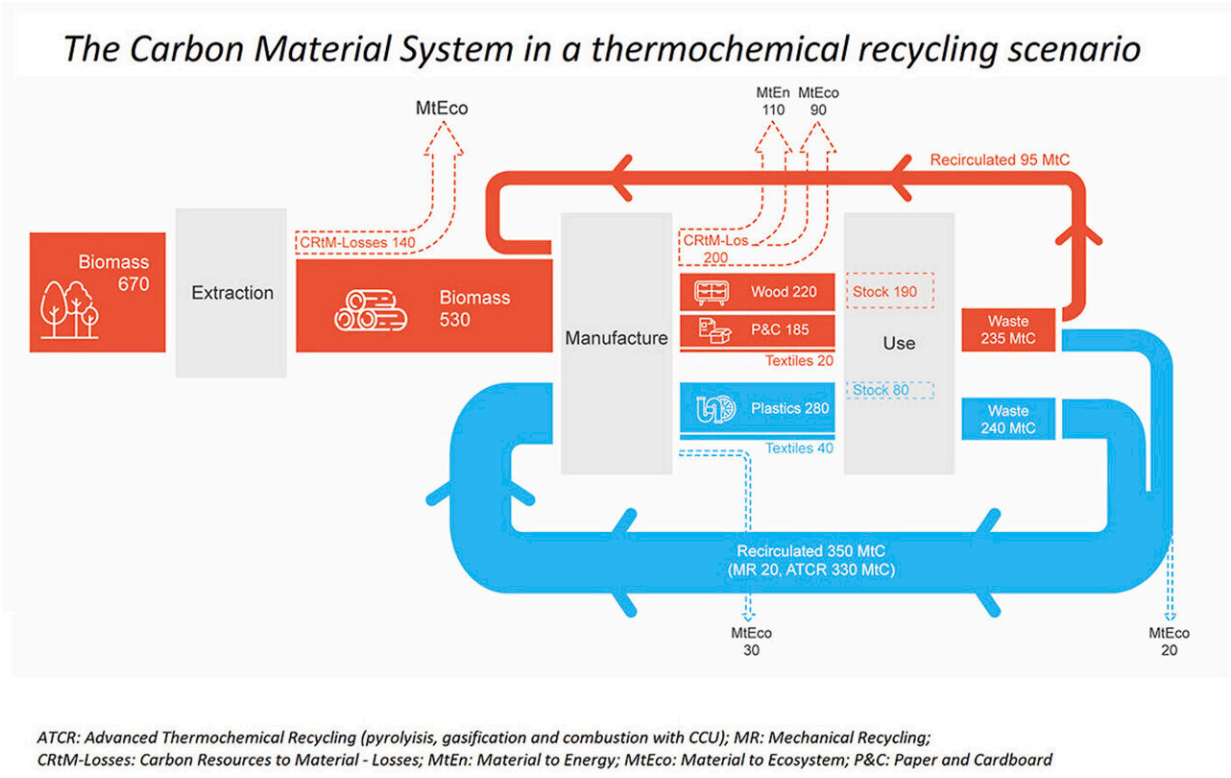
Pioneering recycling turns mixed waste into premium plastics with no climate impact

June 30 2022



Graphical abstract. Credit: *Journal of Cleaner Production* (2022). DOI: 10.1016/j.jclepro.2022.132674

Only a fraction of the material that could be turned into new plastic is currently recycled. Researchers at Chalmers have now demonstrated how the carbon atoms in mixed waste can replace all fossil raw materials in

the production of new plastic. The recycling method is inspired by the natural carbon cycle and could eliminate the climate impact of plastic materials, or even clean the air of carbon dioxide.

"There are enough carbon atoms in waste to meet the needs of all global plastic production. Using these atoms, we can decouple new plastic products from the supply of virgin fossil raw materials. If the process is powered by renewable energy, we also get plastic products with more than 95% lower climate impact than those produced today, which effectively means negative emissions for the entire system," says Henrik Thunman, Professor of Energy Technology at Chalmers University of Technology and one of the authors of the study published in the *Journal of Cleaner Production*.

To achieve circular cycles, we need to make better use of the resources already in use in society. Henrik Thunman and his research team want to focus on an important resource that often goes up in smoke today: the carbon atoms in our waste, which are currently incinerated or end up in landfills instead of being recycled. This is made possible with technologies targeting the carbon contained in plastic, paper and wood wastes, with or without food residues, to create a raw material for the production of plastics with the same variety and quality as those currently produced from fossil raw materials.

Just like nature

Current plastic recycling methods are able to replace no more than 15–20% of the fossil raw material needed to meet society's demand for plastic. The advanced methods proposed by the researchers are based on thermochemical technologies and involve the waste being heated to 600–800 degrees Celsius. The waste then turns into a gas, which after the addition of hydrogen can replace the building blocks of plastics. Using this recycling method could decouple new plastic products from

the supply of new fossil raw materials.

The researchers behind the study are developing a thermochemical recycling method that produces a gas which then can be used as a raw material in the same factories in which plastic products are currently being made from fossil oil or gas. Different types of waste, such as old plastic products and paper cups, with or without food residues, are put into the reactors at the Chalmers Power Central.

"The key to more extensive recycling is to look at residual waste in a whole new way: as a raw material full of useful carbon atoms. The waste then acquires value, and you can create economic structures to collect and use the material as a raw material worldwide," says Henrik Thunman.

The principle of the process is inspired by the natural carbon cycle. Plants are broken down into carbon dioxide when they wither, and carbon dioxide, using the sun as an energy source and photosynthesis, then creates new plants.

"However, our technology differs from the way it works in nature because we don't have to take the detour via the atmosphere to circulate the carbon in the form of carbon dioxide. All the carbon atoms we need for our plastic production can be found in our waste, and can be recycled using heat and electricity," says Henrik Thunman.

The researchers' calculations show that the energy to power such processes can be taken from renewable sources such as solar, wind or hydro power or by burning biomass, and they will be more energy-efficient than the systems in use today. It is also possible to extract excess heat from recycling processes, which in a circular system would compensate for the heat production currently derived from waste incineration, while eliminating the carbon dioxide emissions associated

with energy recovery.

Can replace fossil raw materials

The research has been carried out as part of the FUTNERC project. The researchers have proven that the process can work in collaboration with plastics manufacturer Borealis in Stenungsund, Sweden, where they have verified the results and shown that the raw material can be used to make plastic, replacing the fossil raw materials used today.

"Our goal is to create a circular economy for plastics. Our plastic products are key to the transformation to a sustainable society, so it's important for us to support research like this. We already have projects that create circularity for our plastic products, but more solutions are needed. Therefore, we are pleased with these excellent results, which can help bring us a step closer to our goal," says Anders Fröberg, CEO of Borealis AB.

The study, "Co-recycling of natural and synthetic carbon materials for a sustainable circular economy," was published in the *Journal of Cleaner Production*.

More information: Isabel Cañete Vela et al, Co-recycling of natural and synthetic carbon materials for a sustainable circular economy, *Journal of Cleaner Production* (2022). DOI: 10.1016/j.jclepro.2022.132674

Provided by Chalmers University of Technology

premium-plastics-climate-impact.html