New Frontier for Construction Materials—Decommissioned Wind Blades (URR.7)
March 25, 2021, 9:00 AM – 12:30 PM EST[1]
***via* Microsoft Teams**

Agenda

9:00—9:30 a.m. **Introductions**

Terri Matthews, Director, Town+Gown:NYC @ New York City Department of Design and Construction
Bridget Anderson, Deputy Commissioner, Department of Sanitation of New York

9:30—10:30 a.m. **Wind Blade Repurposing R+D—The Re-Wind Network**

Lawrence Bank, Principal Investigator, The Re-Wind Network, City University of New York/Georgia Tech
Russell Gentry, US PI and US Team, Georgia Tech "**BladePole** — A wind blade repurposed as an electrical transmission pole"
Paul Leahy, Ireland PI and Irish Team, University College Cork and Munster Technological University "**BladeBridge** — A wind blade repurposed as a greenway footbridge"
Jennifer McKinley, Northern Ireland PI and Team, Queens University Belfast "**BladeLogic** — A GIS logistics framework for wind balde repurposing"

10:30—12:00 a.m. **Wind Blade Repurposing – Government and Industry Perspectives**

Jennifer McDonnell, Resource Recovery Program Manager, New York City Department of Environmental Protection
Peter Perrault, Senior Manager, Enel North America, "Perspective: Wind Energy Company"

[1] Recording of Event Planned for Later Posting to T+G Webpage

Jeffrey Elberling, Team Manager, Siemens Gamesa “Perspective: Turbine and Blade Manufacturer”
Jean Clarke, Environmental Advisory Group, Government Department of Environment, Climate & Communications, “Perspective: Ireland’s National Waste Policy”
Kieran Ruane, Lecturer and Chartered Civil & Structural Engineer, Munster Technological University-Cork, “Perspective: Midleton-Youghal Greenway”
Richard McLernon, Belfast City Council, “Perspective: The City Council”
Jonathan Hobbs, Northern Ireland Greenways, “Perspective: Greenway development in Northern Ireland”

12:00—12:30 p.m. **Open Discussion**

Introduction to URR.7. This event, the 7th in our Urban Resource Recovery (formerly Construction+Demolition Waste) series of events, will introduce, to City and State agency members of the Town+Gown community, the topic of wind turbine blade second-life and sustainability of the wind industry, its challenges and its opportunities for both public agencies and private industry. The technology for re-use and repurposing of wind turbine blades is still developing. There are a number of organizations around the world actively looking at this but very little in the way of public agencies engaged in this. This event is the first Town+Gown event that will help to change that.

The Urban Resource Recovery (URR) working group, formerly known as the Construction+Demolition Waste (CDW) working group,[2] is focused on supporting applied research and innovative policy design to close construction material loops. The URR has developed a Closing Loops City Program (CLCP) that initially focuses on recycled concrete aggregate, glass pozzolan and soil, with biosolids and other materials to follow and leverages the City's capital program to increase the re-use of all material generated within the City that is suitable for re-use in construction projects.

From the rapid development of wind energy technology in the past 15 years emerges the new problem to solve, which is how we will dispose of the non-biodegradable blades in current wind turbines in a sustainable way. The Re-Wind project aims at comparing sustainable end–of–life (EOL) repurposing and recycling strategies for composite material wind turbine blades using Data Driven Structural Modelling in a Geographic Information Science (GIS) platform coupled with environmental, economic and social Life– Cycle Sustainability Assessments (LCSA).[3]

The estimated lifespan of non-biodegradable blades is 20 years, which means that we will need to deal with these decommissioned blades in the near future. Under a project entitled "Re-Wind," an interdisciplinary research team comprising experts from City University of New York, Georgia Institute of Technology, University College Cork and Queen's University Belfast is seeking an alternative to unsustainable disposal methods such as landfill and incineration.

[2] Town+Gown working groups accelerate the action research cycle and move Town+Gown's work to the "thought leader" stage and toward a more systemic form of decision-making by providing an architecture for intentional, targeted intentional research projects focused on the identified research gap and increasing academic synthesis and translation of the results to serve as useful applied research resources for policy makers.

[3] See https://www.re-wind.info/.

The problem is one of enormous scale on several levels: a typical 2.0 MW turbine has three 50-meter-long blades containing around 20 tons of fiber reinforced polymer (FRP) composites. It is estimated that by 2050, 39.8 million tons of material from the global wind industry will await disposal. The project is funded under the US-Ireland Tripartite Research Agreement.

The composite nature of the materials used in the construction of wind blades (primarily glass fibers, resins, foams) makes them non- biodegradable and not easy to recycle. Hence, the project sets out to deploy innovative design and logistical concepts for reusing and repurposing these blades. The project began as a team-wide design ideation phase that was followed by workshop at the Digital Fabrication Laboratory at the Georgia Institute of Technology where architecture and engineering students designed and fabricated a prototype 15 m high tower structure from a decommissioned Clipper C96 wind turbine blade, shown below.

Re-Wind. The panelists at this event will focus on upcycling – reusing turbine parts and creating value added products for commercially viable enterprises for both the public and private good. There have been numerous recent conferences and reports sponsored by the wind and composites industries focused primarily on down-cycling and the immediate short-term desire to "make the blade waste problem just go away" and not on sustainable holistic solutions.

Re-Wind's research is being conducted in four fundamental scientific disciplines with specific intellectual foci: Wind Energy and Society, Design for the Built Environment, Structural Mechanics, and, Geographic Information Science (GIS). The objective of this research is to develop a methodology for use by relevant stakeholders – the national and local energy and waste management policy makers, wind energy company executives, wind turbine manufacturers and installers and community members. To make the research manageable and to test the methodology under realistic conditions the scope of the research is limited in both geography and the specific wind blades considered.

Wind Energy. The focus of this group is on the social, environmental and economic sustainability of reuse, recycle and disposal options for decommissioned wind turbine blades. The socio-political, market and community dimensions are considered alongside active community engagement strategies to carve out new market configurations for reuse products, producers and end-users. A key challenge will be quantifying and reducing the medium to long term environmental impacts of wind turbines. LCA's will be carried out to generate friendlier alternatives to landfill and incineration.

Structural Mechanics. The focus is on understanding the residual properties of wind blade composite materials at the end of their service lives, the appropriate load cases for the reused structures or products and their structural design.

Design for the Built Environment. The focus is on the design of systems across the built environment that drive change and best-practice in dealing with decommissioned wind turbine blades. Focus will be placed on developing outcomes that respond to specific geographic, social, cultural and economic scenarios as well as dealing with each blade's highly constrained material properties and geometries. The aim is to create a tectonic that goes beyond the obvious and drives innovation from surface to structure and from object to operation.

Geographic Information Science (GIS). The focus is on developing an open GIS system for wind blade reuse and recycling, containing embedded reuse design options and their environmental, economic and social impacts for subsequent network analysis.

New York State and Wind Turbine Blades: The State of New York's clean energy goals include the production 9,000 megawatts of offshore wind by 2035, and, since March 2018, the State has awarded a total of approximately 4,700 megawatts of new large-scale renewable energy contracts through three separate solicitations, which are expected to provide renewable energy to power up to two million households and meet nearly 10% of the State's electricity needs by 2025. In July 2019, the State completed a significant offshore wind agreement and a renewable energy procurement to produce approximately 1,700 megawatts with two offshore wind projects. The cumulative effect of these actions is intended catalyze significant supply chain investments by the offshore wind sector and position the State as a hub of the nation's offshore wind industry.[4]

Following these efforts, the State has also secured commitments from companies to manufacture wind turbine components within New York with: an offshore wind tower-manufacturing facility to be built at the Port of Albany; an offshore wind turbine staging facility and operations and maintenance hub to be established at the South Brooklyn Marine Terminal; increasing the use of the Port of Coeymans for cutting-edge turbine foundation manufacturing; and, buttressing the ongoing operations and maintenance out of Port Jefferson and Port of Montauk Harbor in Long Island.[5]

These plans will result in an increase in a locally-based supply of decommission wind turbine blades in the future, providing feedstock for up-cycling opportunities of these blades. It has been estimated that by 2050, the mass weight and volume of end of life blades in New York State will be 208,891 metric tons and 8.63 million m^3, respectively.[6]

Between 80 and 90 percent of wind turbine blades are "made of composite materials that combine high-tensile-strength fibers with polymer resins to form glassor carbon-fiber-reinforced polymers (GFRP or CFRP)."[7] Use of these composite materials make for "strong,

[4] See https://www.governor.ny.gov/news/governor-cuomo-executes-nations-largest-offshore-wind-agreement-and-signs-historic-climate.
[5] See https://www.nyserda.ny.gov/About/Newsroom/2021-Announcements/2021-01-13-Governor-Cuomo-Outlines-2021-Agenda-Reimagine-Rebuild-Renew.
[6] Aubryn Cooperman, Annika Eberle and Eric Lanz, "Wind Turbine Blad Material in the United States: Quantities, Costs and End-of-Life Options," *Resources, Conservation & Recycling*, 168 (2021), p. 8. See https://doi.org/10.1016/j.resconrec.2021.105439.
[7] *Ibid.,* p. 2.

lightweight, and durable" blades but will present "challenges for disposal."[8] Of the composite material, "60% to 70% is reinforcing fibers and the other 30% to 40% is resin [with] Balsa wood or foam . . . used in the core of the blade, [and] . . . gel coat and paint . . . used on the exterior; . . . steel fasteners, copper or aluminum lightning protection, and adhesive are other common components within turbine blades."[9] On the processing side, "separating these elements into homogeneous input streams for new uses is a key challenge . . . with composite materials presenting the most difficulty; [moreover, while s]ome recycling processes do not attempt to separate composite materials, . . . processes that do separate composites may be unable to reproduce the structural characteristics of virgin materials."[10]

New York State's "360 Series Regulations" (the "Part 360 regulations") promulgated by the New York State Department of Environmental Conservation (NYS DEC) cover the beneficial use of recovered urban resources generally. [11] The re-use of blades in whole or in large pieces would require a case-specific beneficial use designation (BUD) under 6 NYCRR 360.12(d) because there are not, at present, any pre-determined BUDs for these materials. The NYS DEC regulations outline the process for a case-specific beneficial use determination petition, conforming to requirements, to be submitted to NYS DEC, with NYS DEC determining in writing, on a case-specific basis, whether the proposal constitutes a beneficial use.

With respect to processing facilities, located in New York State, for these blades, where the blades would be crushed or shredded and various materials separated by magnets, eddy currents, relative density, solubility, these processing facilities would need a “facility permit” pursuant to 6 NYCRR Part 361. If most (> 85%) of the outgoing materials can be recycled, a recycling facility registration or permit under 6 NYCRR 361-1 may be possible. While BUDs are needed for the outgoing streams, all outgoing streams for a recycling facility registered or permitted under 6 NYCRR 361-1 receive an “automatic” (pre-determined) BUD under 6 NYCRR 360.12(c)(4)(i) so long as they are recycled and do not end up in disposal. In addition, NYS DEC could potentially grant a BUD to a cement kiln located in New York State that receives a feedstock derived from old blades under 6 NYCRR 362-1, but the facility making the cement kiln feedstock or fuel for cement kilns would need to be permitted as solid waste processing facililty under Parts 361 or 362.

[8] *Idem*
[9] *Idem*
[10] *Idem*
[11] This foundation survey is intended as general background information about NYS DEC's applicable 360 regulations as they may apply to the topics covered by today's event discussion.

Connecting to the Closing Loops City Projects Initiative. Potential capital project uses for decommissioned wind blades, from the Re-Wind DESIGN ATLAS,[12] with links to potential City capital program links, are listed below. Before some of these applications are feasible on City capital projects, however, private investment in Interim Processing Facilities and Higher Value Construction Materials Manufacturing will be necessary, which is specifically beyond the scope of this event.

- **Bleachers:** Long strips of blades or full smaller length blades could be used to construct bleachers (stands) for spectator seating at sporting, music or other events. *(Structure, horizontal, durable)* (Parks)

- **Noise Barriers:** Road and highway traffic noise is one of the worst noise pollution problems worldwide. As urban and residential sprawl encounters heavier and heavier traffic loads on nearby roads and highways, residents and communities are demanding better noise abatement. (*Acoustics, mobility, shield)* (NYC DOT, City Construction Agencies)

- **Wave Attenuator:** Blades or long strips could be either embedded on coastlines to attenuate breaking waves or could be floated horizontally to attenuate wave swells further offshore. (*Structure, embedded or floating*) (Parks, City Infra Construction Agencies working on coastal resiliency projects)

- **Bridge**: One or more wind blades are used to replace the girders of a pedestrian or vehicular bridge. These bridge deck is made of blade parts or of conventional decking materials (timber, concrete, FRP). *(Connection, urban landscape, mobility, bridge)* (Parks)

- **Pile**: The blade would be driven down through the earth to create a stable pile foundation. Concrete could fill the blade and be encased. *(Foundations, structure, inert)* (City Construction Agencies)

- **Tank**: Root profiles could be reconstituted to create various sizes of tanks, these could be buried underground and serviced with existing plumbing infrastructures; given the properties of the turbine blade, the walls of the tank would be waterproof. *(Root section,*

[12] See 10.13140/RG.2.2.13426.32960; Nov 2018 This work is licensed under Attribution-NonCommercial-ShareAlike 4.0 International (CC BY-NC-SA 4.0)

surface, waterproof, inert, interface with existing infrastructure) (City PB Construction Agencies)

- **Cell Tower:** Blades would be embedded vertically in the ground to create cellular towers. Since FRP is electromagnetically transparent the transmitters could be placed inside the section and wiring would be internal. *(Structure, electromagnetically transparent, strong under wind loading)* (DoITT)

- **Façade**: Profiles would be cut out of blades in order to create a range of wall panel sizes. The material could be cut in order to create a series of openings. Thermal layers could be bonded to the already composite material. *(Separation, Acoustics, Thermal performance, texture, relief, openings)* (City PB Construction Agencies)

- **Roof Truss**: Profiles of the blade could be used to create complete roof sections, watertight surface; in pieces, smaller sections could act as trusses interfacing with other roofing materials. *(Double curve profiles, load bearing capacity, structure, interface with other materials)* (City PB Construction Agencies)

- **Chimney Liner**: Full blades could be used as chimneys or as interior liners for concrete/brick industrial chimneys similar to existing FPR liners; the material would be cut out in strips and to line chimneys; the thermal properties of the blade could be exploited to further the lifespan of the chimney; heat resistance may be an issue. *(Thermal performance, longevity, melting point, ease of maintenance)* (City PB Construction Agencies)

- **Geo Retention:** Can be used to hold back earth for a range of applications across commercial or domestic construction sites; size of blade can vary depending on required application. *(Stackability, interlocking, load bearing capacity, length of span)* (City Infra Construction Agencies)

- **Louver Blades:** Cut to length, can be deployed to service a range of ventilation systems; given its air foil geometry, air or even water can be channeled to maximum effect. *(Acoustics, compatibility with other materials, size)* (City PB Construction Agencies)

- **Quiet Pods:** Pod units could be constructed from the root of the decommissioned turbine; the relative simplicity of the circular geometry provides opportunity to face and join with

other materials. *(Acoustics, compatibility with other materials, size)* (City PB Construction Agencies)

- **Barriers:** Various profiles could be crafted into a range of responsive barrier systems that can be customized depending on specific requirements. *(Double curve, acoustics, strength, durability)* (City Construction Agencies)

- **Skate Park**s: Parts of the curved surfaces of blades are embedded in a contoured landscape to create a skate park - some concrete work also needed. *(Double curve profiles, load bearing capacity, surface friction)* (Parks)

- **Storage or Recreation Structures:** The blad leading edge section is used as a barrel vault for storage or recreational structures. *(Archway, embedded or supported)* (Parks)

- **Emergency Shelters:** Large wind blades can have root diameter of up to 5 meters; the root segment of medium to large wind blades can be modified and used for emergency shelters. (OEM)

- **Doors:** The flat parts of the blade could be used for many commodity items requiring flat sections; for building, can be used for doors and window shutters for permanent or temporary protection against wind/rain. *(Small parts, compatibility with hinge, decorative, durable, acoustic)* (City PB Construction Agencies)

- **Roof Section**s: Sections could be mounted and overlapped laterally to create a roofing system; turning and rotating these parts will create a watertight seal. *(Watertight, flip, preventing leakage, connected, overlapping)* (City PB Construction Agencies)

- **Aggregate:** Blade material from the solid composite parts could be cut up and used as a replacement for large (4 mm to 50 mm) natural aggregate for bound or unbound filler; includes short bars for distributed reinforcement (needles). (Strength, abundance, ratios, size of pieces, lifespan) (City Infra Construction Agencies)

- **Filler:** Blade material from the solid composite parts could be ground up to cut up and used as a replacement for natural aggregate for bound or unbound filler. (*Strength, abundance, ratios, size of pieces, lifespan)* (City Infra Construction Agencies)

- **Arch and Pipe Culverts:** Wind turbine blades can significantly differ in their design and size; a large collection of wind turbine blades possesses a significant length of root segment which is straight and round, which could be used to create a series of root segments for pipe culverts. (City Infra Construction Agencies)

- **Benches**: Sections used to create benches and other public/private seating arrangements; parts could cantilever. (Parks)

- **Gateways:** Blades stacked and spanning could create a threshold space for a range of applications including large scale events, conferences, parks etc. (Parks)

- **Bus or Bike Shelters:** Blade sections used to control rain downpour and create shielding from horizontal rain. (NYC DOT)

- **Impact Attenuators**: Composite material have very good energy absorption in certain directions; large sections could be attached to concrete bridge piers in waterways for impact protection from ships could be attached horizontally to docks to act as bumpers/fenders. (NYC DOT, Parks)

- **Playground Equipment:** Given the property of the blade, these could be deployed outside to create a range of playground equipment. (Parks)

- **Pedestal Foundations for Building Construction:** Large diameter (1 meter +) root section is place vertically in ground and used a platform for a small house or multiple sections are used as round piles for large footprint; could also be used for non cylindrical parts (not the root) but needs more design; similar to piles if small diameters. (City PB Construction Agencies)

- **Fence and Perimeter Walls:** Smaller sections could be crafted into interlocking perimeter pieces that could collectively enclose various spaces. (City Construction Agencies)

- **Art Installations:** The raw material could be used in a variety of ways across a variety of disciplines from sculptors using medium to large sized pieces to create works or painters using the fibers and small pieces for texture and relief. (City Construction Agencies)

- **Aqueduct**s: Pieces could be used together to create small to medium scale aqueducts as a means of transporting water around allotment areas, gardens or parks. (City Construction Agencies)

- **Structural Concrete:** Fine Aggregate Blade material from the solid composite parts could be ground up and used as a replacement for fine (less than 4 mm) natural aggregate for bound or unbound filler (City Infra construction Agencies)

- **Unbound Road Base Coarse Aggregate:** Blade material from the solid composite parts could be cut up and used as a replacement for natural aggregate for bound or unbound filler. (City Infra Construction Agencies)

- **Reinforcing Bars for Concrete**: Long strip cut for the solid composite materials in the spar caps and root areas could be used for internal reinforcement for non-critical concrete members (slabs on grade, curb and gutter) (City Infra Construction Agencies)

- **Other Potential Uses:**

    - **Pontoons:** There is increasing interest around the world in floating offshore solar photovoltaic (pv) power; placing solar panels on water (either inshore or offshore) has several attractive properties; competition for other onshore land uses (agriculture, housing, industry, etc.) is eliminated; offshore pv plants are likely to have lower impacts on adjacent communities than onshore pv plants and may therefore be more socially acceptable. *(Floating, interwoven, water resilience, inert, electro transmittance)*

    - **Liquid or Granular Materials for Farming**: Flat shells are laid down above ground and used as troughs to store liquids (such as water) and grain (such as feedstocks); re-manufacturing needed to seal weep holes and ends and seat ends; good for agriculture in rural communities.

    - **Verticalizing Landfills:** Decommissioned Blades could be inserted into the ground around an existing landfill heap, to extend the height of the landfill and consequently the capacity; blades could be overlapped to increase strength, and

used to form a double ring around a current landfill; the inner part of the ring would be backfilled with support material.

- **Wind Attenuators:** Full blades or long strips of blades would be embedded in the ground to create wind barriers for attenuating wind in rural or urban areas, like trees are used in landscape.

- **Artificial Reefs:** Sections of the blade would be submerged into the water and cluster together to form a reef which over time will support marine life.

- **Furniture:** The blade could be used to create a series of furniture elements simply by embracing the existing geometries, or cutting the blade down further and re-assembling. (This work is licensed under Attribution-NonCommercial-ShareAlike 4.0 International (CC BY-NC-SA 4.0) 26 of 28 24 www.re-wind.info)

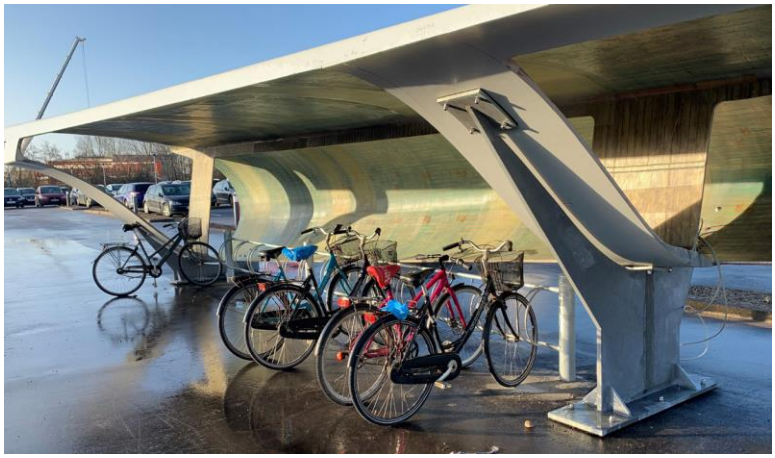
- **Floating Farms:** Blades fashioned together like a raft could serve a range of floating programs such as a farm; long profiles of the blade could be used to create troughs for plants and water storage areas.

- **3D Print Material**: Take the decommissioned wind blade and cut each member on site for easy transport to a local micronisation facility to be turned into a powder-like material; once turned into a powdered substance, the material can be used across a range of powder bed ink-jet head 3D printers Micronisation, ink-jet printing, *(Additive fabrication, binding material, free-form)*

Images of Wind Turbine Blades in Use

Re-Wind BladeBridge, cutting blade to build pedestrian bridge

Re-Wind BladePole, cutting and machining blade for power pole



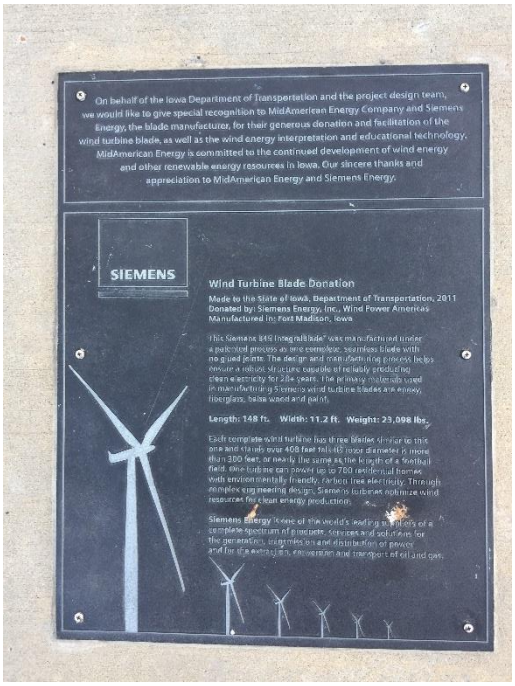
Port of Allborg, Denmark

Superuse Studios, The Netherlands

Anmet, Poland

Noise Barrier, Miljoskarm, Denmark

from https://windeurope.org/data-and-analysis/product/decommissioning-of-onshore-wind-turbines/



Reststop, Casey IA, I-80 Westbound

Presenter Bios

Bridget Anderson is the NYC Department of Sanitation's Deputy Commissioner for Recycling and Sustainability. She is responsible for planning, implementation, and tracking of DSNY's sustainability activities including recycling, composting, HHW and ewaste, textile recovery, and waste reduction. Ms. Anderson directs the agency's sustainable waste management policy research and program development, and its strategic partnerships with the local reuse sector. She has overseen NYC's curbside composting program from its 2013 pilot rollout, through its expansion to a third of NYC residents by 2018, and then its suspension during the COVID-19 pandemic and related budgetary crisis. During COVID, she and her team have managed the city's inter-agency Emergency Home Food Delivery program "GetFood NYC" serving over 1.5 million homebound and food insecure New Yorkers to date.

Lawrence (Larry) Bank has a faculty appointment as a Research Engineer at the Georgia Institute of Technology and an Adjunct appointment at the City College of New York. From 2014-2015 he served as a Program Director in the Materials Engineering and Processing (MEP) at the US National Science Foundation. From 2010 to 2013 he was the Associate Provost and then Vice President for Research and Sponsored Programs at the City College of New York. From 2008 to 2010, he was the Program Director for Structural Materials and Mechanics (SMM) at the US National Science Foundation while on leave from the University of Wisconsin-Madison. Dr. Bank received his BSc degree from the Technion in Israel in 1980, and his MS and PhD degrees from Columbia University in New York City in 1982 and 1985, respectively. Prior to this Dr. Bank studied in the School of Architecture and the School of Civil Engineering at the University of Cape Town in South Africa. He has previously been employed as a Structural Engineer with LERA (Leslie Robertson and Associates) in New York City, and as a faculty member at Rensselaer Polytechnic Institute (RPI), The Catholic University of America, the University of Wisconsin-Madison, and the City College of New York (CCNY). He is the author of the textbook "Composites for Construction," (Wiley, 2006), over 200 technical publications, and 9 patents and invention disclosures. He is a Distinguished Member of the American Society of Civil Engineers (ASCE), Fellow of the American Concrete Institute (ACI) and a Fellow (and Past President) of the International Institute for FRP in Construction (IIFC). *Russell Gentry* is the Director of the Digital Building Laboratory and Associate Professor of Architecture and Civil Engineering at the Georgia Institute of Technology. He teaches graduate courses in building structures and computationally-driven design, fabrication and construction systems.

Jean Clarke is Senior Advisor at the Environment Advisory Unit of the Irish Government Department of the Environment, Climate and Communications. Jean has worked on policies in the areas of circular economy, waste, reducing the use of plastics, and has served on the National Waste Prevention Committee.

Jeff Elberling works for Siemens Gamesa Renewable Energy (SGRE) as a chief engineer within their Service Innovation division, based just outside of Detroit, MI. His work focuses on optimizing operational performance of SGRE's global service fleet, specializing in blade-related technology developments in end-of-lifetime solutions, inspection methodologies, condition monitoring, surface treatments & protections, and automation & robotics. Jeff began working for Siemens Wind Power in April 2010 as a mechanical service engineer for several years before serving as the team lead for the composites/blades engineering team, as well as the team manager for the Service R&D Blades Performance team. Jeff is originally from Michigan and graduated from Michigan State University in 2009 with a B.S in Mechanical Engineering and a B.A. in Spanish.

Russell Gentry leads the Design Thrust of the Re-Wind project that is developing re-use applications for decommissioned wind turbine blades. He was Visiting Research Professor at Queen's University Belfast, working on Re-Wind research in Ireland during the 2019-2020 academic year. Dr. Gentry is the chair of ASTM D30.10, Composites for Civil Structures and co-chair of American Concrete Institute Committee 440K – Material Characteristics. He serves on the editorial board of the ASCE Journal of Composites for Construction and on the Council of the International Institute for Fiber Composites in Construction (IIFC).

Jonathan Hobbs is a volunteer campaigner on active travel issues in Belfast, Northern Ireland. He established the "Northern Ireland Greenways" campaign in 2012 to raise awareness of the potential reimagining of the country's abandoned railway network - which secured the backing of a government strategy in 2016 - and also runs the "Bikefast" campaign on everyday urban cycling issues in Belfast.

Paul Leahy is Lecturer in Wind Energy at University College Cork, Ireland, and a Funded Investigator at the Science Foundation Ireland MAREI Centre for Energy, Climate and Marine Research. He holds a B.E. from UCC (Electrical Engineering, 1995) and a PhD in Plasma Diagnostics for Fusion Energy (UCC and Culham Centre for Fusion Energy, 2001). Dr. Leahy's research team investigates topics in wind energy, energy storage and climate change impacts. He is a Principal Investigator of the Re-Wind circular economy project on repurposing end-of-life wind turbine blades where he works with colleagues and PhD students on environmental, social and business integration of wind turbine blade repurposing solutions, and also leads the H:Wind industry-academic collaborative project on offshore wind to hydrogen conversion.

Terri Matthews is Director of Town+Gown, an open platform Citywide university-community collaboration program, based at the New York City Department of Design and Construction that brings academics and practitioners together to create knowledge in the built environment. A graduate of Boston College, Boston College Law School and New York University Wagner Graduate School for Public

Service, Ms. Matthews has worked in both the public and private sectors. In addition to her public finance law experience at several national bond firms, Ms. Matthews' governmental experience at New York City spans both the legislative and executive branches. Her areas of focus have included public budgeting, public finance, performance measurement, public procurement and built environment public policy. She is admitted to practice in Massachusetts and New York.

Jennifer McDonnell is a resource recovery professional with fifteen years in the fields of solid waste, recycling and biosolids management. She brings a breadth and depth of experience to the field of waste water resource recovery having worked in the consumer products and grocery industries prior to specializing in organic and mineral residuals and biosolids (R&B). Jennifer's commitment to organics recovery was nurtured as the Green Mission Specialist for Whole Foods Market Northeast, where she led the adoption of commercial composting for over 40 stores. While at Casella Organics, Jennifer was part of the leadership team managing 800K tons/year of R&B throughout the Northeast. There she built expertise in composting, land application, codigestion, and product marketing. Currently the Resource Recovery Program Manager for the New York City Department of Environmental Protection, she is part of the Office of Energy, a group leading a renewed effort to increase the beneficial use of biosolids, realize GHG reductions, harness renewable energy sources and transform wastewater treatment to resource recovery. Jennifer has a dual BA from Brown University in Human Biology and Organizational Behavior, is a Certified Recycling Professional (Rutgers University), a Sustainable Resource Management Professional (SRMP) and a 2014 graduate of the Water Environment Federation's Water Leadership Institute.

Jennifer McKinley, Professor, Geography, School of Natural and Built Environment, Queen's University, Belfast, UK, is Director of the Centre for GIS and Geomatics and Director of Research for a cross disciplinary Environmental Change and Resilience Cluster, Queens University Belfast. Jenny is a Chartered Fellow of the Geological Society of London and Executive Council member of the International Union of Geological Sciences (IUGS). Her research involves the application of Geographic Information Science in sustainable energy, ground and remote sensed earth processes, health and the environment, criminal and environmental forensics. She has authored more than 100 scientific articles, including peer-reviewed journal articles and numerous international conference contributions. Interdisciplinary collaboration and strong partnership working underpins all of her research. Jenny is Principal Investigator for the US Ireland Re-Wind project for Queen's University Belfast.

Richard McLernon is the Resilience Project Coordinator in Belfast City Council, responsible for coordinating structures and workstreams linked to the Council and City Climate Plans. His background is in community development and community safety, more recently working on climate and resilience. The Resilience work programme was initiated through the Rockefeller 100 Resilient Cities Programme (now Global Resilient Cities Network) and has evolved into a climate planning programme, with a focus on Adaptation, Energy and Environmental Sustainability. Richard leads initiatives such as the Belfast One

Million Trees Programme, Belfast workstream of the Horizon 2020 Upsurge Project, and coordination of the internal and external climate programmes, working to the Commissioner for Resilience (now Climate Commissioner).

Peter Perrault is a Sustainability Management Certified Professional (SMCP) whose experience spans over 15 years working at the nexus of sustainability and technology. He was the first President of the Board of Directors for the Sustainability Management Association, and has "sat on all sides of the table" as a sustainability practitioner; within local government, NGOs, industry groups and global corporations. Peter has held leadership positions with the UN Global Compact Supply Chain Traceability Task Force, the Silicon Valley Leadership Group's Environment Committee, and was a member of the Technical Working Group that developed the WRI/GHG Protocol *ICT Sector Guidance* for emissions reporting. With Enel North America, Peter works across Enel business lines, leading the company's efforts in the region to transform its business towards an inclusive circular economy and to develop sustainable solutions for Enel customers. He received a Master's degree in Economics from University of San Francisco and his Bachelor's degree in Economics with a minor in Political Science from Humboldt State University.

Kieran Ruane is a lecturer in the Department of Civil, Structural and Environmental Engineering at Munster Technological University in Cork, Ireland. He is a Chartered Engineer with over 27 years' experience in the design and delivery of award-winning civil and structural engineering works of all scales. Kieran is a former Director of RPS Consulting Engineers where he was responsible for civil design services across a range of disciplines. Kieran is President of the Civil Engineering Research Association of Ireland for 2021 and 2022 and was Chairperson of the Institution of Structural Engineers (Republic of Ireland Region) in 2018 and 2019. He is a visiting lecturer at the School of Engineering at University College Cork. Kieran's research interests include bridge engineering and management, infrastructure asset management and computational modelling. He is currently working with the Re-Wind team on the design, testing and construction of a pedestrian bridge from decommissioned turbine blades which will be delivered to the Midleton – Youghal Greenway in County Cork in 2021.