

SMART Wind strategies

- Identify common distributed wind manufacturing gaps and barriers
- Prioritize solutions to those gaps for today and for future scalability
- Facilitate a rapid transfer of innovation into American-manufactured wind turbines, open new market opportunities, expand distributed wind applications
- Reduce lifecycle costs, maintain high product quality and value
- Secure U.S. global competitiveness and leadership



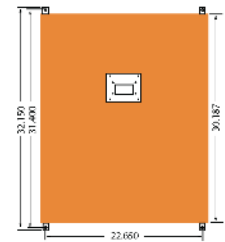
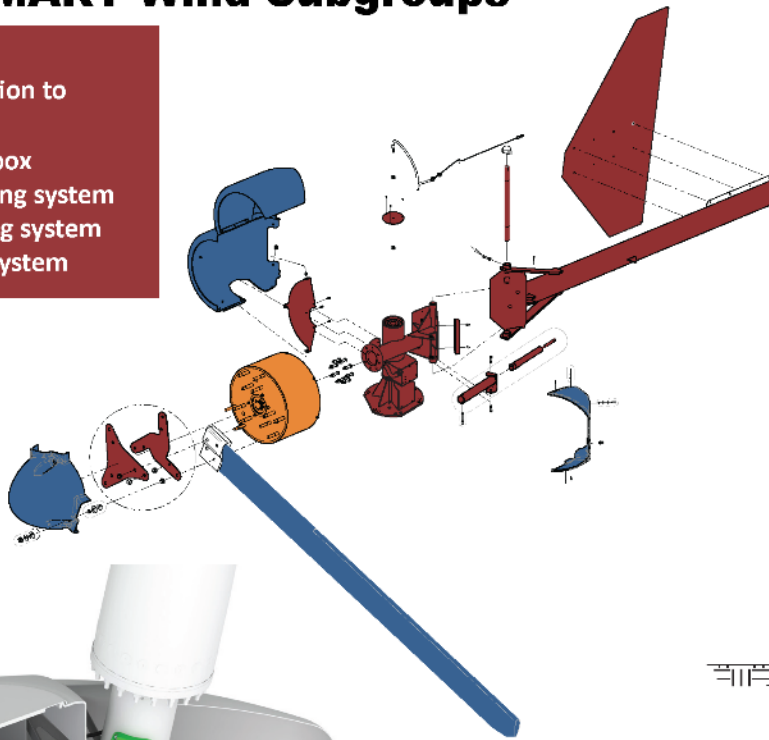
SMART Wind Subgroups

Mechanical Systems

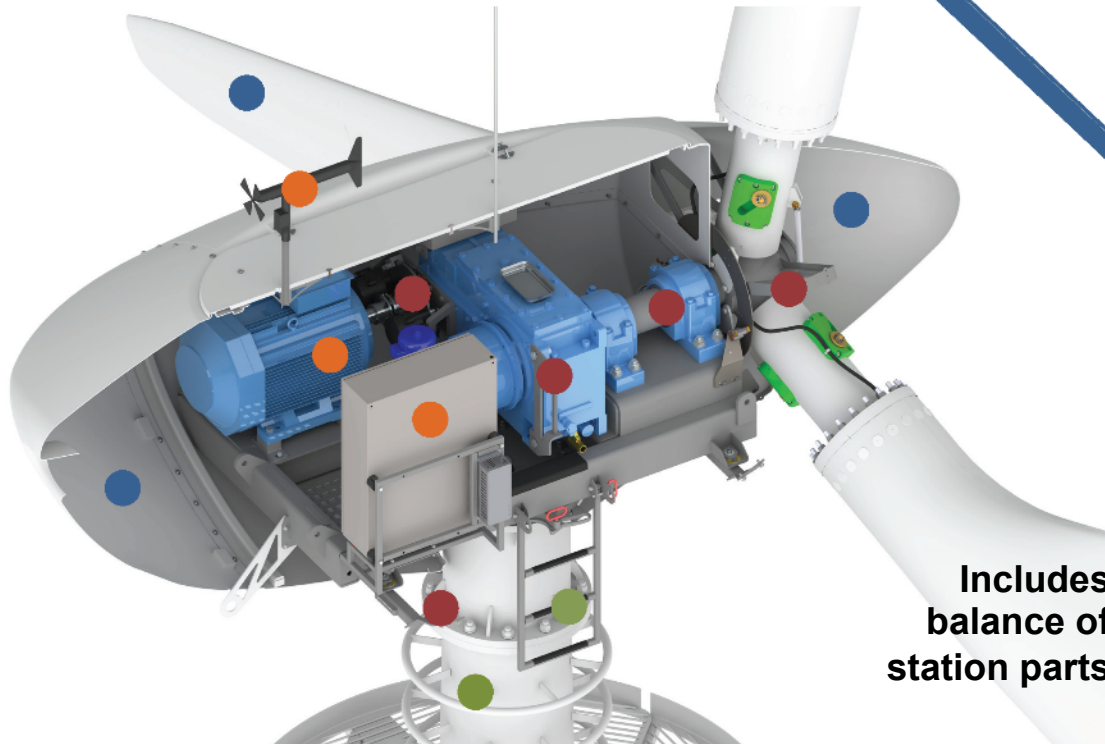
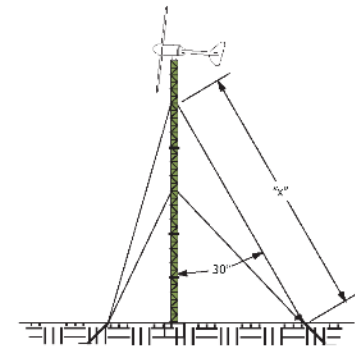
- Rotor, hub, mainshaft, mainframe; rotor connection to generator, generator support
- Tower top/bed plate, tower adapter
- Shafts
- Bearings
- Braking system
- Gearbox
- Pitching system
- Furling system
- Yaw system

Support Structures

- Tower
- Access ladder
- Foundation
- Anchoring system
- Permitting



Inverter



Includes
balance of
station parts

Composites

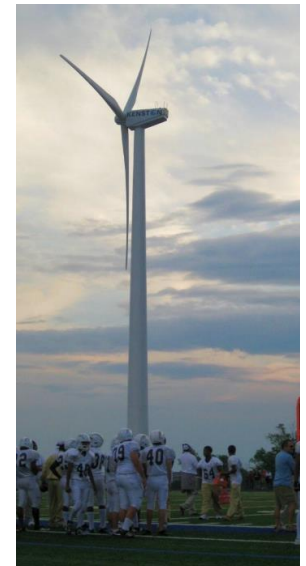
- Anything using fibre-reinforced or carbon resins including:
- Blade
- Nacelle housing
- Nosecone
- Tower

Electrical Systems

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

Focus on opportunities and gaps that enable:

- **Turbines to be more cost competitive**
- **Turbines to be more productive**
- **Installation costs go down with safe installations**





Aeronautica Windpower



Bergey Windpower



Black Island Wind Turbines



Dakota Turbines



Endurance Wind Power



Eocycle Technologies



Northern Power Systems



Pika Energy



Primus Windpower



Ventera Wind

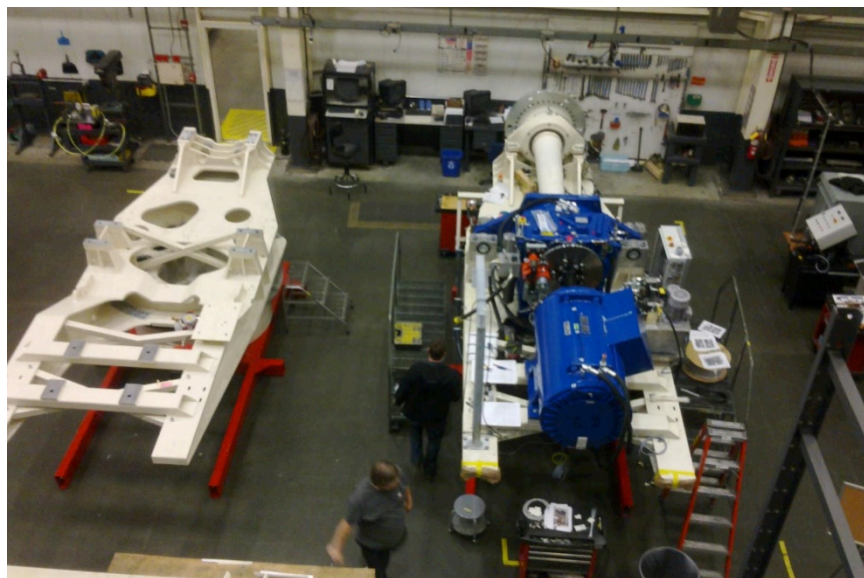
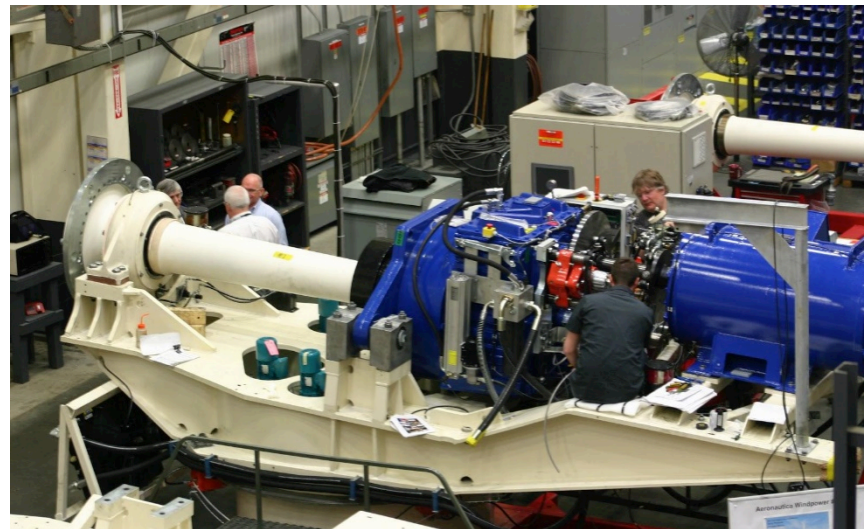
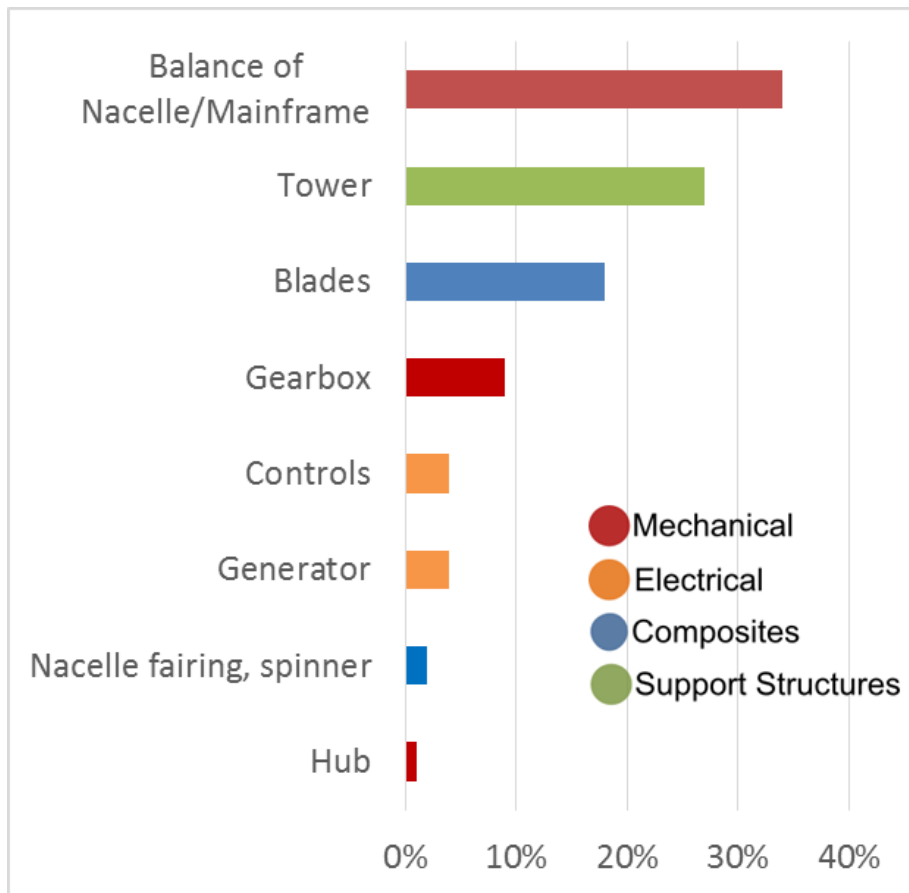


Xzeres Wind

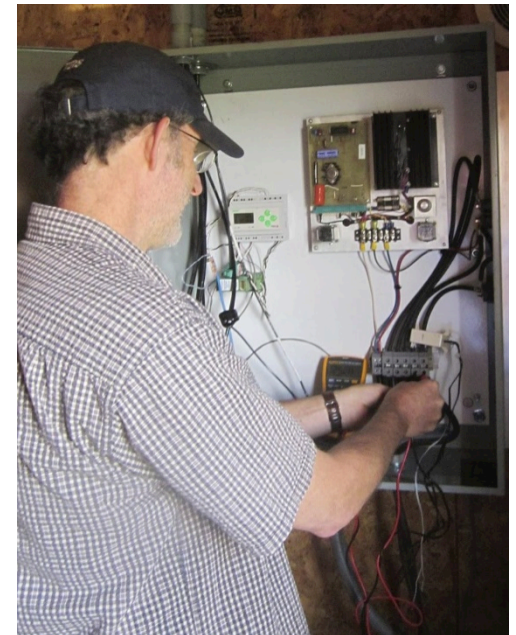
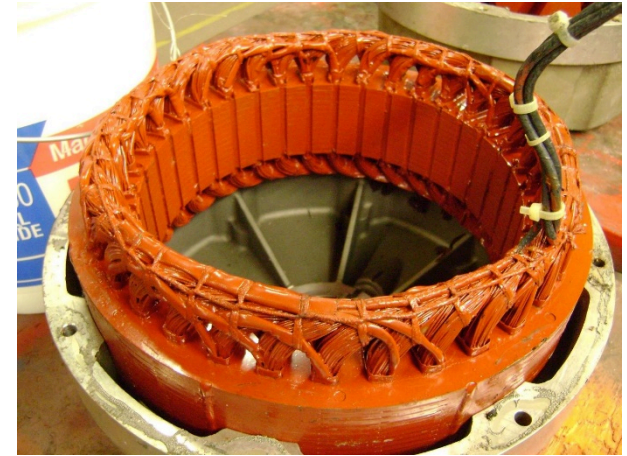
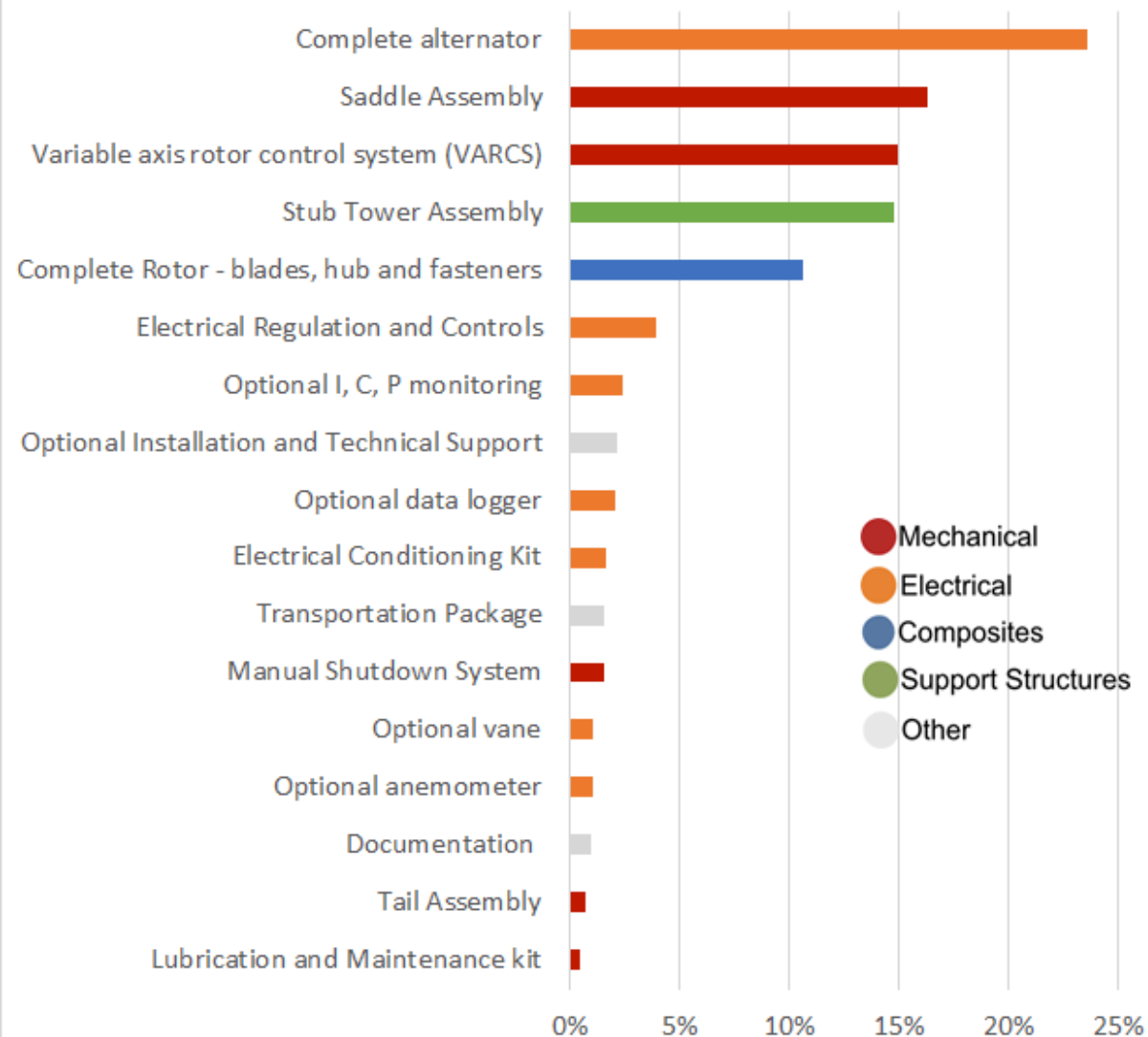
**Thank you to our
OEM Steering Group
Members.**

- Questionnaire
- Interviews
- Calls
- Feedback
- Guidance
- Turbine info

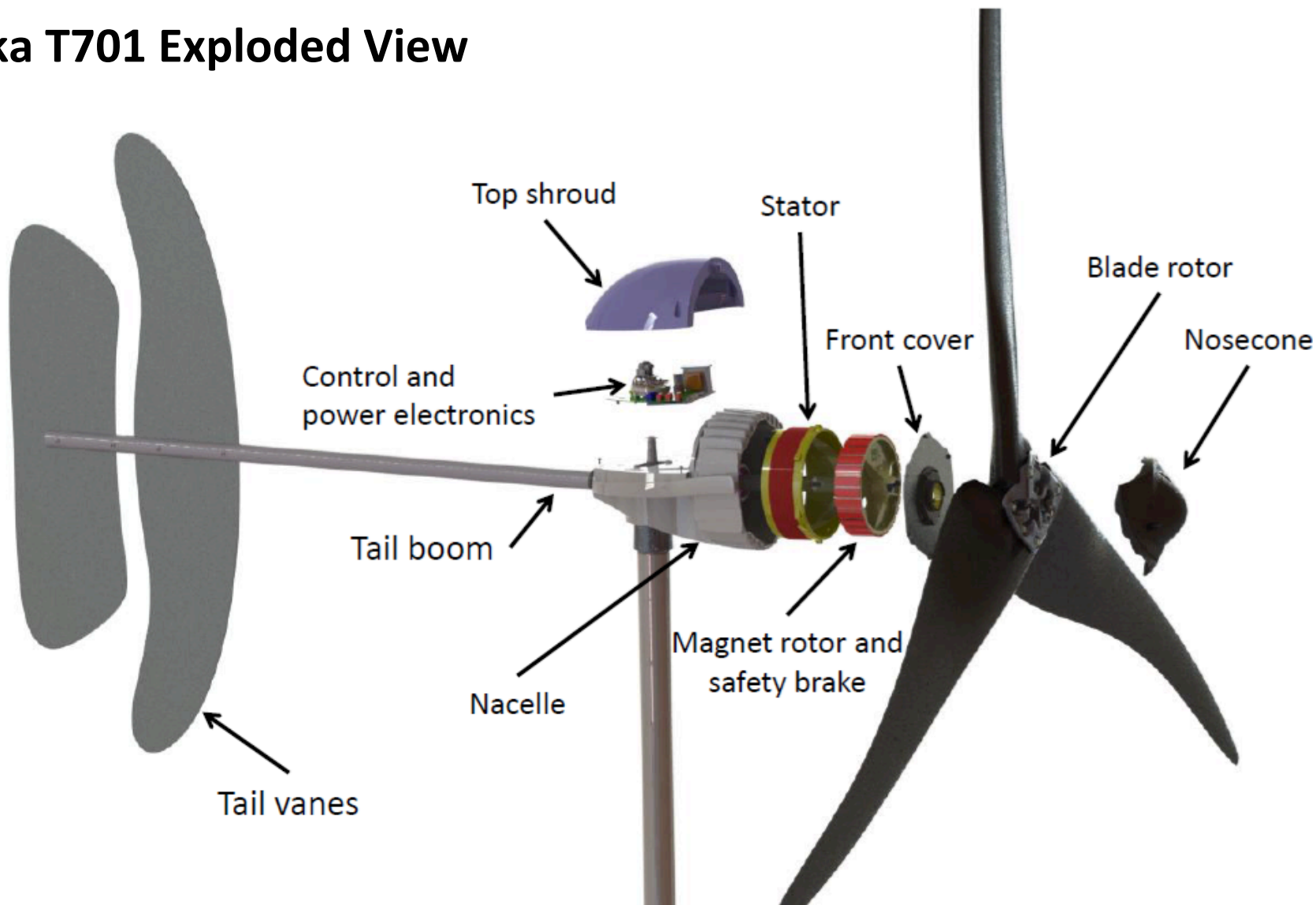
Aeronautica AW-54-750kW BOM



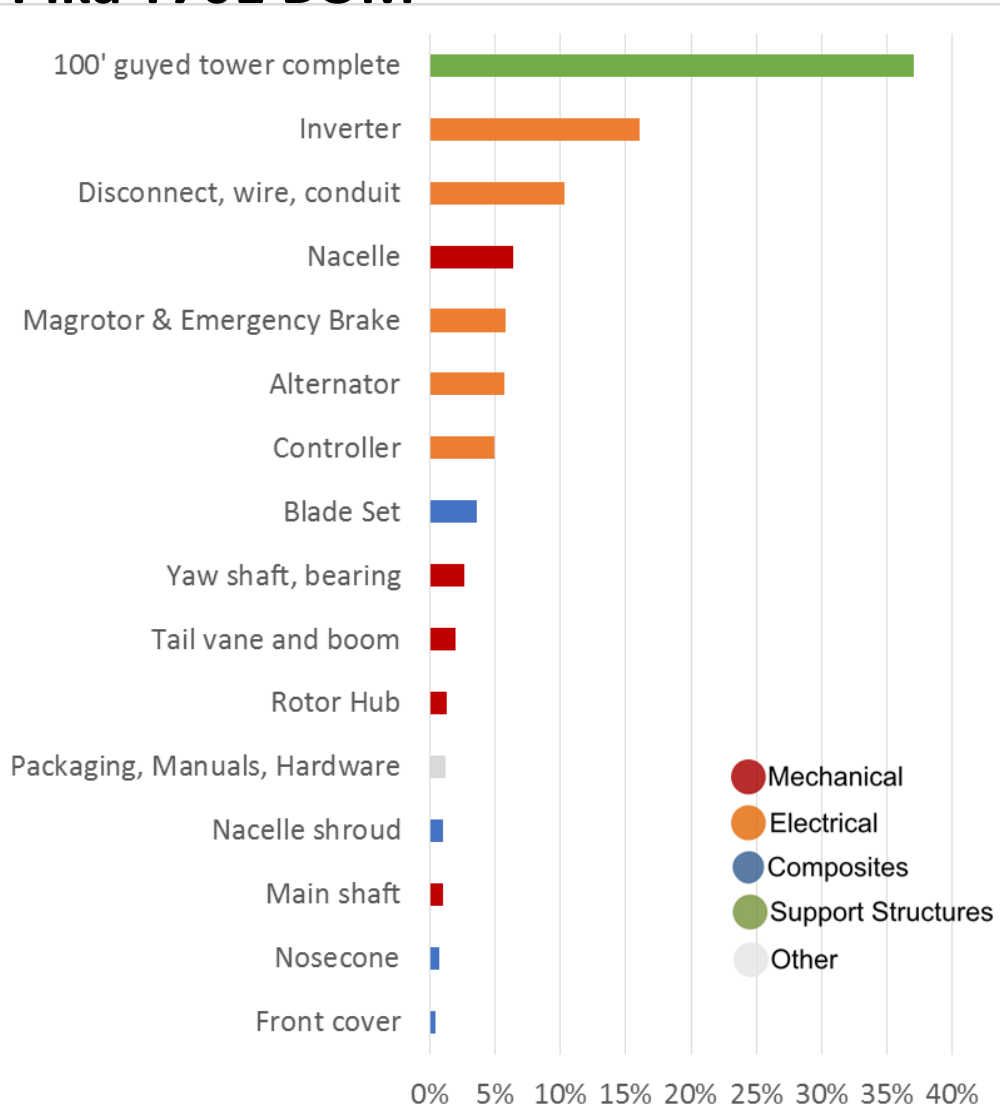
Black Island 48V HR3 Top Level BOM



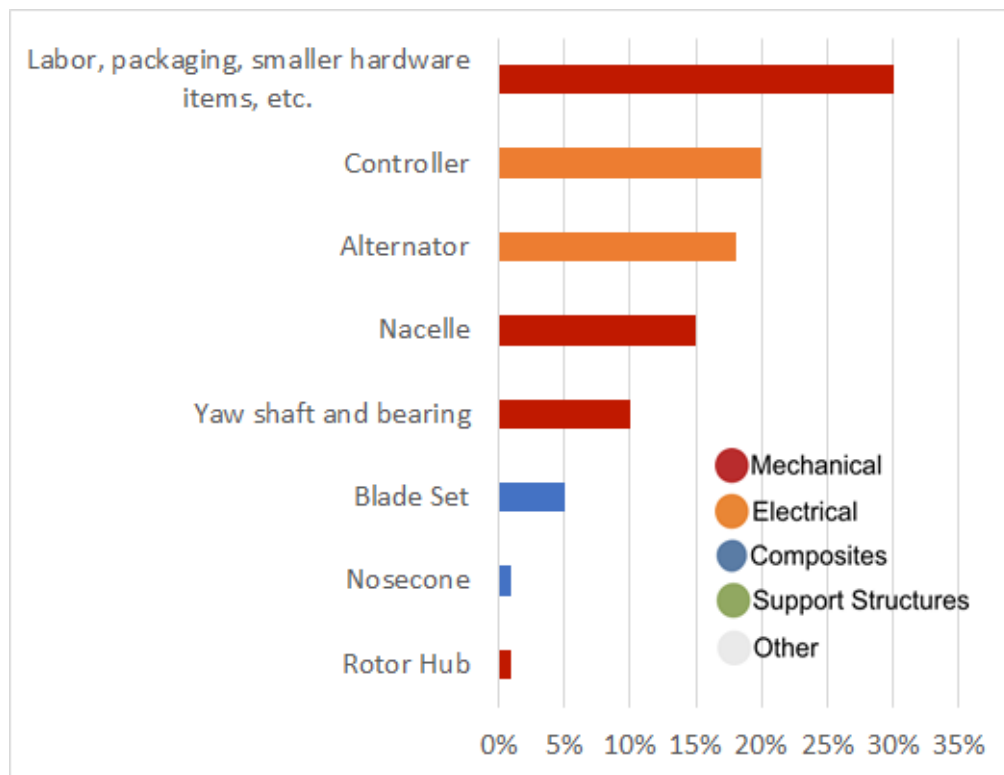
Pika T701 Exploded View



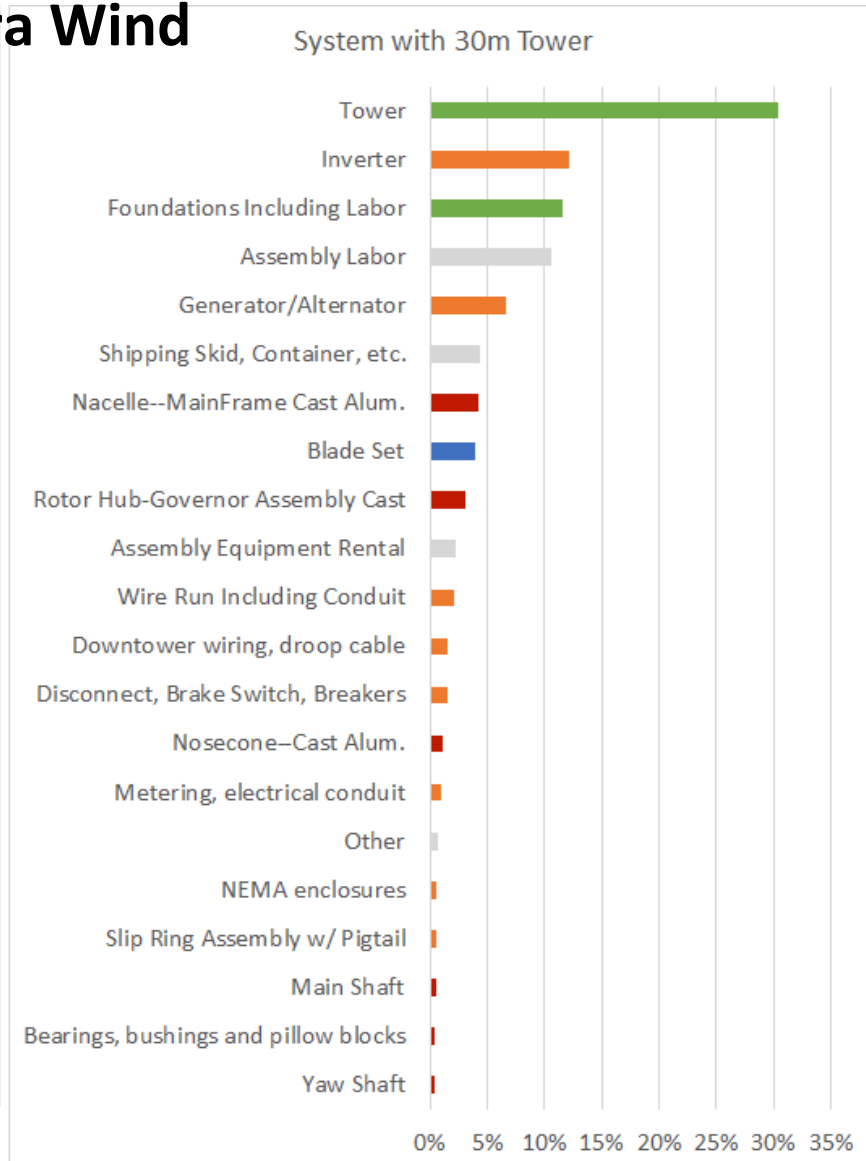
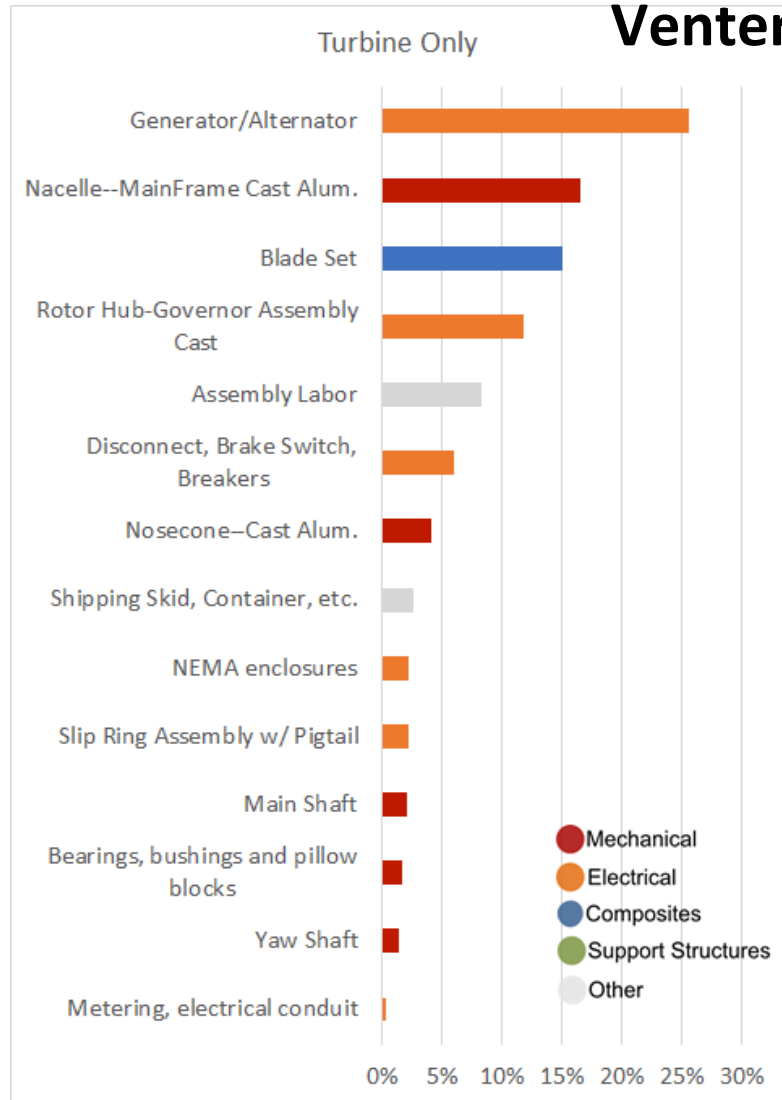
Pika T701 BOM



Primus Windpower Air BOM



Ventura Wind



SMART Wind Questionnaire Results (Electrical)

Academic and Research Group

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

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 the manufacture components
- 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

Hard-to-Produce/Source Parts



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

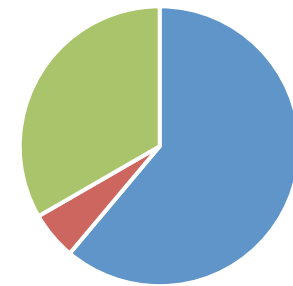
Support Structure

- 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?



■ Yes ■ No ■ Maybe

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, magnets
- 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

Make	Model	Generator type		Controller		Inverter		Electrical opportunities, thoughts
Dakota Turbines	DT-30	PMG	make	custom controller	make	custom inverter	make	
Bergey	Excel 6 & 10	PMG	make	custom controller for battery charging; no controller for grid-intertie in U.S.; custom controller for Japan market	make	custom inverter	make	Inverters are still pretty expensive to build due to low annual volumes. Can variable speed drives be made to work with turbines?
Pika Energy	T701	PMG	make	custom controller	make	custom inverter	make	
Primus Wind Power	AIR Family	PMG	buy	custom uptower controller	buy	none - DC turbine		Made in North America to avoid China, down tower controller, one rotor/stator combo for all voltages?
NPS	NPS 100	PMG	make	Custom	make	Custom	make	
Eocycle	Eocycle 25	PMG-TFPM	make	Mita-Teknik/ Eocycle	buy/make	ABB	buy	
Aeronautica	AW 54-750	Induction	buy	Mita-Technic, customized	buy	none		
Aeronautica	AW 30-250	Induction	buy	Mita-Technic, customized	buy	none		
Endurance	E-3120/ E-4660	Induction	buy	Phoenix Contact	buy	none		Controller function, parts and layout are highly customized for individual turbines. Any opportunity to reduce cost, complexity and size in a customized unit is welcome (e.g. printed circuits to reduce manual wiring costs - can PCBs be 3-D printed?). Induction generators are common and robust, and I struggle to see opportunity for major changes there.