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Natural Resources Research Institute

NRRI Now

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Weird and Warm

A Black-capped chickadee on a frosty winter day. Photo by Peter Lewis on Unsplash

Talk around the NRRI water cooler lately has been about our weird northern Minnesota winter. As I write this in late January, it's a wet, foggy day that can't decide to rain or snow!

But my wildlife ecologist colleagues tell me it's not all bad news -- nor all good news -- for the critters who contend with the weather rollercoaster in the northern woods. Deer may be enjoying easier foraging. Forest carnivores may have better hunting success. But their prey -- small mammals and rodents -- lose their protective snow cover, and may be having a tough time.

For the birders reading this, here's a bit more info from our NRRI Avian Ecologists:

Warm winter impact on birds>

What's your favorite (and least favorite) thing about the 2023-24 winter? Let me know and I'll share your thoughts in our March newsletter.

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NRRI launches $4.5M DOE 'Green Steel' project

Dan Carrigan and Matt Anthony load the potgrate pilot furnace at NRRI Coleraine.

June Breneman
Feb 8, 2024

U.S. Department of Energy and NRRI fund project to develop biocarbon to replace fossil carbon in steelmaking process

Duluth, Minn. – The University of Minnesota Natural Resources Research Institute (NRRI) in Duluth received a $2.9 million grant from the U.S. Department of Energy (DOE) matched with $1.6 million in NRRI internal funding to develop a bio-based carbon product to replace fossil fuel in electric arc furnace steelmaking. The project kicks off in February.

The research employs a patent-pending densification technology that can transform engineered biocarbon (often called biochar) into a product that can be used to replace fossil coal in the electric arc furnace (EAF) for steelmaking. EAF steel production is a more efficient and lower carbon emission process than traditional blast furnace steelmaking.

According to the World Steel Association, every ton of steel produced contributes 1.9 tons of carbon dioxide into the atmosphere. Even so, the American Iron and Steel Institute (AISI) says the U.S. steelmaking industry, predominantly using the EAF technology, is the cleanest and most energy efficient of the leading steel industries in the world. However, industry leaders are aiming to reduce or eliminate fossil fuels in the production process for an ultimate goal called “green steel.”

“At NRRI we are able to replicate some of the chemical, physical and metallurgical properties of fossil fuels using locally sourced woody biomass waste materials,” said Matt Mlinar, research group leader and co-principal investigator on the DOE project.

The DOE grant also includes funds to implement a unique, new internship program that will make the project’s STEM research activities available to rural northern Minnesota college students.

Non-Fossil Fuels 101

Fossil coal is made up of plants and other organic matter buried deep within the earth, subjected to intense heat and pressure over millions of years, becoming a concentrated carbon source. Engineered biocarbon is made by heating biomass in a low oxygen kiln. It is then pressed into briquettes or pellets to achieve properties that allow for direct substitution of the fossil coal used at the electric arc furnace.

Production of biocarbon-based pellets is carbon neutral, processing woody biomass resources and waste streams while capturing the off-gasses and recirculating it back into the system as an energy source. It also uses steel industry byproducts and other industry waste streams.

“Our goal will be to tweak the formulation and, by 2026, demonstrate this process at a tonnage scale in an actual steel mill,” explained Brett Spigarelli, the project’s principal investigator.

Introducing the Team

Brett Spigarelli, Principal Investigator and Senior Research Scientist: Spigarelli will be overall lead on the project and responsible for keeping it within scope.

Matt Mlinar, Co-PI and Minerals and Metallurgy Research Group Leader: Mlinar will be leading the management of the project. He will assist with keeping the project on budget and schedule.

Eric Singsaas, Co-PI and Materials and Bioeconomy Research Group Leader: Singsaas will lead the Materials and Bioeconomy team while serving as the subject matter expert on biocarbon.

Brian Barry, Chemistry and Materials Science Program Leader: Barry’s role is to employ advanced biocarbon characterization techniques to better understand the fundamental characteristics of the biocarbon.

Matt Young, Biomass Conversion Specialist & Engineer: Young will lead the engineered biocarbon optimization and production efforts.

Rod Johnson, Metallurgist and Endowed Taconite Chair: Johnson will lead the mineral and byproduct characterization efforts.

Tiffany Sprague, Diversity/Equity/Inclusion Leader: Sprague will be leading a first-of-its-kind diversity, equity, and inclusion action plan. She will implement a new internship program aimed at diversification of STEM activities related to this project.

Collaborators from outside of NRRI include techno-economic analysis expert Malek Alkasrawi, life cycle analysis expert Tait Bowers from Long Trail Sustainability, and diversity, equity, and inclusion expert Amy Myrbo from Amiable Consulting.

The mission of NRRI is to deliver integrated research solutions that value our resources, environment and economy for a sustainable and resilient future.

NRRI is 'catalyst' for sauna builders

Entrepreneurial co-founders Joel Vikre and Justin Juntunen stand by the Cedar and Stone company sauna in Duluth.

June Breneman
Feb 7, 2024

New materials meet extreme conditions to bring wood innovations into new markets.

No one knows for sure how old the sauna tradition is. Some literature dates the heat and steam bathing ritual to before 7,000 BCE in Finland.

But with the help of NRRI, two entrepreneurs are bringing new materials science to this well-loved tradition by subjecting cross-laminated and thermally modified wood to the extremes of the sauna environment.

“Moisture and extreme temperature swings are the enemy of wood,” said Joel Vikre, co-founder of Cedar and Stone Saunas. “Saunas go up to 200 to 210 Fahrenheit, then you walk away, and in the winter it’ll drop to well below zero pretty quickly.”

Traditional saunas in Europe are made with logs, “the gold standard,” according to Vikre. Solid wood construction doesn’t have gaps to hold moisture and heat gets evenly distributed inside.

But Vikre, and fellow co-founder Justin Juntunen, are innovating with cross laminated timber, sometimes called mass timber, for walls and floors. And they’re using thermally modified wood for siding and architectural design points.

The men were introduced to the materials science behind these wood innovations by NRRI’s wood products industry specialist, Patrick Donahue, who recently retired.

"As entrepreneurs, we have a weird penchant for risk," said Juntunen. "We go out and try new things, but we need that backup of science and data to support what we want to try. NRRI is a catalyst for us. We need their rigorous research to support the things we want to do or problems we're solving."

Beautiful & Functional

Thermal modification is wood heated in a low oxygen kiln, essentially cooking the wood, to make it more dimensionally stable, water resistant and imparting a darker, "tropical" wood color throughout. This chemical-free process was industrially developed in Finland and is widely marketed in Europe, but the industry is nascent in the U.S. Over some 20 years, NRRI has been testing the process on many varieties of domestic wood species and engineered wood materials, developing specifications to expand its use..

Photo right: Joel Vikre and Justin Juntunen stand inside a Cedar and Stone Sauna.

As a result of NRRI's research, Arbor Wood Co. started marketing thermally modified wood to high end architectural firms and is building a manufacturing plant in Bagley, Minn., that recently started up. Cedar and Stone plans to be one of their best customers.

"Working with Arbor Wood has been great. We're like kindred spirits, growing alongside each other," said Juntunen. (See video of their partnership here.)

The other wood innovation for their saunas – cross laminated timber – was more challenging to incorporate. A manufacturer in Ontario, Canada, had the materials but their processing backlog meant waiting a year for what they needed. So, with coaching from NRRI, Juntunen and Vikre decided to make their own.

Cross laminated timber, called CLT in the industry, is made of several layers of kiln-dried lumber boards stacked in alternating directions, bonded with structural adhesives, and pressed to form a solid, rectangular panel. Juntunen and Vikre found that it could be a modern version of solid logs for their saunas. They made their panels with specifically different wood species to impart unique properties. And they built a sauna that is still in active use by a client in Minneapolis.

"They love it. It's a cool, cute building," said Juntunen. "And still, no one has reproduced what we did with that CLT. But making those panels was a labor of love. It was very challenging."

The Ontario manufacturer agreed to sell them raw, uncut CLT, which could be shipped in a reasonable timeframe. Again, with coaching from NRRI, they bought an extra large circular saw and learned to process the CLT for walls, windows and doors.

Eventually, Juntunen wants to expand their CLT processing with a computer numerical control (CNC) router and make up the cost by selling services to external clients.

"And that will get us closer to building our saunas with local wood, because what we get from Ontario is mostly spruce," said Vikre. "We'd like to produce CLT with aspen, hemlock or white pine, which could be really interesting."

Afloat

Today the company employs about 40 people in full and part-time positions, building about three custom saunas a month. Since starting in 2020, they've seen about 65 percent growth each year, as they continue to innovate in their construction methods.

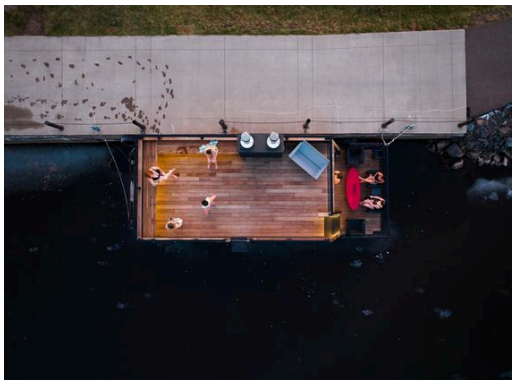

Photo left: Ariel view of sauna tied to a dock

And just to push the limits a bit further, a Cedar and Stone sauna is now afloat on Lake Superior near Canal Park in Duluth.

"So, CLT is wood and shouldn't get wet, right? But we put it on a boat. And the deck is made from thermally modified wood with wood framed doors and windows," said Vikre. "We'll find out pretty quickly if we destroy them or they can handle it."

Meanwhile, Cedar and Stone enjoys hosting new and experienced folks in Duluth and Minneapolis at their rental, community saunas, with a goal to host one million over the next decade.

"We're a stress-destroying company," said Juntunen. "And we also want to build as sustainably as possible. Our customers want something beautiful and they want saunas produced in America. We're trying to create a vertically integrated system with locally sourced materials."

NRRI Ongoing Research

NRRI continues to innovate with these materials, including developing a mass timber product from thermally modified wood.

NRRI Wood Products Program Manager, Matt Aro, is experimenting with wood strand-based mass timber materials produced from thermally modified balsam fir, a low-value, underutilized wood material commonly found in northern Minnesota. This project is funded by the U.S. Forest Service in partnership with Washington State University, the U.S. Forest Service Forest Products Laboratory, and industry.

Photo right: Matt Aro

NRRI and UMD's Bureau of Business and Economic Research are also conducting a market feasibility study for a Swiss company looking to develop a unique wood strand composite material called "Scrimber." The panels are efficiently made with higher performance and lighter weight than traditional mass timber.

"They want to scale-up and make prototypes of Scrimber panels for larger-scale testing, demonstration, and validation," said Aro. "Our study will help them to better understand if it's feasible to have a Scrimber plant in Minnesota."

To learn more about NRRI's Future Forest Industries strategic initiative, visit the webpage here.

Meet the Researcher - Sunil Tripathy

Sunil Tripathy stands by NRRI's pilot scale biomass conversion kiln at NRRI Coleraine.

June Breneman
Feb 7, 2024

Sustainability meets mining industry for this minerals engineer from India.

When Sunil Tripathy was ready to take his career in India's steel industry to a new level, NRRI and Minnesota rose to the top of his list.

"Its emphasis on the balance between academic and applied research – and the concept of mine-to-metal, as well as laboratory to pilot-scale – stood out as a key attraction," said Tripathy. "And I enjoy the customer interactions at the heart of iron ore mining operations. The alignment was an ideal fit for me."

Tripathy joined the team of mineral processing engineers at NRRI's Coleraine facilities near Grand Rapids, Minn., in July of 2023. The warm summer weather matched the humid climate of Jamshedpur, India – until it didn't, come January. "But the work-life balance at NRRI and the community in Grand Rapids made us feel at home in the United States," he added.

Photo left: Sunil Tripathy

Tripathy brings skills in geometallurgy, dry separation, iron ore beneficiation, and finding value in waste materials, which are especially valuable to the team. He had a long career as a researcher with Tata Steel and received a doctoral degree in Mineral Engineering from the Indian Institute of Technology (Indian School of Mines) Dhanbad, India in 2016. He also completed a postdoctoral fellowship at the University of Lorraine in Nancy, France, in 2021.

“I wanted to expand my research with a vibrant and dynamic team,” Tripathy explained. “At NRRI, we are seeking solutions for different sustainable indicators of mineral processing and metallurgy processes.”

Sustainable Projects

Minnesota’s variety of ferrous and non-ferrous ore deposits intrigues Tripathy as he focuses his research toward mining and minerals sustainability.

He’s currently working on a project with an industry collaborator to replace fossil fuels with engineered biocarbon in the lead battery recycling industry to reduce the carbon emissions footprint. Fossil coal (called coke in this process) is used in the lead smelting process, and Tripathy is working to understand the reducibility of different biocarbon resources to compare with fossil coal.

A second project underway is exploring dry options for minerals processing, to use less – or perhaps no – water in the iron ore flow sheets. He is also focused on water conservation in mining and mineral processing through the recycling of processed water through efficient and economical dewatering.

Tripathy most enjoys the cross-collaborative nature of the research across NRRI’s multi-disciplinary teams.

“I am working with the minerals processing and metallurgy team, which is collaborating with the biocarbon researchers, and soon will expand into geology and materials chemistry groups both at NRRI and UMD,” he said.

Off Hours

While research dominates his work life, he also enjoys browsing technical literature and taking on roles of editor or reviewer for many journals and funding agencies when away from work.

“But I also enjoy playing and watching cricket matches,” added Tripathy, who catches it on Netflix when he can. “I love to watch the winning strategy of the players while playing different formats – Test Matches, One Day Internationals and T-20s."

One Last Thing

Impacts of road salt

NRRI Environmental Engineer, Dr. Chan Lan Chun, is quoted in this Scientific American article: Why Does Salting Roads Make Them Safer?

Read the Article>

NRRI Organization Overview

NRRI was created by the MN Legislature in 1983 to deliver applied research informing environmental stewardship and economic development of the state's natural resources. It is a nationally unique model for integrated research focused on three strategic initiatives: Ecosystem Resilience, Future Forest Industries, and Iron and Minerals of the Future.

As part of the University of Minnesota system research enterprise, NRRI employs over 140 scientists, engineers, technicians, staff and students in two industrial research facilities. Through collaborative partnerships, we deliver the innovative tools and solutions needed to utilize and sustain Minnesota's valuable natural resources.

Find out more: NRRI website • Facebook • X • Instagram • YouTube • LinkedIn

NRRI Facilities Overview

NRRI has extensive laboratory capabilities to discover and deliver at the bench-to-pilot scales, reducing risk inherent in commercializing innovations.

NRRI Duluth has 19 labs that address the needs of land, wildlife, water and minerals research, as well as several technology development labs and the LP Innovation Center, developed in partnership with LP Building Solutions.

NRRI Coleraine, a former U.S. Steel R&D facility, is a 27-acre industrial-scale site that was acquired in 1986. The minerals processing and metallurgy labs provide bench to pilot-scale research to broaden the state's portfolio of ore resources while impacting process efficiencies and improved production of taconite. The engineered biocarbon product development lab tests processes for converting a variety of biomass into fuel and carbon materials up to commercial demonstration scale.

NRRI Fens is a 425-acre property near Zim, Minnesota, was acquired in 1986 to restore its function as a valuable peatland and fens bog after being drained in the 1950s for farmland. Decades of effort have restored the peatland - nature's most effective carbon sequestration solution - and the restoration credits were sold to state agencies. Ongoing research on the site will continue to inform successful peatland restorations across the nation.

NRRI Mission

Deliver integrated research solutions that value our resources, environment and economy for a sustainable and resilient future.

NRRI Vision

Discover the economy of the future.