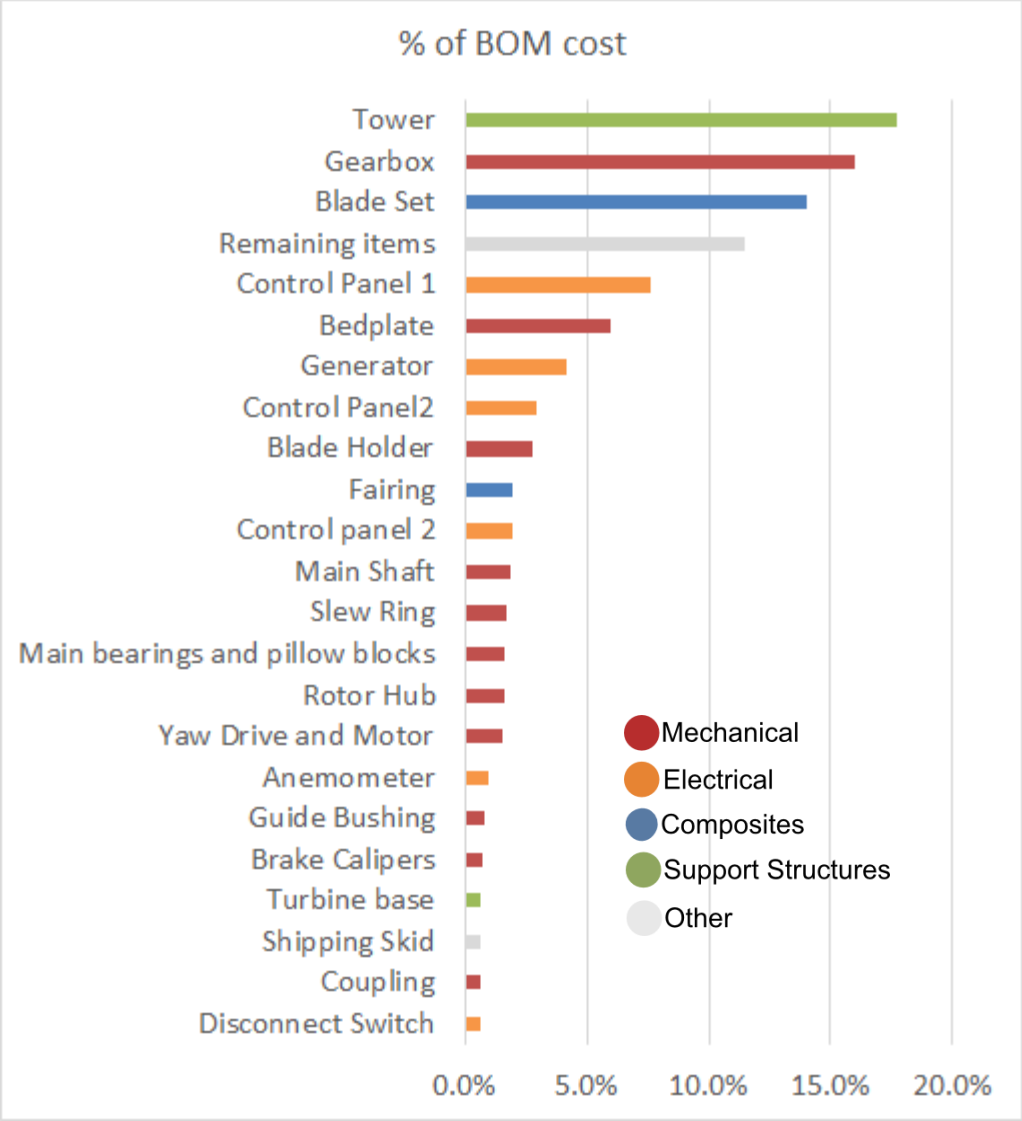
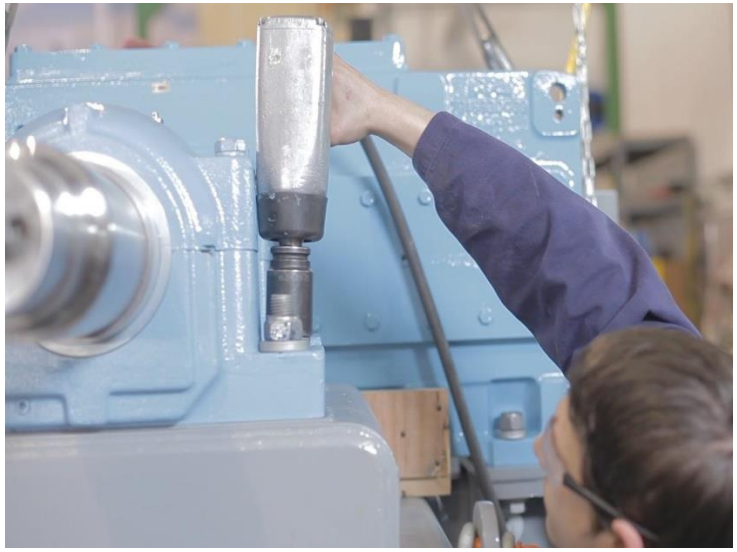
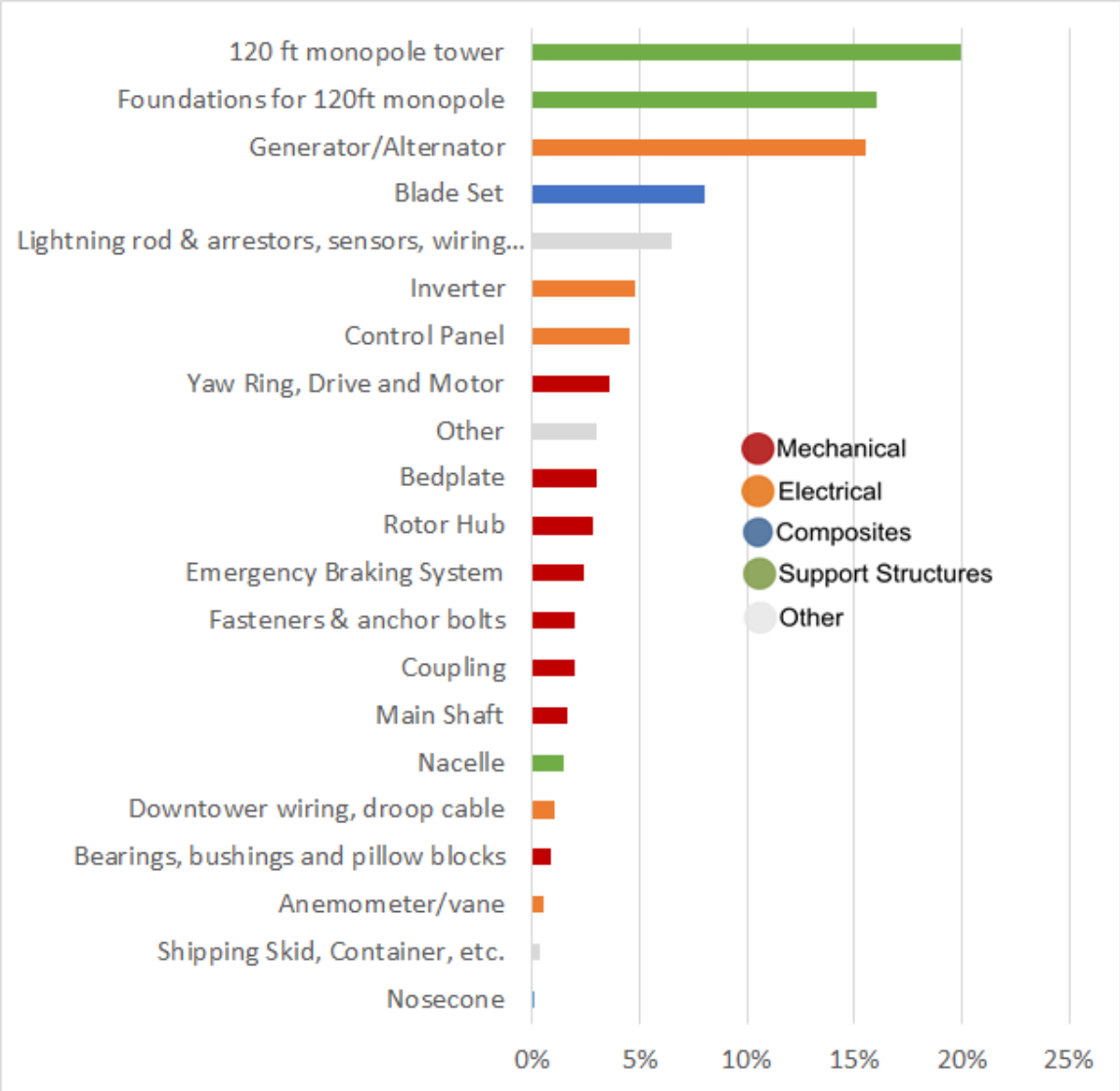
Endurance E3120





Eocycle 25 Top Level BOM



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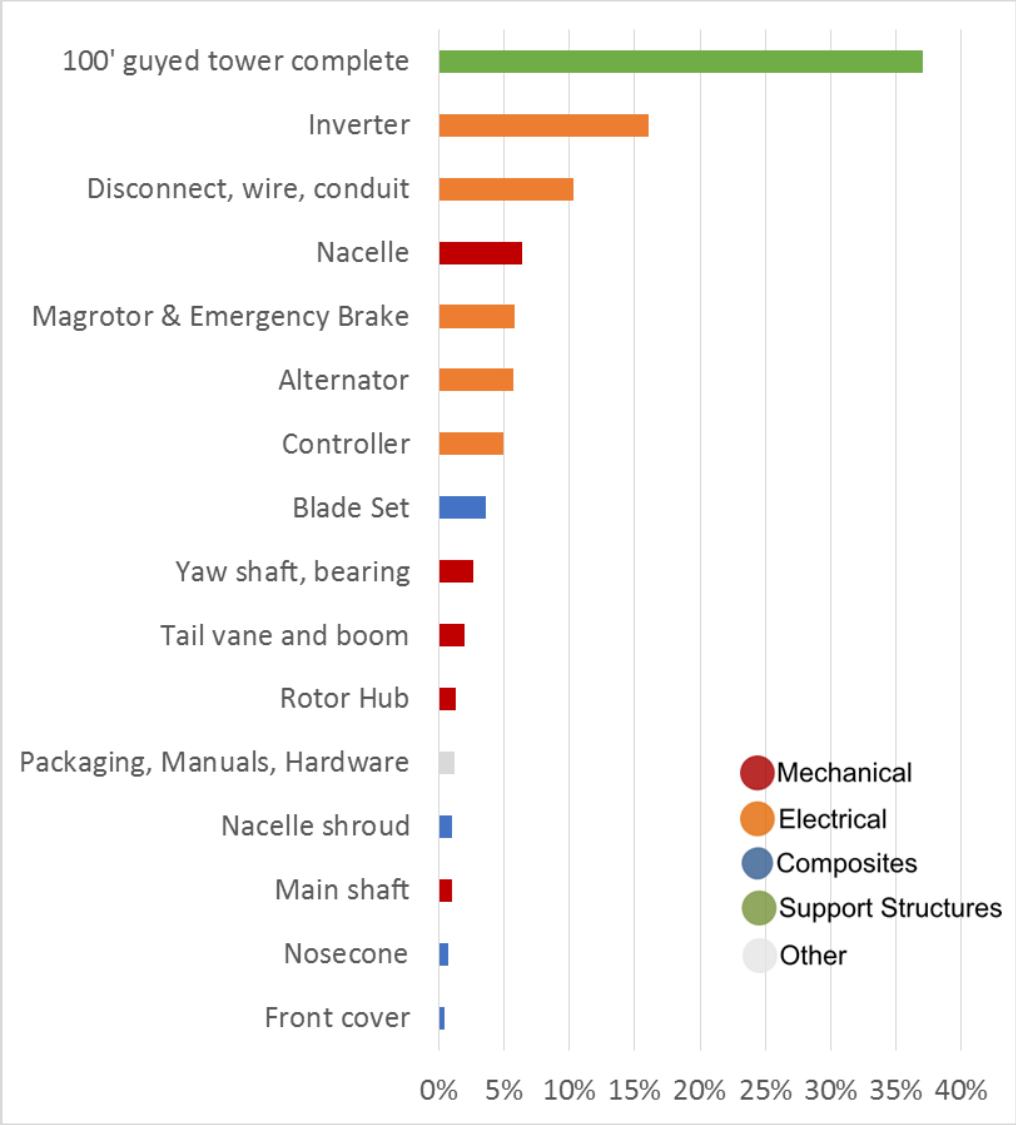
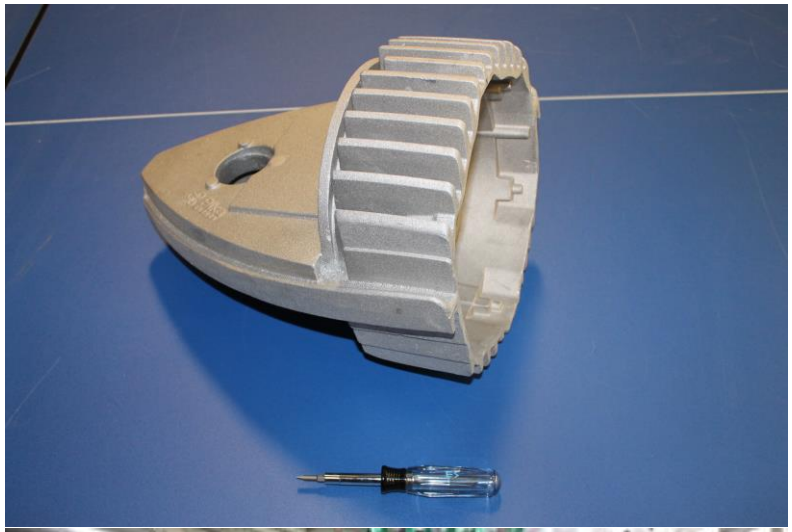
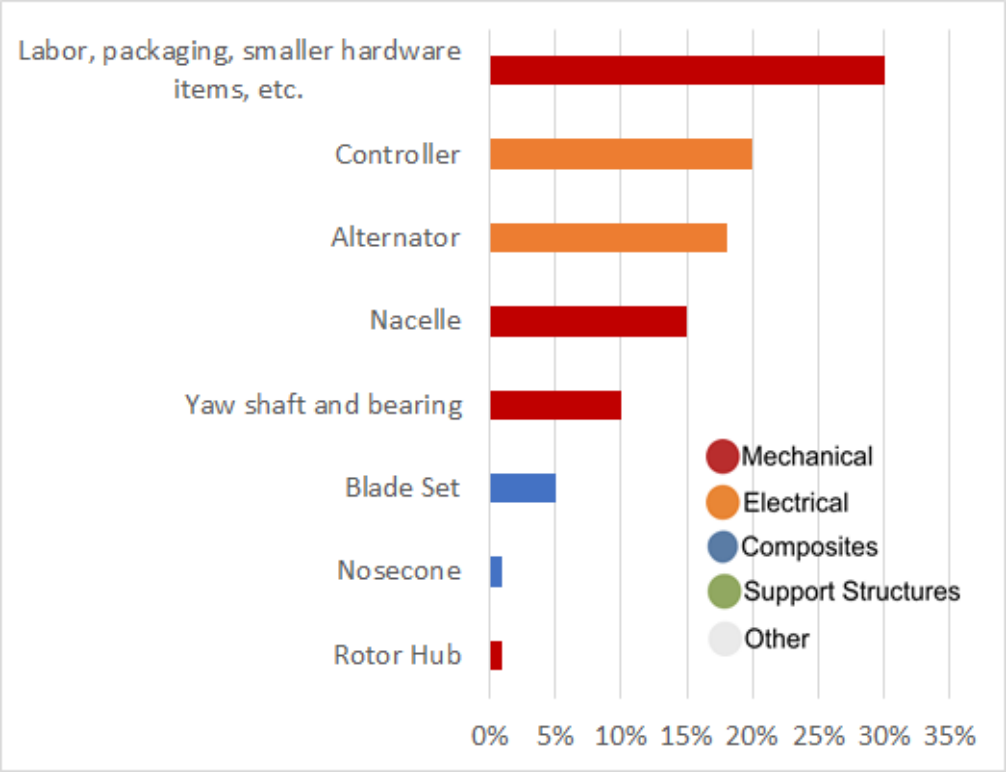
Pika T701 BOM

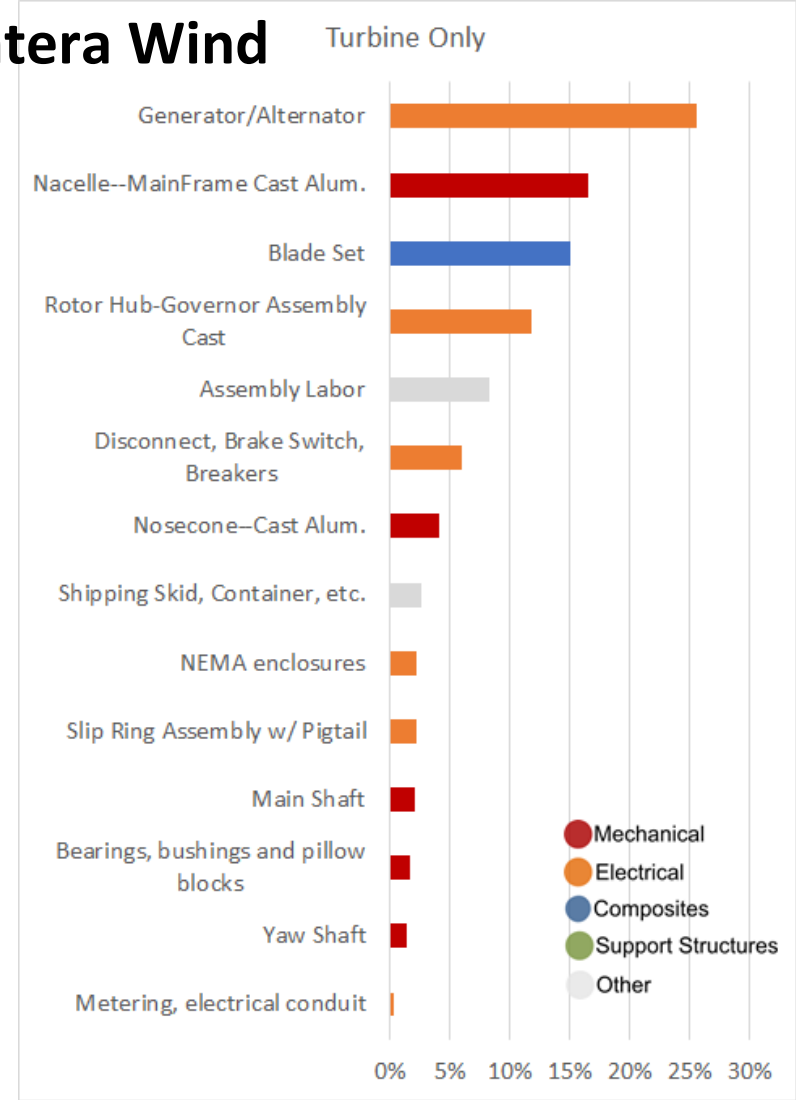


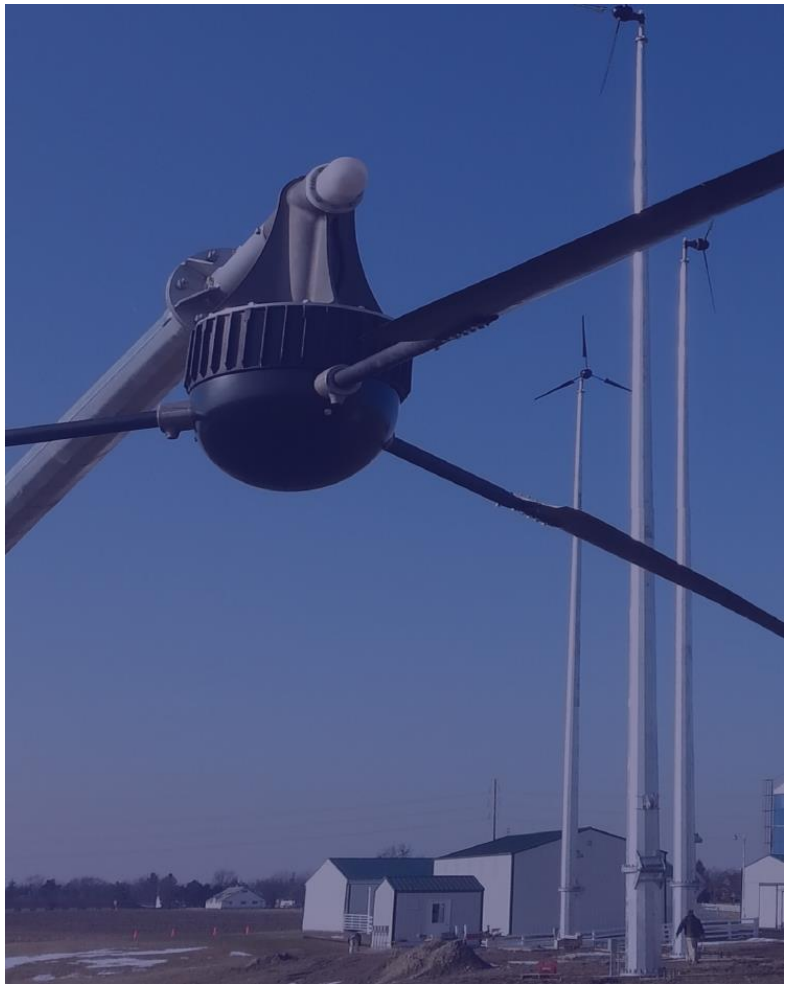


Primus Windpower Air BOM



Ventera Wind





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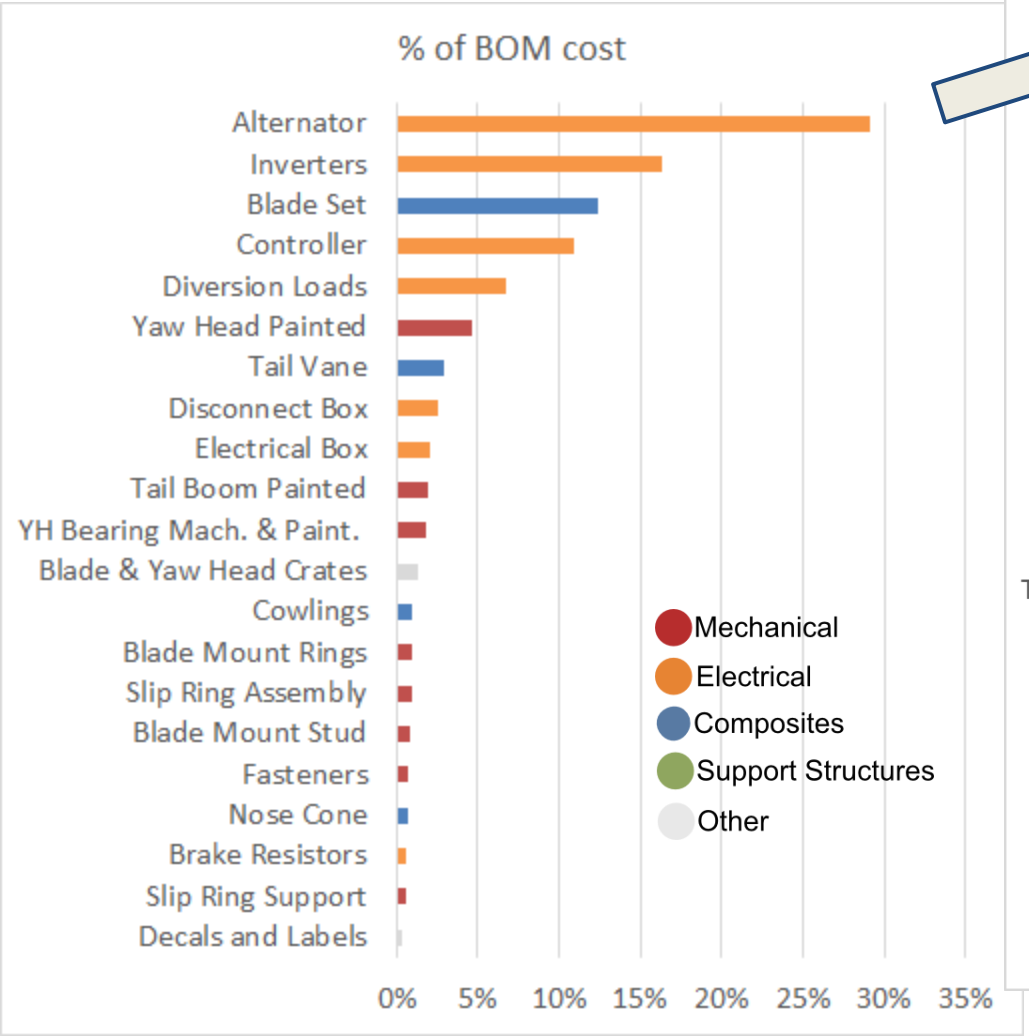
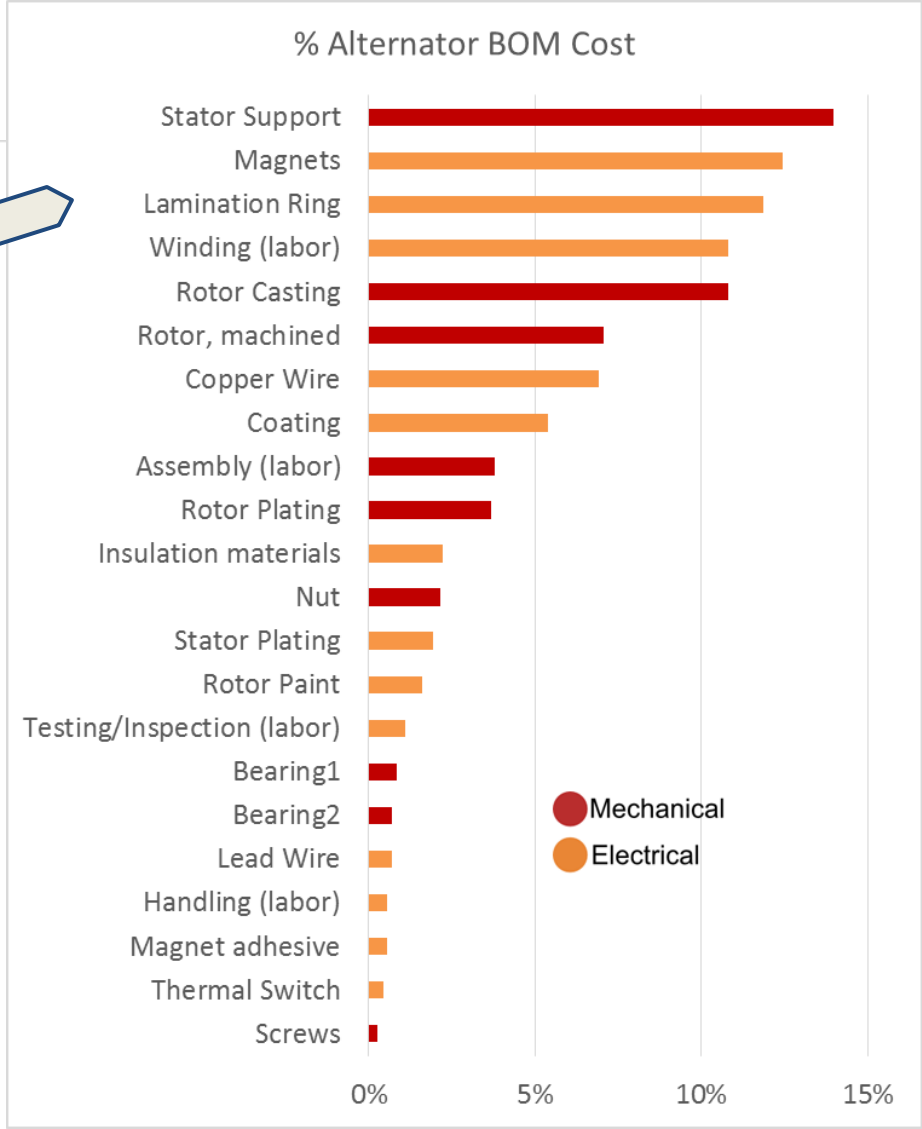
Xzeres 442SR





SMART Wind Questionnaire Results

Academic and Research Group

Thank you to our Academic and Research Members for their insight provided with the Questionnaire

Selected New Research Opportunities

Composites

- Flutter avoidance R&D- Rick Damiani (NREL)
- Damage detection methods & advanced composite structural design - Pier Marzocca (Clarkson University)
- Low-wind blade design- Patrick LeMieux (CalPoly)
- Blade testing, structural dynamics, non-destructive inspection, etc – Chris Niezrecki (UMASS - Lowell)
- Advanced blades and blade surface soiling and erosion effects on turbine performance - Case van Dam (UC-Davis)
- New blades (~14m) are being designed for the SNL SWiFT facility – Brian Naughton (SNL)
- Composites Engineering Research Lab (CERL) on infused thermoplastic blades – Paul Williamson (MOWEI)

Support Structure

- Tower and support structure design optimization – Rick Damiani (NREL)
- Streamlining of foundations and installation practices – Roger Dixon (Skyland Renewables)

Electrical

- Multi-level inverter technology – Ruth Douglas-Miller (KSU)

Mechanical

- Pitch control and actuation and control design for maximum energy capture - Patrick Lemieux (CalPoly)

Possible Manufacturing Evolution?

- Machining of stator lamination stacks to avoid shorting between laminations.
- Machining of tape wound cores to avoid shorting between layers
- Methods for automating layup of glass fiber for composite wind turbine blades
- Improvements to gear life through surface treatments
- Reliable, repeatable, low-cost corrosion protection for large ductile iron castings
- Leading edge erosion, composite repair
- Value engineering for small wind foundation and tower design
- Reducing prices for electronic printed circuit boards with low volume production
- Rapid prototyping for use in blade design iteration
- Autoclave/out-of-autoclave processes

Other opportunities/ideas

- Identify regional manufacturer expertise (steel forging, electrical components, casted items, etc) and encourage entry/ conduct meetings with such suppliers to enter wind turbine sector
- Specialized and cost effective manufacturing of stators, rotors, windings and housing for the alternator / generator
- Thermoplastic, injection molded composite blades (http://www.osti.gov/scitech/biblio/921599)
- Absence of dynamic aspects of design and loads analysis
- Speak directly with the machining companies that manufacture product
- Alternator design and manufacturing methods for cost reduction and reliability improvement is critical
- Power electronics manufacturing for small production runs at reasonable cost

SMART Wind Questionnaire Results

OEM Steering Group

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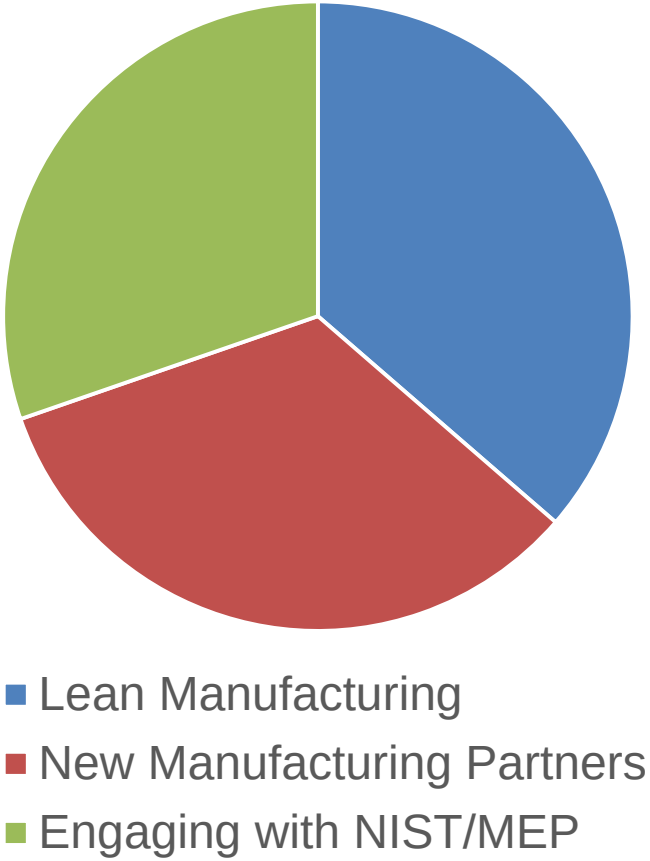
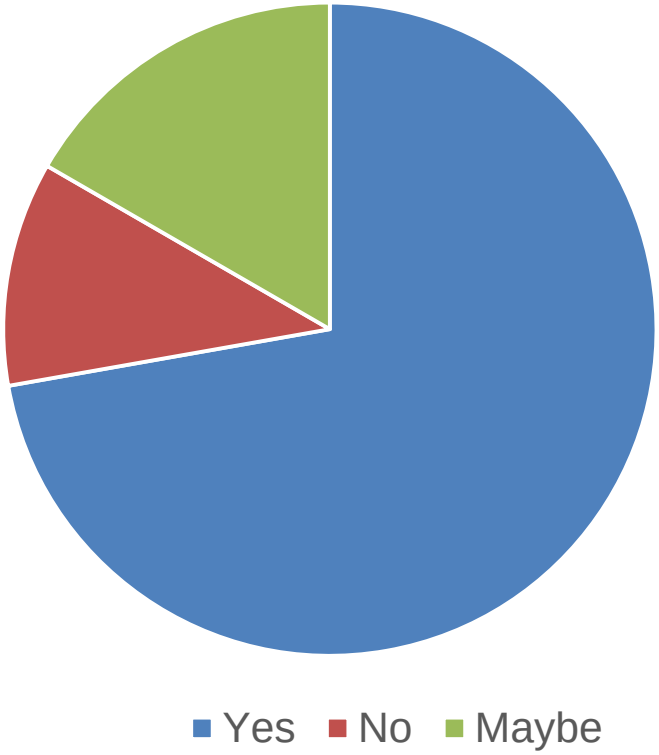
Interest in learning about manufacturing



Interested in evolving design with manufacturing expertise?



Composites

- Blade design and manufacturing optimization
- Automated composite manufacturing as an industry-wide effort
- Green blades--sustainable materials such as bamboo

Power Electronics

- Standardizing power electronics

Mechanical – castings

- Learning best practices for CNC machining of near-net-shape castings
- Advanced casting techniques, get more functionality out of fewer parts

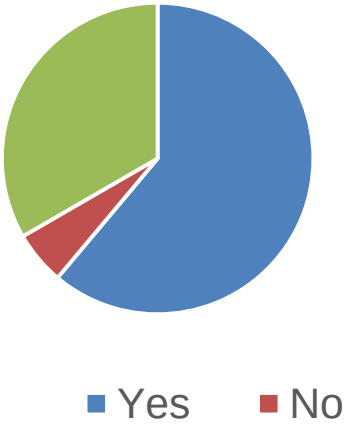
Support Structure

- Manufactured solutions for foundations, save site logistics cost and complexity

Other

- Tooling and part handling for low volume manufacturing
- Lowering the manufacturing gaps of our suppliers so as to reduce their costs and our price of components
- Fixturing to reduce labor

Interested in new manufacturing partnerships?



What would it take to bring non-U.S. manufacturing back to the U.S.?

Magnets

- It would probably take Federal incentives to get the production of magnets up and running
- Can't source magnets in U.S., competitive U.S. supplier of NdFeB (One OEM is not interested in changing from China magnet supply.)

Lower overall costs

Expertise and prior experience of the supplier in wind turbine components (design and fabrication)

Reduced part costs and minimum quantities of purchase as well as one time/ongoing tooling and set up costs

Would like to source generators from the U.S.

Bulk-purchase material opportunities?

- Magnets
- Wire, switching, semiconductors, disconnect boxes, fuses, fuse holders, contactors, relays
- Composite materials for blades and nacelle covers
- Sensors
- Sheet metals
- Fasteners
- Foam core for fiberglass blades
- Design and CAD software seats

Bulk purchase opportunities?

- Anemometers and tail vanes
- Bearings and alternators
- Large orders of towers (still need unique adaptors)

Expertise

- A supplier ratings and capability exchange--to pool our knowledge of who can supply what at the best quality and price
- Aggregated ordering of small-lot castings
- Gain big-company capabilities regarding supplier selection and purchasing power through purchase aggregation and group contracting
- Knowledge of current state of the art in manufacturing at our scale
- Access to subject-area experts (machinists, mold-makers, etc.)
- Access to state-of-the-art tooling

OEM Research Topics of Interest

Electrical

- Inverters, lightning protection systems, PLCs, phase converters, controller electronics
- Stator/generator design, better ways to automate stator winding

Composites

- Review of composite blade structural design and dynamic behavior
- Blade design and manufacturing optimization, molded blades using carbon fiber

Support Structures

- Better dynamic simulation capability for monopole towers.
- Reduce costs of towers and foundations (Standardization of towers)

Mechanical

- **Fluids in cold climates**
- **Better familiarity with FAST**

Other

- **No/low maintenance designs**
- **Focus on removing BOS costs (e.g. Instruction manual, training, Installation, shipping, etc) - finding ways to work together with/ride the coattails of solar could help us scale up faster**

Hard-to-Produce/Source Parts

Gary

Installer perspective

- *What do installers need to be safe, efficient, especially uptower, during install and commission, operation and maintenance*

- ***Training**: Safety training, rigging and hoisting training, good site assessment, having good construction practices, electrical safety, how to be general contractors.*

- ***Tracking Reliability**: What is breaking? What is contributing most to **O&M costs**?*
  - *This is a very important point to focus on. Not only do failures contribute to O&M but they contribute to bad PR for wind energy.*

Patrick

Other ideas

Challenges with low volume/lack of scale

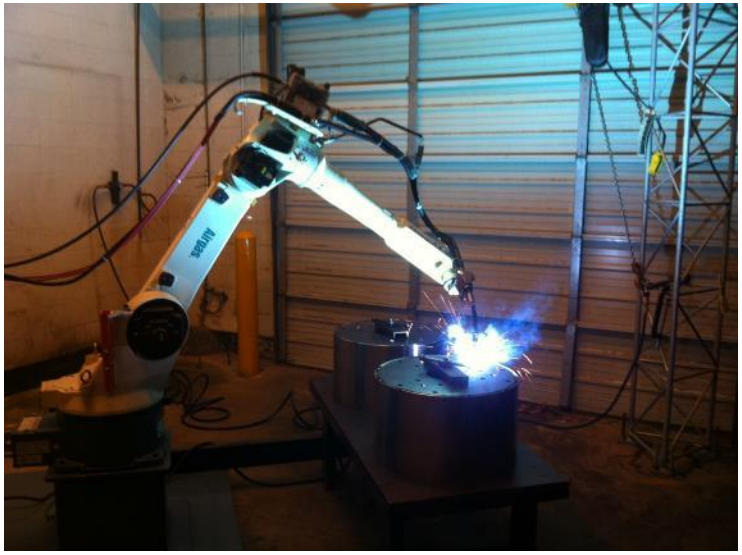
- *difficult to justify investments, working with suppliers*

Flexible manufacturing

***Process engineering** is key*

Lean practices

In-process testing



Are there opportunities for **small volume automation** in the US distributed wind Industry?

Are there opportunities for **small volume automation** in the US distributed wind Industry?

Summary of Mechanical subgroup gaps and opportunities

Castings

Near-net-shape = reduced secondary operations

Advanced casting techniques functionality with fewer parts and reduced weight

Challenges with low volume/lack of scale

Process improvements

Process engineering

In-process testing

Machining, mold-making,. Etc. experts

State-of-the-art, low volume manufacturing

Fixturing, tooling, part handling

Small Volume Automation

Just-in-time

Lean manufacturing

Flexible manufacturing

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Lean manufacturing

Flexible manufacturing

Design changes and certification impacts

Low-maintenance designs

Turbine design tools

- Dynamics
- FAST

Turbine controls, improved productivity

Gearbox life, surface treatments

Corrosion protection

- Ductile iron castings

New (US) manufacturing partners, suppliers

- Lower costs
- Reduced minimum quantitites
- Tooling costs

Using MEPs

Bulk/aggregate purchasing

- Sheet metal
- Fasteners
- Design tools, CAD
- Small lot castings
- Gain big-company capabilities through purchase aggregation and group contracting

Bearings

Cold climates, fluids, lubricants

Removing balance of system costs – training, installation, shipping

- Look at PV industry

Turbine reliability

- What is/isn't failing?

The end