

Disposing of wet/mixed organic wastes: Filtering the flow to landfills and WTE plants

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***Higher value use of "wet/mixed bio-organic wastes"
stream now going to landfills and WTE facilities***

Until now it has been an intractable problem:

***"There are two obstacles to near-term implementation of
bioconversion technologies for processing the NYC wastes, either to
methane gas or to alcohol:***

- a) Such technologies have not been implemented on a large scale in the U.S.;***
- b) they would require a sizable market (estimated at 0.5 million tons) for the compost product;***
- c) they are bound to meet with siting challenges."***

***-- from "Life After Fresh Kills: Moving Beyond New York City's
Current Waste Management Plan"***

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In other words:

- 1. Composting options and markets are not developed in urban areas*
- 2. End use market must accommodate large size of this stream: > 8,000 tons per day and must accept food and yard wastes, miscellaneous organics, mixed paper and cardboard*
- 3. Energy or fuel production is only end-use market that is large enough for NYC stream*
- 4. Reduces mass flow to WTE plants, reducing expenses and political objections to siting*
- 5. Waste to ethanol technology not developed*

Ethanol production? Familiar problems:

- Despite the nearly exclusive attention given to biomass-to-ethanol production, it is not the only route: there are other fuels that can be made.*
- Acid hydrolysis has been known for a century. It was used during World War II to convert biomass waste into sugars, followed by fermentation to ethanol.*
- But fermentation yield is low because sugars are destroyed very quickly.*
- The solution is to bypass fermentation: degrade to furfural and levulinic acid and hydrogenate directly to MeTHF, a heterocyclical ether that is a component for a DOE recognized, renewable motor fuel.*

COMPARISON OF BIOMASS CONVERSION PROCESSES

PROCESS TYPE	OPERATING TEMPERATURE	PROCESSING TIME	MEDIUM	END PRODUCTS
<i>Anerobic Microbial Decay</i>	<i>Ambient</i>	<i>weeks/years</i>	<i>moisture</i>	<i>compost, CH₄</i>
<i>Aerobic Microbial Decay</i>	<i>100°F</i>	<i>days/weeks</i>	<i>moisture / air</i>	<i>compost, CO₂</i>
<i>Fermentation</i>	<i>110°F</i>	<i>72 hours</i>	<i>water / yeast</i>	<i>ethanol, CO₂</i>
<i>Enzymatic saccharification (pretreatment)</i>	<i>110°F 300°F</i>	<i>60 hours 10 minutes</i>	<i>genetically engineered microbes acid/water</i>	<i>ethanol, CO₂</i>
<i>Acid Hydrolysis</i>	<i>400°F</i>	<i>20 minutes</i>	<i>water / acid 15-30 atm</i>	<i>furfural, char formic acid levulinic acid</i>
<i>Liquefaction</i>	<i>700°F</i>	<i>10-15 minutes</i>	<i>dry / NaCO₃ 250 atm</i>	<i>bio-oil</i>
<i>Supercritical water</i>	<i>930°F</i>	<i>10 minutes</i>	<i>water 100 atm</i>	<i>turbine fuel gas bio-oil, carbon</i>
<i>Pyrolysis</i>	<i>1,200 °F</i>	<i>5-10 sec</i>	<i>nitrogen</i>	<i>bio-oil, char, tar</i>
<i>Gasification</i>	<i>1,700°F</i>	<i>30 sec</i>	<i>steam / air</i>	<i>H₂, methanol</i>
<i>Combustion</i>	<i>2,700°F</i>	<i>< 1 sec</i>	<i>dry air/ O₂</i>	<i>heat, flyash, CO₂</i>

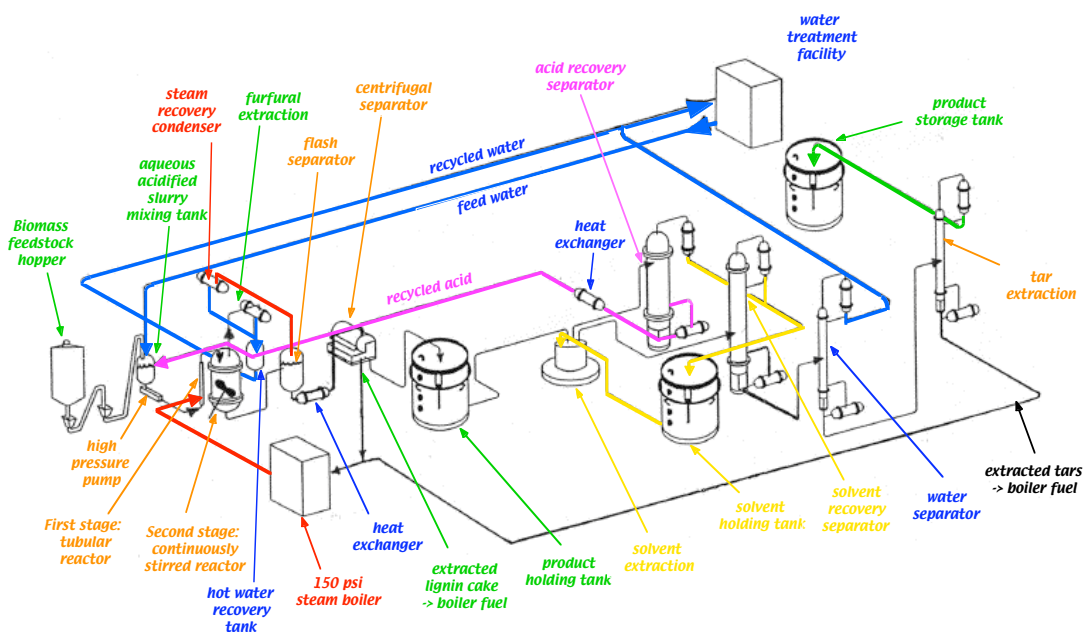
Preprocessing stage for millions of mobile WTE “plants”

- *P-Series fuels have been recognized and supported by the U.S. DOE. The fuel is economic, yet renewable, the level of regulated and toxic emissions is lower, and carbon dioxide emissions are reduced by 50%, compared to gasoline.*
- *P-Series is a family of liquid, renewable, non-petroleum fuels that are formulated for flexible fuel vehicles (FFV's), whose engines are designed to run on gasoline/alcohol blends. They are blends of*
 - *liquid hydrocarbons derived from natural gas production*
 - *ethyl alcohol*
 - *MeTHF*
- *For a synopsis, see the DOE web page:
<http://www.afdc.doe.gov/altfuels.html> and click on P-Series.*
- *WTE conversion takes place in portable 4-wheel combustors*

An alternative to the alternative

- *Hydrolysis has no air intake because the biomass is not oxidized, it is catalytically broken down with dilute acids.*
- *There are no flue gases or stacks -> no need for air emissions handling equipment.*
- *Hydrolysis takes place in water, so wet biomass is acceptable – no need to dry as would be for a direct WTE plant*
- *Conversion takes place at low temperatures (400° F), so secondary toxics (e.g. dioxins) are not formed.*
- *The capital and construction costs can about half as much as a full capacity WTE plant*

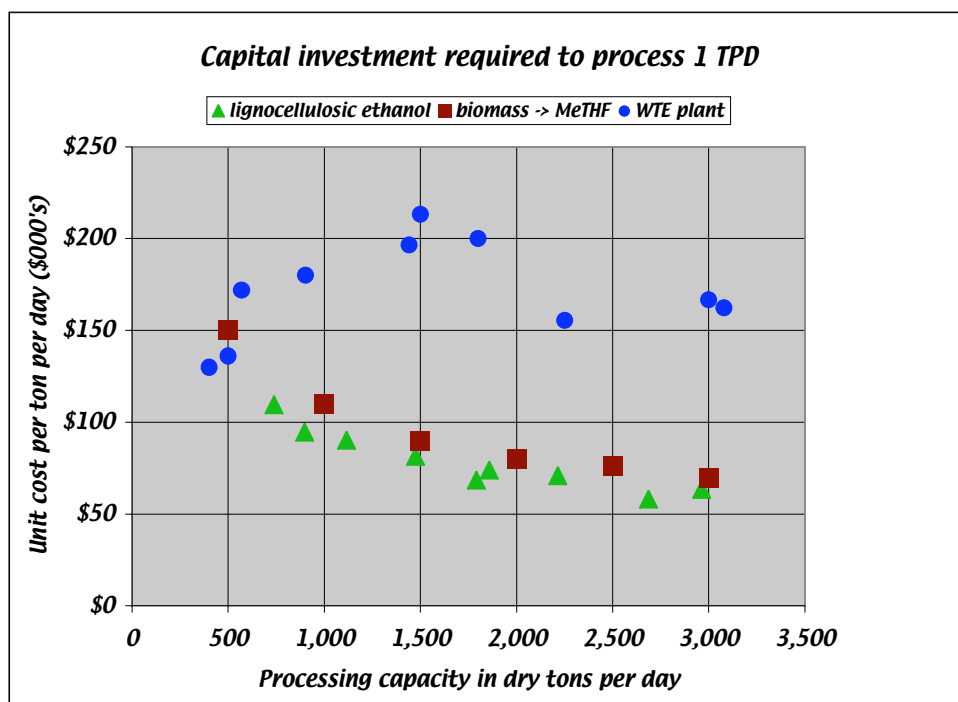
Process diagram for two stage dilute acid hydrolysis reactor



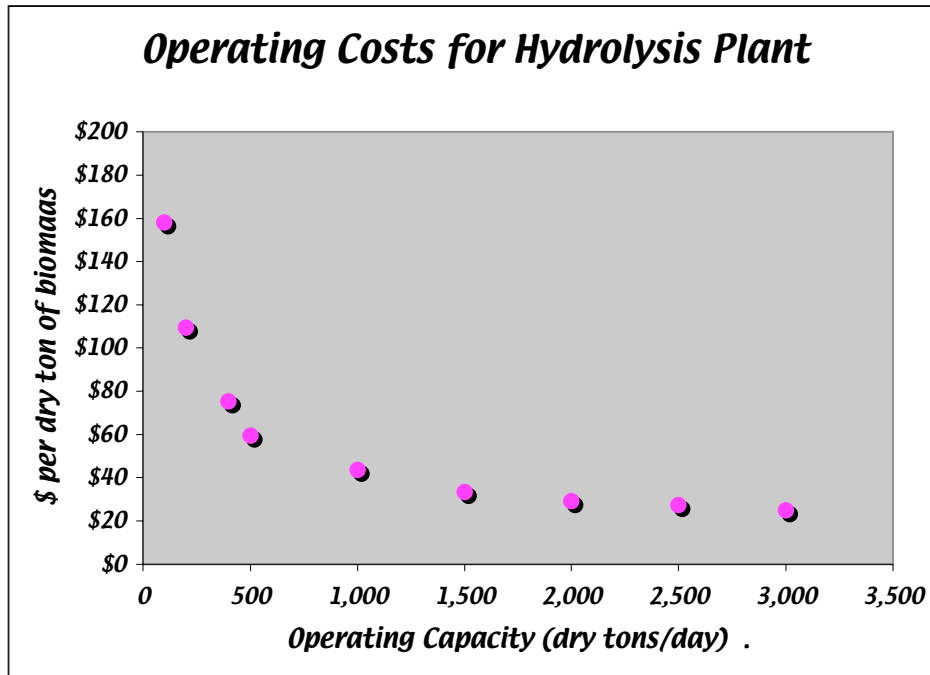
Process Description

- *The Biofine reactor system is a continuous process that includes an automatic feed loader, two-stage reaction system, acid catalyst separator, levulinic acid recovery and computer controls.*
- *Wet organic waste is mixed with an acid-water solution to form a slurry.*
- *Steam is injected and slurry is forced into a high temperature tubular reactor; hemicellulose broken down to furfural and cellulose into 5-hydroxymethylfurfural*
- *Slurry is injected into a lower pressure second stage continuously mixed reactor. Furfural is flashed off the top and the levulinic acid formed is concentrated and recovered.*
- *Dilute acid catalyst is recycled within the process and aqueous vapors are condensed and recycled.*
- *Solid char formed from the lignin in the feed is fed to a gasifier to make hydrogen. Levulinic acid is refined and hydrogenated to make the final product.*

**Economy of Scale is reached at 1,000 - 1,500 tons per day capacity
Capital cost of a plant is about half that of a WTE plant**



**For > 1,000 tons per day capacity, net handling cost is < \$40/dry ton
Sales of motor fuel reduce the disposal cost by half**



Technology Developed and Demonstrated

- **Biofine process for cellulose conversion developed by Biometrics in Waltham, MA**
<http://www.biometricsma.com/news.htm>
- **Supported by USDOE and NYSERDA, pilot plant built in South Glens Falls, NY in 1997**
<http://www.oit.doe.gov/forest/factsheets/biofine.pdf>
- **Process won the EPA's Presidential Green Chemistry Challenge Award in 1999**
<http://www.nyserda.org/press/press1999.html#South%20Glens%20Falls>
- **Multistep catalytic hydrogenation process developed by PNNL converts levulinic acid to 2-methylTHF**
<http://www.pnl.gov/news/1998/98mthf.htm>
- **Commercial sized plant constructed and operating in Italy**
http://www.bdi-us.com/crnt_lecal.html