

## Recycling Carbon Dioxide for Energy

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**M**arco Castaldi, head of the Combustion and Catalysis Laboratory, focuses his research on understanding catalytic and non-catalytic reactions that occur when carbon dioxide is introduced into thermal conversion processes such as the gasification of coal. He recently developed and tested a simple method for converting biomass to fuel in which he added carbon dioxide to the process. When he did, he found that he produced significantly more fuel and less waste.

Humans currently produce nearly 30 billion tons of carbon dioxide each year, almost all of which ends up in the atmosphere. Most strategies to combat global warming focus on reducing the amount of carbon dioxide being emitted or on ways to remove the gas from the atmosphere. Castaldi's aim is to redirect a portion of those emissions to a useful purpose.

Producing energy from biomass is generally done in one of two ways: by burning the material and using the heat to spin a turbine or by extracting the carbon and hydrogen in plant material and using it to produce a hydrocarbon fuel. Of the two, the latter is more efficient and much less harmful to the environment. Synthesis gas, or syngas, is produced by heating biomass in a reaction vessel and injecting steam. It can be used as a stand-alone fuel or, as its name implies, to synthesize other chemicals and fuels. The reaction is an energy- and water-intensive process that can also leave behind large amounts of carbon in the form of unprocessed lignin.

Five years ago, Castaldi began investigating what would happen if he reused some of the carbon dioxide generated during syngas production by pumping it back into the reaction chamber. When he did, he discovered that the carbon dioxide reacted with the biomass resulting in higher efficiency. He also found that replacing about 30 percent of the steam with carbon dioxide reduced water usage and converted all of the biomass to syngas, leaving behind only a carbonless char.

Castaldi estimates that if the biomass were used to replace 20 percent of existing demand for transportation fuels, 1.4 billion tons of carbon dioxide would be kept from the atmosphere. Incorporating carbon dioxide into the fuel-making process would increase this to more than 1.8 billion tons—the same as removing 308 million vehicles from the roads.

"This is what engineering does best," said Castaldi. "Developing processes that can extract value from unwanted materials—to help make the world a better place."

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