 Department of Chemical Engineering fact: More than $12M in energy-related research in last two years.

Gasification

RENEWABLE ENERGY FROM BIOMASS

Fossil fuels — coal, oil and natural gas — are essential to the energy and economic health of the United States, supplying more than 85 percent of all the energy consumed. Fossil fuels also provide nearly two-thirds of the country's electricity and virtually all transportation fuels, according to the U.S. Department of Energy.

But in the last half century, concerns about pollution, global warming, limited resources, and increasing costs have led to research into alternative ways to fulfill the country's growing fuel and energy needs.

Kevin Whitty, associate professor of chemical engineering, is leading research to develop clean energy technologies from renewable feedstocks. He is building a unique system to convert biomass into synthesis gas (a gas rich in hydrogen and carbon monoxide), which can subsequently be converted into automotive biofuel, electric power and other useful chemicals.

Biomass — which includes trees, plants, and agricultural and animal waste — stores energy from the sun, either through absorption of the sun's energy (photosynthesis), or by consumption of plant matter by animals. When burned as fuel, biomass releases heat and carbon dioxide (CO_2). However, since trees and plants absorb excess carbon dioxide from the air during their growing lifetime, they are considered a renewable energy resource.

"If we plant enough to replace the biomass we're burning for fuel, there will be no net increase in biomass-based CO_2 emissions. This makes it cleaner than fossil fuels," says Whitty, a member of the Institute for Clean and Secure Energy, which was organized from a long tradition of energy research at the University of Utah beginning in the 1950s to study energy, combustion and high-temperature fuel utilization processes.

BLACK LIQUOR AS BIOMASS

One biomass Whitty uses is a byproduct of the papermaking process called "black liquor." To make paper, wood fibers that become paper are separated from lignin, a chemical compound that keeps wood fibers together. Paper mills use the lignin byproduct, or black liquor, for its energy value to power their facilities.

"Almost one percent of all energy production in the United States today comes from black liquor," says Whitty. "But you never hear about it because they make it in the paper mill and they burn it on-site."

He adds, "You could grow trees and plants specifically for energy production, but we're focused on using existing biomass resources. Rather than allowing waste biomass to decay in forests, fields or landfills, we can make use of its energy value to help displace energy that would otherwise be produced from fossil fuels."

In 2005, the U.S. Department of Energy and U.S. Department of Agriculture released results from a joint study that determined there are over one billion tons of readily-available biomass per year that could be used for production of biofuels, and that such fuels could meet more than one-third of the country's current gasoline consumption.

CONVERTING BIOMASS INTO FUEL

Whitty is converting biomass and black liquor to usable fuel through a high-temperature process called gasification, which involves converting solid fuel to synthesis gas. The gas is burned to produce electrical power in a manner similar to natural gas, or it is catalytically converted to transportation fuels or chemicals.

"Unlike fermentation-based processes such as corn-to-ethanol, gasification allows us to use all the biomass, not just the sugar or starch portion," says Whitty. "This lets us process fuels such as forest residues and energy crops much more efficiently, and with significantly lower water and fossil energy requirements, than conventional technology."

In his research facility, Whitty has two pressurized gasifier reactors that process biomass. One injects the biomass directly into a heated fluidized bed of sand, where it is converted into hydrogen-rich synthesis gas by reacting with steam. Ash in the fuel is removed through a cyclone or a lock hopper below the bed.

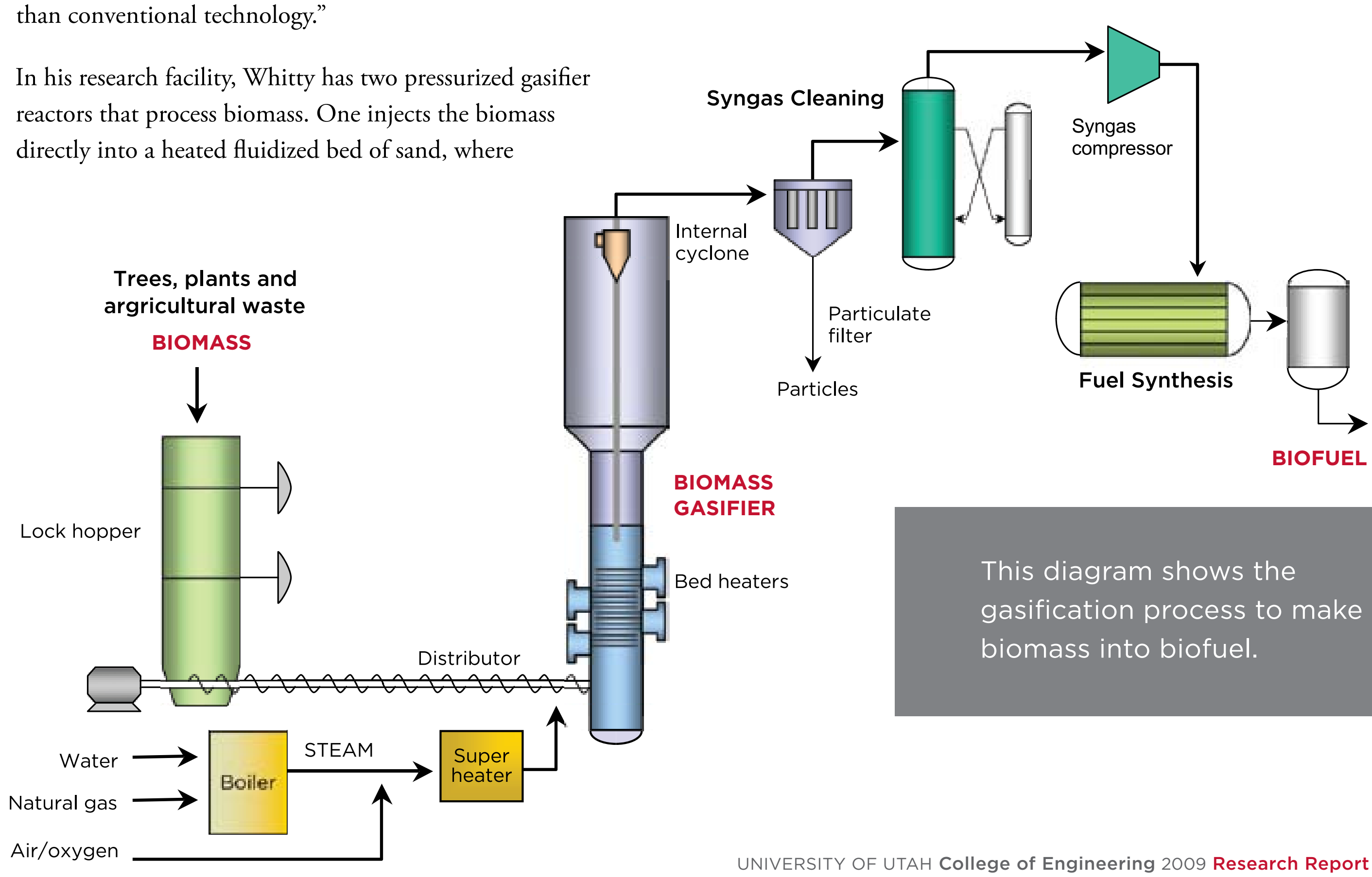
The other reactor is a pressurized entrained-flow gasifier that feeds the fuel and oxygen into the reactor to produce synthesis gas through partial oxidation. The high-temperature gas and molten ash exit the bottom of the reactor and enter a water-cooled quench system where the synthesis gas is separated from the condensed material.

Each gasifier has its advantages: The entrained-flow gasifier provides better conversion to synthesis gas, while the fluidized gasifier processes larger particles and is more energy-efficient.

"Both machines have the capacity to process about one ton of feedstock per day," says Whitty. "As this technology matures we will see these types of systems built on a much larger scale."

Whitty is collaborating with RTI, a research institute in North Carolina, to install a synthesis gas purification system in his facility that will remove tar, ammonia and sulfur that can contaminate downstream fuel or power production systems. There are also plans to construct a Fischer-Tropsch catalytic fuel production system to produce transportation fuel from the purified synthesis gas.

"This scale and cutting-edge technology makes our research unique," says Whitty. "No other university research facilities have the resources to go from start to finish, converting biomass to biofuel in the manner we are doing here."



This diagram shows the gasification process to make biomass into biofuel.