The Institute for Advanced Composites Manufacturing and Innovation Circular Economy for Wind Workshop Report

Plaza Ballroom - The Henry Hotel - Detroit, Michigan

October 7, 2021

Authors: Mitchell L. Rencheck, Matthew Korey, Lillie Ghobrial, Derek Berry, and Soydan Ozcan

Introduction

Wind turbine blade waste is anticipated to amount to approximately 2.2 million tons or more by 2050 (more than the equivalent weight of 6 empire state buildings). However, no existing recycling technologies for the composites in wind turbines are currently at cost-parity with landfilling. As such, there is little industrial drive to recycle these materials, so they are currently buried. If it were possible to develop a circular economy for wind blades it could directly reduce material feedstock costs for many composites industries, facilitate the tremendous, anticipated growth of the domestic off-shore wind energy sector, and help the U.S. achieve net-zero manufacturing and energy generation. However, to enable circular economies for wind blades, several questions need to be answered. These include:

1. Why is it bad to landfill wind turbine blades?
2. Why isn't recycling blades at cost parity with landfilling?
3. What is the U.S. DOE's perspective on this problem and what do they plan to do about it?
4. What are people doing about this right now? What solutions exist?
5. What known and forthcoming barriers exist to recycling of composites in wind turbines?

This event was hosted as part of the Institute for Advanced Composites Manufacturing Innovation (IACMI)'s Fall Members Meeting in Detroit, Michigan. Representatives from academic institutions, national laboratories, chemical manufacturers, fiber manufacturers, wind turbine manufacturers, end users, recyclers, wind turbine repairers, investment firms, and the Department of Energy (DOE) participated in this 3-hour, hybrid virtual and in-person meeting. In total, 78 people attended on the phone and in person. The purpose of the meeting was to encourage collaborative development of technologies to generate market pull for end-of-life composites and decarbonize the wind energy technologies industry.

Workshop Summary

The workshop was opened by Dr. Soydan Ozcan – Oak Ridge National Laboratory (ORNL) – Chair of the Circular Economy Working Group and Derek Berry – National Renewable Energy Laboratory (NREL) – Chair of the Wind Energy Working Group. Dr. Robert Marlay – Director of the U.S. Department of Energy (DOE) Wind Energy Technologies Office (WETO) then shared the U.S. DOE perspective on the future of wind energy technologies. Dr. Marlay mentioned that to reach the WETO energy generation goal 50,000 wind turbine blades (WTBs) will need to be manufactured for new wind turbines and 80,000 blades will need to be manufactured to replace existing blades. A few areas of materials research were identified to be sustainable composites, thermoplastic resins, multi-functional blades, materials for improving reliability, repairability, and recyclability. Additionally, research and development ideas of next generation WTBs were automating and further scaling-up blade manufacturing, creating a circular economy for WTBs, light weighting WTBs, improving blade sensors, improving weather tolerance of WTBs, and

improving blade maintenance procedures and reliability. Dr. Marlay was followed by Steve Nolet – TPI Composites – who shared a comprehensive updated on the state of wind turbine manufacturing and other considerations. Mr. Nolet discussed the current landscape in blade recycling from an industrial perspective citing that 8,000 blades were decommissioned in 2021 and the cheapest option at end-of-life for decommissioned blades is to landfill. Mr. Seb Beloe – WHEB Asset Management – then gave a talk on the investment opportunities in the circular economy for wind energy technologies. Mr. Beloe mentioned that environmental/social/governance businesses are booming showing the opportunity for a growth in WTB recycling. However, it was also noted that just because WTB is recyclable does not mean it will be recycled. Dr. Aubryn Cooperman – NREL – gave an update on the size of the wind turbine waste market in the U.S. Dr. Cooperman commented about the 2.2M blades reaching end-of-life by 2040 and cited that there is a good business case for end-of-life WTBs to be integrated into infrastructure (i.e. shelters, bridges, etc.). Dr. Matthew Green – Arizona State University – gave an update on Research and Development Opportunities in Wind Energy. Dr. Green mentioned about ideal material requirements that current research is tackling such as increasing the mechanical performance while decreasing the weight and cost. Dr. Green also shared some current research about blade reliability using molecular force sensors to track damage as deformation occurs. Following the presentation portion, was a panel presentation facilitated by Lillie Ghobrial – ORNL – and included all speakers and Tyler Christoffel – U.S. DOE WETO.

The panelists fielding the questions of the audience for the panel discussion included Dr. Aubryn Cooperman from the National Renewable Energy Laboratory, Dr. Matthew Green from Arizona State University, Mr. Seb Beloe from WHEB Asset Management, Mr. Tyler Christoffel from the U.S. Department of Energy, WETO. The DOE's circular economy (CE) outlook is to reduce material usage, extending material/part lifetimes or life expectancies, and enable recyclability and re-use at end of life (EoL). From an industrial perspective being cognizant of CE and sustainability issues are leading to technological advancements (i.e. Big Area Additive Manufacturing at University of Maine). However, before CEs can be fully implemented into the wind industry, an economic case must be made by making CEs the least cost pathway industry wide. Industry panelists were in favor of prioritizing CE research at the industrial, national laboratory, and University levels in order to lower the cost pathway for developing a CE within the wind industry.

The baseline cost for landfilling WTBs was mentioned to be $70/ton, which should be taken as the metric to surpass when researching avenues of using EoL WTBs. A follow-up to this metric, questioned what the cost of recycling WTBs is today and would the DOE be able to subsidize? The possibility of congress to pass regulatory action on EoL WTBs would drastically change the cost to landfill WTBs and has the power to change socially driven decisions from investors to create more interest in CE research, especially within the wind industry. Additionally, as more WTBs are landfilled, space will become less available driving up the price per ton to landfill WTBs. As the cost of WTBs continues to increase, the minimization of the levelized cost of energy will be essential to compete with other energy generation methods.

Specific discussion of current CE research, regarding WTBs, was focused on thermoplastic blade materials. From an industry perspective there is a large amount of potential, but many challenges and projects await researchers. One such mentioned area was the weldability of thermoplastic resin candidates for WTBs as little research and insight is available. Concerns about the creep and fatigue of thermoplastic resins were expressed, but the panelists mentioned that the addition of fibers are able to

overcome this concern. Other comments were regarding about how Elium, a promising thermoplastic resin for WTBs, breaks down when thermally recycling, is able to be separated from the fibers at EoL, performs with respect to creep and fatigue as the resin is recycled beyond their primary lifetime? Other notable potential thermoplastic blade resins mentioned were polyethylene terephthalate (PET) as it has similar properties to epoxy with industrial readiness to process 50M lb/yr.

Brainstorming

There were two brainstorming break-out sessions- one held virtually and hosted by Derek Berry (NREL), Lillie Ghobrial (ORNL), and Mitchell Rencheck (ORNL), as well as an in-person brainstorming session hosted by Matt Korey (ORNL) and Steve Nolet (TPI Composites).

Virtual Brainstorm Takeaways:

- Interest in a possible demonstration project to take new vitrimer polymer systems and manufacture them into a WTB at NREL. The team at ORNL could then take that blade and recycle it back into a re-manufacturable feedstock to be re-integrated into the manufacturing line at NREL.
- Thermoplastics are a very promising options, but Elium is the main thermoplastic resin material familiar to industry. Others are in development but have low technology readiness levels. More work should be done to prove thermoplastic resin feasibility and scale up (e.g. Thermoplastic Blade Demonstrations).
- Smart separations of blades for better recycling and remanufacturing is a need, but a more direct connection and partnership with owner operators or those doing the decommissioning is also needed to understand their processes.
- Additional points were made by the recyclers, but the group did not get into detail and notated areas for further discussion, such as cost and environmental impacts of state-of-the-art wind turbine blade recycling pathways (e.g. cement kiln co-processing). Finally, it was determined that end of life recycling pathways need to be located at end use locations to minimize transportation costs and logistics.

In-Person Brainstorm Takeaways:

- It was uncovered that recovery options for end-of-life composites were of highest interest to the attendees, including re-use and re-manufacturing opportunities that re-integrate material at a higher point in the value chain for a composite part (a.k.a. upcycling).
- Demonstration project ideas were identified for direct re-use of WTBs including direct re-manufacturing of continuous, glass fiber-filled composites for applications such as bike racks, bridges, soundproofing, and marine rehabilitation.
- Direct utilization pathways at the point of use for WTBs were also identified by industrial recyclers including use of spar caps as railing for removal of end-of-life parts.
- The team was less interested in pursuing research technologies where composites are shredded and burned for energy and fiber recovery – except for pyrolysis – due to concerns about environmental sustainability. However, the advantage of mixed stream processibility of such systems offers a more short-term solution to the problem and should be pursued as well.

Conclusions

The conclusions from this workshop indicate that the potential to enable recycling, reuse, and better circular economy of the wind energy technologies space is tremendous. Currently, inhibiting the ability to recycle, reuse, and establish a circular economy in wind energy technologies are several logistical, business, and economical challenges that prevent widespread recycling in the U.S.. Potential scenarios that could change the wind energy technology recycling landscape are the ability of the DOE to subsidize wind blade recycling, congress passing regulatory action on blade recycling, and changing investor decisions to invest in research and development in WTB recycling. However, steps are already being taken to allow for better recyclability in next generation WTBs through the utilization of thermoplastic resins over thermoset resins. Further research and development efforts are underway in identifying thermoplastic resins, understanding the mechanical performance when reinforced, and characterizing how the thermoplastic resins will break down upon recycling.

Within the capabilities available to IACMI members, several obvious demonstration projects were identified. Exploring new vitrimer and thermoplastic resins in a blade demonstration was of high interest by all attendees. Other project ideas included opportunities for down cycling WTBs, either by transforming the blade into a structure such as a bike rack or bus shelter or by completely down-cycling the blade material for utilization in another application. Additional R&D areas requiring further investment to economically commercialize WTB recycling technologies were identified to be pyrolysis and cement kiln co-processing. From this workshop, an IACMI project team of academic, industry, and national lab representatives were identified to pursue direct utilization strategies for end-of-life WTB using facilities within the IACMI consortium. The group concluded that more discussion would be required, and a second workshop or meeting should be held to discuss details related to recycling of existing WTBs versus new materials for future WTBs.

Wind/CE IACMI Working Group Panel Notes:

- DOE CE Outlook
- Material use reduction
- Lifetime extension
- Recyclability/re-use
- What is CE perspective from industry?
- Sustainability issues are leading to technology development (BAAM at UMaine)
- What needs to be done to overcome barriers for commercializing?
- Nolet – economics is most important component
- CE needs to be lowest cost path
- Should be research priority
- What is likelihood in moving to thermoplastic blades?
- Huge potential, but a lot of challenges await for researchers
- Weldability is an area where little insight and research has been given
- Elium resin is thermoplastic because not crosslinked
- Thermoplastics have issues with creep and fatigue, does Elium follow that trend?
- Can overcome with fibers
- Does break down to monomers while other thermoplastics do not
- What happens to creep and fatigue process as the material begins to be recycled?
- How to separate out filler and elium resin?
- PET is similar to epoxy, so is it possible to return to monomer?
- Has capacity to do 50M lbs/yr
- What is baseline cost for landfilling WTB?
- $70/ton (metric to beat)
- Follow-up: Where are we today with cost of recycling? And can DOE subsidize?
- Regulatory action by congress can change everything
- As landfill space decreases cost will increase
- What are thoughts from the investors to drive scalability research, tax credits?
- Government regulation can change social decisions
- Minimize LCOE, needs to still be able to compete with other sources of energy

Wind/CE IACMI Working Group Brainstorming Notes:

How can the national labs support industry CE goals for wind?

- Change in processing materials (lower cost)
- Labs can support feasibility, demonstration, and validation of the industry and university R&
- Develop separations technology
- Project Idea: Cut out certain parts on-site and send off parts to appropriate end of life solution

What is the highest-risk, highest impact R&D we need to focus on?

- Need non-central processing/recycling to make cost-effective. Need localized solutions near areas with high wind turbine density
- Develop scale-up of novel blade material and demo blade
- The solution should be focused on cost-effective decommissioning (separation, on-site recycling, etc.)
- Short term
- Workforce development
- Labor
- Repurpose
- Long term
- Future materials

How do we create a market pull for recycled wind blades?

- Create higher value in material through separation
- Make solution more cost-effective than landfilling

What is the current knowledge related to state of R&D and other knowledge gaps that need to be rectified?

- Clear terminology
- i.e. are we recycling or actually downcycling?
- How is the field defining sustainability

Where/how can we create public/private partnerships? Where can we partner?

- Engineering education for undergraduate and graduate students on composites, sustainability, and circular economy development

Industry R&D Needs/Potential Projects:

- Take new materials (vitrimer/resin system with filler) and manufacture into 13m blade to be tested at NREL. Then, recycle and re-manufacture another 13m wind blade to be tested at NREL.
- Novel blade material selection => blade manufacturing and structural analysis => re-use/recycle => blade manufacturing and structural analysis
- TEA of recycling process (estimated costs from lit review and data collection from labs)
- Ge-co processing not close to commercialization (more than a few years out)
- Localize end of life solutions to areas with high density of wind turbine blades to avoid transportation (cost reduction as major metric)
- Demonstration and exploration of down cycled solutions for wind turbine blades currently in use
- Bike racks, components in bridges, sound walls near interstates and highways
- Coral reef development (industry partner Orbital)
- Down cycling project idea: Decommissioned wind turbine blade would be sent to carbon rivers for Epoxy-GF material retrieval. The epoxy-GF composite would be sent to ORNL for mechanical recycling or size reduction. Granulate or sheets would be sent to Orbital for use in down cycled application such as housing, inserts/laminates, artificial coral reef. NREL would conduct and LCA of the whole process.

Attendee List

Name	Attendance Type
Badesha, Amolak	In-person
Balgude, Abhijit	Virtual
Bassetti, Steve	Virtual
Beloe, Seb	Virtual
Benson, Bowie	In-person
Berry, Derek	Virtual
Bhagia, Samarthya	Virtual
Brosius, Dale	In-person
Campbell, Mike	In-person
Christoffel, Tyler	Virtual
Cieslinski, Mark	Virtual
Cooperman, Aubryn	Virtual
Coughlin, Dan	Virtual
Davis, Dustin	In-person
Deo, Ravi	Virtual
Dereims, Arnaud	Virtual
Dignan, Mariah	Virtual
Dorgan, John	Virtual
DRZAL, Lawrence	Virtual
Duncan, Ashley	Virtual
Fox, Joe	In-person
Franc, Alan	In-person
Ghobrial, Lillie	Virtual
Ginder, Ryan	In-person
Gordon, Brian	Virtual
Green, Matthew	Virtual
Haight, Jeremy	Virtual
Halil, Tekinalp	Virtual
Hallissy, Benjamin	Virtual
Halsband, Adam	In-person
Halsband, Adam	Virtual
Hardin, Rich	Virtual
Hardin, Richard	In-person
Hartman, Liz	Virtual
Henao-Barragan, Yulizza	Virtual
Henken, William	In-person
Hopkins, John	In-person

Johnson, Stephen B	Virtual
Jones, Ross	Virtual
Kardos, Marton	Virtual
Knouff, Brian	In-person
Koester, David	Virtual
Korey, Matthew	In-person
Kort, Kenneth	Virtual
Lambert, Greg	Virtual
Mainka, Hendrik	In-person
Marlay, Robert	Virtual
Morgan, David	In-person
Murray, Ben	Virtual
Narasimhan, Kamesh	In-person
Norris Jr, Robert E.	Virtual
Ozcan, Soydan	Virtual
Pachha, Ranjit	Virtual
Penumadu, Dayakar	Virtual
Perraut, John	In-person
Radford,Donald	Virtual
Rangarajan, Arvind	Virtual
Raybon, Michelle	Virtual
Rencheck, Mitch	Virtual
Retz, Kevin M	Virtual
Selim, Mohamed	Virtual
Sickels, Mark	Virtual
Sloan, Jeff	Virtual
Snowberg, David	Virtual
Squires, Cindy	Virtual
Stephenson, Scott	Virtual
Stonecash, Jared	In-person
Swan, Dana	In-person
Szegner, John	Virtual
Tasca, Coryne (CONTR)	Virtual
Vaidya, Uday	In-person
Villez, Kris	Virtual
Walker, Roo	Virtual
Winkel, John	Virtual
Wylezinski, Andrzej	Virtual
Zhang, Mingfu	Virtual
Zhao, Xianhui	Virtual
Zuzek, Ashley	Virtual

Circular Economy for Wind Workshop Agenda

October 7, 2021

12:30pm-3:00pm EST

Microsoft Teams: Please register on the IACMI website to receive call-in information

Plaza Ballroom - The Henry Hotel - Detroit, Michigan

For issues or questions, please contact Kim Hoodin, IACMI Event Manager at khoodin@iacmi.org

About this Workshop:

Wind turbine blade waste is anticipated to amount to approximately 2.2 million tons or more by 2050 (more than the equivalent weight of 6 empire state buildings). However, no existing recycling technologies for the composites in wind turbines are currently at cost-parity with landfilling. As such, there is little industrial drive to recycle these materials, so they are currently buried. If it were possible to develop a circular economy for wind blades it could directly reduce material feedstock costs for many composites industries, facilitate the tremendous, anticipated growth of the domestic off-shore wind energy sector, and help the U.S. achieve net-zero manufacturing and energy generation.

To enable circular economies for wind blades, several questions need to be answered. Several are identified below, and the purpose of this meeting is to answer them:

1. Why is it bad to landfill wind turbine blades?
2. Why isn't recycling blades at cost parity with landfilling?
3. What is the U.S. DOE's perspective on this problem and what do they plan to do about it?
4. What are people doing about this right now? What solutions exist?
5. What known and forthcoming barriers exist to recycling of composites in wind turbines?
    a. Technical barriers (i.e., wind blades aren't designed to be recycled)
    b. Supply chain limitations (i.e., not enough wind blade waste yet to supply any significant industry)
    c. Others, to be identified in the meeting
6. What are the capabilities of IACMI members (industrial stakeholders, national labs, academic institutions, DOE representatives, other key national associations, industrial recyclers, investment firms, etc.)?
7. How can we leverage the existing capabilities of IACMI members to circumvent the identified barriers in this meeting?

Hosted as part of the Institute for Advanced Composites Manufacturing Innovation (IACMI)'s Fall Members Meeting in Detroit, Michigan, this free and open to the public event includes in-person and virtual attendance options. Representatives from academic institutions, national laboratories, chemical manufacturers, fiber manufacturers, wind turbine manufacturers, end users, recyclers, wind turbine repairers, investment firms, and the Department of Energy (DOE) will benefit from participating.

Final Meeting Agenda

Topic	Time (EST)	Speaker
Welcome and Introduction	12:30-12:35	**Soydan Ozcan,** ORNL Chair, Circular Economy Working Group **Derek Berry**, NREL Chair, Wind Energy Working Group
U.S. DOE Perspective	12:35-12:50	**Robert Marlay, Director,** U.S. Department of Energy Wind Energy Technologies Office (WETO)
State of Wind Manufacturing and Considerations	12:50-1:00	**Steve Nolet,** TPI Composites
Investment Firms	1:00-1:10	**Seb Beloe**, WHEB Asset Management
Circular Economy	1:10-1:20	**Aubryn Cooperman,** NREL
Areas of Research Opportunity in Wind Energy	1:20-1:30	**Matthew Green,** Arizona State University
Panel Discussion	1:30-2:00	**Aubryn Cooperman,** NREL **Matthew Green,** Arizona State University **Seb Beloe**, WHEB Asset Management **Steve Nolet**, TPI Composites **Tyler Christoffel**, U.S. Dept of Energy, WETO ***Facilitator:*** *Lillie Ghobrial, ORNL*
Brainstorming Session	2:00-2:45	***In-Person Facilitator: Matthew Korey****, ORNL* ***Virtual Facilitator: Derek Berry, NREL/Lillie Ghobrial, ORNL***
Summary	2:45-2:55	**Matthew Korey**, ORNL **Derek Berry**, NREL
Closing Remarks	2:55-3:00	**Soydan Ozcan**, ORNL

About the Presenters

Soydan Ozcan, Senior R&D Scientist – Oak Ridge National Laboratory
Chair – IACMI Circular Economy Working Group

Dr. Soydan Ozcan is a Senior R&D Scientist in the Manufacturing Science Division of Oak Ridge National Laboratory (ORNL). Ozcan is currently the Thrust Lead for Development of Bio-Derived Materials & Manufacturing at the ORNL's Manufacturing Demonstration Facility (MDF). His research addresses the broad and vital issue of identifying novel, high-value biomaterials from renewable sources. He facilitates the development of composite recycling technologies and utilizing various composite techniques to repurpose them into useful applications. Ozcan and his team are developing manufacturing techniques and exploring new materials to improve energy efficiency during composite manufacturing, decrease material waste, and improve material cost and performance. Ozcan's team is integrating a smart circular economy concept within product development, production processes, use, and re-use systems right from the beginning. Applied R&D of Ozcan's team engages over thirty industrial partners and delivers research with more direct applications to society. Ozcan is also a prolific researcher published nearly 100 papers, holds 21 issued and pending patents, has published 9 book chapters, and has been an active speaker with more than a hundred presentations, and short courses are given on the manufacturing of materials related topics and research.

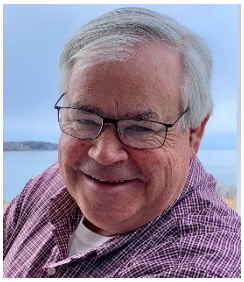
Derek Berry, Senior Engineer – National Renewable Energy Laboratory
Chair – IACMI Wind Energy Working Group

Derek Berry is a Senior Engineer at NREL and the Director of the Wind Turbine Technology Area within the Institute for Advanced Composites Manufacturing Innovation (IACMI), a Manufacturing USA Institute. He leads the NREL/IACMI team in the research of innovative composite materials and manufacturing for wind turbine blades and other components. Previously, he was the NREL Engineering Supervisor at the Wind Technology Testing Center in Boston, Massachusetts, where he was responsible for large-scale wind turbine blade test engineering operations. He also serves as the U.S. delegate to the International Electrotechnical Commission technical committee for Wind Turbine Blade Design and Manufacturing. Prior to NREL, Derek spent 15 years as a wind blade design, manufacturing, and testing engineer at TPI Composites. Derek is a graduate of the U.S. Air Force Academy with a degree in aeronautical engineering.

Robert Marlay, Director, Wind Energy Technology Office – U.S. Department of Energy

Dr. Robert Marlay is the Wind Energy Technologies Office Director in the Office of Energy Efficiency and Renewable Energy (EERE), a U.S. Department of Energy (DOE) agency. Over the course of his public service career, Dr. Marlay has held numerous leadership positions in DOE and with the U.S. Navy. He has worked in national security, science, energy research, technology development, and policy and international affairs. Before coming to EERE, he was the Director of DOE's Office of International Science and Technology Cooperation from 2010 to 2018, working with more than 40 countries. He also served as the founding Director of the U.S. China Clean Energy Research Center, a collaborative platform for joint research for the benefit of both countries. Three previous times, Dr. Marlay has worked in various leadership capacities at EERE. He started his Federal service as a GS-3, Engineering Aid, at the Weapons Systems Division in the Naval Air Test Center at Patuxent River, Maryland. He holds a Ph.D. in nuclear science and engineering from MIT and B.S. degree in engineering from Duke University. He is a licensed Professional Engineer; a Fellow of the American Association for the Advancement of Science; a recipient of DOE's Distinguished Career Service Award; and an Ambassador in DOE's Clean Energy Education and Empowerment initiative designed to attract, retain and advance the careers of professional women in the field.

Steven Nolet, Senior Director, Innovation & Technology – TPI Composites, Inc.
Steering Committee – Circular Economy Working Group



Steven Nolet is Senior Director for Innovation & Technology at TPI Composites, Inc. Warren, Rhode Island. He is responsible for managing the advanced development activities for TPI in both the company's wind and non-wind related businesses. In addition, Mr. Nolet's 40-year experience in design, manufacturing and testing of anisotropic materials, is used to provide guidance, oversight and support of engineering design programs that include advanced composite laminate analysis, Finite Element Analysis, 3-D modeling of structural systems for aerospace, transportation and renewable-energy applications. In addition, Mr. Nolet is closely involved with technical sales activities which include cost and technical proposal generation and sales support of new projects in a variety of markets including wind, transportation and automotive. Mr. Nolet also manages the growing TPI Intellectual Property portfolio and is a principal architect of the "TPI Academy" focused on technical training for the ever-expanding global engineering team. Steve holds a Master's and a Bachelor's degree in the discipline of Aeronautical and Astronautical Engineering from the Massachusetts Institute of Technology in Cambridge, Massachusetts and is a named inventor on more than 32 granted patents in the fields of composites materials, product design and manufacturing.

Seb Beloe, Partner – Head of Research, WHEB Asset Management

Seb Beloe has spent 25 years working at the nexus of business, investment and sustainability. Since 2012 he has been a partner and head of research at WHEB Asset Management where he is a member of the senior management and investment teams. Prior to WHEB, Seb was head of SRI Research at Henderson Global Investors, where he advised on investment strategy for more than £1bn of investments. Seb also spent ten years in senior roles at Sustainability, a leading think-tank and consultancy. Seb is part of expert committees for the BSi and sits on the advisory council of the Future-Fit Foundation. He has two degrees in environmental science and technology from the University of East Anglia and Imperial College, London.

Aubryn Cooperman, Researcher – National Renewable Energy Laboratory

Dr. Aubryn Cooperman is an engineering analyst at the National Wind Technology Center, part of the National Renewable Energy Laboratory. She specializes in technoeconomic analysis of wind energy systems in all phases of their life cycle, from design and installation to decommissioning. She holds a Ph.D. in Mechanical and Aeronautical Engineering from the University of California, Davis, where her research focused on active control of wind turbine blades.

Matthew Green, Associate Professor – Arizona State University

Dr. Matthew Green is currently an Associate Professor with tenure within Chemical Engineering at ASU. He joined the faculty at ASU in 2014 as an assistant professor. His research is focused on the design and synthesis of novel, ion-containing polymers to be used in applications such as water purification, carbon dioxide capture, nanocomposites, and micellar solution assemblies. He obtained bachelor's degrees in chemical engineering and chemistry (2007), and a doctorate in chemical engineering at Virginia Tech working with Prof. Timothy Long (2011). Then, he worked as a postdoctoral researcher at the University of Delaware in the Chemical and Biomolecular Engineering Department with professors Thomas Epps, III and Millicent Sullivan.

Tyler Christoffel, ORISE Fellow – U.S. Department of Energy

Tyler is an Oak Ridge Institute for Science and Education (ORISE) Science, Technology, and Policy Fellow on appointment at the Department of Energy in the Wind Energy Technologies Office (DOE-WETO). Tyler has been supporting DOE-WETO's technology R&D team for nearly a year in the areas of reliability, O&M, and circular economy. Prior to his fellowship at DOE, Tyler completed his B.S. in mechanical engineering and his M.S. in aerospace engineering at Penn State where he was involved in research in the areas of wind turbine generators (undergraduate research) and rotorcraft modelling and simulation (graduate research).

Lillie Ghobrial, Wind Energy Program Manager – Oak Ridge National Laboratory

Lillie is the Wind Energy Program Manager for Oak Ridge National Lab. She is also a Research Scientist in Advanced Composites Manufacturing and is the Technology Impact Manager for the Manufacturing Demonstration Facility at ORNL. Prior to joining ORNL in March 2021, she worked for the U.S. Department of Energy Wind Energy Technologies Office in several areas including as lead for the Manufacturing, Materials, and Design Innovation R&D portfolio and technology manager for materials, circular economy, and reliability projects. Lillie holds a B.S. in Physics and M.S. in Advanced Energy and has worked across clean energy technologies and industries for over 8 years.

Matthew Korey, Postdoctoral Research Associate – Oak Ridge National Laboratory
Co-Chair – Circular Economy Working Group

Dr. Matthew Korey specializes in the development of novel, circular economies for plastic materials. His doctoral work at Purdue University focused on designing for sustainability using bio-based materials for replacements for monomers, pre-cursor units, and additives for composite systems. His postdoctoral work focuses on mechanical, chemical, biological, and thermochemical methods of composite recycling and the use of advanced re-processing techniques to recycle industrial composites waste.