Sustainability benchmarks for plastics recycling and redesign

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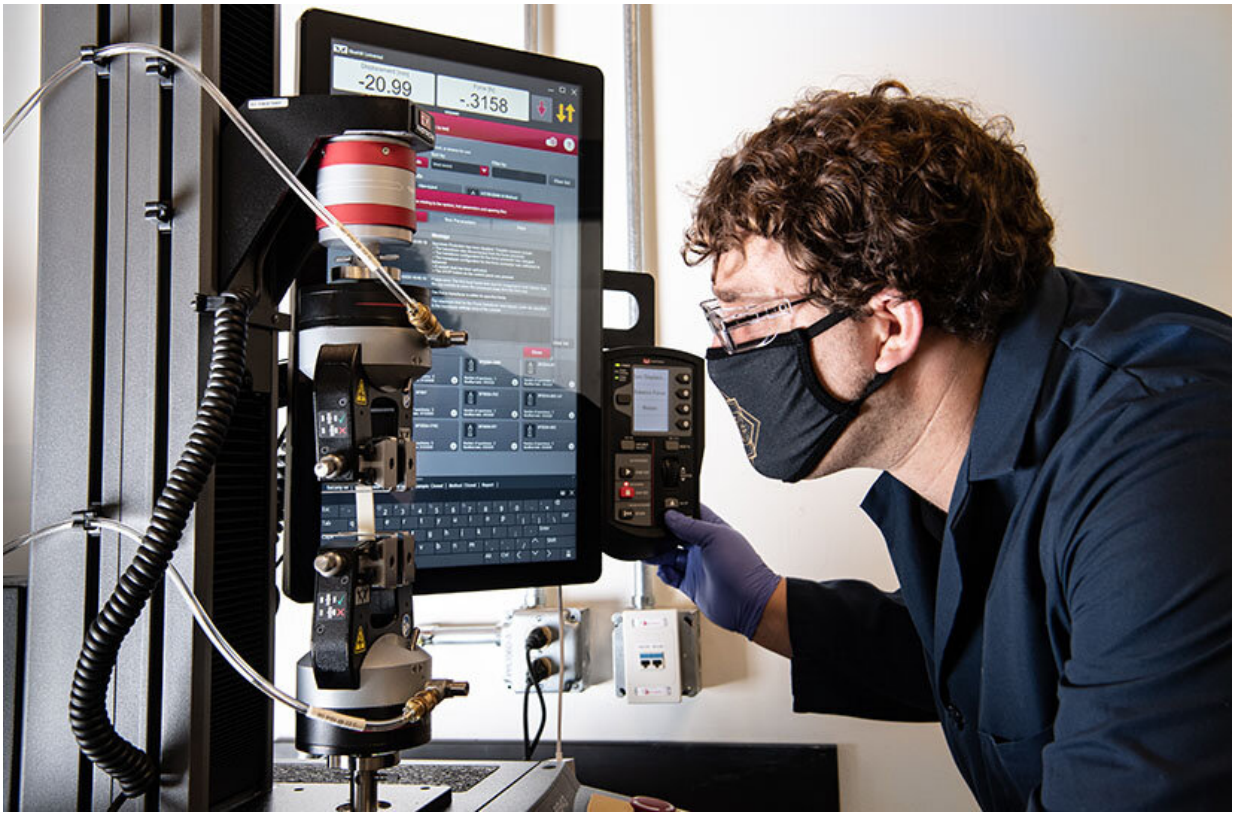

NREL researcher Nic Rorrer tests a sample of a new plastic formulation for its tensile properties. As part of Gregg Beckham's plastics research group, Rorrer is working on the redesign of nylon (aka polyamide) polymers so they can be chemically recycled with more efficient and less energy-intensive processes. Credit: Dennis Schroeder, NREL

Researchers developing renewable plastics and exploring new processes for plastics upcycling and recycling technologies will now be able to easily baseline their efforts to current manufacturing practices to understand if their efforts will save energy and reduce greenhouse gas emissions.

Benchmark data calculated and compiled at the National Renewable Energy Laboratory (NREL) provide a measurement—at the supply chain level—of how much energy is required and the amount of greenhouse gases emitted from the production of a variety of plastics in the United States.

"Today, we employ a predominantly linear economy for many of the materials we use, including plastics," said Gregg Beckham, a senior research fellow at NREL. "Many people and organizations around the world are looking at ways to make our materials economy circular."

To that end, NREL leads the BOTTLE Consortium, a partnership involving research laboratories and universities to develop methods to upcycle today's waste plastics and redesign tomorrow's plastics to be recyclable by design. BOTTLE stands for Bio-Optimized Technologies to keep Thermoplastics out of Landfills and the Environment.

Beckham is the senior author of a newly published paper in the journal *Joule*. The article, titled "Manufacturing energy and greenhouse gas emissions associated with plastics consumption," reports on 18 plastics, each with a global consumption of more than 1 million metric tons per year. The co-authors of the study, all from NREL, are Scott Nicholson, Nicholas Rorrer, and Alberta Carpenter.

The estimates draw from a resource developed at NREL, the Materials Flows through Industry (MFI) tool, which tracks energy and material flows throughout the manufacturing supply chain to estimate energy

requirements and greenhouse gas emissions.

"MFI is a publicly available tool that can be readily adapted for new technology options," Nicholson said. "We're constantly looking to add new production processes to the database. Researchers can request an MFI account and work with NREL to incorporate their own process data into the tool and calculate impacts for a proposed new supply chain."

Using the MFI tool, if a proposed manufacturing method is estimated to require more energy or produce more greenhouse gases than the status quo process, Nicholson said "a comparison of the sources and types of impacts can help us figure out what aspects of a new process could be targeted for improvement."

To give some context with respect to the broader industrial landscape, the polymers covered in this study represent approximately 95% of global production, a combined 360 million metric tons annually. According to the U.S. Energy Information Agency, plastics production accounted for about 11% of all manufacturing energy consumption in the United States as of 2014. The United States is responsible for generating the largest share of waste plastics in the world, according to a newly published analysis in Science Advances.

This MFI tool analysis reflects only U.S. consumption of plastics, considering where it is used on its own or incorporated into another material. Polyester fiber, for example, is not counted when it is used overseas to make clothes that are then imported to the United States. Future capabilities currently being developed by the MFI tool team will allow users to analyze global supply chains instead of just those based on U.S. manufacturing.

Two organizations within the Department of Energy—the Advanced Manufacturing Office and the Bioenergy Technologies Office—funded

the research. The work was performed as part of the newly formed BOTTLE Consortium, which is part of the Department of Energy's Plastics Innovation Challenge.

More information: Scott R. Nicholson et al. Manufacturing energy and greenhouse gas emissions associated with plastics consumption, *Joule* (2021). DOI: 10.1016/j.joule.2020.12.027