Cutting greenhouse gases: wood chips in, alcohol out

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California researchers plan to make biofuels in a novel way that doesn't involve food crops or microbial fermentation.

A new research effort involving three University of California campuses and West Biofuels LLC, will develop a prototype research reactor that will use steam, sand and catalysts to efficiently convert forest, urban, and agricultural "cellulosic" wastes that would otherwise go to landfills into alcohol that can be used as a gasoline additive.

"We have a very feasible design to combine individual components of technology that have been proven separately into a successful biomass processing prototype," said Robert Cattolica, leader of the research program and a professor of mechanical and aerospace engineering at UC San Diego's Jacobs School of Engineering. Cattolica is the principal investigator of the project, which includes researchers at UC San Diego, Davis, and Berkeley.

Since carbon dioxide is naturally recycled from the atmosphere into cellulose in plants and back into the atmosphere as carbon dioxide when plants decompose, burning biomass-derived fuel such as alcohol in internal combustion engines has a zero net effect on the amount of carbon dioxide in the atmosphere. On the other hand, burning fossil fuels continually adds carbon dioxide, a greenhouse gas, to the atmosphere.

The new biofuels research project was inspired by California's Global

Warming Solutions Act, which was signed into law by Governor Arnold Schwarzenegger in September 2006. The act requires a 25 percent reduction in greenhouse gas emissions in California by 2025. Substituting biomass fuel for petroleum would help California achieve its goal. The two-year UC project is funded with a $1.85 million grant from West Biofuels LLC, a San Rafael, CA, company that is developing the biomass-to-alcohol technology, and a $1.15 million state-funded UC Discovery Grant.

“My company is excited about partnering with the University of California on a very promising technology that could eventually have a significant beneficial impact on our environment while also reducing California's reliance on oil imports,” said Peter Paul, chief executive officer of West Biofuels.

The alcohol currently added to gasoline sold in California is derived from corn, sugar cane, beets, or other farm crops. About 95 percent of the alcohol additive comes from outside of California and as far away as China. Rather than fermenting food crops into ethanol, Cattolica’s project will use a thermo chemical process to break down shredded cellulosic wastes into a mixed alcohol, predominately ethanol. “The technology we’re developing will tap a huge, energy-rich resource that now is literally going to waste,” said Cattolica.

The prototype reactor will mix the wastes with high temperature sand in a reaction chamber while the mixture is heated with steam. The gasification process generates an energy rich combination of hydrogen (H_2), carbon monoxide (CO), methane (CH_4), and carbon dioxide (CO_2). Those gases will be catalytically “reformed” into alcohols. About 30 percent of the energy content of the starting material will be burned to supply the energy needed to operate the plant.

This will actually include a three-step process. First, the biomass will be

gasified thermochemically in a process that is widely used around the world to process wood, coal, and other carbon-containing materials into a “producer gas.” The methane in producer gas is typically burned to power electricity-generating power plants. However, the new reactor will catalytically “reform” the producer it into syngas, a mixture of hydrogen gas and carbon monoxide. In the final step, the syngas will be catalytically converted into mixed alcohols with a “synthesis” catalyst similar to one developed in the late 1980s by Dow Chemical Company.

In order for all the processes to run at maximum efficiently, the researchers will make use of highly sensitive laser sensors developed at UCSD to continuously monitor the entire operation. Process-control algorithms under development at UCSD’s Center for Control Systems and Dynamics (CCSD) will use the sensor data to continuously fine-tune steam temperatures and flows, gas mixtures, and catalyst regeneration to achieve the most efficient and reliable conversion of the biomass into fuel.

Cattolica’s team, which includes nine UC professors and seven post-doctoral fellows, will conduct research on a $1 million, 4-ton-per-day reactor. West Biofuels is building the reactor and will donate it to the University of California. Lessons learned will be incorporated into a 100-ton-per-day pilot plant, which could generate one 10,000-gallon tanker truck of mixed-alcohol fuel for every seven semi-tractor trailer trucks of biomass waste. California generates a huge volume of such wastes.

The Orange County basin alone produces about 30,000 tons of urban green wastes per day, which is simply dumped at landfills and used as compost. Cattolica said that waste supply could generate 3 million gallons per day of mixed-alcohol fuel, which is equivalent to all the ethanol currently added to California gasoline.

The biomass processing technology could also permit California to reduce its dependence on outside sources of ethanol. Motorists in California currently purchase more than 900 million gallons of ethanol a year, or 25 percent of the national total. However, the state produces only about 5 percent of the ethanol fuel it consumes. Schwarzengger issued an executive order in 2006 that requires the state to produce at least 20 percent of its biofuels by 2010, 40 percent by 2020, and 75 percent by 2050.

Cattolica said green wastes generated in San Diego and the Los Angeles and San Francisco Bay areas represent a huge untapped energy resource.

“The more paper and cardboard, agricultural and forest wastes, and sludge and municipal solid waste that we can process into biofuels the sooner the state can meet the state’s biofuels goals,” said Cattolica. “This is all attainable, and it will allow us to continue using internal combustion engines, reduce our dependence on fossil fuels, and reduce the production of greenhouse gases.”

Source: University of California - San Diego