

SMART Wind Consortium

Overview of DWEA OEM Steering Group Members, Top-Level Manufacturing Gaps & Opportunities Summary of Questionnaire Results

**Trudy Forsyth and Brent Summerville
Launch Event, Albany, NY
October 16, 2014**





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

Aeronautica Windpower

Contact: **Brian Kuhn, Tim Stearns**

Summary

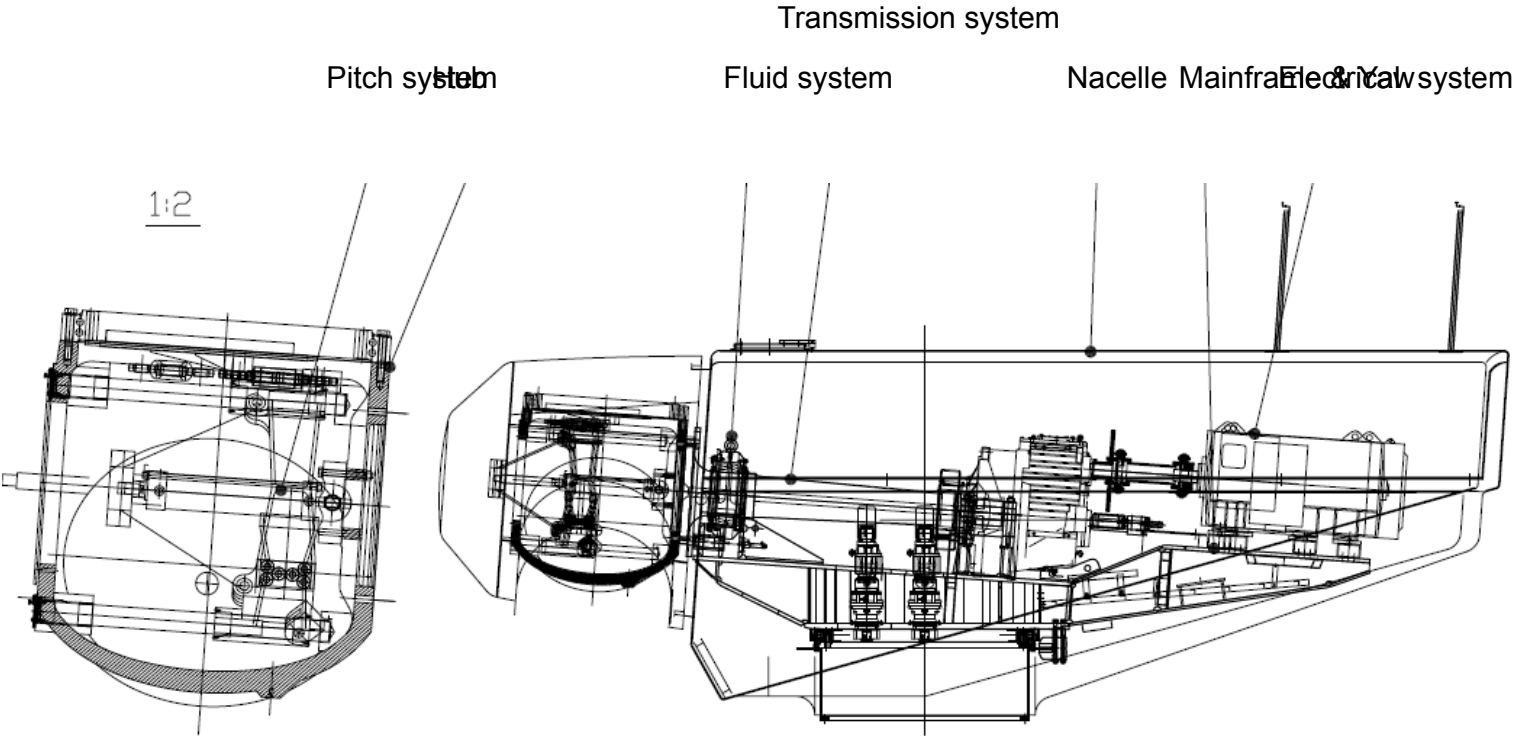
- Turbine: AW750 (47 m & 54 m rotors), Danish (Norwin) design
- In business 7 yrs, started with refurbishing, first 750 kW in 2011
- Opportunities in castings; US-made has cost issues, other sources have quality issues
- Blades made in MI; towers in TX & MI; nacelles, rotor, controls in NH; sales, marketing, service in Plymouth, MA
- Subgroups: Mechanical, Electrical



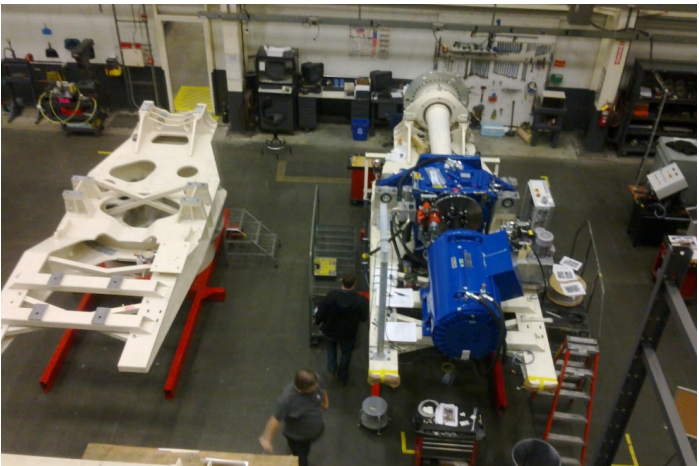
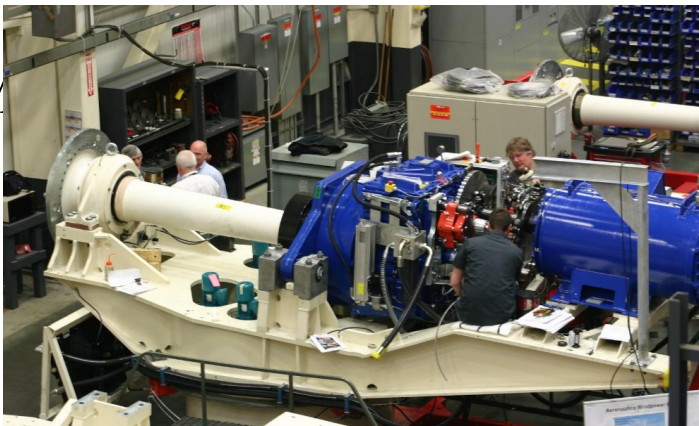
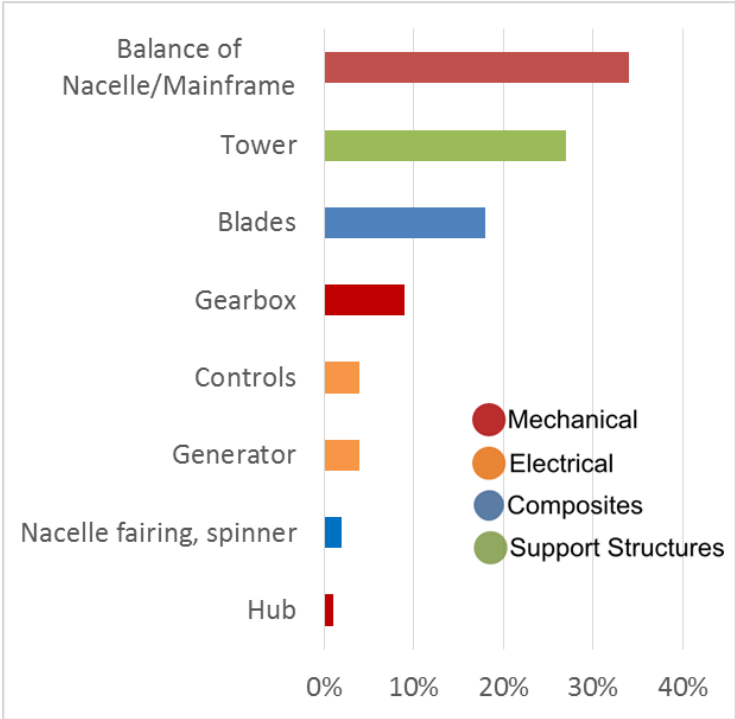
www.aeronauticawind.com



Aeronautica AW750



Aeronautica AW-54-750kW BOM



Bergey Windpower Company

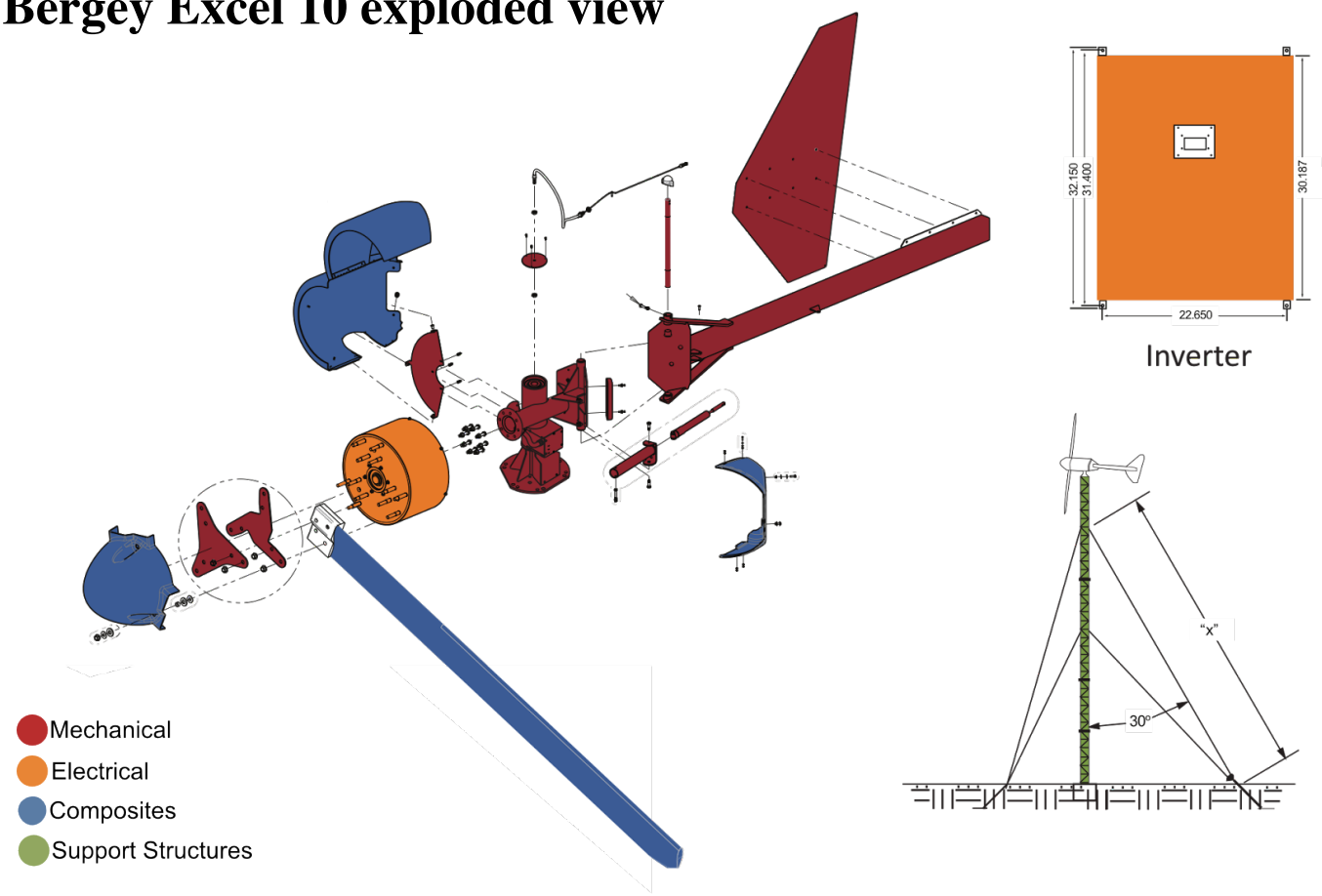
Contact: Mike Bergey

Summary

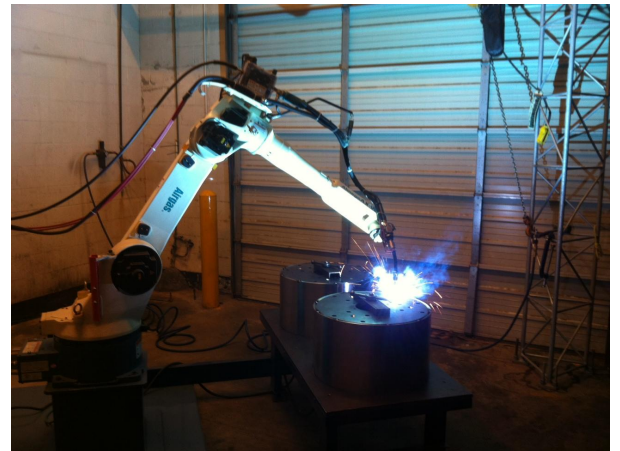
- Turbines: Excel 6 & 10, both AWEA certified by SWCC
- In business 37 yrs, first turbine in 1980
- Opportunities in blade material advances, process improvements, automation
- Manufactured in Norman, OK
 - Interested in bringing some components currently produced by vendors in-house
- Subgroups: Mechanical, Electrical, Composites, Support Structures



Bergey Excel 10 exploded view



Bergey Windpower Company



Black Island Wind Turbines

Contacts: Patrick Quinlan, Bill Stein

Summary

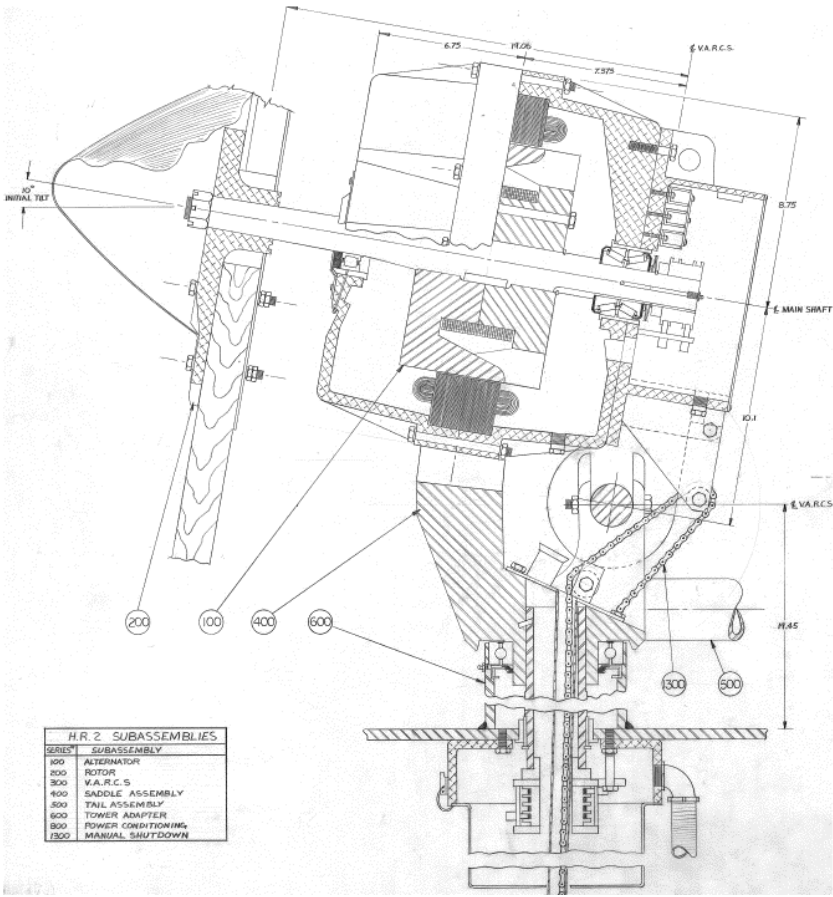
- Turbine: HR3, tested at AEI facility in Canyon, TX
- Originated from 1978 U.S. Department of Energy contract to develop a high-reliability small wind turbine
- In business 3 yrs, first turbine in 2013
- Opportunities in blades, generators, and castings, Manufactured in Hadley, MA
- Interested in small volume automation and professional development for the industry
- Subgroups: Electrical, Composites



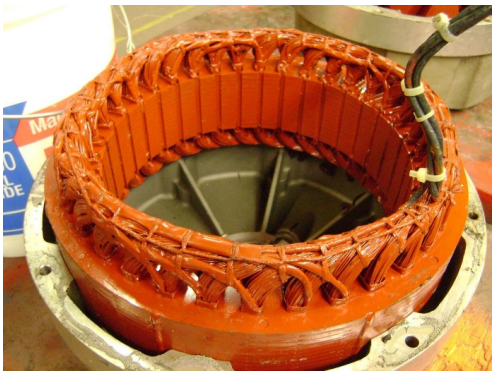
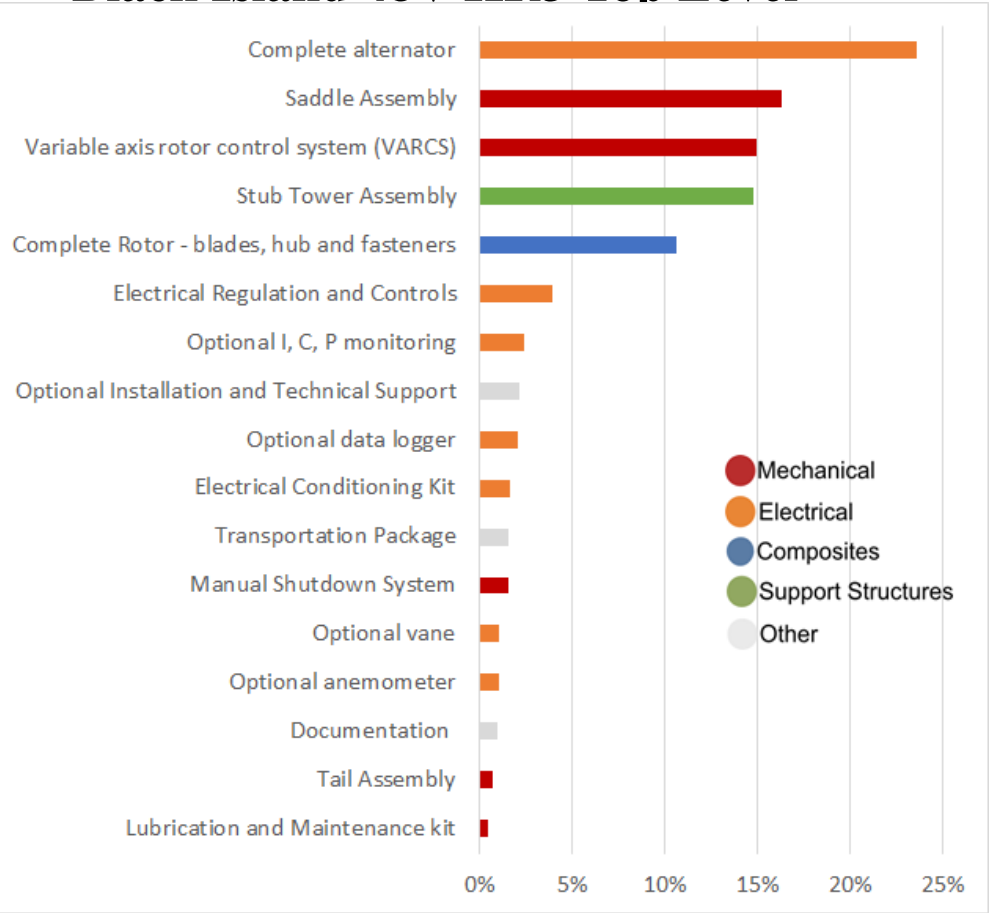
www.blackislandwindturbines.com



Black Island Wind Turbines HR3



Black Island 48V HR3 Top Level



Dakota Turbines

Contact: **Keith Monson**

Summary

- Turbine: 30 kW DT30, under test at High Plains Small Wind Test Center for AWEA certification by SWCC
- In business 8 yrs, first turbine in 2011
- Interested in finding new manufacturing partners using lean manufacturing techniques
- Bulk order for towers
- Most parts manufactured in-house, including blades and inverter, in Cooperstown, ND
- finding human resources has been challenging
- Subgroups: Electrical, Composites



www.dakotaturbines.net



Dakota Turbines DT30



Endurance Wind Power Company

Contact: David Laino



Summary

- Turbine: E-3120, granted SWCC Performance Certification
- In business 7 yrs, first E-series in 2009
- Focused on reduced COE, making parts less expensively (which entails lower cost and/or higher reliability)
- Most parts are made by suppliers, turbine assembled in Surrey, BC
 - Just-in-time manufacturing
- Opportunities in tower supply/manufacturing
- Subgroups: Mechanical, Support Structures

www.endurancewindpower.com



Endurance E-3120

Electrical Systems

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

Distributed wind energy turbine systems, subsystems, components and piece parts divided into four subgroups

Mechanical Systems

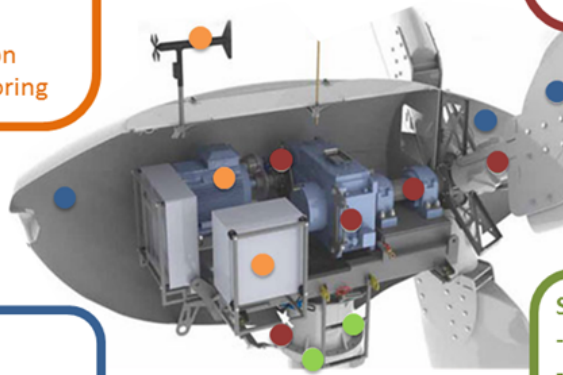
- Shafts
- Bearings
- Braking system
- Gearbox
- Pitching system
- Furling system
- Yaw system

Composites

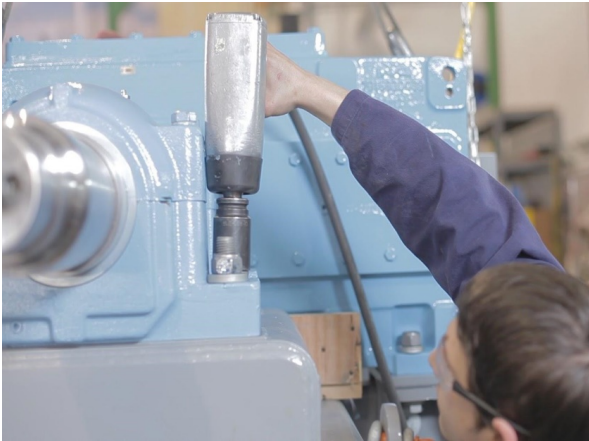
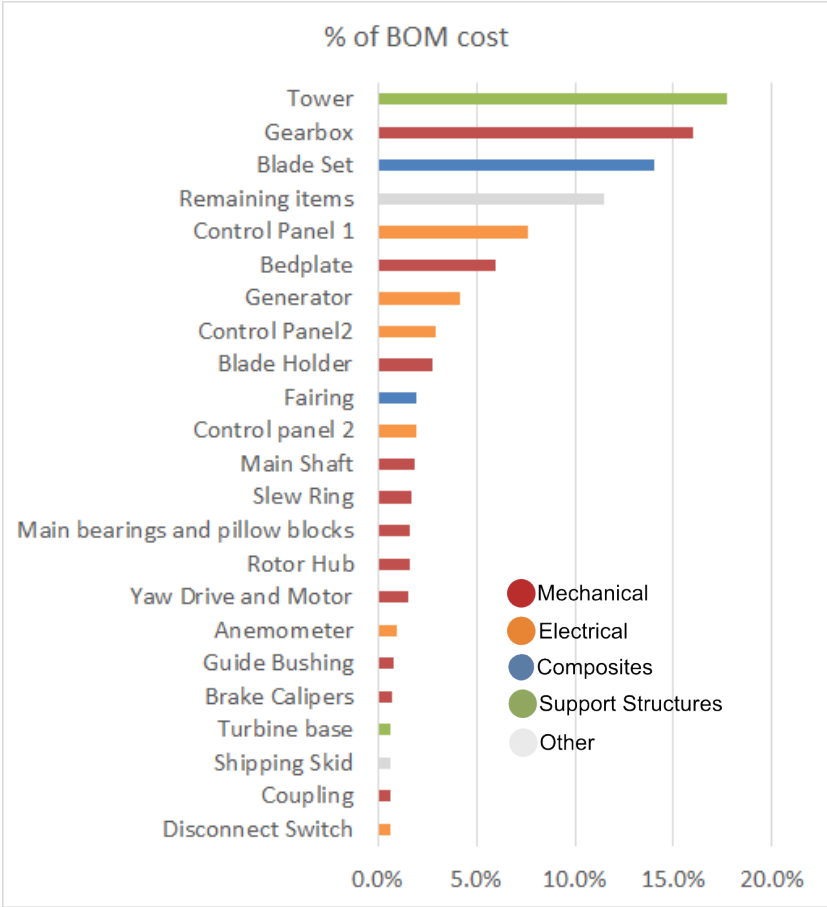
- Blades
- Nacelle housing
- Nosecone
- Tower

Support Structures

- Tower
- Access ladder
- Foundation
- Anchoring System
- Permitting



Endurance E3120



Eocycle Technologies

Contact: Claude Bourget

Summary

- Turbine: EOCYCLE 25, pursuing AWEA & BWEA certifications with Intertek
- In business 13 years, first turbine in 2010
- See opportunities with towers, blades as a minimum
- Low volume manufacturing is challenging
- All parts are fabricated by suppliers, turbine assembled in Gaspé, Qc
- Subgroups: Support Structures, Composites

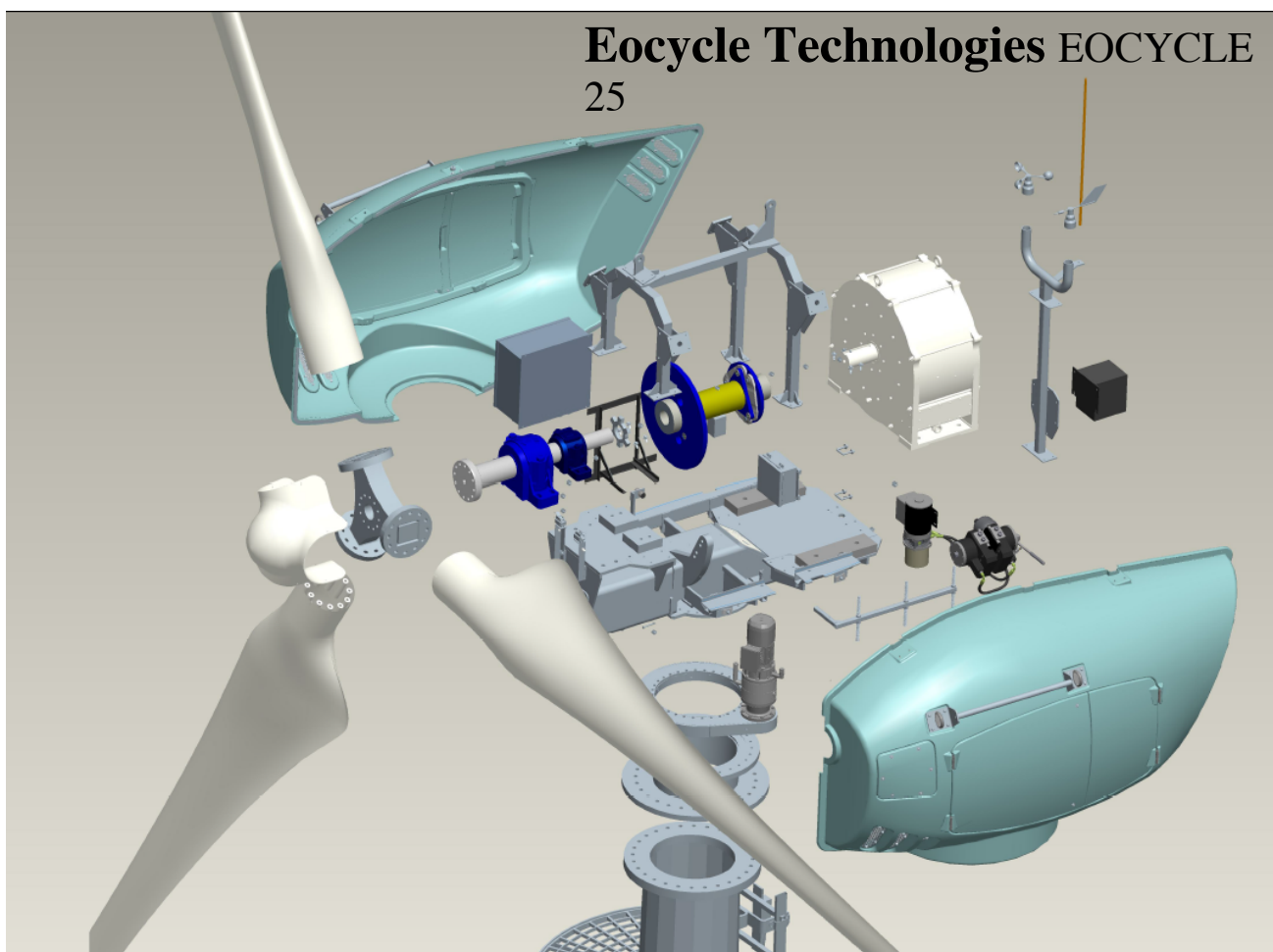


www.eocycle.com

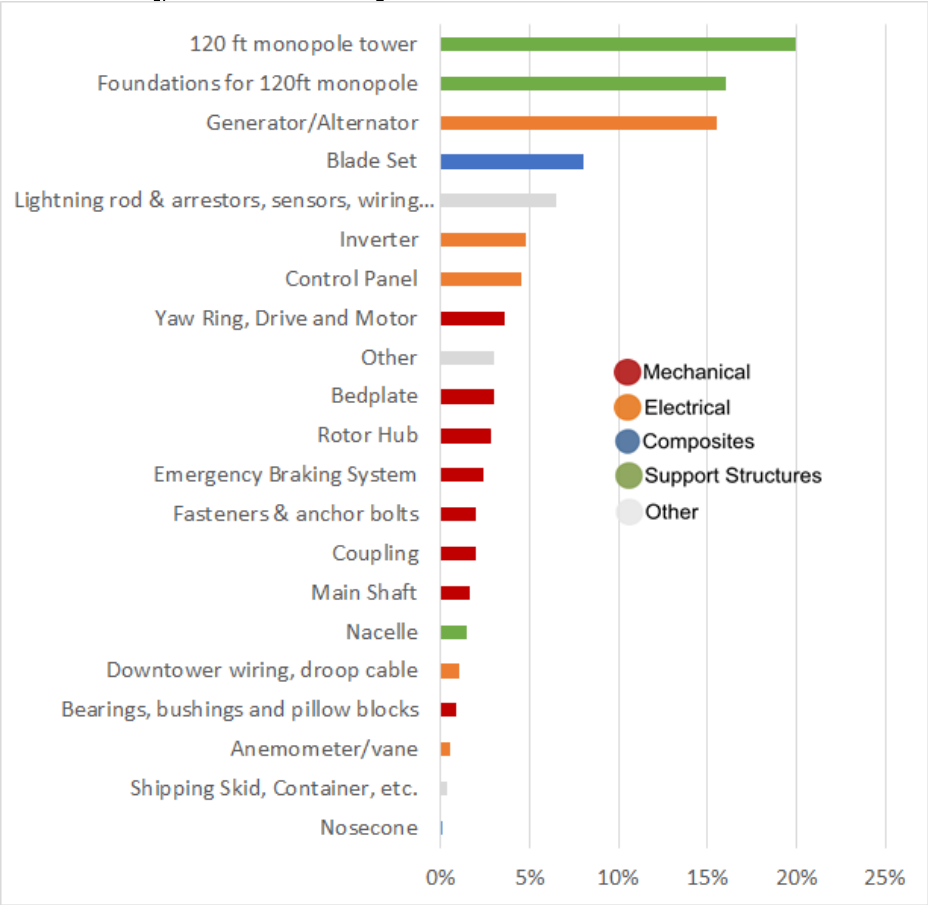


Eocycle Technologies EOCYCLE

25



Eocycle 25 Top Level BOM



Northern Power Systems

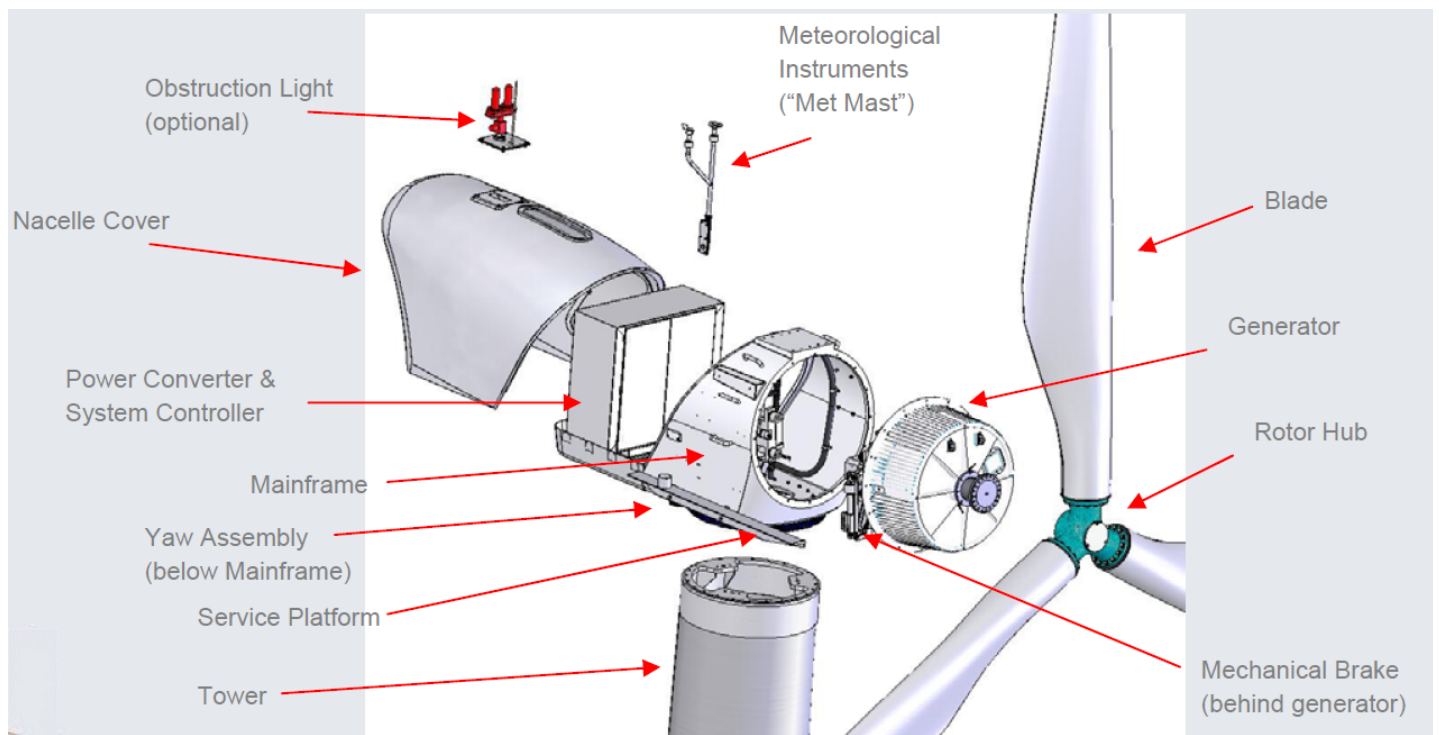
Contact: Chris McKay

Summary

- Turbines: NPS 100C
- In business 40 years, first turbine in 1978
- Interested in automation, in-process testing
- opportunities in blade manufacturing, reducing labor, flexibility, just-in-time
- Turbine manufactured in Barre, VT
- Subgroups: Mechanical, Electrical, Composites, Support Structures



Northwind 100



Northern Power Systems



Pika Energy

Contacts: Andrew Hickock, Ben Polito



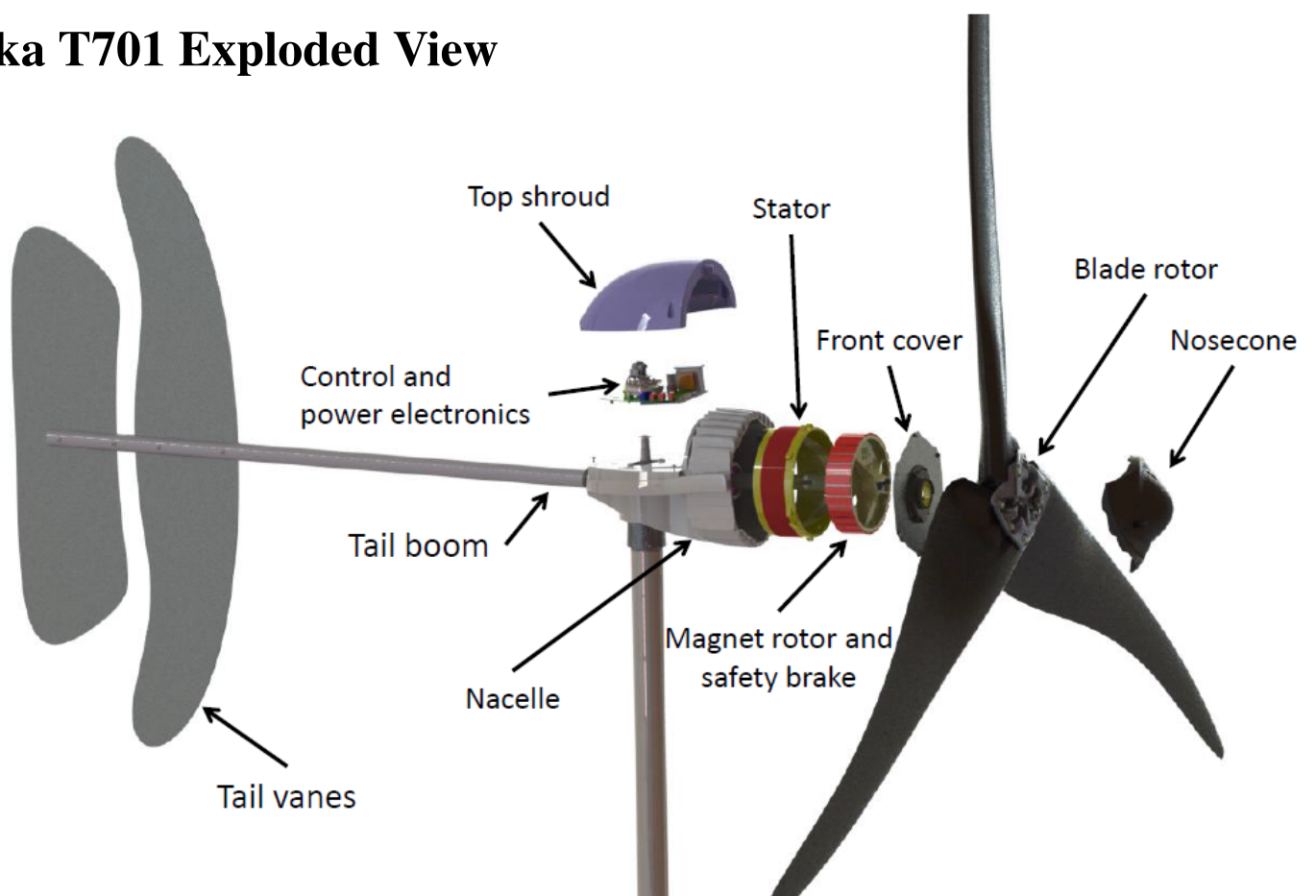
www.pika-energy.com

Summary

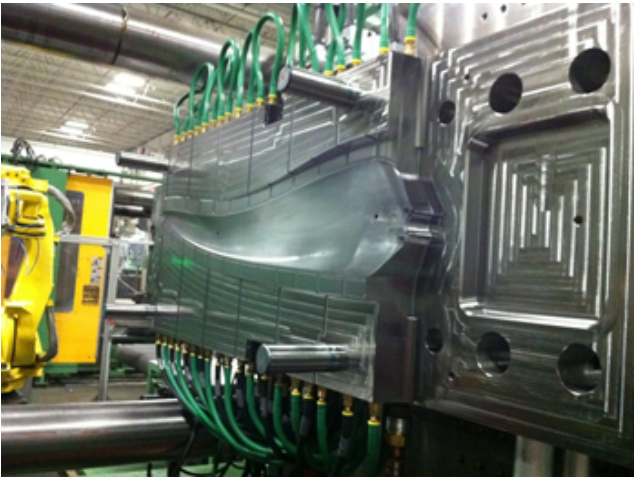
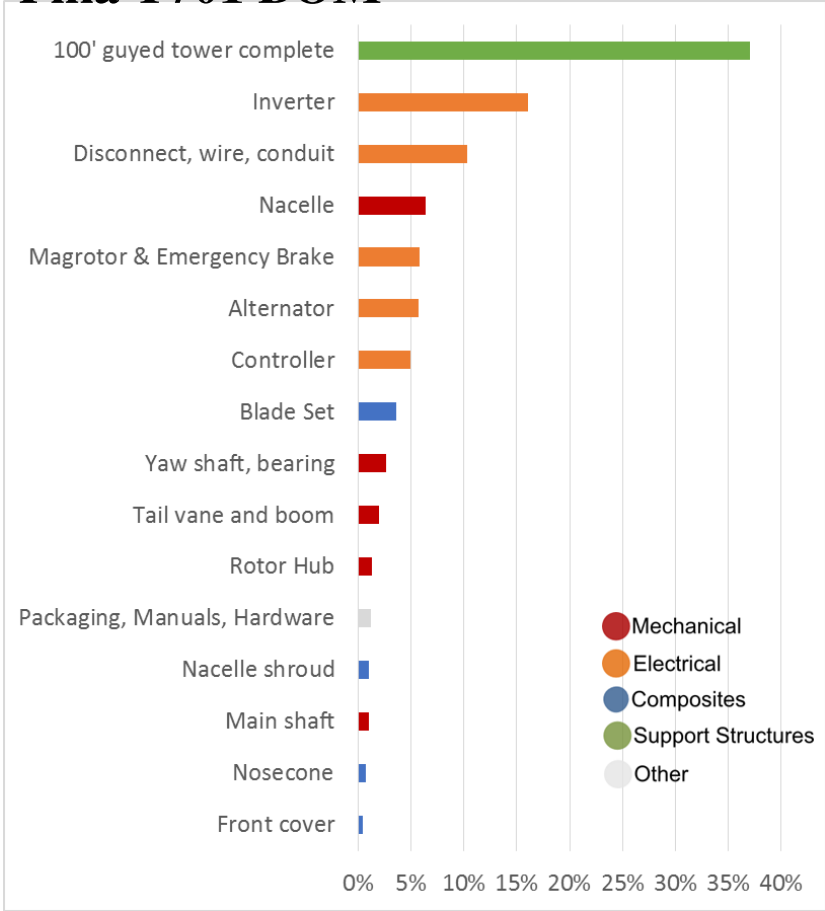
- Turbine: Pika T701, under test at High Plains Small Wind Test Center for AWEA certification by SWCC
- In business 4 years, first turbine in 2013
- See opportunities with castings, blade manufacturing, US-made towers, foundations and power electronics
- Low volume manufacturing is challenging in terms of both capital investments and suppliers
- Turbines assembled in Westbrook, ME
- Subgroups: Support Structures, Electrical



Pika T701 Exploded View



Pika T701 BOM



Primus Windpower
Contact: **Ken Portolese, Ken Kotalik**

primus*windpower*

www.primuswindpower.com

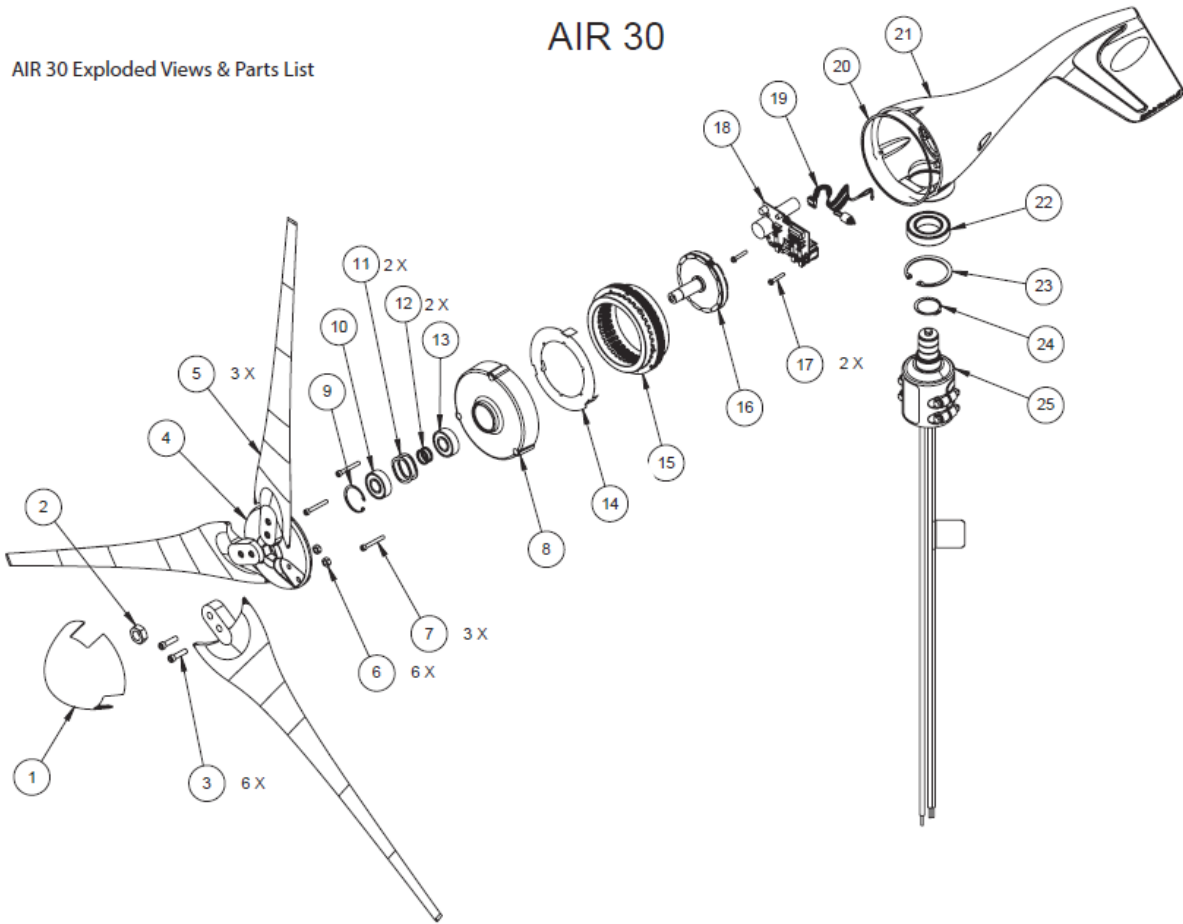
Summary

- Turbines: Air 30, 40, Breeze, X
- Typically paired with PV, hybrid
- In business 2 yrs, first turbine in 1995; part of larger Primus Metals
- Sourcing in US sometimes involves design changes, tooling costs
- Challenges with microturbines may differ from larger turbines
- Towers can quickly drive up system costs
- Manufactured in Lakewood, CO
- Subgroups: Electrical

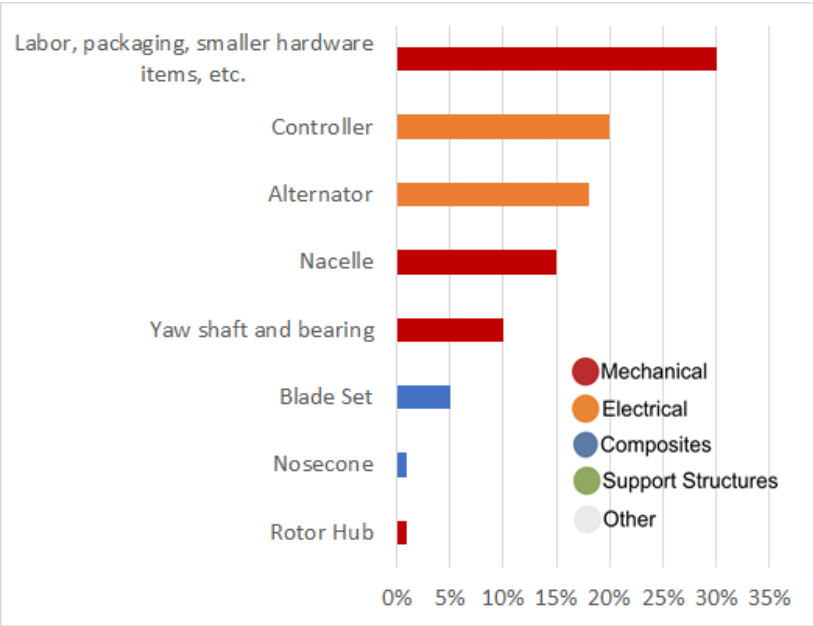


AIR 30 Exploded Views & Parts List

AIR 30



Primus Windpower Air BOM



Ventera Wind

Contact: Tom Williams

Summary

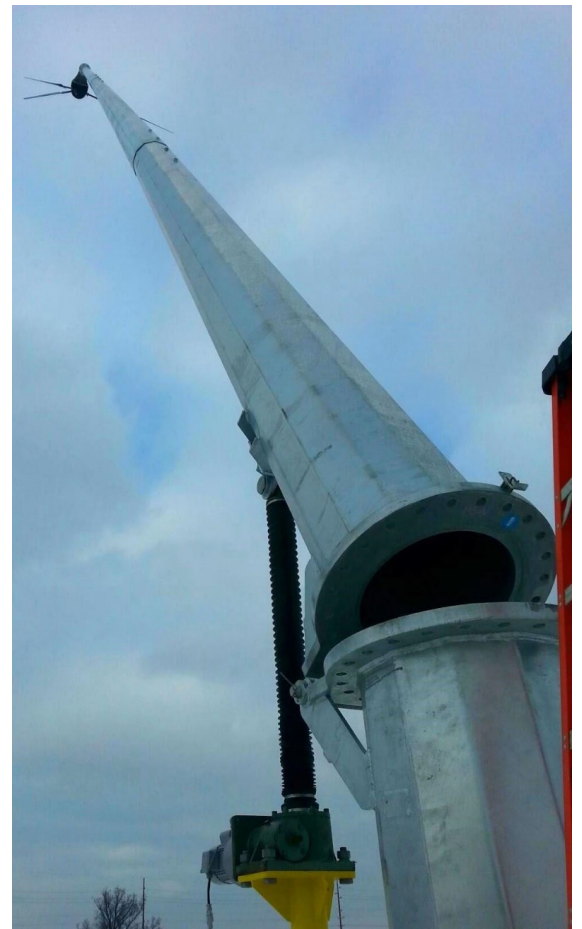
- Turbines: VT10
- In business 3 yrs, first turbine in 2007
- Interested in improvements in the whole process, raw material to meter, including training and reliability monitoring
- Opportunities castings, US-made hydraulic or screw jack erected towers, blades, inverters and controller
- Manufactured in Minnesota; nearly all parts sourced in US
- Subgroups: Mechanical, Electrical

VENTERA WIND

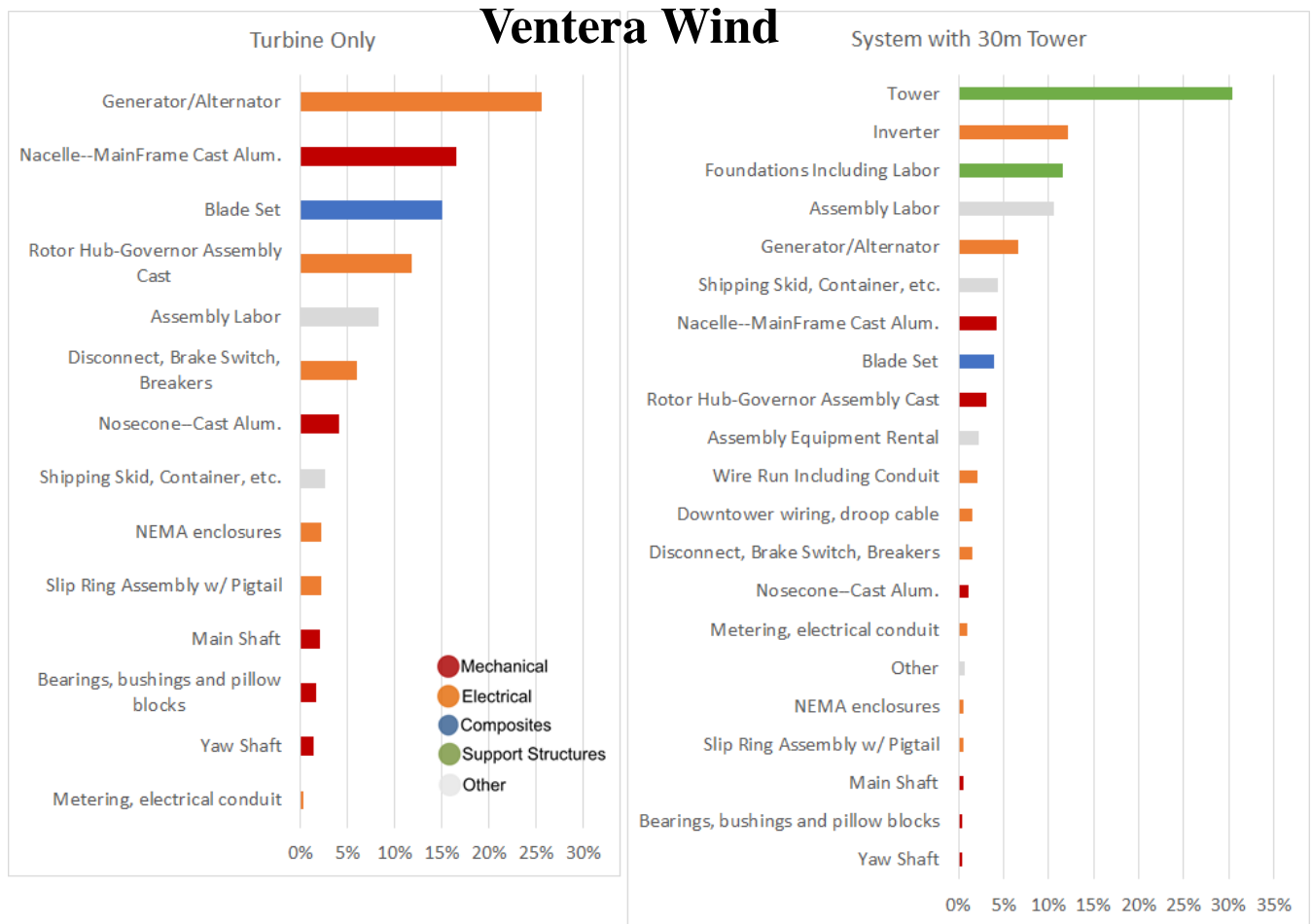
www.venterawind.com



Ventura Wind



Ventura Wind



Xzeres Wind

Contact: John McCoury

Summary

- Turbines: 442SR (under test in Texas for AWEA Std certification with SWCC), Skystream (SWCC certified)
- In business 5 years, first turbine in 2010
- Interested in design improvements, changes and impacts on certification
- Opportunities in blades and alternators
- Most parts are made by suppliers, turbines assembled in Wilsonville, OR
- Subgroups: Electrical, Composites



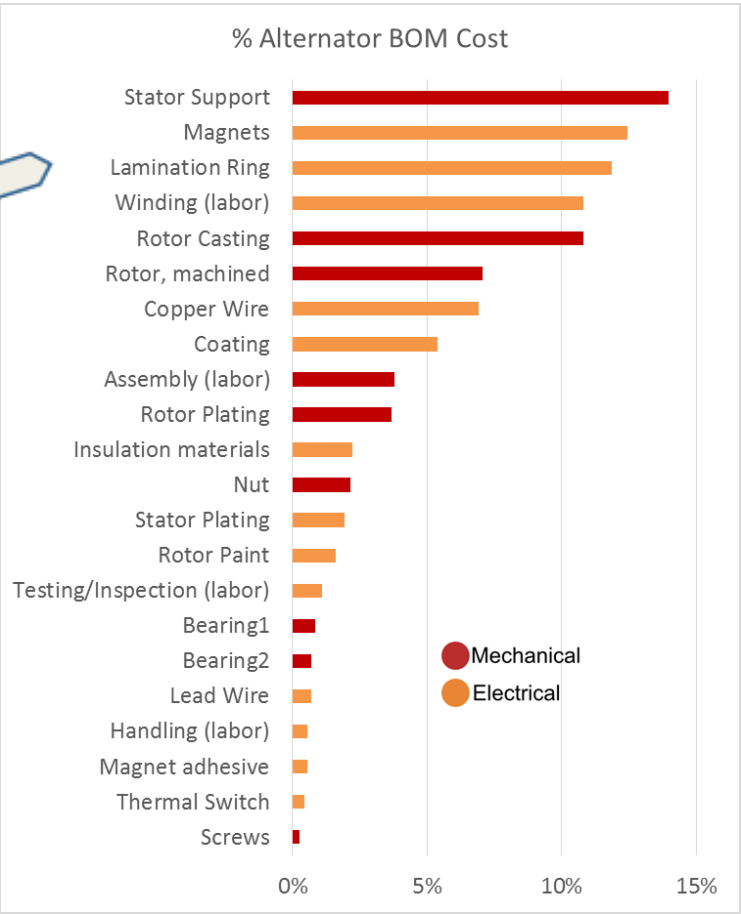
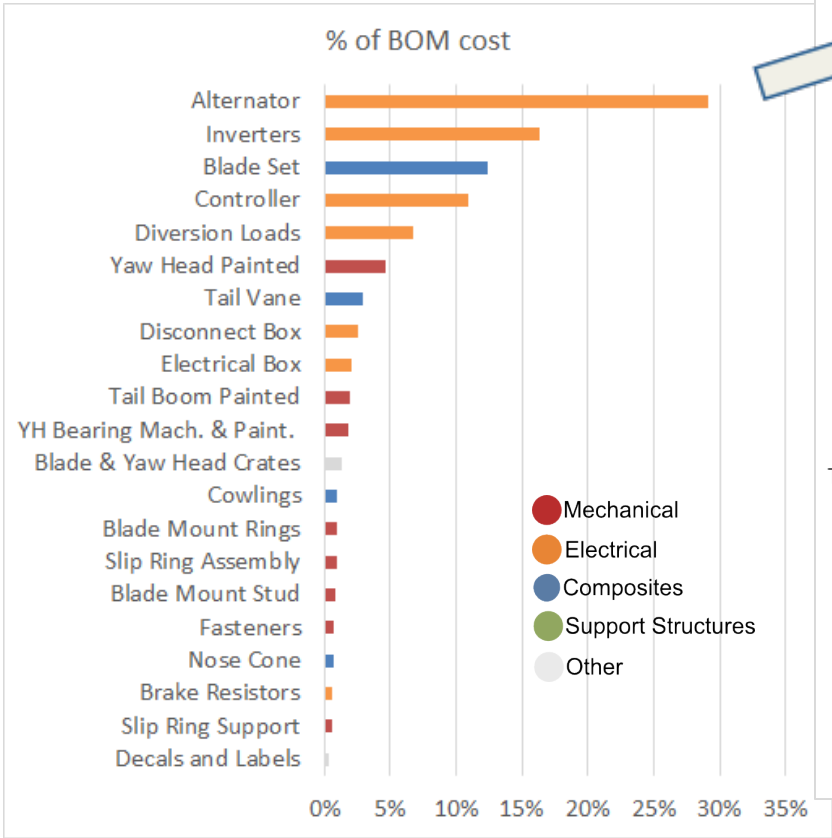
www.xzeres.com



Xzeres 442SR



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

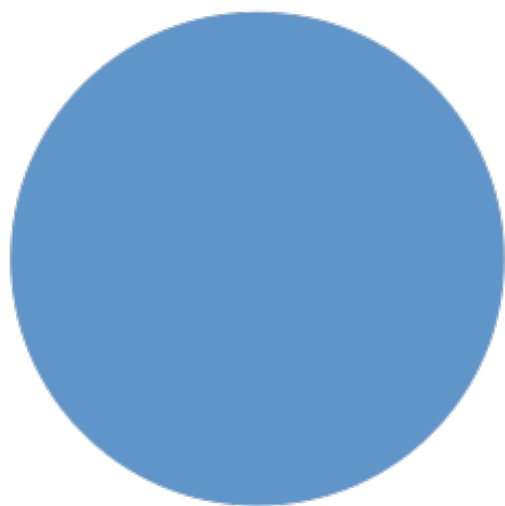
Other opportunities/ideas

- 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 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

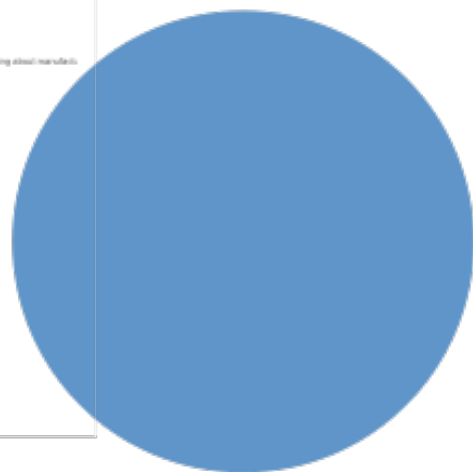
OEM Steering Group

Interest in learning about manufacturing



Interested in evolving deisgn with manufacturing expertise?

■ Interested in learning about manufacturing



■ Interested in learning about manufacturing

Hard-to-Produce/Source Parts



A word cloud of terms related to wind turbine components, arranged in a horizontal, slightly curved shape. The words are in black, sans-serif font of varying sizes. The largest words are 'towers', 'blades', 'castings', and 'inverters'. Other prominent words include 'alternators', 'stator', 'magnets', 'winding', 'generator', 'power-electronics', 'foundations', 'rings', 'springs', 'coils', 'circuit-boards', 'US-made', 'slip', 'rotor', and 'Wiring'.

towers
alternators
blades
castings
inverters
stator
magnets
winding
generator
power-electronics
foundations
rings
springs
coils
circuit-boards
US-made
slip
rotor
Wiring

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

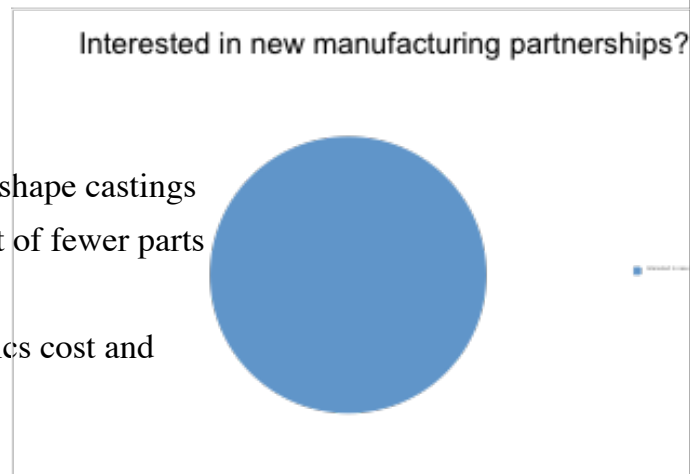
- Learning best practices for CNC machining of near-net-shape castings
- Advanced casting techniques, get more functionality out of fewer parts

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



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**



Roadmap