

Wind Turbine Materials Recycling Prize Voucher Lab Capabilities Profile

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INTRODUCTION

The Wind Turbine Materials Recycling Prize is a $5.1 million competition with a goal of awarding funding to designers of novel technologies and highly capable commercial entities to help develop a cost-effective and sustainable recycling industry for two high-impact categories of wind energy materials: fiber-reinforced composites and rare earth elements. This prize is explicitly focused on advancing technologies that enhance the ability to recycle materials when wind energy projects are decommissioned.

The Department of Energy (DOE) Wind Energy Technologies Office (WETO) is launching this prize in support of the Wind Energy Technology Recycling Research, Development, and Demonstration program (henceforth referred to as the Wind Recycling Program) that was authorized by the Energy Act of 2020 and appropriated funding through the Infrastructure Investment and Jobs Act. For this prize, DOE invites competitors to present innovative technologies that have not been applied to the recycling of wind energy system materials, as well as technologies that could substantially improve existing wind energy technologies material recycling processes. These may be technologies with commercial maturity in other industries as well as novel technologies that have not yet been applied commercially anywhere in the United States.

DOE currently funds research, development, and demonstration efforts to develop novel materials and manufacturing technologies for the wind energy industry and has been assessing the current state of the art and future needs for recycling of all wind energy system materials. Of particular concern to DOE are materials without industrial-scale and/or economically self-sustaining recycling options, especially those materials that are considered to be critical to the continued development of the United States' clean energy economy.

VOUCHER OVERVIEW

Vouchers will be available to winners of the Accelerate! phase to access tools, equipment, and expertise at the national laboratories so that they may develop, test, and validate their technologies. By the Accelerate! phase submission deadline, competitors must submit a Voucher Work Plan.

The single slide should describe the work you plan to do with your voucher funds. Suggested content includes:

- Identification of the team and the team point of contact for voucher work.
- Identification of up to three national laboratories that you would like to work with and rank them.
- A brief description of your innovation.
- A description of your proposed scope of work.
- A description of progress made over the competition period, including national labs you worked with previously.

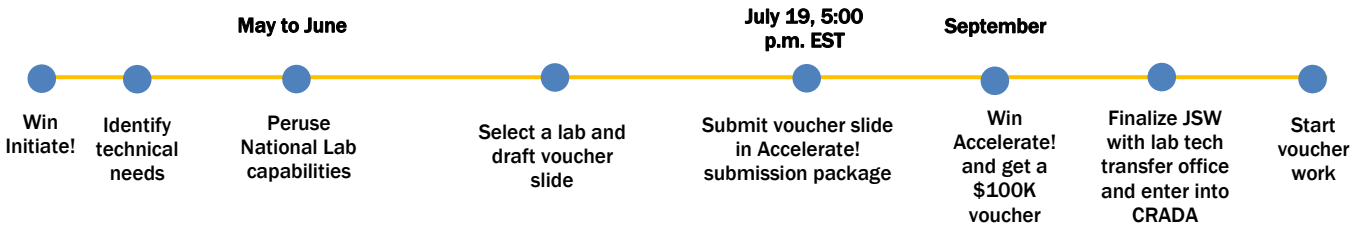
The Voucher Work Slide must be submitted to HeroX as a PowerPoint slide.

VOUCHER FUNDING

Vouchers are part of the Wind Turbine Materials Recycling prize and may only be used at national laboratories. The funds will be provided directly to the laboratory on behalf of the Accelerate! Phase winner to conduct a mutually agreed upon scope of work between the laboratory and the team.

VOUCHER PROCESS

PROCESS TO WORK WITH A NATIONAL LAB



Step 1. Win the Initiate! Contest and identify your technical needs should you win the Accelerate Phase 2 of the competition.

Step 2. Familiarize yourself with national lab capabilities in the following ways:

- Start the process by reviewing your technical needs and peruse lab capabilities provided in this document to determine which lab(s) has the capabilities that meet your technical needs.

Step 3. Include your voucher slide in your Accelerate! Phase 2 submission package**,** due on **July 19, 2024**.

Step 4. Should you win the Accelerate! Phase 2, more details will be shared with you about this process. You will be able to meet with the lab you selected and develop a joint-statement-of-work (JSW). Then you will enter into a cooperative research and development agreement (CRADA) so that work can commence.

Step 5. After the agreement and/or CRADA has been signed, the voucher work can begin.

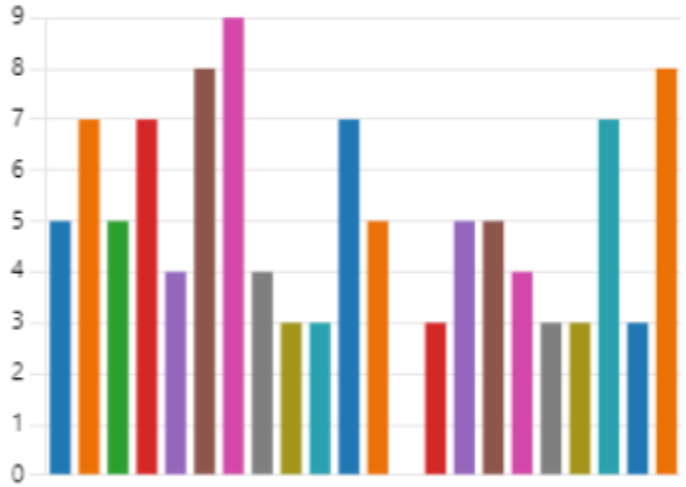
CAPABILITIES

This section provides overviews of select U.S. Department of Energy (DOE) national labs, categorized by topic areas identified by the Initiate! winning teams to be highly relevant to the Wind Turbine Materials Recycling Prize. The “at-a-glance” and “lab capabilities matrix” tables below provide a summary of lab capabilities. Following these two tables in the “national lab profiles” section you will find a narrative summary of the capabilities and experience that each lab offers.

If you win an Accelerate Phase 2 voucher, you will work with a Technical Representative(s) at your selected national lab(s) to complete a detailed Statement of Work (SOW) for the voucher work as well as any other requirements such as a cooperative research and development agreements (CRADA). More details will be provided after Accelerate! Phase 2 winners have been announced.

AT A GLANCE LAB CAPABILITIES

Adhesive materials	5
Technoeconomic Analysis	7
Risk Assessment	5
Emissions Analysis/LCA	7
Community Benefits Analysis	4
Composites and/or magnetic m...	8
Characterization of recycled co...	9
Coating materials and applicatio...	4
Building and construction mater...	3
Mechanical size reduction	3
Waste material analysis	7
Rheology - polymer and asphalt	5
HSE considerations for high tem...	0
Hydrogen storage and energy c...	3
REE purification	5
In-situ characterization tools for...	5
Computation fluid dynamics	4
Thermodynamic modeling	3
Mass spectrometry (inductively ...	3
X-ray diffraction and XPS	7
DFT simulation	3
Mechanical testing	8



LAB CAPABILITIES MATRIX

		DOE National Labs							
#	Capabilities	NREL	Sandia	PNNL	ANL	Ames	LBNL	ORNL	INL
1	Adhesive materials	X	X	X	X			X	
2	Technoeconomic Analysis	X	X	X	X		X		X
3	Risk Assessment	X	X	X			X	X	
4	Emissions Analysis/LCA	X	X	X	X		X	X	X
5	Community Benefits Analysis	X		X	X		X		
6	Composites and/or magnetic materials manufacturing technologies design, process modeling, scaling, facility design, and digitalization	X	X	X	X	X		X	X
7	Characterization of recycled composite and/or magnetic materials and products	X	X	X	X	X	X	X	X
8	Coating materials and application processes		X		X	X		X	
9	Building and construction materials	X		X					X
10	Mechanical size reduction	X			X				X
11	Waste material analysis	X		X	X	X	X	X	X
12	Rheology - polymer and asphalt	X		X	X			X	X
13	HSE considerations for high temperature processes								
14	Hydrogen storage and energy conversion			X					X
15	REE purification			X	X	X		X	X
16	In-situ characterization tools for observing reactions			X	X	X		X	X
17	Computation fluid dynamics	X	X	X	X				
18	Thermodynamic modeling	X	X						X
19	Mass spectrometry (inductively coupled plasma, liquid chromatography)				X			X	X
20	X-ray diffraction and XPS			X	X	X	X	X	X
21	DFT simulation	X		X		X			X
22	Mechanical testing	X	X		X		X	X	X

NATIONAL LAB PROFILES

Ames National Laboratory

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Ames National Laboratory (Ames) delivers critical materials solutions to the nation. For over 75 years, Ames National Laboratory has successfully partnered with Iowa State University of Science and Technology to lead in the discovery, synthesis, analysis, and use of new materials, novel chemistries, and transformational analytical tools especially focused on rare earth elements. Ames is supporting critical materials supply chains by establishing advanced capabilities in metals refining and alloy processing.

Ames manages the Critical Materials Innovation (CMI) Hub, an Energy Innovation Hub focused on accelerating technologies to establish resilient and robust supply chains for rare earth materials and other materials critical for clean energy technologies. CMI uses the strategic approaches of Enhancing and Diversifying Sources, Developing Substitutes, and Building a Circular Economy. Ames' expertise within CMI centers on rare earth element refining, alloying and permanent magnet discovery and fabrication, as well as in the design of the systems that use magnetic materials. Ames' capabilities also extend to the reuse, remanufacturing, and recovery of REE from manufacturing wastes and end-of-life devices containing REE permanent magnets.

Rare Earth Metals Production: Ames National Laboratory pioneered the process of rare earth metal production using thermometallic reduction methods. Ames is the only DOE National Laboratory that routinely produces rare earth metals from rare earth salts at pilot scales (1.5-3 Kg) and is considered the world's preferred source of ultrahigh purity rare earths. Coupled with Ames' expertise and capabilities in permanent magnet science and processing, Ames is the optimal laboratory to assess and evaluate purity of recovered rare earth metals from recycled sources and to validate their reinsertion into magnet production. Through the newly announced DOE METALLIC critical material supply chain facility, Ames will expand its refining capabilities to reduce the energy intensity of rare earth metals production while expanding the refining capabilities to accept a wider variety of feedstock from primary and secondary sources, including manufacturing and end-of-life wastes.

Advanced Magnet Alloys and Processing: Ames has a full range of processing capabilities to assist companies in demonstrating value of recycled/recovered REEs to be reprocessed back into permanent magnets including alloying, strip casting, hydrogen decrepitation, jet milling, sintering, post-sintering heat treatment and magnet characterization.

Rare earth permanent magnets are at the heart of highly efficient motors and generators needed for clean energy technologies and are key components in state-of-the-art scientific instruments. Unfortunately, conventional magnet manufacturing processing suffers from batch-to-batch reproducibility. REE permanent magnet properties derive from both chemistry and microstructural control, including chemistry, morphology, and nature of the grain boundary phase. Advances in grain boundary engineering will be essential to enhance microstructural uniformity at scale. Smart manufacturing approaches will enable precision synthesis of nanoparticulate powder and targeted additions needed to develop optimized and uniform microstructures. Linking data (such as chemistry, particle size, grain boundary precipitate morphology) across manufacturing steps will be critical to define process control parameters that will lead to more uniformity of magnets at

production scale. Achieving precision processing in magnet fabrication will lead to reducing the content of dysprosium, perhaps the most critical of the REE, while minimizing wastage in magnetic fabrication related to sub-par performance.

Advanced Magnet Facility: Ames is commissioning a magnet prototyping facility that will serve as a National Resource for addressing critical material challenges by supporting energy efficient domestic magnet production. The flexible platform will enable rapid manufacturing of kg-scale magnets needed for rapid testing and validation of new materials and magnet processing developed through Ames, CMI, academic, and industrial partners. The magnet manufacturing prototype facility will demonstrate synthesis of kilogram-scale batches of high-performance magnet alloys. Magnet formulations with no or reduced critical materials content are feasible using recycled REEs.

Permanent Magnet Systems Design and Prototyping: Ames supports the CMI with the capability to design systems that use permanent magnets and other magnetic materials. This capability uses systems level modeling and prototyping as a virtual testbed for qualifying the suitability of new, improved, or recycled materials for applications. In cases in which a material, such as permanent magnet, requires additional improvement to be suitable for an application, this capability helps to understand the extent of improvement needed. It also helps to understand if system optimization can be made to facilitate the use of recycled materials in application. As needed, the system can be prototyped as a means of derisking the process of its use in applications.

Materials Preparation Center (MPC): Many of the materials processing capabilities at Ames are accessible through our Materials Preparation Center. MPC offers a wide range of services in metallurgical, materials science and engineering, materials chemistry, and materials physics involving the use of high purity rare earth metals, high purity alloys and intermetallic compounds, and single crystals. With capabilities ranging from small-scale arc casting and single crystal preparation to ingot casting with vacuum induction melting (VIM), casting and plasma arc melting (PAM), this breadth of capabilities positions MPC to assist research groups in the reuse and recovery of REE magnets from a variety of sources including wind generators.

Permanent Magnet Reuse, Remanufacturing and Recovery: Ames is a leader in efficient recycling of permanent magnets from devices like wind generators and electric vehicles. Recycling capabilities in Ames includes approaches that enable the reuse and remanufacturing of permanent magnets, as well as approaches to recover rare earths in their elemental forms. Tied with Ames capabilities in permanent magnets development, recycling at Ames ensures that the recovery efficiency and purity of rare earth are suitable for commercial applications. Hence, the Laboratory is equipped with the capabilities to purify and qualify recycled products for reinsertion into the supply chain. Ames invented, matured, and deployed the acid-free dissolution recycling technology currently being performed at pilot scale and recommended to the Department of Defense in the recent National Defense Authorization Act. The technology has been recognized with several awards for its environmental benefits and excellent recovery efficiency.

Idaho National Laboratory

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Idaho National Laboratory is one of the U.S. Department of Energy's 17 national laboratories. With roughly

5,000 scientists, engineers and support personnel, the lab also stands as one of Idaho's largest employers. At INL's three primary facility areas – the Advanced Test Reactor Complex, Materials and Fuels Complex, and Research and Education Campus – researchers perform work in support of DOE's mission to "discover the solutions to power and secure America's future." More specifically, INL is the nation's center of nuclear energy research and development of clean, renewable energy alternatives. Day-to-day management and operation of the laboratory is the responsibility of Battelle Energy Alliance. INL has been part of the Critical Materials Institute for the past decade and is a current member of the newly formed Critical Materials Innovation Hub. INL anchors the Recycle/Recovery Focus Area of CMI. INL's expertise in recycle/recovery of renewable energy device structural materials and critical materials is known nation-wide. INL has multiple skills, capabilities, and technologies targeted at recycle/recovery of materials from wind, solar, eWaste, and other resource streams.

Oak Ridge National Laboratory

Lab Point of contact: Parans Paranthaman
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ORNL has the expertise in critical rare earth element (REE) recovery and additive manufacturing of permanent magnets.

Core capabilities and specialized equipment for fiber and composite processing and evaluation have been built and exploited within the Carbon and Composites Group at the Oak Ridge National Laboratory (ORNL) over multiple decades of research efforts including projects sponsored through direct funding and CRADA collaborations via DOE (BETO, VTO, HFTO, WETO, ARPA-E), DARPA and other DOD/national security offices, and USDA as well as internal investments. These research and development efforts have resulted in multiple technologies being licensed by private industry start-ups for commercialization, such as renewable lignin-based composites, plasma-based processing of polymeric fibers, thermally reprocessable vitrimer composite formulations for enhanced material recovery, and self-sensing fiber-reinforced composites. The Carbon and Composites Group maintains seven key polymer synthesis, characterization, and processing laboratories which are available to support this work, wielding a suite of varied characterization tools, including DSC, TGA, TMA, DMA, BET surface area analysis, extensional rheology, shear rheology, polarized microscopy, tensile testing, gel permeation chromatography and electrical resistivity analysis. Where useful, these capabilities can be easily augmented with the broader core competencies established throughout ORNL, the nation's largest multi-program national laboratory operated by UT-Battelle, LLC for the DOE Office of Science.

Lawrence Berkeley National Laboratory

Lab Point of contacts: Yuxin Wu, Peng Peng (TEA, LCA, community benefits)
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LBNL has a range of capabilities for material analysis and property testing. They can be summarized below:

(1) Large scale, 10s to 100s of meters, strain/stress response measurements with distributed fiber optic sensing technologies;

(2) Large scale, 100s to 1000s of meters, geophysical surveys, such as magnetic property mapping with airborne geophysical tools;

(3) Laboratory scale material characterization tools, including XRD, handheld x-ray fluorescence, Laser induced

breakdown spectroscopy, SEM;

(4) small scale material strain/stress responses at continuum scale - mm resolution strain and temperature measurements of small (<m) samples;

(5) x-ray micro-tomography at the ALS beamline.

The Energy Analysis and Environmental Impacts (EAEI) Division at Lawrence Berkeley National Laboratory has strong capabilities in techno-economics analysis (TEA), life cycle assessment (LCA), and community benefits analysis. Our researchers work collaboratively to develop methods and guidelines for low-TRL (emerging) technologies to establish industrial processes to improve performance, costs, and minimize environmental impacts and unforeseen risks. EAEI hosts models for various analyses for deployment and application, including cost of production, life-cycle cost, product markup analysis, etc.

Pacific Northwest National Laboratory

Point of contact: Alicia Mahon
alicia.mahon@pnnl.gov

The numbers below correspond to the Lab Capabilities Matrix on page 7.

(1) **Adhesive materials**- experience in multi-material joining with metal/metal, metal/composite, and composite/composite adhesive bonding and surface modifications with laser and plasma treatments; modeling tools of fracture behavior in joints both with fasteners with adhesives and adhesives only.

(2) **Technoeconomic Analysis**- experience performing cost comparisons and using LCOEs to determine economic viability

(3) **Risk Assessment**- extensive experience preparing NEPA documents and associated permitting processes, including on/offshore wind

(4) **Emissions Analysis/LCA**- extensive background in life cycle research, assessments, and policy implementation that has focused on industrial scale renewable energy systems (e.g., hydrogen, biofuels) as well as consumer and commercial products; proficiency in multiple LCA modeling platforms; access to databases.

(5) **Community Benefits Analysis**- direct technical assistance (TA) to communities, community engagement, socioeconomic impact studies, workforce development, reviewing CBAs

(6) **Composites and/or magnetic materials manufacturing technologies design, process modeling, scaling, facility design, and digitalization**- preprocessing recycled composite and magnetic materials like NdFeB from feedstocks; reclaiming carbon and glass fiber with depolymerized resin through a unique solvolysis process; IP in atmospheric pressure process for fiber and resin recovery for large composite object such as pressure vessels and automotive parts

(7) **Characterization of recycled composite and/or magnetic materials and products**- analysis of end-of-life magnets and other recycled materials; characterization of recycled composite and magnetic materials and products like NdFeB from feedstocks using a combination of various advanced techniques, including SEM, S/TEM, AFM, XRD, XRF, EPMA, and Raman.

(9) **Building and construction materials-** developing calcination-free and carbon-efficient production of alternative cementitious binders from tailing wastes like red mud; experience with whole building LCA, lighting, and HVAC and their respective environmental footprints and strategies for reducing their overall impacts.

(11) **Waste material analysis**- experience in waste material analysis using a combination of various advanced techniques, including SEM, S/TEM, AFM, XRD, XRF, EPMA, and Raman; analyzing red mud in detail using 10+ characterization tools and found several special minerals that concentrated REEs and thus developed several novel techniques for REE recycling from red mud and applied several patents

(12) **Rheology - polymer and asphalt**- rheology for polymers and thermosetting resin systems

(14) **Hydrogen storage and energy conversion**- Experience in developing porous materials and metal hydrides for Hydrogen storage; Experience with water demand and LCA for green hydrogen production; experience in high-pressure storage with the HFTO office in design, materials, and costs; Cryogenic storage design, materials testing, and costs; materials compatibility in hydrogen for polymers

(15) **REE purification**- experience in developing adsorbent and core shell magnetic particles for REE extraction from geothermal brine and produced waters; REE separation and purification using a combination of machine

learning and inorganic chemical/physical methods like recrystallization; developing magnetic core shell particles along with materials that inherently magnetic and adsorb REEs and other critical minerals from various sources

(16) **In-situ characterization tools for observing reactions**- experience in in-situ XPS, Raman and NMR analysis of materials under realistic operating conditions; experience in observing reactions using advanced in situ techniques, including in situ heating/liquid cell S/TEM, AFM, Raman, and IR, and several unique techniques developed at PNNL such as high-pressure high temperature (high P-T) AFM, high P-T Raman, and in situ Environmental TEM-AFM.

(17) **Computation fluid dynamics**- experience in CFD modelling for various fluids, hydro power, wind turbine, carbon capture, biomedical, turbulence, etc.

(20) **X-ray diffraction and XPS-** novel Cryo-XPS and 2D XPS imaging systems along with in-situ high temperature XRD for materials and interface analysis

(21) **DFT simulation**- expertise in physical metallurgy and understanding mechanical properties of materials at nanoscale using advanced in situ environmental TEM-AFM and SEM-AFM techniques; polymers and composites characterization and testing; testing of all things polymer composites; fracture, fatigue, strength, modulus, and impact

Sandia National Laboratories

Point of contact: Brandon Ennis
blennis@sandia.gov

The wind energy program at Sandia National Laboratories has a long history of characterization and assessment of composite materials for use in wind turbine blade design or other structural applications. Sandia has performed and managed mechanical characterization of composites of use to the wind industry for forty years, covering a range of reinforcement fibers and resin systems to develop one of the most comprehensive test databases of fiber-reinforced polymers. In addition, Sandia and its partners have expertise in characterizing how wind blade composites age and degrade under varying conditions. Extensive design and simulation capabilities have been applied across many scales, from fiber geometry design using finite element micromechanical analysis to full wind blade design using multi-fidelity toolsets. Sandia has also worked closely with partners to manufacture wind blade designs developed at Sandia for scaled testing at 9m and 13m blade lengths, to assess performance of novel material and design approaches. Sandia has expertise in life cycle assessment (LCA), including a recent effort focused on composite wind turbine blade recycling. During this work, Sandia conducted a thorough literature review, engaged with industry, and created detailed process models of existing and emerging recycling approaches. Using data from these sources, Sandia has performed formal life cycle impact assessment to characterize material yields, energy consumption, greenhouse gas emissions, and other environmental metrics. This analysis has been used to identify challenges and opportunities across the wind blade recycling supply chain, including considerations for decommissioning, transportation, downsizing, material separation, and material recovery. The knowledge, data, and models gained during this initial effort can be applied toward future projects to quantify the efficiency and environmental impact of emerging recycling approaches. Sandia staff have performed technoeconomic analyses (TEA) on the topics of carbon fiber manufacturing, composite manufacturing, blade segmentation, blade operation, blade repair, and blade recycling. Within these projects, TEA has been used to assess a range of metrics, including the levelized cost of energy, minimum selling price, internal rate of return, and net present value. These metrics can be used to inform decisions across the lifetime of a project, ranging from initial capital costs to long term operational considerations. Sandia's TEA models are built upon the same

fundamental process models as LCA, meaning Sandia is well poised to perform parallel TEA and LCA, enabling the identification of economic and environmental trade-offs. Assessment capabilities for remanufactured products from recycled fiber includes performing LCA and TEA of remanufacturing processes, market identification and assessment for recycled products, finite element analysis modeling of mechanical performance, and physical specimen fabrication in various composite forms.

National Renewable Energy Laboratory

Point of contacts: Brian Smith, Kendra Ryan
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The National Renewable Energy Laboratory (NREL) is the premier U.S. national laboratory focused on advancing the foundational science, engineering, and applied research to advance renewable energy technology. NREL has pioneered many of the components and systems that have taken wind energy technologies to new heights, providing global leadership in fundamental wind energy science research, development, and validation activities. NREL works with the U.S. Department of Energy to enhance sustainability and resilience in the supply chain of critical materials on which decarbonized energy systems will depend. Our research in circular economy for energy materials strives to achieve sustainability by reducing waste and preserving resources through the design of materials and products with reuse, recycling, and upcycling in mind from the start.

Category: Adhesive materials
Point of Contact: Nicholas Rorrer
Capability Areas of Expertise Description: Materials research and applications; Polymer chemistry for composite materials: Recyclable composite materials and resin systems; Novel materials that are manufacturable and recyclable by design and enable recycling of existing composite structures.
Category: Technoeconomic Analysis
Point of Contact: Aubryn Cooperman, Pietro Bortolotti
Capability Areas of Expertise Description: Technoeconomic modeling and LCOE impact analyses; Historical market and technology trends; Future cost and deployment scenarios; Jobs and economic development impacts models; Blade design and aeroservoelastic simulations; Detailed blade manufacturing modeling.

Category: Risk Assessment
Point of Contact: David Snowberg
Capability Areas of Expertise Description: Project and technical risk register development. Manufacturing process failure modes effects analysis.

Category: Emissions Analysis/LCA
Point of Contact: Sherif Khalifa
Capability Areas of Expertise Description: Life cycle assessment of energy performance and environmental impact of wind energy; Standardized LCA methods and calculations. Circular economy modeling and analysis. Process modeling and scale-up.

Category: Community Benefits Analysis
Point of Contact: Chloe Constant
Capability Areas of Expertise Description: Outreach and engagement for community impact issues

and facilitation of information exchange; Cost/benefit energy impact analyses; Social science research of wind energy acceptance.

Category: Composites and/or magnetic materials manufacturing technologies design, process modeling, scaling, facility design, and digitalization
Point of Contact: Composites: Derek Berry, Pietro Bortolotti; Magnetics: Latha Sethuraman
Capability Areas of Expertise Description: Manufacturing processes at scale; Manufacturing optimization, including labor, cycle time, materials, CapEx, inspection, quality, energy usage, etc.; Integration new and emerging technologies to produce novel manufacturing processes.

Category: Characterization of recycled composite and/or magnetic materials and products
Point of Contact: Composites: Robynne Murray; Magnetics: Latha Sethuraman
Capability Areas of Expertise Description: Recycling and reuse research; Thermoplastic material system characterization and processing at scale; Industry collaborations across supply chains; High-impact, circular-economy research initiatives; Composite processing and structural validation. Magnet strength and performance characterization.

Category: Building and construction materials
Point of Contact: Michael Deru
Capability Areas of Expertise Description: Building performance simulations [including use of recycled materials], BIM model development, Assessment of building operational emissions, material selections impacts on building emissions.

Category: Mechanical size reduction
Point of Contact: Latha Sethuraman
Capability Areas of Expertise Description: Component design and size optimization as demonstrated in the MADE3D project.

Category: Waste material analysis
Point of Contact: Derek Berry, Sherif Khalifa
Capability Areas of Expertise Description: Modeling and analysis of composite waste from blade manufacturing; Prediction of future waste volume from turbine components; Material property characterization of recycled materials.

Category: Rheology - polymer and asphalt
Point of Contact: Sunilkumar Khandavalli
Capability Areas of Expertise Description: Rheological characterization of polymers, modeling of non-newtonian fluid dynamics for roll-to-roll processes. X-ray scattering testing.

Category: Computational fluid dynamics
Point of Contact: Michael Sprague
Capability Areas of Expertise Description: High- and mid-fidelity modeling of fluids and structures; High performance computing; Validation, predictive modeling, and simulation. Software engineering for open-source community codes.

Category: Thermodynamic modeling
Point of Contact: Chuck Booten
Capability Areas of Expertise Description: Heat transfer modeling, fluid mechanics, HVAC system analysis and testing.

Category: DFT simulation
Point of Contact: Jacob Clary
Capability Areas of Expertise Description: Density functional theory (DFT) and many-body "beyond-DFT" methods to predict materials thermochemical and optoelectronic properties. High performance computing.

Category: Mechanical testing
Point of Contact: Composites: Scott Hughes; Magnetics: Robb Wallen
Capability Areas of Expertise Description: Structural Research Facilities for material and structural characterization and validation; Industrial-scale Composites Manufacturing Education and Technology Facility; Composite multiscale validations; Composite performance characterization. Dynomometer facilities to test the reliability of magnetic components.

Argonne National Laboratory

Point of Contact: Jeff Spangenberger
JSpangenberger@anl.gov

The Materials Recycling R&D Group at Argonne develops cost-effective methods to recover, reuse, and recycle materials from end-of-life materials and various natural sources (e.g., ores, minerals, geothermal brines, produced waters, mine tailings, etc.). We conduct research at the bench/pilot scale and translate it into continuous, scalable operations. Our pilot lab includes many single or unit operations that can be rearranged to prepare and separate complex streams of material so that they can be recycled. We've worked on waste streams that include: lithium-ion batteries, electronics waste, auto shredder residue, metals, plastics, tires, and household appliances. We have scalable equipment that can recover and produce clean streams of plastics, metals, and other valuable or critical materials from waste streams. Dry material processing includes equipment such as a shredders, granulators, screeners, air classifier, color-based sorting equipment, rotary kiln, microwave furnace, as well as ferrous and non-ferrous separation equipment. Dry processing is used to prepare and concentrate materials for recovery and recycling. The heating processes in a rotary kiln or microwave furnace may be used to burn off carbonaceous material or react to a material with something else to improve extraction and separation. Wet material processing includes sink/float tanks, froth flotation columns, drum washer, mixers, filter press, tanks for dissolution/crystallization/precipitation, and membrane-based electrochemical separation systems to separate materials using aqueous solutions. Sink/float separations use simple density separations using salts to increase the density of the aqueous solution, froth flotation separates hydrophobic materials from hydrophilic materials by injection of small air bubbles in the aqueous solution, and kinetic based separations in the sink/float systems use the movement of aqueous solutions to separate materials by shape, size and density. Some wet material processing equipment (i.e., mixing and drum washer) will use non-aqueous solvents such as carbonate solvents (i.e. diethyl carbonate) for washing materials and dissolving or removing certain components. A material recovery process may utilize a combination of dry and wet material processing steps in order to increase the purity of a material for recovery or recycling. Capabilities List: Currently have ~3,000 ft2 of highbay space adjacent to the Materials Engineering Research Facility (MERF). Undergoing a renovation to increase this to 20,000 ft2 of highbay space with installation of new pilot-scale equipment for materials recycling and recovery.

- Materials preparation and feeding:
  - Shredding and granulating
  - Screw and belt conveyors

- Materials separation and purification:
  - Non-ferrous separation
  - Ferrous separation
  - Air classification
  - Wet separation (density, froth flotation, elutriation)
  - Liquid-liquid separation
  - Size separation
- Materials processing:
  - Low intensity screening
  - High intensity screening
  - Continuous centrifugal dryer
  - Furnaces/ovens
  - In-house materials characterization tools (FTIR, XRF, XRD, ICP-MS, ICP-OES, TGA-DSC, BET surface area, particle size analysis, SEM).
- TEA/LCA modeling tool:
  - We propose to leverage Argonne's R&D 100 Award-winning model EverBatt, which estimates the cost and environmental impacts of every stage of the battery recycling value chain and has been used by four winning teams of DOE's Lithium-ion Recycling Prize, to develop a similar model that can be used to evaluate U.S. domestic recycling solutions submitted to competition for the WTMR Prize.

QUESTIONS

Please send your questions to the Wind Turbine Materials Recycling Prize mailbox at: windturbinematerialsrecycling.prize@nrel.gov