Fact Sheet about CE-CERT process

1) How efficient our process?

In terms of Cold Gas Efficiency (Biomass feedstock to Syn Gas[1] product), our process has 75% to 85% that depends on other process condition. These values are almost identical to the numbers from conventional gasification process using partial oxidation reaction.

Definition of cold gas efficiency is :

$$\frac{\textit{Energy Content of Product Gas}}{\textit{Energy Content of Feedstock + Process Energy Required}}$$

Overall process efficiency to the final product, which is FT-liquid[2] from the biomass feedstock, is estimated to 41%. It will be increased to 84%[3] if the FT-fuel gas byproduct [4] is included.
Biodiesel process claims 50 to 60% for their efficiency (from soy oil to biodiesel). But their overall efficiency drops to 15 to 18% by addition of soy oil extraction process. (From soy plant to soy oil to biodiesel)[5]

Definition of overall process efficiency is:

$$\frac{\textit{Energy Content of Liquid Fuel Product}}{\textit{Energy Content of Feedstock + Process Energy Required}}$$

In terms of simple mass balance, for every 1 ton of Biomass (Dry) input, our process can produce the 121 Kg (or 0.95 Barrels) of FT Liquid Fuel together with Additional 33 Kg of Wax and 170 Kg of Fuel gas.

2) What is uniqueness?

The competitive advantages of our technology are its performance and cost benefits.

The process uses (recycled) hydrogen and steam as the reactants and employs unique operating conditions that dramatically increase the rate of feedstock conversion (by a factor of 10) to fuel gas. Also it doesn't require external hydrogen sources.

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[1] Mixture of Carbon Monoxide and Hydrogen
[2] Fischer-Tropsch Liquid Product, Mixture of aliphatic hydrocarbon with carbon number of 5 to 20. These can be primary feedstock for the subsequent process for producing various type of transportation fuel to meet the corresponding product specifications.
[3] At 85% of cold gas efficiency
[4] Gas mixture containing carbon number of 1 to 4.
[5] NREL/SR-580-24089 UC Category 1503 Life Cycle Inventory of Biodiesel and Petroleum Diesel

In contrast to certain gasification technology, which requires high temperatures and a source of pure oxygen (air separation unit required) for creating fuel gas, our technology operates at moderate temperatures and requires no oxygen. This reduces both capital and operating costs compared to competitive technologies.

Another feature is the slurry feed for the solid fuels that enables transport into the pressurized reactors. Also it doesn't require drying the feedstock. It's effectiveness were proved in the certain innovative previous attempts[6]. Other technologies have to use a complex lock hopper system for dry feeding.

The composition of synthesis gas can be easily controlled by changing the water to carbon ratio of the slurry. So it can be used in any process that requires careful control of the synthesis gas composition. Competitive process requires separate water gas shift reactor for the adjusting the synthesis gas composition.

Addition of hydrogen in the gasification process not only increases the yield of product gas but also decreases the fraction of gases with higher carbon number, which can be the precursor for the formation of tar.

3) *Current Status?*

Process Development Unit (PDU)[7] has been developed and operated. PDU is for the demonstration of whole CE-CERT process conceptually and its functionality.

Also it has been served as deriving engineering data for the future scale up and locating engineering barriers.

For the next stage of the development, a pilot scale plant with the capacity of 10 ton per day is under the planning stage.

For the intellectual properties regarding CE-CERT process, UC OTT files total 9 patents to US Patent Office.

4) *Process Economics*

The assumptions are made such that the FT liquid and wax are for sale as a product, certain part of the fuel gas is converted into the electricity for sale.

The initial analyses are performed on a plant processing four hundred tons of dry biomass feed per day. Capital costs were estimated to be around $ 90 million. The annual operating and maintenance cost were estimated to 6 % of the capital cost.

The analysis shows that the production cost is most sensitive to the feed delivery cost, tipping fee, if available, and the capital cost of the plant. With the typical assumption of $20 per ton feed preparation cost, $58 tipping fee, the 10-year average

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[6] Some partial oxidation process developed by GE and E-gas uses slurry feed technique.

[7] Also known as LISP, PDU can produce 2 gallon of FT liquid from the 50 lb of biomass feedstock during the 24 hr of continuous operation

production cost of the fuel per gallon is be estimated 1.02 dollar. With zero tipping fees, the production cost will be increased to $1.83 per gallon.

A 10-year average sale price of $2.50 per gallon with a tipping fee provides a 13 % internal rate of return on the capital investment. If a higher carbon content material such as coal, plastics, tire rubber are used as the feedstock, the IRR is increased to 22% for the same condition. The 10-year average production cost of the fuel per gallon for the coal feedstock will be about a dollar per gallon.

5) CA Biomass availability

Preliminary investigation into the availability of California biomass indicates a potential flow of 110 million metric ton of available mass per annum. The distribution of this carbon is 30 million metric ton from agricultural and forestry residues using only the lower limit of forestry residue availability, 69 million from MSW and 11 million from other sources.

We estimated that a minimum net 85 million bbl of Fischer-Tropsch liquid fuel (synthetic diesel) would be generated annually in California from sustainably harvested agricultural, forestry and municipal solid waste residues. Agricultural and forestry residues alone could yield 24.6 million bbl[8].

California consumed 681.3 million bbl of petroleum-derived products in 2002, 89.5 million of those barrels being distillate fuels (EIA, 2003). 96% of California's distillate market demands could be met with CE-CERT technology.

Also, the process can help solve many of the growing waste problems by reducing the size of waste to be disposed or land filled. Should make much more of the ability to destroy wastes. A way to solve many pressing problems and get some tipping fees that could help with costs.

6) Emissions

One of the major advantages of the process is its environmental impact; it, along with some other gasification based processes, is probably the cleanest way to use the proposed feeds. Air emissions of components of concern are negligibly small or not detectable. Sulfur is reduced to under a ppm in the effluent gases, NOX is not formed in the conversion process. Heavy metals or other compounds of concern are captured with only undetectable amounts escaping the process, ash is in a form that should pass leachability limits and CO and hydrocarbon emissions will be negligibly small. At this time carbon dioxide is vented, but if carbon capture and sequestration becomes required

[8] "Availability Assessment of Carbonaceous Biomass in California as a Feedstock for Thermo-chemical Conversion to Synthetic Liquid Fuels", presented in ISAF XV Oct. 2005, Corinne Valkenburg1, Joseph M. Norbeck, Chan Seung Park

or desirable, it can be accomplished in this process easier than in many others including combustion in particular.

7) Technology issues

Feed Preparation: One of the key innovations in the CE-CERT process is that the composition of product synthesis gas can be easily controlled by changing the water to carbon ratio of the feed slurry. However, because of the polymeric structure of the biomass, only limited concentrations of biomass slurry can be formed. CE-CERT also developed a simple and unique method to make high solid content biomass slurry. It was successfully demonstrated in the lab scale bench reactor that the stable biomass slurry could be obtained in the wide range of biomass contents.

Gas Cleanup: Conventional technology for the warm gas clean up was proven to be sufficient for the various gas clean-up demands in the CE-CERT process for the biomass feedstock. For the feedstock with more harsh impurities like tire or coal, new cleanup technologies like regenerative sorbents is under development actively.

Gasifier Design: Several different design of steam hydro-gasifier have been developed and tested in the different places, to find out the optimum design for the pilot or commercial scale gasifier.