SMART Wind Roadmap Actions Ranking

Thanks for your time to help establish industry priorities on topics for RD&D efforts and rank actions that the SMART Wind Consortium has identified to meet long-term, pre-competitive industry research needs of the U.S. distributed wind turbine industry.

Your response to this survey is extremely valuable to finalize the Sustainable Manufacturing, Advanced Research & Technology (SMART) Wind Roadmap and fulfill DWEA's two year grant from the U.S. Dept. of Commerce's NIST AMTech program.

Actions have been grouped by the four SMART Wind Subgroups (Composites, Electrical, Mechanical, and Support Structures-Towers and Foundations) and the overall wind turbine system--and sorted by near-term (0-3 years), mid-term (3-7 years), and long-term (7-10 years) applicability. If any sections or actions are less critical or relevant to your interests, feel free to skip over them.

This survey should take about 10-25 minutes to complete. Please submit only one response per company, organization, or Subgroup Lead. All individual responses will be kept confidential and the data will only be used in aggregate with others to identify trends and opportunities. This system will allow editing within the same browser if cookies are enabled, but if you'd like to preview a PDF version of all questions before responding please contact agardere@distributedwind.org.

We will incorporate these results into the SMART Wind Roadmap to be published in Spring 2016. Thanks again for your participation.

* Indicate which sector of the distributed wind industry you are most active or familiar with:

- ◯ Micro/residential (up to 20 kW)
- ◯ Commercial/mid-size (above 20 kW up through MW-scale wind turbines in distributed applications)

* Indicate which perspective your responses to this survey are primarily representing:

- ◯ OEM of full wind turbine system
- ◯ OEM of wind turbine system component - specify which component(s) below
- ◯ Installer/technician
- ◯ Other Industry Member - specify type of business below
- ◯ Academic
- ◯ Government
- ◯ Non-Profit

Please specify component or type of business

SMART Wind Roadmap Actions Ranking

Micro/Residential: Composites Near Term Page 1

* Select up to 4 of the following possible actions for ranking that you believe are the most critical for the U.S. distributed wind industry to pursue Near Term (0-3 years). Please note only up to 4 selections will be counted (leave less critical actions blank).

- [ ] Develop families of blades with common bolt patterns that could be used in part or in whole by multiple OEMs
- [ ] Develop new solution to improve blade stiffness without weight penalty
- [ ] Explore new efficient manufacturing solutions, including microwave bonding and joining, automated fabric and tape laying, pultrusion, injection and additive manufacturing processes
- [ ] Develop joint proposal for DOE Composites Manufacturing Institute technology demonstration
- [ ] Develop improved and verifiable fatigue life prediction methods to support IEC61400-2 standards
- [ ] Determine need for and, if warranted, develop technique(s) for post-manufacturing testing of blades to identify defects by non-destructive means and/or to examine cycled blades to examine for wear patterns that develop over time
- [ ] Develop spectrum load testing methodology for small wind turbine blades (most failures may occur at low cycle fatigue; small turbine blades may respond better to spectral loading, depending on manufacturing technique and materials)
- [ ] Validate blade design through blade structural testing
- [ ] Explore new materials and processes for blades (carbon-fiber, thermoplastics, H-glass, sustainable products such as natural cellulose fibers for reinforcement and bio-based resins) to obtain high strength, stiffness, toughness, and adhesion
- [ ] None of these are critical
- [ ] No response (select to skip this question)

Comments/other actions you believe are critical

SMART Wind Roadmap Actions Ranking

Micro/Residential: Composites Near Term Page 2

Micro/Residential: Composites Mid Term Page 1

Encourage development of 13-m, 14-m blade for Sandia SWIFT program that might also be commercialized; could be part of technology demonstrator

Develop practical approaches for achieving damage tolerant design

Investigate ways to work with manufacturers of other products, share info (e.g., surfboard manufacturers)

Address the fact that XFoil, Navier-Stokes (may need fundamental research) don't predict roughness, and that in-flow conditions are not well understood

Develop methodologies for manufacturing process control

Develop methods and models that describe production defects effects during production

Conduct a study to evaluate aeroacoustics with vortex generators

Explore possibilities of monitoring blade degradation while in service as to predict remaining lifetime and to support the development of better damage models

Identify low cost and reliable health and usage monitoring systems (HUMS) for blades that can be used to evaluate the effect of lightning strikes, ice, and hailstorms

Research experimental mechanics for load determination in small blades; real-time loading of blades

Develop better blade reliability information

Develop coatings and systems that resist erosion, icing, along with fiber treatment to minimize hydrophobic matrix and hydrophilic fiber issues

Work with Sandia and Montana State to build on materials database and blade design

Develop materials with longer life cycles

None of these are critical

No response (select to skip this question)

Comments/other actions you believe are critical

Micro/Residential: Composites Mid Term Page 2

* Rank order your top Composites mid-term actions (selected in previous question) with 1st being most important, and 8th being least important. You can either drag and sort or use the pull down menu to rank your choices.

- [ ] Develop airfoils that are not so sensitive to surface roughness; test them in wind tunnels
- [ ] Document research results on composite blade structural design and dynamic behavior
- [ ] Develop better open source design and analysis tools for composites in blade structures; more capabilities are required than are currently available
- [ ] Encourage development of 13-m, 14-m blade for Sandia SWIFT program that might also be commercialized; could be part of technology demonstrator
- [ ] Develop practical approaches for achieving damage tolerant design
- [ ] Investigate ways to work with manufacturers of other products, share info (e.g., surfboard manufacturers)
- [ ] Address the fact that XFoil, Navier-Stokes (may need fundamental research) don't predict roughness, and that in-flow conditions are not well understood
- [ ] Develop methodologies for manufacturing process control
- [ ] Develop methods and models that describe production defects effects during production
- [ ] Conduct a study to evaluate aeroacoustics with vortex generators
- [ ] Explore possibilities of monitoring blade degradation while in service as to predict remaining lifetime and to support the development of better damage models
- [ ] Identify low cost and reliable health and usage monitoring systems (HUMS) for blades that can be used to evaluate the effect of lightning strikes, ice, and hailstorms
- [ ] Research experimental mechanics for load determination in small blades; real-time loading of blades
- [ ] Develop better blade reliability information
- [ ] Develop coatings and systems that resist erosion, icing, along with fiber treatment to minimize hydrophobic matrix and hydrophilic fiber issues
- [ ] Work with Sandia and Montana State to build on materials database and blade design
- [ ] Develop materials with longer life cycles

- [ ] None of these are critical
- [ ] No response (select to skip this question)

Micro/Residential: Composites Long Term Page 1

* Select up to 3 of the following possible actions for ranking that you believe are the most critical for the U.S. distributed wind industry to pursue Long Term (7-10 years). Please note only up to 3 selections will be counted (leave less critical actions blank).

- Develop integrated, iterative approach between design and blade manufacturing
- Explore whether 13-m to 27-m modular space frame blades are possible; they would not require molds
- Develop long-term contracts, enough materials and parts to drive costs down
- Identify and/or engineer new materials that can lead to an increase in tensile strength in the fiber direction, increase in shear strength in the out-of-plane direction, and increase in a compressive strength
- None of the above are critical
- No response (select to skip this question)

Comments/other actions you believe are critical

Micro/Residential: Composites Long Term Page 2

* Rank order your top Composites long-term actions (selected in previous question) with 1st being most important, and 3rd being least important. You can either drag and sort or use the pull down menu to rank your choices.

- [ ] Develop integrated, iterative approach between design and blade manufacturing
- [ ] Explore whether 13-m to 27-m modular space frame blades are possible; they would not require molds
- [ ] Develop long-term contracts, enough materials and parts to drive costs down
- [ ] Identify and/or engineer new materials that can lead to an increase in tensile strength in the fiber direction, increase in shear strength in the out-of-plane direction, and increase in a compressive strength
- [ ] None of the above are critical
- [ ] No response (select to skip this question)

Micro/Residential: Electrical Near Term Page 1

* Select up to 7 of the following possible actions for ranking that you believe are the most critical for the U.S. distributed wind industry to pursue Near Term (0-3 years). Please note only up to 7 selections will be counted (leave less critical actions blank).

- Leverage dynamometer testing facilities at NREL (10 kW-5 MW)
- Explore better ways to automate stator winding
- Use robots for coil placement as opposed to custom insertion machine; collaborate with printed circuit board or automotive industry on this approach
- Leverage power system simulators at NREL to test grid compatibility and system integration aspects of distributed wind generators (1 MVA-4 MVA) at the Energy Systems Integration Facility (ESIF) and National Wind Technology Center (NWTC)
- Develop more sophisticated grid monitoring
- Integrate all renewable energy and tie systems together so that distributed wind turbines become part of the “internet of everything” (interoperability is important: resiliency, reliability, power management)
- Incorporate storage; examine existing and proposed small-scale solutions (Tesla, Enphase)
- Invite the Small Motor and Motion Association to give a seminar and guage their interest in the distributed wind industry
- Collaborate with PV inverter manufacturers to explore higher-volume manufacturing and bulk pricing opportunities
- Design inverters with fewer parts
- Develop high-frequency inverters with SiC for increased efficiency, reduced audible noise, reduced cost, and a solution for increased ripple currents experience with variable-frequency drives (VFDs); need low-loss magnet materials
- Develop a core inverter module that is UL/IEEE compliant; can be built in volume; utilizes wind band gap switching and higher bus voltages
- Collaborate with consumer power electronics industry as costs are very carefully controlled
- Collaborate with the electric vehicle industry on power electronics
- None of the above are critical
- No response (select to skip this question)

Comments/other actions you believe are critical

Micro/Residential: Electrical Near Term Page 2

* Rank order your top Electrical near-term actions (selected in previous question) with 1st being most important, and 7th being least important. You can either drag and sort or use the pull down menu to rank your choices.

- [ ] Leverage dynamometer testing facilities at NREL (10 kW-5 MW)
- [ ] Explore better ways to automate stator winding
- [ ] Use robots for coil placement as opposed to custom insertion machine; collaborate with printed circuit board or automotive industry on this approach
- [ ] Leverage power system simulators at NREL to test grid compatibility and system integration aspects of distributed wind generators (1 MVA-4 MVA) at the Energy Systems Integration Facility (ESIF) and National Wind Technology Center (NWTC)
- [ ] Develop more sophisticated grid monitoring
- [ ] Integrate all renewable energy and tie systems together so that distributed wind turbines become part of the “internet of everything” (interoperability is important: resiliency, reliability, power management)
- [ ] Incorporate storage; examine existing and proposed small-scale solutions (Tesla, Enphase)
- [ ] Invite the Small Motor and Motion Association to give a seminar and guage their interest in the distributed wind industry
- [ ] Collaborate with PV inverter manufacturers to explore higher-volume manufacturing and bulk pricing opportunities
- [ ] Design inverters with fewer parts
- [ ] Develop high-frequency inverters with SiC for increased efficiency, reduced audible noise, reduced cost, and a solution for increased ripple currents experience with variable-frequency drives (VFDs); need low-loss magnet materials
- [ ] Develop a core inverter module that is UL/IEEE compliant; can be built in volume; utilizes wind band gap switching and higher bus voltages
- [ ] Collaborate with consumer power electronics industry as costs are very carefully controlled
- [ ] Collaborate with the electric vehicle industry on power electronics
- [ ] None of the above are critical
- [ ] No response (select to skip this question)

Micro/Residential: Electrical Mid Term Page 1

* Select up to 4 of the following possible actions for ranking that you believe are the most critical for the U.S. distributed wind industry to pursue Mid Term (3-7 years). Please note only up to 4 selections will be counted (leave less critical actions blank).

- Leverage electromagnetic and thermal design capabilities at NREL to develop new generators for wind turbines (low cogging, high efficiency, robust generators)
- Collaborate with electric vehicle industry on generator/motor development
- Research improved technology for stator laminations (helical winding, notching)
- Research bulk purchase opportunities (wire, switching, semiconductors, disconnect boxes, fuses, fuse holders, connectors, relays, anemometers and tail vanes, magnets)
- Research the use of smaller inductors for inverters using wind bandgap magnetic materials
- Pursue the commercialization of Litz wire for use in inverter inductors
- Research variable-frequency drives (VFDs) in distributed wind application; continue to partner with VFD manufacturers such as ABB, expressing the need for development for successful implementation in this type of application
- Incorporate new wide band gap switching materials (e.g. Silicon Carbide, SiC, and Galium Nitride, GaN) into power electronics
- Encourage trade schools and universities to focus on and offer training for the growing power electronics industry
- None of the above are critical
- No response (select to skip this question)

Comments/other actions you believe are critical

Micro/Residential: Electrical Mid Term Page 2

* Rank order your top Electrical mid-term actions (selected in previous question) with 1st being most important, and 4th being least important. You can either drag and sort or use the pull down menu to rank your choices.

- [ ] Leverage electromagnetic and thermal design capabilities at NREL to develop new generators for wind turbines (low cogging, high efficiency, robust generators)
- [ ] Collaborate with electric vehicle industry on generator/motor development
- [ ] Research improved technology for stator laminations (helical winding, notching)
- [ ] Research bulk purchase opportunities (wire, switching, semiconductors, disconnect boxes, fuses, fuse holders, connectors, relays, anemometers and tail vanes, magnets)
- [ ] Research the use of smaller inductors for inverters using wind bandgap magnetic materials
- [ ] Pursue the commercialization of Litz wire for use in inverter inductors
- [ ] Research variable-frequency drives (VFDs) in distributed wind application; continue to partner with VFD manufacturers such as ABB, expressing the need for development for successful implementation in this type of application
- [ ] Incorporate new wide band gap switching materials (e.g. Silicon Carbide, SiC, and Galium Nitride, GaN) into power electronics
- [ ] Encourage trade schools and universities to focus on and offer training for the growing power electronics industry
- [ ] None of the above are critical
- [ ] No response (select to skip this question)

Micro/Residential: Electrical Long Term Page 1

* Select up to 4 of the following possible actions for ranking that you believe are the most critical for the U.S. distributed wind industry to pursue Long Term (7-10 years). Please note only up to 4 selections will be counted (leave less critical actions blank).

- Collaborate with micro-hydro industry on generator and power converter (market expansion)
- Investigate how to meet new IEEE 1547 requirements with induction generators
- Collaborate with marine hydrokinetic generation industry (market expansion)
- Develop magnetics and capacitive components with national labs; utilize thermal management simulations (e.g., Argonne National Lab)
- Research standardizing power electronics; how have other industries standardized their product offerings?
- None of the above are critical
- No response (select to skip this question)

Comments/other actions you believe are critical

Micro/Residential: Electrical Long Term Page 2

* Rank order your top Electrical long-term actions (selected in previous question) with 1st being most important, and 3rd being least important. You can either drag and sort or use the pull down menu to rank your choices.

- Collaborate with micro-hydro industry on generator and power converter (market expansion)
- Investigate how to meet new IEEE 1547 requirements with induction generators
- Collaborate with marine hydrokinetic generation industry (market expansion)
- Develop magnetics and capacitive components with national labs; utilize thermal management simulations (e.g., Argonne National Lab)
- Research standardizing power electronics; how have other industries standardized their product offerings?
- None of the above are critical
- No response (select to skip this question)

Micro/Residential: Mechanical Near Term Page 1

* Select up to 4 of the following possible actions for ranking that you believe are the most critical for the U.S. distributed wind industry to pursue Near Term (0-3 years). Please note only up to 4 selections will be counted (leave less critical actions blank).

- Find cost-effective condition monitoring of gearboxes
- Investigate hydrostatic transmissions for small and medium wind turbines
- Research fluids in cold climates
- Explore best practices for computer numerical controlled (CNC) machining of near-net-shape castings
- Quantify the cost required for QA management and effects of poor quality from imported castings
- Research advanced casting techniques, get more functionality out of fewer parts
- Identify regional manufacturer expertise and encourage entry/conduct meetings with such suppliers to enter wind turbine sector
- Research the standardization of some components and group ordering
- None of the above are critical
- No response (select to skip this question)

Comments/other actions you believe are critical

Micro/Residential: Mechanical Near Term Page 2

Rank order your top Mechanical near-term actions (selected in previous question) with 1st being most important, and 4th being least important. You can either drag and sort or use the pull down menu to rank your choices.

	Find cost-effective condition monitoring of gearboxes
	Investigate hydrostatic transmissions for small and medium wind turbines
	Research fluids in cold climates
	Explore best practices for computer numerical controlled (CNC) machining of near-net-shape castings
	Quantify the cost required for QA management and effects of poor quality from imported castings
	Research advanced casting techniques, get more functionality out of fewer parts
	Identify regional manufacturer expertise and encourage entry/conduct meetings with such suppliers to enter wind turbine sector
	Research the standardization of some components and group ordering
	None of the above are critical
	No response (select to skip this question)

Micro/Residential: Mechanical Mid Term Page 1

* Select up to 5 of the following possible actions for ranking that you believe are the most critical for the U.S. distributed wind industry to pursue Mid Term (3-7 years). Please note only up to 5 selections will be counted (leave less critical actions blank).

Research parts and assemblies that can be redesigned with additive manufacturing in mind, such as advanced 3D metal printing for prototyping structural components

Develop a siphon tube in gearbox for pump/vacuum oil removal (cleaner and faster)

Research intensive quench for gears, improvements to gear life through surface treatments

Increase performance and replacement interval for lubricants

Develop information on brake materials that give good life and consistent brake torque

Understand and refine bushing materials for long life and low maintenance in sliding fit applications such as centrifugal pitching systems

Research a reliable method for galvanizing large ductile iron castings

Develop a supplier directory for wind turbine parts and components; provide information on supplier capabilities; pool knowledge of who can supply what at the best price

Speak directly with machining companies that manufacture product, streamline design for easy manufacturability

None of the above are critical

No response (select to skip this question)

Comments/other actions you believe are critical

Micro/Residential: Mechanical Mid Term Page 2

Rank order your top Mechanical mid-term actions (selected in previous question) with 1st being most important, and 5th being least important. You can either drag and sort or use the pull down menu to rank your choices.

- Research parts and assemblies that can be redesigned with additive manufacturing in mind, such as advanced 3D metal printing for prototyping structural components
- Develop a siphon tube in gearbox for pump/vacuum oil removal (cleaner and faster)
- Research intensive quench for gears, improvements to gear life through surface treatments
- Increase performance and replacement interval for lubricants
- Develop information on brake materials that give good life and consistent brake torque
- Understand and refine bushing materials for long life and low maintenance in sliding fit applications such as centrifugal pitching systems
- Research a reliable method for galvanizing large ductile iron castings
- Develop a supplier directory for wind turbine parts and components; provide information on supplier capabilities; pool knowledge of who can supply what at the best price
- Speak directly with machining companies that manufacture product, streamline design for easy manufacturability
- None of the above are critical
- No response (select to skip this question)

Micro/Residential: Support Structures - Towers Near Term Page 1

* Select up to 5 of the following possible actions for ranking that you believe are the most critical for the U.S. distributed wind industry to pursue Near Term (0-3 years). Please note only up to 5 selections will be counted (leave less critical actions blank).

Determine how to refine TIA 222 for more wind turbine tower loads and deflections

Conduct modal analysis and create Campbell diagrams for a number of tower cases with soil variations and interactions for the turbine and towers; use results as input to technical discussions on fatigue for IEC 61400-2

Design, build, and test a family of towers for different OEMs

If there is interest from multiple OEMs, work together to negotiate as a cooperative with suppliers (possible better terms)

Pole manufacturers are in almost every state, but many may be unaware of the small and distributed wind industries; determine whether they could be open to new partnerships (e.g., highway signs, transmission lines, etc.)

Develop automated methods or better tools to ensure higher quality, repeatable tower welds

Explore the possibility of creating an industry-standard, tapered tower design with flange attachments

Adapt distributed wind turbine towers to have higher US manufacturing content similar to utility and wireless (self-support, galvanized, slip joints, step bolts)

Conduct dedicated finite element analysis to verify the effect of uncertain positioning and friction on modal performance for slip joints

Use test data to validate better dynamic simulation capability for monopole towers; develop models that capture the turbine-tower coupling effects

Collaborate with partner organizations to build cost-competitive domestic structural support supply chain

None of the above are critical

No response (select to skip this question)

Comments/other actions you believe are critical

Micro/Residential: Support Structures - Towers Near Term Page 2

Rank order your top Support Structures - Towers near-term actions (selected in previous question) with 1st being most important, and 5th being least important. You can either drag and sort or use the pull down menu to rank your choices.

- [ ] Determine how to refine TIA 222 for more wind turbine tower loads and deflections
- [ ] Conduct modal analysis and create Campbell diagrams for a number of tower cases with soil variations and interactions for the turbine and towers; use results as input to technical discussions on fatigue for IEC 61400-2
- [ ] Design, build, and test a family of towers for different OEMs
- [ ] If there is interest from multiple OEMs, work together to negotiate as a cooperative with suppliers (possible better terms)
- [ ] Pole manufacturers are in almost every state, but many may be unaware of the small and distributed wind industries; determine whether they could be open to new partnerships (e.g., highway signs, transmission lines, etc.)
- [ ] Develop automated methods or better tools to ensure higher quality, repeatable tower welds
- [ ] Explore the possibility of creating an industry-standard, tapered tower design with flange attachments
- [ ] Adapt distributed wind turbine towers to have higher US manufacturing content similar to utility and wireless (self-support, galvanized, slip joints, step bolts)
- [ ] Conduct dedicated finite element analysis to verify the effect of uncertain positioning and friction on modal performance for slip joints
- [ ] Use test data to validate better dynamic simulation capability for monopole towers; develop models that capture the turbine-tower coupling effects
- [ ] Collaborate with partner organizations to build cost-competitive domestic structural support supply chain
- [ ] None of the above are critical
- [ ] No response (select to skip this question)

Micro/Residential: Support Structures - Towers Mid Term Page 1

* Select up to 6 of the following possible actions for ranking that you believe are the most critical for the U.S. distributed wind industry to pursue Mid Term (3-7 years). Please note only up to 6 selections will be counted (leave less critical actions blank).

Explore slip-fit, tapered compared to mechanically coupled towers from a loads and dynamic perspective

Determine what can be learned from other industries about tower building and lifting approaches; NREL could offer workshop on how dynamic loads differ between wind turbines and transmission towers to educate tower manufacturers

Improve U.S. monopole design and supply for base diameters above 80”

Identify how to reduce cost and ensure flatness of tower flanges

Conduct design review, testing for at least a six-month period, and third-party certification of each new support structure and foundation design and concept prior to commercialization

Explore different welding methods and develop inexpensive scalability strategies (i.e., spiral welding in the field, robotic welding, etc.)

Determine how to enable time-efficient work platforms, tie-off points, and better climbing and safety approaches

Investigate hot dip galvanizing options including cost-effective coatings

Develop performance specifications in the distributed wind industry for tower coatings

Research sound-deadening material for application inside the tower

Find U.S. small batch/tailored galvanizing partner (perhaps through MEPs)

Develop tower coatings for touching up nicks (e.g., from shipping) using kits/cartridges application

Examine HS Code: 7308.20 / Custom duty on Chinese poles

None of the above are critical

No response (select to skip this question)

Comments/other actions you believe are critical

Micro/Residential: Support Structures - Towers Mid Term Page 2

Rank order your top Support Structures - Towers mid-term actions (selected in previous question) with 1st being most important, and 6th being least important. You can either drag and sort or use the pull down menu to rank your choices.

	Explore slip-fit, tapered compared to mechanically coupled towers from a loads and dynamic perspective
	Determine what can be learned from other industries about tower building and lifting approaches; NREL could offer workshop on how dynamic loads differ between wind turbines and transmission towers to educate tower manufacturers
	Improve U.S. monopole design and supply for base diameters above 80”
	Identify how to reduce cost and ensure flatness of tower flanges
	Conduct design review, testing for at least a six-month period, and third-party certification of each new support structure and foundation design and concept prior to commercialization
	Explore different welding methods and develop inexpensive scalability strategies (i.e., spiral welding in the field, robotic welding, etc.)
	Determine how to enable time-efficient work platforms, tie-off points, and better climbing and safety approaches
	Investigate hot dip galvanizing options including cost-effective coatings
	Develop performance specifications in the distributed wind industry for tower coatings
	Research sound-deadening material for application inside the tower
	Find U.S. small batch/tailored galvanizing partner (perhaps through MEPs)
	Develop tower coatings for touching up nicks (e.g., from shipping) using kits/cartridges application
	Examine HS Code: 7308.20 / Custom duty on Chinese poles
	None of the above are critical
	No response (select to skip this question)

Micro/Residential: Support Structures - Towers Long Term Page 1

* Select up to 4 of the following possible actions for ranking that you believe are the most critical for the U.S. distributed wind industry to pursue Long Term (7-10 years). Please note only up to 4 selections will be counted (leave less critical actions blank).

Work with New Mexico's MEP and other MEPs to transition highway sign manufacturers to turbine tower manufacturers

Investigate research in sub-surface corrosion protection methods and materials

Investigate composites for towers (no huge cost advantage; fiberglass still expensive compared to steel)

If using slip-fit towers, determine how installers climb

Account for human safety and safe installation requirements in future designs, such as increase the number of anchor points, address spacing of climbing pegs, ensure clip-off points (see Roadmap for full list of recommendations)

None of the above are critical

No response (select to skip this question)

Comments/other actions you believe are critical

Micro/Residential: Support Structures - Towers Long Term Page 2

Rank order your top Support Structures - Towers long-term actions (selected in previous question) with 1st being most important, and 4th being least important. You can either drag and sort or use the pull down menu to rank your choices.

	Work with New Mexico's MEP and other MEPs to transition highway sign manufacturers to turbine tower manufacturers
	Investigate research in sub-surface corrosion protection methods and materials
	Investigate composites for towers (no huge cost advantage; fiberglass still expensive compared to steel)
	If using slip-fit towers, determine how installers climb
	Account for human safety and safe installation requirements in future designs, such as increase the number of anchor points, address spacing of climbing pegs, ensure clip-off points (see Roadmap for full list of recommendations)
	None of the above are critical
	No response (select to skip this question)

Micro/Residential: Support Structures - Foundations Mid Term Page 1

* Select up to 5 of the following possible actions for ranking that you believe are the most critical for the U.S. distributed wind industry to pursue Mid Term (3-7 years). Please note only up to 5 selections will be counted (leave less critical actions blank).

- Investigate the use of imbedded angle profiles with 60 degree angle may not need anchor bolts if embedded in reinforced concrete
- Investigate commercial capability of other earth-anchor systems, e.g. helical anchors
- Investigate spread leg foundations commercial and functional viability for distributed wind turbines
- Form team of foundation installation experts to perform time-motion study of installation, with the goal of reducing labor hours
- Fiber-reinforced concrete may have significant cost-saving potential for turbine foundations; explore technical limitations and opportunities
- Develop performance specifications in the distributed wind industry for tower coatings
- Work with crane manufacturer for hydraulic tower design for erection and maintenance
- Develop helical foundation specific for this industry
- Develop common, pre-fabricated foundations for multiple turbines. Consider cheap materials such as cheap steel. Perhaps design for worst-case soil conditions
- Facilitate forum to identify specific countries' structural requirements and expertise (e.g., Japan)
- Identify new ways to reduce the amount of concrete needed for distributed wind turbine foundations
- None of the above are critical
- No response (select to skip this question)

Comments/other actions you believe are critical

Micro/Residential: Support Structures - Foundations Mid Term Page 2

Rank order your top Support Structures - Foundations mid-term actions (selected in previous question) with 1st being most important, and 5th being least important. You can either drag and sort or use the pull down menu to rank your choices.

- [ ] Investigate the use of imbedded angle profiles with 60 degree angle may not need anchor bolts if embedded in reinforced concrete
- [ ] Investigate commercial capability of other earth-anchor systems, e.g. helical anchors
- [ ] Investigate spread leg foundations commercial and functional viability for distributed wind turbines
- [ ] Form team of foundation installation experts to perform time-motion study of installation, with the goal of reducing labor hours
- [ ] Fiber-reinforced concrete may have significant cost-saving potential for turbine foundations; explore technical limitations and opportunities
- [ ] Develop performance specifications in the distributed wind industry for tower coatings
- [ ] Work with crane manufacturer for hydraulic tower design for erection and maintenance
- [ ] Develop helical foundation specific for this industry
- [ ] Develop common, pre-fabricated foundations for multiple turbines. Consider cheap materials such as cheap steel. Perhaps design for worst-case soil conditions
- [ ] Facilitate forum to identify specific countries' structural requirements and expertise (e.g., Japan)
- [ ] Identify new ways to reduce the amount of concrete needed for distributed wind turbine foundations
- [ ] None of the above are critical
- [ ] No response (select to skip this question)

Micro/Residential: Turbine System Near Term Page 1

* Select up to 9 of the following possible actions for ranking that you believe are the most critical for the U.S. distributed wind industry to pursue Near Term (0-3 years). Please note only up to 9 selections will be counted (leave less critical actions blank).

- Certify small wind and medium wind hardware (challenging due to costs)
- Obtain better understanding of fatigue for IEC 61400-2
- Encourage international and foreign standards/codes/licensing that allow access to export markets
- Conduct a gap analysis for certification requirements in most compelling markets, i.e. what is the scope of work for certifying a turbine for not only the domestic market bur for the most vibrant international markets at the same time
- Assess how changing wind turbine system may impact machine certification
- Research the use of “hot wire” anemometers
- Coordinate American distributed wind pavilions at key global trade shows; host in
- Conduct trainings on technology selection, site evaluation, installation, and maintenance in key export markets
- Pursue Market Development Cooperator Program (MDCP) Export Awards to promote sales of U.S.-made distributed wind turbines and components in growing international markets
- Conduct trade missions and other match-making events in key international markets; match U.S. firms’ travel funds for foreign missions
- Connect MEPs and OEMs
- Assist OEM with tooling and part handling for low-volume manufacturing; fixturing to reduce labor
- Pursue lean manufacturing
- Partner with vendors to identify and adjust high-cost specifications
- Work with developers of supply chain/scheduling & planning optimization software to adjust inventory and facility strategies
- Update aerodynamic models in FAST v8 to include towers and tails
- Provide educational courses on computer-aided engineering tools (e.g., FAST, Crunch) for industry, college students
- Eliminate excavation with screw-in anchors, which need to be installed at an angle (What are the limitations of this approach? Could re-tensioning be part of maintenance?)
- None of the above are critical
- No response (select to skip this question)

Comments/other actions you believe are critical

Micro/Residential: Turbine System Near Term Page 2

Rank order your top Turbine System near-term actions (selected in previous question) with 1st being most important, and 9th being least important. You can either drag and sort or use the pull down menu to rank your choices.

- Certify small wind and medium wind hardware (challenging due to costs)
- Obtain better understanding of fatigue for IEC 61400-2
- Encourage international and foreign standards/codes/licensing that allow access to export markets
- Conduct a gap analysis for certification requirements in most compelling markets, i.e. what is the scope of work for certifying a turbine for not only the domestic market bur for the most vibrant international markets at the same time
- Assess how changing wind turbine system may impact machine certification
- Research the use of “hot wire” anemometers
- Coordinate American distributed wind pavilions at key global trade shows; host in
- Conduct trainings on technology selection, site evaluation, installation, and maintenance in key export markets
- Pursue Market Development Cooperator Program (MDCP) Export Awards to promote sales of U.S.-made distributed wind turbines and components in growing international markets
- Conduct trade missions and other match-making events in key international markets; match U.S. firms’ travel funds for foreign missions
- Connect MEPs and OEMs
- Assist OEM with tooling and part handling for low-volume manufacturing; fixturing to reduce labor
- Pursue lean manufacturing
- Partner with vendors to identify and adjust high-cost specifications
- Work with developers of supply chain/scheduling & planning optimization software to adjust inventory and facility strategies
- Update aerodynamic models in FAST v8 to include towers and tails

- [ ] Provide educational courses on computer-aided engineering tools (e.g., FAST, Crunch) for industry, college students
- [ ] Eliminate excavation with screw-in anchors, which need to be installed at an angle (What are the limitations of this approach? Could re-tensioning be part of maintenance?)
- [ ] None of the above are critical
- [ ] No response (select to skip this question)

Micro/Residential: Turbine System Mid Term Page 1

* Select up to 4 of the following possible actions for ranking that you believe are the most critical for the U.S. distributed wind industry to pursue Mid Term (3-7 years). Please note only up to 4 selections will be counted (leave less critical actions blank).

Fund development of standardized condition monitoring and remote debugging modules for an industry of varied hardware; hardware is not expensive, the expense is getting something useful from cheap hardware (development of code/system/modules to handle data; library of modules/hardware)

Work with U.S. Commercial Service global network to connect U.S. firms with overseas assemblers, so U.S. products and services can be more easily integrated into nearby markets

Research/monitor trade barriers and global market opportunities

Initiate a new “Made-in-America” effort to address dumping of steel and determine how common OEM design and supply (e.g. tower flange) could boost volume

Work with U.S. DOE on future collegiate wind competitions to include a distributed wind theme inviting projects that focus on advanced manufacturing for distributed wind-scale technology

Many OEMs cannot afford a high-quality process engineer to implement process improvements; explore funding independent auditors to provide expertise for advanced manufacturing specific for wind; provide a neutral, unbiased roving process engineer

Research robotics, low-cost automation techniques for the volumes in the distributed wind industry; robotics could be mobile and multi-purpose (molding, winding, welding, painting, etc)

The utility-scale wind industry may be able to offer lessons from designing, installing and maintaining met towers, which are sometimes left in the field for 6 to 7 years; aviation requirements for taller towers should be researched

Ensure training opportunities for small wind installers to erect, maintain, and operate distributed wind turbines (training is especially needed for installers who climb non-tilting towers)

None of the above are critical

No response (select to skip this question)

Comments/other actions you believe are critical

Micro/Residential: Turbine System Mid Term Page 2

Rank order your top Turbine System mid-term actions (selected in previous question) with 1st being most important, and 4th being least important. You can either drag and sort or use the pull down menu to rank your choices.

- [ ] Fund development of standardized condition monitoring and remote debugging modules for an industry of varied hardware; hardware is not expensive, the expense is getting something useful from cheap hardware (development of code/system/modules to handle data; library of modules/hardware)
- [ ] Work with U.S. Commercial Service global network to connect U.S. firms with overseas assemblers, so U.S. products and services can be more easily integrated into nearby markets
- [ ] Research/monitor trade barriers and global market opportunities
- [ ] Initiate a new “Made-in-America” effort to address dumping of steel and determine how common OEM design and supply (e.g. tower flange) could boost volume
- [ ] Work with U.S. DOE on future collegiate wind competitions to include a distributed wind theme inviting projects that focus on advanced manufacturing for distributed wind-scale technology
- [ ] Many OEMs cannot afford a high-quality process engineer to implement process improvements; explore funding independent auditors to provide expertise for advanced manufacturing specific for wind; provide a neutral, unbiased roving process engineer
- [ ] Research robotics, low-cost automation techniques for the volumes in the distributed wind industry; robotics could be mobile and multi-purpose (molding, winding, welding, painting, etc)
- [ ] The utility-scale wind industry may be able to offer lessons from designing, installing and maintaining met towers, which are sometimes left in the field for 6 to 7 years; aviation requirements for taller towers should be researched
- [ ] Ensure training opportunities for small wind installers to erect, maintain, and operate distributed wind turbines (training is especially needed for installers who climb non-tilting towers)
- [ ] None of the above are critical
- [ ] No response (select to skip this question)

Thanks again for sharing your perspective. All of your responses are confidential and will only be used in aggregate with other responses to gain an understanding of research priorities for the U.S. distributed wind industry. The name of the individual responder is optional, but please indicate your affiliation so we can keep track of which SMART Wind participants have responded.

* Respondent Information

Name (optional)

Company/Organization

If you are not already subscribed to the SMART Wind Consortium and would like to receive a copy of the Roadmap with the aggregated results of this ranking survey as well as information on future SMART Wind activities, please provide your email address.

Email Address

Email Address (optional)

How might your company or organization support DWEA and the SMART Wind Consortium in order to build the U.S. distributed wind industry?

Attend and/or help plan future SMART Wind events

Serve as a speaker and/or sponsor for future SMART Wind events

Assist with preparing funding applications to pursue SMART Wind actions

Join DWEA as a member / renew DWEA membership (for details see http://distributedwind.org/about-membership/)

Financially support SMART Wind-led competitions

Serve as a mentor for newcomers to distributed wind

Other (please specify)