Our first REMADE Circular Economy Tech Summit & Conference recently brought together the brightest minds in research, industry, and policy to make the Circular Economy a reality in the United States. Here are five key takeaways from our two-day event held March 20-21 at the National Academies of Sciences Building in Washington, D.C.:

- Nice ideas aren't enough
- Carrots and (measuring) sticks are needed
- Decision-makers need the right tools for the job
- Remember: Trash is cash
- The robots are here—to improve recycling and remanufacturing

Read on for a deeper dive into each takeaway.

The "how-to" Circular Economy conference

"We need to regenerate, eliminate, and circulate—all by design."

That's according to Andrew Morlet, who is the CEO of the Ellen MacArthur Foundation, one of the most influential advocates for building a circular economy to meet global challenges like climate change and resource scarcity. A circular economy is designed to keep materials in use for as long as possible, all while eliminating waste and regenerating natural systems.

Morlet's words were part of his opening address at the first REMADE Circular Economy Tech Summit & Conference, which was organized by the REMADE Institute in partnership with the Foundation.

With support from the U.S. Department of Energy (DOE), REMADE's two-day scientific conference showcased recent research into promising strategies and technologies for accelerating the transition to a circular economy. More than 300 attendees heard keynotes and plenaries from sustainability pioneers like Morlet, Nabil Nasr, Tom Graedel, and John Warner, and from Sally Benson of the White House's Office of Science and Technology Policy, and Diana Bauer from the DOE's Office of Energy Efficiency and Renewable Energy. Innovative thought-leaders Martin Stuchtey, Doyne Farmer, Kevin Surace, and Matanya Horowitz also spoke. Three themed tracks featured nearly 60 research presentations, sharing innovative technologies and analysis from leading universities and companies from across the United States and beyond.

If you missed it, the five takeaways below will give you a look at important lessons from the event about what we need to do today to get to a circular economy tomorrow.

1. Nice ideas aren't enough

According to geologist and economist Martin Stuchtey, "Circular economy decouples us from resource use, but, currently, it also decouples us from reality."

Far from putting a damper on circular economy as an idea, Stuchtey's comment during his keynote address aimed to catalyze action. He is the CEO and founder of the Landbanking Group GmbH, which has pioneered a method for economists to consider natural resources—coined "natural capital"—into how they make decisions. Stuchtey believes a circular economy demands a change in how we financially value assets, including those we take for granted in the natural world, like forests, lakes, and valleys.

Doyne Farmer, another economist and keynote presenter who is from the Institute for New Economic Thinking at Oxford University, echoed Stuchtey's urgency. He argued that shifting to 100-percent clean energy now could save the economy at least $12 trillion in energy systems costs alone by 2050. But, to get there, we need to transform economic modeling from the ground up.

Industrial ecology is a field where many of the fundamental concepts behind circular economy were born, beginning in the 1990s. One of the most important being a series of methodologies for thinking about the interactions of all the systems—economic, material, energy, social, and ecological—that sustain the world today.

Thomas Graedel, a professor emeritus at Yale University who co-authored industrial ecology's first textbook, currently studies the flows of materials within our industrial ecosystem. In his plenary presentation, Graedel presented research that tested actual recycling rates in intensive industries like steel production against modelled scenarios where maximum recovery rates were predicted based on current material flows. Not surprisingly, he found ample opportunity to recover and reuse valuable materials across industries.

John Warner opened his keynote with a reminder that our attachment to one approach over another—"nice ideas"—when it comes to circular economy is often counter-productive. Instead, Warner advocates for building mutual support to create a circular economy for industrial chemicals. The author of 1998's seminal *Green Chemistry: Theory and practice*, he pointed to the metabolic and regenerative processes found in ecosystems as evidence of what is possible for a greener chemistry.

But, Warner stressed, getting there means overcoming an immense challenge: Synchronizing innovation and cooperation across industry sectors and borders.

2. Carrots and (measuring) sticks are needed.

A company can do things within its walls to lower its environmental impacts, but it can't create a circular economy on its own. Businesses, consumers, and government all have roles to play—and, importantly—changes to make.

But what exactly does that look like? How will progress be measured? The need for policies, product standards, and metrics that can put meaningful numbers to circularity was stressed throughout the conference.

Policies that are designed to trigger radical shifts in how we produce and consume are still rare, but new initiatives are underway. Attendees learned about some of those from Sally Benson, a chief strategist at the White House's Office of Science and Technology Policy. She explained how the Biden Administration looks at circular economy from an impact perspective. How can a circular economy be leveraged to build strong supply chains, create more jobs, and cut emissions? How can it dovetail with efforts to improve air and water quality, secure the U.S. food system, and reduce reliance on the extraction of raw resources?

The free flow of data, especially from tools like life cycle analysis assessment (LCA) and industrial roadmaps, will be critical to raising the circular economy tide. This is according to Diana Bauer, who is deputy director of the U.S. Department of Energy's Advanced Materials and Manufacturing Technologies Office. During her keynote, Bauer laid out her office's goal of merging and scaling up

existing LCA databases and roadmapping strategies to coordinate access to knowledge across industry sectors.

A speaker from the National Institute of Standards and Technology (NIST) offered a look into the body's plans for circular economy standards. He pointed to NIST's plans to support early standards and guidance from the International Organization for Standardization and ASTM before eventually releasing tools for measuring circularity.

3. Decision-makers need the right tools for the job

The REMADE conference represented an important milestone in the evolution of circular economy from a theory into an actionable strategy for manufacturers and governments. For many presenters, the principal challenge now is to convert scientific analyses (like those of Graedel and other scientists) into practical tools that can guide decision-making at the ground level.

How can a business calculate its circularity?

Manufacturers in a circular economy need to factor in how much post-consumer, end-of-life material they can recover. It's likely that there will be an imbalance between their demand for products and materials and the availability of recovered material within their geographic location or industrial sector. This was the focus of a study from Cambridge University (United Kingdom), which introduced a calculator to determine a "circularity index" to better determine when circular systems can support low-carbon outcomes.

When is it profitable for a company to make a product more sustainable?

To answer this question, a researcher from MIT introduced a decision-support tool that models profit changes based on sustainability decisions. The tool allows businesses to set cost-reduction targets and gives them the ability to forecast profit growth based on different criteria. Of note, the research indicated the role that policies like carbon taxes could serve to incentivize sustainability product development without hindering business growth.

Another clear message throughout the conference was that circularity has to start in the design phase.

Researchers from Rochester Institute of Technology (RIT) presented a tool that merges current knowledge about remanufacturing—design for remanufacturing (DfReman)—into a plugin for common, off-the-shelf computer-aided design (CAD) products. They see such a framework as critical to realizing the full potential of remanufacturing, where used or worn parts and products are returned to a like-new condition, to enable circularity.

A presentation from the University of Illinois Urbana-Champaign introduced work to develop a tool that would allow designers to consider the entire life cycle of a product. It relied on a design process that integrates recovery, recycling, remanufacturing, and other circularity methods known as "design for re-X." If realized, it would account for contingencies that are unique to circular economy decisions, such as changes in the reliability of recovered materials and the wide variability they can present in terms of quality and condition.

4. Remember: Trash is cash

The rate of material that is recovered from today's waste streams and recycled into new industrial feedstocks will need to grow exponentially if a circular economy is going to work. A series of presentations at the conference explored strategies and technologies that could get us there.

If you think separating out plastic packaging at home is a pain, imagine how challenging it becomes when tons of different kinds of it need to be sorted at a recycling facility. A study from Michigan State University investigated whether it was possible to modify the properties of post-consumer polymers at the site of separation in order to return the valuable materials to manufacturers.

Post-consumer plastics are typically "down-cycled." That is, they end up in products or applications that are of a lower value than their original use. But a study from UMass Lowell wanted to find ways to "up-cycle" one of the most common—and most difficult to recycle—forms of plastic waste: low-density polyethylene (LDPE) films like those used for plastic bags. According to the researchers, upcycling recycled polymers into new uses could see the global plastics recycling market increase from a 2018 value of $37.8 billion to $72.6 billion by 2026. They concluded that upcycling recovered LDPE feedstocks comes down to a change in product design: Designers should embrace the properties of the recycled polymer, rather than designing in spite of them.

Imagine plastic packaging that, once discarded, broke down naturally within a few months into compost. Research presented from Sandia National Laboratory asked whether plant-based biodegradable plastics—currently limited to restaurant service-ware—could form the basis of "non-persistent" materials in a circular economy. But significant challenges will need to be overcome to get there: The study found that most composting facilities cannot accept biodegradable plastics. It also recognized that conventional plastic packaging keeps air, water, and light out to allow for shelf-stable products—all conditions that make biodegradable plastic break down.

The advent of "fast fashion" in the 20th century transformed how we buy, wear, and get rid of clothes. Today, the life cycle of textiles spans a complex process for extracting and processing raw materials, and then producing fabrics that are subsequently sent to manufacturers to make garments. While some post-consumer clothes get reused, most end up in landfills or are incinerated. As a presenter from Accelerating Circularity Inc. noted, blended textiles—which mix plastic and natural fibers—are very difficult to recycle.

To consider circular economy outcomes for clothing, it has to become easier for companies to sort textiles from the waste stream and trace the different materials they contain. A paper from the University of Michigan reviewed research into mechanical and chemical processes for sorting clothes that leveraged advanced technologies like QR codes, radio frequency identification (RFID), rare-earth fluorescents, fiber barcodes, and even synthetic DNA.

5. The robots are here—to improve recycling and remanufacturing

Sorting of post-consumer waste in recycling facilities is largely done by humans or by using brute mechanical techniques. The accuracy and fast-processing of artificial intelligence (AI) systems that use cameras and light sensors—a vision-inspection system—make it a perfect technology for sorting large volumes of waste materials.

A plenary by Matanya Horowitz, CEO of AMP Robotics Corp., showed how AI can enable entirely new sorting devices. Thanks to the incredible specificity that AI can achieve, these could be used to characterize waste materials much faster—and cheaper—than existing methods.

“AI is uniquely well-suited for recycling larger streams of waste, even municipal solid waste,” Horowitz noted. “It is ready to completely revolutionize sorting and separation at recycling facilities.”

Vision-based AI could also dramatically quicken the pace of material identification and sorting required by other industrial methods that can enable circularity. Two research projects led by RIT applied vision inspection to the remanufacturing environment.

Remanufacturers collect “cores”—used components and equipment from the market—and inspect them to determine if they can be successfully brought back to a like-new or better condition. An RIT study showed how vision inspection could streamline that process using machine learning to identify and classify collected parts. Another RIT paper applied a similar vision-inspection system to printed circuit boards retrieved from the market to speed the repair and recovery of valuable metals and components to accelerate the remanufacturing of consumer electronics.

Watch this space

According to REMADE CEO Nabil Nasr, the recent REMADE Circular Economy Tech Summit and Conference is the first of what will be many more.

“We have the *what* and the *why* of what circular economy can be. Now we need the *how*,” Nasr said. “And that’s where REMADE comes in. And that’s what this conference is all about.”

All conference proceedings will be published in a forthcoming book.