Cellulosic Ethanol Industry Report

Data Behind An Oil Independence Strategy Using Biomass Waste in Landfills

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There has been some doubt raised by skeptics as to whether the energy in grain alcohol, also known as Ethanol, can be harnessed practically. One concern revolves around whether the expense of production outweighs the benefits of its energy output. For certain, there are issues with its economics.

For starters, Corn Ethanol is quickly becoming a boondoggle due to its economic threshold of 15% of demand, because government subsidies of 51¢ per gallon of ethanol is not enough - even in larger production quantities. Corn Ethanol producers must sell leftover grain pulp as supplements in cattle feed and other organic products to maintain a healthy bottom line (http://www.mbi.org/Dry Mill.pdf). The increase in price of corn per bushel has affected beef, milk, and tortilla prices. Considering how one fifth of corn now being produced in the U.S. goes toward Ethanol production, there remains a supply gap (National Geographic, October 2007). However, corn is not the only source of Ethanol.

There are other organics that produce Ethanol, not just crops. Cropless sources, like switchgrass, mesquite brush, household trash, and cellulosic organisms, all contain sugars that be fermented into making Ethanol (National Geographic, October 2007). The critical difference is that cropless organics produce sugars in the inner cell tissue under a hardened exterior, and they also contain sugars that stop the fermentation process needed to make the Ethanol. More energy is expended in the breakdown of cell tissue and separation of sugar, typically requiring methods that destroy much of the sugars, resulting in significantly lower yields than corn. This Cellulosic Ethanol produce only 75 gallons of fuel per ton of biomass, as compared to Corn's 120 per equivalent ton (BlueFire Ethanol; Wikipedia.org). Experts have agreed that Cellulosic Ethanol holds promise, but not at that amount. In order to be profitable using sources of organic material such as Municipal Solid Waste, Cellulosic Ethanol needs to produce much more than 120 gallons per ton to compensate for organic decay rates, climate zones, and population density.

For Fuel Freedom boasts 2.3 times as much Ethanol as Corn stock. Its proprietary process takes the non-fermentable sugars and the excess pulp, as well as using organisms for use in other processes that create additional biomass. The result is Cellulosic Ethanol production using this method is multiplied by a factor of 4.4 and will significantly reduce the cost to produce it. That is good news when considering Corn Ethanol in July 2007 cost $2.62 at the pump, while its equivalent energy to a gallon of gasoline was $3.71 (National Geographic, October 2007). To understand this difference, the energy equivalent of Ethanol to gasoline is about 30 miles per gallon less.

The Energy Impact of Ethanol

Overall, Cellulosic Ethanol does not require as much energy to produce compared to Corn Ethanol. An industry lifecycle model was researched to estimate variations in vehicle fuel productivity (GM.com\Company\OnlyGM\pdf\2005_Ethanol_Brochure.pdf), called The Greenhouse gases, Regulated Emissions and Energy use in Transportation (GREET). The GREET model was developed through Argonne National Laboratory's Center for Transportation Research, with support from the U.S. Department of Energy's (DOE's) Office of Energy Efficiency and Renewable Energy (EERE).

The computations prove cell-based ethanol (cellulosic) requires less energy than cornstarch ethanol, and both require less energy than petroleum-based fuels. The fossil-fuel energy expended per unit of ethanol delivered is 74% as measured in millions of British thermal units (Btu), compared to 123% for gasoline (2005_Ethanol_Brochure, Figure 1, 2nd page). Solar energy is not taken into account when calculating energy balance, even though the total energy needed to produce a unit of ethanol is more than the total energy needed to produce a unit of gasoline, because solar energy produces no additional environmental impact. Meaning, ethanol ends up requiring less energy for both fossil energy and petroleum energy (2005_Ethanol_Brochure, Figure 2).

The Environmental Impact of Ethanol

Ethanol is also proven to reduce greenhouse gases (GHG). A comparison of liquid by volume, the model shows Cellulosic Ethanol reduces GHG emissions by 85%, and Corn Ethanol by 18-29% compared to Petroleum (2005_Ethanol_Brochure, Figure 3). According to Renewable Fuels Association, Ethanol produces 16.2 lbs of GHG's per gallon, compared to 20.4 in gasoline. The model shows any type of alternative fuel in transport vehicles can contribute to reduction in fossil fuel impact, but cellulosic ethanol produces the greatest energy benefit and least emissions (www.GM.com\Company\OnlyGM\pdf\2005_Ethanol_Brochure.pdf). Therefore, ethanol has a positive net fossil energy value, and a closed-loop system of production can further reduce that impact to the environment.

By comparison, ethanol in Brazil is quite different in terms of output and energy. Sugarcane Ethanol produces 7 times the energy required to make it, whereas Corn Ethanol is only an additional 0.3. The emissions are different as well, since Sugarcane only produces 9 lbs of carbon per gallon. The high octane of 113 causes it to burn at higher compression, causing it to leverage more horsepower. It helps that the cheap labor contributes to the 87¢ per gallon low production cost. However, the climate in the Continental U.S. is unsuitable for sugarcane, and other crops are not sustainable in certain climates.

Cellulosic Ethanol Chemistry

Source Stocks

According to Wikipedia.com and primary sources, producing ethanol from cellulose promises to greatly increase the volume of fuel ethanol that can be produced in the U.S. and abroad. The U.S. is capable of supplying 1.3 billion tons of crop-based biomass per year, and that would cover over a third of the nation's fossil fuel needs. The U.S. does not have the 4.4 billion tons in biomass for 100% of demand, so a process that derives 3 to 5 times of the end-product is needed.

One bushel of corn produces about 2.8 gallons of ethanol. Waterless or cropless sources of cellulose, such as agricultural residues, grasses, branches, and paper waste are starch-based processes, and require a pre-process to ferment the sugars because the starch must first be broken down into sugars before its sugars can be fermented. In some parts of Europe, particularly France and Italy, wine and durum wheat are used due to massive oversupply. Ethylene hydration has been more economical to process ethanol than fermentation when oil is scarce.

What is Cellulosic Ethanol

Cellulosic ethanol or gasohol is ethanol fuel produced from cellulose, a naturally occurring complex carbohydrate polymer commonly found in plant cell walls. Cellulosic ethanol is chemically identical to ethanol from other sources, such as corn or sugar, and is available in a great diversity of biomass including waste from urban, agricultural, and forestry sources.

Cellulosic ethanol differs in that it requires an extra processing step called cellulolysis – breaking cellulose down into sugars. Extra processes are needed because cellulosic materials contain lignin and hemicellulose. Lignin has no fermentation value without consumption or conversion and forms the exterior cell wall that prevents access to the sugars. There are at least two methods of production of cellulosic ethanol (see "Production methods", below): Cellulolytic method: hydrolysis followed by fermentation of the generated free sugars. Gasification, also called synthesis gas fermentation or catalysis (Fischer-Tropsch process). Neither process generates toxic emissions when it produces ethanol. Hydrolyzed hemicellulose polysaccharides will break down into mostly five-carbon sugars. The hydrolysis of starch into glucose is accomplished more rapidly by treatment with dilute sulfuric acid, fungal amylase enzymes, or some combination of heat, acid, and/or enzymatic activity.

Fermentation Process

Fermentation occurs when yeast (Saccharomyces cerevisiae) expel carbon dioxide while digesting sugars in an oxygen-free atmosphere in a process known as sugar signaling, resulting in the production of beer. Sugar signaling is a mechanism controlled by the yeast to impose gene expression as they consume. Yeast metabolizes glucose by affecting the mRNA levels of hexose transporters, and conserving glucose repression by switching off transcription factors.

The most ethanol-tolerant strains of yeast can survive in up to about 15% ethanol (by volume), so the beer is typically siphoned off before it kills the yeast. The overall chemical reaction conducted by the yeast may be represented by the chemical equation ($C_6H_{12}O_6 \rightarrow 2\ CH_3CH_2OH + 2\ CO_2$). Yeast will oxidize any ethanol into acetic acid (vinegar) in the presence of oxygen and perform what is called aerobic respiration by producing just carbon dioxide and water. Otherwise, ethanol solutions are toxic to the cultivation of yeast.

Brewing and ethylene hydration are ethanol-water mixtures. For use as a fuel, ethanol must be purified after fermentation. Fractional distillation can reduce water content in ethanol to 4.4% water (percentage by weight). 95.6% ethanol by volume has a boiling point of 172.8 °F (as an azeotrope concentrate), making further distillation unreasonable, so molecular sieves are used to purify it. Precursors to sieves contained calcium oxide (lime) rather than zeolite salts which convert the hydrogen into calcium hydroxide and thereby dissolving some of the water instead of capturing it. The synthetic zeolite gravel can be reused after blow-drying it with hot CO_2. Another method is using toxic benzene or cyclohexane to bind with the water and ethanol into a ternary azeotrope so its boiling point is lowered to 148.8 °F and distillation can continue. Vapor saturation of distillation membranes have also been shown to separate ethanol from water. Current research is looking into pressurizing the azeotrope out at pressures between atmospheric and 70 torr (9.333 kPa) in a vacuum to become an ethanol-rich mixture, but it is not presently economical.

Beer Production

The source stock is ground or chopped and diluted into a meal. The meal is heated with acids and enzymes to breakdown the composite material into a what is called a mash. Non-fermentable sugars and pulp are then separated through some combination of acid, chromatography, and/or filtration. The mash is transformed by cooking, primarily to kill bacteria acceptable for breakdown stages. The mash is allowed to cool before yeast is introduced. Ammonia is added for pH control and as a nutrient to the yeast. As yeast grows, it ferments sugar into ethanol and releases carbon dioxide (CO_2) as a by-product. The beer runoff is then distilled to separate ethanol and the stillage is recycled, separated by centrifugation and evaporation into solubles, or used for by-products. The distilled 190 proof ethanol is then dehydrated through molecular sieves to become anhydrous ethanol (200 proof), because the presence of water not only retards performance but can also oxidize ethanol into vinegar (acetic acid) in extreme conditions. The remnant is denatured with 5-15% gasoline for vehicles that do not use a choke to start and to make it undrinkable (Lincolnland Agri-Energy, Dogwood Energy Mash 101, Wikipedia).

The most fundamental fermentation ingredient is water, as much as 90-97%. For proper fermentation, water must be clean from biological, physical and chemical contamination. The mineral content will also have an effect on pH and enzyme activity. Wells, rivers and lakes tend to fluctuate in their mineral content, especially in sulfur and iron. Municipal utilities are chemically treated with chlorine or chloramines. However, chlorine is eliminated by carbon filtration or when boiling the mash water and letting the gas out overnight. Chloramines require Campden tablets, resulting in calcium, water and bicarbonate. Any chlorine or chloramines will affect the yeast's metabolism and produce chlorophenols. This is also true of using too much chlorine as a sanitizer.

Minerals, such as salts, calcium, carbonate, sulfate and trace minerals like zinc and copper, are used by yeast for nutrients. Calcium and Magnesium are necessary yeast nutrients in the biochemical processes of fermentation. Calcium ions from gypsum or calcium carbonate helps produce an acid that controls acidity and alkalinity (pH) and provides essential chemical and biologic reactions for enzymes. Calcium interacts with malt phosphates to lower pH in both the mash and the boil, helping protein coagulation, and even helps with yeast flocculation. Carbonate is used to separate vegetable dyes made from bark and provide alkalinity to balance the acids. Magnesium is used by yeast in the production of enzymes required for fermentation, but competes with Calcium and must be kept below twenty milligrams per liter. Sulfates tend to cause bitterness in higher concentrations, but are typically not toxic. However, in high quantities minerals can destroy yeast (zinc, sodium) or cause the ethanol to burn impurely (iron). Every water district can tell you what sources are used for your area and can provide a water profile (brew-monkey.com and alkenmrs.com/beer/water.html).

Physical Properties

Purchasers of specialty denatured alcohols must have a government-issued permit for the particular formulation they use and must comply with other regulations. It is intended that it be difficult to isolate a product fit for human consumption from completely denatured alcohol. Incidentally, the denatured ethanol used in the United Kingdom contains (by volume) 89.66% ethanol, 9.46% methanol, 0.50% pyridine, 0.38% naphtha, and is dyed purple with methyl violet.

Ethanol's hydroxyl group is able to participate in hydrogen bonding. At the molecular level, liquid ethanol consists of hydrogen-bonded pairs of ethanol molecules, rendering ethanol thicker and not as explosive verses less polarized compounds of similar molecular weight. As a vapor there is little hydrogen bonding, for ethanol vapor consists of individual ethanol molecules.

Ethanol, like most short-chain alcohols, is colorless and has a refractive index of 1.3614. It is miscible with water and with most organic liquids, including non-polar liquids such as aliphatic hydrocarbons. Organic solids of low molecular weight are usually soluble in ethanol. Among ionic compounds, many monovalent salts are at least somewhat soluble in ethanol, with salts of large, polarizable ions being more soluble than salts of smaller ions. Most salts of polyvalent ions are practically insoluble in ethanol.

Chemistry of Ethanol

Ethanol is produced both as a petrochemical, through the hydration of ethylene, and biologically, by fermenting sugars with yeast. Chemical formula of ethanol is (C_2H_5OH) (carbon, hydrogen, oxygen). The prevalent chemical group of ethanol is its hydroxyl proton, that makes it a light acid; less acidic than water. Combustion of ethanol forms carbon dioxide and water ($C_2H_5OH + 3\ O_2 \rightarrow 2\ CO_2 + 3\ H_2O$).

Under acid-catalyzed conditions, ethanol reacts with carboxylic acids to produce ethyl esters and water ($RCOOH + HOCH_3CH_2 \rightarrow RCOOCH_3CH_2 + H_2O$).

The reverse reaction, hydrolysis of the resulting ester back to ethanol and the carboxylic acid, limits the extent of reaction, and high yields are unusual unless water can be removed from the reaction mixture as it is formed. Esterification can also be carried out using more a reactive derivative of the carboxylic acid, such as an acyl chloride or acid anhydride. A very common ester of ethanol is ethyl acetate, found in for example nail polish remover.

Ethanol can also form esters with inorganic acids. Diethyl sulfate and triethyl phosphate, prepared by reacting ethanol with sulfuric and phosphoric acid, respectively, are both useful ethylating agents in organic synthesis. Ethyl nitrite, prepared from the reaction of ethanol with sodium nitrite and sulfuric acid, was formerly a widely-used diuretic.

Strong acids, such as sulfuric acid, can catalyze ethanol's dehydration to form either diethyl ether or ethylene (2 $CH_3CH_2OH \rightarrow CH_3CH_2OCH_2CH_3 + H_2O$), ($CH_3CH_2OH \rightarrow H_2C{=}CH_2 + H_2O$).

Although sulfuric acid catalyses this reaction, the acid is diluted by the water that is formed, which makes the reaction inefficient. Which product, diethyl ether or ethylene, predominates depends on the precise reaction conditions.

Ethanol is also used as industrial solvent made from petrochemicals, typically by the acid-catalyzed hydration of ethene, represented by the chemical equation ($C_2H_4 + H_2O \rightarrow CH_3CH_2OH$).

The catalyst is most commonly phosphoric acid, adsorbed onto a porous support such as diatomaceous earth or charcoal; this catalyst was first used for large-scale ethanol production by the Shell Oil Company in 1947.[1] Solid catalysts, mostly various metal oxides, have also been mentioned in the chemical literature.

In an older process, first practiced on the industrial scale in 1930 by Union Carbide,[2] but now almost entirely obsolete, ethene was hydrated indirectly by reacting it with concentrated sulfuric acid to product ethyl sulfate, which was then hydrolyzed to yield ethanol and regenerate the sulfuric acid ($C_2H_4 + H_2SO_4 \rightarrow CH_3CH_2SO_4H$), ($CH_3CH_2SO_4H + H_2O \rightarrow CH_3CH_2OH + H_2SO_4$).

Ethanol can be oxidized to acetaldehyde, and further oxidized to acetic acid. In the human body, these oxidation reactions are catalyzed by enzymes. In the laboratory, aqueous solutions of strong oxidizing agents, such as chromic acid or potassium permanganate, oxidize ethanol to acetic acid, and it is difficult to stop the reaction at acetaldehyde at high yield. Ethanol can be oxidized to acetaldehyde, without over-oxidation to acetic acid, by reacting it with pyridinium chromic chloride.

Ethanol will also react with alkali electrolytes (sodium) and convert into ethoxide ion (CH_3CH_2O) by hydrogen gas ($2CH_3CH_2OH + 2Na \rightarrow 2CH_3CH_2ONa + H_2$).

In aprotic solvents, ethanol reacts with hydrogen halides to produce ethyl halides such as ethyl chloride and ethyl bromide via nucleophilic substitution ($CH_3CH_2OH + HCl \rightarrow CH_3CH_2Cl + H_2O$), ($CH_3CH_2OH + HBr \rightarrow CH_3CH_2Br + H_2O$).

Ethyl halides can also be produced by reacting ethanol by more specialized halogenating agents, such as thionyl chloride for preparing ethyl chloride, or phosphorus tribromide for preparing ethyl bromide.

Using Landfill Biomass

Biomass Basics

Biomass is a way of describing all organic material, and the products made from plant life grown from photosynthesis. Biomass from municipal solid waste landfills is a renewable resource that generates negative greenhouse gases because of the intervention of methane that is 21 times more potent than CO_2. Cellulose and hemicellulose are two primary components that make up the majority of biomass from municipal solid waste. They can be broken down to complex sugars and fermented in a process that leads to ethanol and other by-products. The fossil-fuels use to grow and transport the waste products have already been calculated into the product's lifecycle. The carbon dioxide that is released into the atmosphere when it is burned to make the initial product is offset by the carbon dioxide used during plant growth. So if waste end-products are burned to make bio-fuel and its CO_2 is captured for use in other processes, than the production and use of bio-fuels from waste will significantly reverse environmental, economic, and security concerns.

Municipal solid waste biomass already supplies over 3% of the total U.S. energy consumption, through steam-powered industry using pulp, natural gas pipelines fed from capped landfills, and some electrical generation from forestry by-products and other industrial waste. Energy crops and cropless sources of biomass, like solid waste, can provide enough ethanol and biodiesel for transportation and reduce and perhaps eliminate American reliance on foreign oil.

Biomass can be converted into sugar and thermochemical platforms from which other industrial products could be made. These biorefineries would create products in the form of fuel, chemicals, materials, and power normally associated with petroleum. Such would be accomplished through enzymatic and hydrolysis pretreatment of cellulose and hemicellulose to breakdown carbohydrates into their component sugars for fermentation, and utilize non-fermentable sugars and lignin in processes that create products for additional energy through catalytic conversion or other similar process. Biomass residue can also be converted to synthesis gas, pyrolysis oil, or hydrothermal liquid to create other thermochemical platforms. An industry that meets all these criterias would be a major player in the Biomass Program (eere.energy.gov).

Solid Waste Uses

There are already projects for sequestration of carbon in municipal solid waste landfills in the United States. Only 40.4% of organic trash is diverted for other purposes where recycling programs exist. Municipal solid waste (MSW) contains 68.2 – 70.8% organics, and out of that as much as 40 – 50% cellulose, 9 – 12% hemicellulose, and 10 – 15% lignin on a dry weight basis, with cellulose and hemicellulose representing 81.6% of the average organic portion (See Material Count on following page). When refuse is entombed in a landfill, microorganisms begin to decompose the waste and produce carbon dioxide (CO_2) and methane (CH_4) as by-products. Sampled garbage tends to have as little as 1% cellulose and cellulose to lignin ratios less than 0.1%. More consistent rates of decomposition are as follows (kg Carbon sequestered):

Greens	Food 0.08	Organics 0.22	Waste 0.22	Leaves 0.30	Grass 0.32
Woods	Ofc Paper 0.05	Corrugated 0.26	Gloss 0.34	Branches 0.38	News 0.42

Landfills that mitigate methane gas are expected to reduce carbon by 4.1% whereas 2.5 in unmitigated sites. Certainly, solid waste would be an ideal source for alternative fuel. These findings are important in determining greenhouse gas emission inventories (Research Bulletin, 3:3, www.erefdn.org).

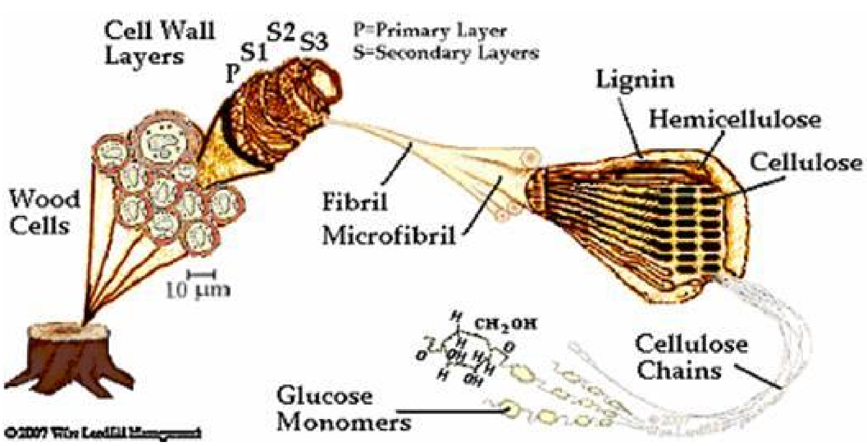
Material Count (Annual Tonnage of Waste)

San Bernardino County

Source: CA Integrated Waste Management Board (www.ciwmb.ca.gov/profiles)

Material	Category	Mtr'l Tons	% of Ttl	Org vs Inrg
Manures	OrgncMn	3,900	0.2%	
Branches and Lumber	OrgncWd	82,203	3.8%	
Leaves and Grass	OrgncGr	110,295	5.2%	
Food Waste	OrgncFd	269,691	12.6%	
Residue & Scrap Organics	OrgncRes	416,837	19.5%	
Magazines and Catalogs	PaperGls	26,495	1.2%	
Ledger & Notepads	PaperLgr	26,724	1.2%	
Envelope & Miscellaneous	PaperEnv	66,157	3.1%	
Newspaper and Directories	PaperNws	75,088	3.5%	
Other Office Paper	PaperLtr	214,361	10.0%	
Cardboard & Corrugated	PaperCrd	222,536	10.4%	70.8%
Gypsum Board (Limestone)	OrgncGy	14,642	0.7%	
Asphalt, Paint, Oils, Textiles, Tires	Chemical	77,641	3.6%	
Flat Sheets, Containers	Glass	78,995	3.7%	
Cans, Appliances, Shards	Metal	111,270	5.2%	
Rock, Soil & Demolition	Composite	147,048	6.9%	
Plastic Container, Film	Plastic	194,436	9.1%	29.2%
Waste Stream Totals		**2,138,319**		

Now, the siphoned lignin and remaining pulp from fermentation can be used as a by-product. Some glass collected for recycling becomes broken, color-mixed, or otherwise contaminated, and cannot be used in container manufacturing, but can be used as aggregate. Glass aggregate can also be acquired from modified lignin residue (WLM). Alternate markets for such glass includes blasting media, cement substitute (Pozzolan), construction backfill ceramic floor tiles, hot mix asphalt, utility trench fill, roadbed construction, roofing shingle granules, and vitrification processes (Minergy.com). Recycled glass aggregate has been used in projects involving pipe-bedding, trench backfill, filter sand in county park pool filters, and sandblasting in place of virgin rock aggregate. These applications resulted in an initial cost-savings, but are not considered stable prices because the availability and quality of recycled glass aggregate has historically been variable in nature. Recycled glass will cost roughly about the same as that of virgin sand (King County, Washington).



Composition of Wood Products

Paper is one of the most prevalent materials in biomass waste from landfills, and its composition is important to ethanol production. Paper is compressed cellulosic fibers and chemical agents, typically softwood spruce or hardwood aspen with cotton linters and organic fillers, but can also contain synthetic fibers, such as polypropylene and polyethylene. Paper may be made up of fillers such as chalk or china clay, to bring out desired characteristics of the paper. Instead of cotton, hemp, or rice may be used, and all of them contain fermentable sugars (Wikipedia.com).

The cell structure of the wood in paper is similar to other plants, according to Wood Technology, published by McGraw-Hill. The cell tissue contains an outer wall, a hardened exoskeleton made up of a pectin-rich membrane. Inner plant cell walls are made with layers of cords, called fibrils. These fibril are made of a few fibers, called microfibrils. Microfibrils strands are made of many strings called cellulose chains. The cellulose chains contain basins of glucose in what are called monomers. Lignin, fills the unoccupied space surrounding the links of cellulose chains.

The composition of wood is:

Organic Compounds	Hardwoods	Softwoods
Cellulose	40-44%	40-44 %
Hemicellulose	15-35%	20-32%
Lignin	18-25%	25-35%

The fibrils lay in a criss-cross pattern at an angle, like denim. First, they lay at 50-70 degrees in 4 to 6 layers, then at 10 to 30 degrees perpendicular in 30-40 layers for thin rings and over 150 layers in latewood, then lay again at 60 to 90 degrees in original direction in about 4 to 6 layers.

Their chemical composition is:

Element	Percent
Carbon	49%
Hydrogen	6%
Oxygen	44%
Nitrogen	slight
Ash	0.1%

This composition and its exoskeleton is so difficult to penetrate and is what makes the preprocess so important (Wood Technology, McGraw-Hill).

Lignin Responsiveness

The properties of lignin makes it very light-sensitive and causes the acidity in the paper. Depolymerization and the breaking of the molecular chains occur in a photochemical reaction, principally due to UV rays. It also reacts to chemical acid and pollutants by breaking the hydrogen bonds between the molecules and loses its resistance to degradation. Humidity will oxidize the carbon atoms.

Ultraviolet (UV) rays in certain artificial light, such as fluorescent and metal halogen lamps, are especially harmful when exceeding 75mW/Lumen 9, 50 lux., or the heat-producing IR rays, not found in typical incandescent or tungsten bulbs.

Temperature and relative humidity conditions can accelerate deterioration, if higher than 20°C and 55-60%. High temperature and relative humidity encourages mold growth, insect activity, and the oxidation process. Dry heat below 25% humidity, is believed to cause paper to become brittle. Climatic fluctuations cause expansion and contraction, which can lead to structural damage in paper, weaken the attachment of synthetics, and cause distortions such as the rippling of paper. Ubiquitous pollutants from industrial gases, auto emissions, and heating compounds are readily absorbed into paper, where they form harmful chemicals that can embrittle. Wood attracts xylophagous insects. Metal helps to increase the humidity. Wood pretreated with protective coatings can be insulated with hygroscopic material against breakdown (Université de Florence).

Lignin is somewhat malleable, as determined by residue and dissolution separation processes. Attempts at isolating lignin produces a material dissimilar to the lignin in wood. Sulfuric or hydrochloric acid tends to condense its structure, whereas sulfonates and alkali used in pulping processes tend to highly modify the properties in lignin (Wood Technology, McGraw-Hill).

Because paper has already undergone a process, its resistance differs from wood. When paper is made, paper manufacturing processes can use either chemical or mechanical processes when utilizing wood pulp. It is the hydrogen bonding of the added fibers that gives paper its surface strength. So, by mixing with water and applying mechanized action, the hydrogen bonds in the paper can be broken and fibers can be separated again.

Originally, the pulping process separates fibers from each other and exposes cellulose or hemicellulose tissues. In the mechanical pulping process, although there are some differences in method, essentially wood is chipped or ground up and then are squeezed or pressed and between two steel discs or rotating stones while being fiberized. However, its ability to resist decomposition remains intact. Mechanical pulping does not remove lignin, so lignin retention is over 95%, making yellow stains and deteriorating over time (Wikipedia.com).

The Effect of Lignin on Biodegradability

Lignin is especially difficult to decompose, and reduces the availability of the other cell properties. Cellulose, hemicellulose, and lignin vary greatly in what rates they decay. Cellulosic material requires very few enzymes to break it down because it is made up of simple repeated structures, mostly found in fibrils. Hemicellulose is made up of more complex structures in the way they separate fibrils into microfibrils and incorporate lignin to bind the structure together. Hemicellulose contains sugars like xylose, arabinose, galactose, mannose, and the fermentable glucose. Lignin is a complex polymer of phenylpropane units, which are cross-linked to each other through several different chemical bonds. Lignin is hard to penetrate, and cellulose is easy to destroy by the same process without controls. This biochemical complexity is what makes the preprocess so important.

Several fungal organisms are designed to break lignin apart. Extracellular lignin and manganese peroxidases have been shown to brake down by white-rot fungi and Actinomycetes, as much as 20 percent of the total lignin. Lignin is the most resilient of the plant cell tissue, and prevents availability of the sugars by its resistance to penetration and degrading activities.

For Fuel Freedom Management's labs have discovered that paper contains other organics that also contain sugar, like cotton linters. Therefore, sugar content of softwood paper products will vary with different contents of cotton fibers. It is this additional sugar content that makes biomass from waste profitable. Paper manufacturers use different amounts of cotton for different products, and that changes the potential for fermentation:

Potential Fermentation

Cotton fiber as % of weight in various paper products

	% Fiber	% Glucose	% of Papers	Sugar by Wt.
Cardstock/Cardboard	0%	37.0%	47.1%	17.4%

Envelopes	25%	61.5%	10.5%	6.4%
Bond/Letter Writing	50%	83.8%	34.0%	28.5%
Announcements/Ledger	75%	90.8%	4.2%	3.8%
Magazines/Gloss	0%	37.0%	4.2%	1.6%

Based on the approximate sugar content of softwood paper products, if 30% cotton linters can be expected, that would mean raising the Glucose yield to about 68% of the paper weight, with Mannose and Xylose at about 4 and 3% by weight, respectively.

Unrecycled paper contains an average of 20.7% more fermentable sugar than wood alone, and the sugars that do not ferment, primarily xylose, can be siphoned off as food for algae used in bio-diesel and more ethanol production.

To understand this relationship better, a mathematical model for availability of interior organic material can be expressed in terms of the amount of lignin based on anaerobic degradation techniques. The difference in lignified tissue can vary greatly. For example:

Lignin Content	Biodegradable fraction	
Newsprint	21.9	21.7%
Office paper	0.4	81.9%

It would take almost 4 times the newsprint to provide the same sugars as office paper. Overall biodegradable cellulose content may differ when comparing solid waste mixtures. This biodegradable carbon content can then be used to calculate biodegradable carbon/nitrogen ratios:

	Ttl C/N	Carb/Nitr	Ttl Mtrl%	Cell Wall%	Lignin%	Carbon%	Nitrogen%
Newspaper	115.5	54.2	39.3%	97.0%	20.9%	18.4%	0.3%
Wheat	88.7	58.4	51.1%	95.0%	23.0%	33.6%	0.6%
Maple	51.2	45.1	49.7%	32.0%	12.7%	43.8%	1.0%
Bird Dung	9.6	9.3	43.3%	38.0%	2.0%	41.8%	4.5%

When correcting carbon/nitrogen ratio calculations for lignin content, there may be a reduction in the carbon/nitrogen goal. The C/N ratio of 30:1 includes some discount for lignin, because it is part of the carbon materials.

Minute quantities of nitrogen can increase lignin degradation under aerobic conditions. The introduction of white-rot fungi (Phanerochaete chrysosporium) at 39-40°C (optimum growth temperature), along with 0.12% nitrogen (dry weight), lignin degradation in alder pulp increased from 5.2% to 29.8%. Under similar anaerobic conditions, various cultures produced 11% increase in degradation. Additional nitrogen did not provide further benefit.

Factors that affect the decomposition rate are: sufficient nitrogen, moisture, temperature and pretreatment. Degradability of lingo-cellulosic materials can be enhanced by pretreatments, like the introduction of alkali and heat, grinding and milling, and jet steaming in combination with proprietary fungal and enzymatic intervention (The Effect of Lignin on Biodegradability, Tom Richard).

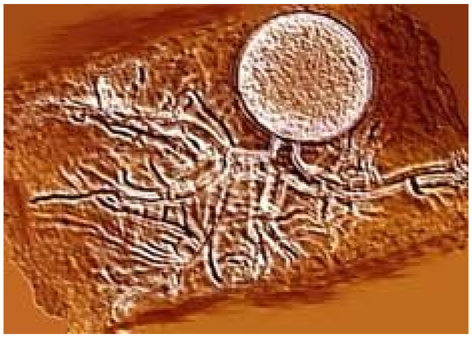
Lignin Penetration by Organics

Organic Properties

An environmentally and economically secure preprocess to penetrate the lignin in aged biomass and wood-based products is a key ingredient to resolving cellulosic ethanol's drawbacks. A proprietary combination of bacteria, fungi, microbes, mold, and enzymes not only colonize lignified tissues of plant fiber but also make ethanol, given specific growth conditions. They are pervasive biodegraders. Certain organics produce enzymes that chemically weaken the lignin fiber and their reproductive development penetrates the fiber by the physical forces exerted on the tissue. The precise mechanism by which they are attracted to the lignified tissues is not known. The chemoattraction these organics were carefully determined in a study at various concentrations, temperatures and pH's. The optimum concentration, temperature and pH for chemoattraction varied for each of the organics tested.

Microbiology

Some organics in this blend possess hydrogenosomes, which generate hydrogen and ATP, but also acetate and formate as end-products of a prokaryotic-type mixed-acid fermentation. We show that certain fungi also possess an alcohol dehydrogenase E (ADHE). We demonstrate that these cultures under specific conditions of temperature, time, and food source, that this proprietary combination consumes cell walls of cellulosic structures with minimal degradation to its interior. These observations require a refinement of the process for commercialization purposes, but sufficient quantity should produce similar results.



Characteristics of the cellulolytic system of the process with respect to adsorption onto microcrystalline cellulose were examined. Cellulolytic enzymes were separated by gel filtration chromatography into a high-molecular-mass complex with an apparent mass of approximately 1,200 to 1,400 kDa and proteins of lower molecular weights. Adsorption of cellulolytic enzymes was not only very fast (within 2 min, equilibrium was attained) but also very effective: Avicelase, endoglucanase, and beta-glucosidase activities from the high-molecular-mass complex were almost completely removed. Adsorption of these enzyme activities was proportional and appeared to obey the Langmuir isotherm. For Avicelase, endoglucanase, and beta-glucosidase activities, the maximum amounts adsorbed (Amax) and apparent adsorption constants (Kad) were 16.8, 600, and 33.5 IU/g and 284, 6.93 and 126 ml/IU, respectively. The results of this study strongly support the existence of a multiprotein enzyme complex. This complex was found not to be specifically associated with cell wall fragments as judged by chitin determination. Any cell fragments consumed by these organics without interruption convert crystalline cellulose solely into glucose, in contrast with bacterial cellulosomes which produce cellobiose (University of Nijmegen, The Netherlands).

Bio-diesel By-products

Bio-diesel Facts

Biodiesel facts are gathered from Wikipedia except where noted. Plants use photosynthesis to convert solar radiation into chemical energy. Chemical energy is stored in plant cells. An alcoholysis or trans-esterification of the oils stored in plants using methanol or ethanol will separate fatty acids from the glycerol, results in converting its glycerol into short linear alcohols. The separated plant oils are known as biodiesel.

Basic facts regarding biodiesel's use: Biodiesel reduces carbon monoxide (CO) and carbon dioxide (CO2) emissions by 50% and 78%, respectively. Biodiesel contains less benzopyrene (71%) and less benzofluoranthene (56%) hydrocarbons. Biodiesel expels 50 parts per million less particulates (20%) on vehicles equipped with particulate filters. U.S. Department of Energy concluded that biodiesel is less toxic than table salt and degrades as quickly as sugar in their Biodiesel Handling and Use guidelines. Biodiesel successfully completed the Health Effects Testing requirements (Tier I and Tier II) of the 1990 Clean Air Act. Biodiesel's higher cetane composition, in products with lower than 40 cetane rating, improves performance and fuel intake overall. The flash point of biodiesel (>150 °C) is significantly higher than that of petroleum diesel (64 °C) or gasoline (−45 °C). Most biodiesel has a somewhat higher gel point than petroleum diesel and may require storage tanks to be heated in cooler climates.

Bio-diesel Infrastructure

Biodiesel can be distributed using today's infrastructure, and its use and production are increasing rapidly. Fuel stations are beginning to make biodiesel available to consumers, and a growing number of transport fleets use it as an additive in their fuel. Biodiesel is generally more expensive to purchase than petroleum diesel but this differential may diminish due to economies of scale, the rising cost of petroleum and government tax subsidies. In Germany, biodiesel is generally cheaper than normal diesel at gas stations that sell both products and is sold at every tenth gas station [http://www.ufop.de/english_news.php].

Bio-diesel Conversion

Biodiesel does not require conversion, per se. Although biodiesel can be used in lieu of or in combination with petroleum-based diesel, biodiesel will decompose rubber gaskets and hoses in vehicles built before 1992. However, normal wear and maintenance would have prompted replacement with the non-reactive FKM substitute product, as ordered by regulation so 5% biodiesel could be introduced to lower emissions. Biodiesel will also corrode alluminum parts, but their expense is not absorbed by typical maintenance.

Biodiesel has slightly better viscocity than petrodiesel, contributing to longer fuel injector life. Some vehicle manufacturers exclaim biodiesel promotes lower engine wear because it burns cleaner. Its corrosive properties removes carbon buildup in fuel lines, and tends to clog the fuel injectors in short order. For this reason, car manufacturers recommend that the fuel filter be changed about 700 miles for a few months after switching to biodiesel.

Biodiesel produces 10% to 25% more nitrogen oxide (NOx) emissions than petrodiesel. A catalytic converter can be installed to capture some NOx emissions, since bio-diesel does not contain sulpher. Nitrogen oxide comes from the chemical reaction when cetane and oxygen come in contact with nitrogen in the air, yet NOx is not completely eliminated. One solution is cerium-oxide diesel fuel additives to improve fuel consumption by 11% in standard equipment.

Most manufacturers provide consumers with lists of cars that will run on biodiesel to offset costs incurred in producing environmental vehicles as per government regulation. Older diesel Mercedes are popular for conversions to biodiesel or waste vegetable oil. Scania and Volkswagen engines, as well as the converted Ford Focus and Virgin Voyager, run on 100% biodiesel. Peugeot and Citroën HDI diesel engines run on 30% biodiesel. In the UK, diesel engine warranty restrictions call for maximum 5% biodiesel blend due to economic uncertainty.

Biodiesel can also be used as a heating fuel in domestic and commercial boilers. Existing oil boilers may require conversion to run on biodiesel, but the conversion process is believed to be relatively simple. According to Energy Information Administration and US Department of Energy, the estimated diesel fuel used in transportation and heating oil in the United States is about 50 billion US gallons (http://tonto.eia.doe.gov/dnav/pet/pet_cons_821dst_dcu_nus_a.htm). Waste vegetable oil and animal fats would not be enough to meet this demand. In the United States, estimated production of vegetable oil for all uses is about 24 billion pounds (11 million tons) or 3 billion US gallons (0.011 km³), and estimated production of animal fat is 12 billion pounds (5.3 million tons) (Van Gerpen, 2004). According to the United States Environmental Protection Agency (EPA), restaurants in the US produce about 300 million US gallons (1,000,000 m³) of waste cooking oil (WVO) annually. WVO could be used to produce biodiesel, but it is more profitable in other products like soap. Algae, having the highest biodiesel yield, can produce 250 times the amount of oil per acre as products like soybeans. A global biodiesel fuel solution would have to include algae.

Bio-diesel Algae-culture

From 1978 to 1996, the U.S. National Renewable Energy Laboratory experimented with using algae as a biodiesel source in the "Aquatic Species Program". UNH Biodiesel Group estimated the replacement of all vehicle fuel with algae biodiesel to be over 50%. Left-over dried algae can be processed to make ethanol. Phoenix, Arizona public works is already experimenting on bio-reactors for algae for production on a large scale.

The Department of Energy (DOE) and Department of Agriculture (USDA) jointly allocated production costs and determined biodiesel yields 3.2 times the fuel for every unit of fossil fuel energy consumed (Minnesota Department of Agriculture). It was also determined petrol-diesel has a 0.843 energy yield, 0.805 EY for gasoline, and 1.34 for ethanol. Biodiesel has a higher energy density and higher efficiency in diesel engines, so the effective energy yield ratio is one gallon of biodiesel to 2.25 gallons of ethanol.

Bio-diesel From Waste

Thermal depolymerization (TDP) is a relatively new process to convert complex organic materials into what is known as light crude oil. Source stock can come from landfill waste, like recycled tires, wood and plastic. Using a similar process as geological forces used to create fossil fuel, pressure and heat is applied to compress long chain polymers of hydrogen, oxygen, and carbon into short-chain hydrocarbons that resemble petroleum. Its high efficiency rating is based on consuming only 85% of the energy for conversion, after utility power usage.

It has been estimated that in the United States, agricultural waste alone could be used to produce 3.7 billion barrels of oil per year. The USA currently consumes 7.5 billion barrels (232.5 billion US gallons) of oil per year. Vast amounts of land and fresh water would be needed to produce enough oil to completely replace fossil fuel usage. It would require twice the land area of the US to be devoted to soybean production, or two-thirds to be devoted to rapeseed production, to meet current US heating and transportation needs.

Location Considerations

Infrastructure

The biggest setback to where a company might sell ethanol to consumers as a primary fuel source would be whether sufficient infrastructure exists. In most cases, little modification needs to take place in regard to gas stations since gasohol transport and delivery is compatible with petroleum-based products. As findings will show (below), there are many gas stations with ethanol pumps already available in the U.S.

Gas Stations Available

State	No. of Stns
Alabama	1
Arkansas	1
Massachusetts	1
Mississippi	1
Idaho	2
West Virginia	2
Dist. of Columbia	3
California	4
Oklahoma	4
Oregon	4
Utah	4
Virginia	4
Wyoming	4
Arizona	5
Kentucky	5
Maryland	5
Montana	5
New Mexico	5
Tennessee	5
Washington	5
Georgia	6
New York	6
Nevada	8
Pennsylvania	10
Florida	12
North Carolina	12
Colorado	14
Kansas	14
Texas	19
Ohio	21
Michigan	27
Nebraska	29
North Dakota	31
South Carolina	37
Indiana	46
South Dakota	50
Iowa	56

Wisconsin	61
Missouri	66
Illinois	127
Minnesota	307
	1,029

Gas Station Availability Notes:

Data current as of January 2007. AK, CT, DE, HI, LA, ME, NH, NJ, RI, VT do not have ethanol pumps as of Nov 2006. Some stations require station credit card. Station count is always the greater of two numbers when sources differ, due to data that may be out of date from one of the sources. Data sourced from U.S. Department of Energy & National Ethanol Vehicle Coalition org. Clean State station locations acquired from http://www.e85refueling.com/locationsplain.php?state=id*StateName*, and Alternative Fuels Locator from http://afdcmap2.nrel.gov/locator/FindPane.asp.

From this data, there is found to be 86 Participating Clean Cities in 45 States across the U.S. Existing distribution is sufficient to get alternative fuel to market through networks like Ethanol Products, NEDAK Ethanol, and Provista Renewable Fuels Marketing (a Division of U.S. BioEnergy and cooperative with Cenex).

The only reason gasohol or ethanol stations do not exist in greater number and more consistent locations is due to supply of a significant fuel source, hence the push for viable cellulosic ethanol. Already vehicle manufacturers are gearing up for several alternative fuel scenarios, depending on fuel availability, and flex-fuel technology is at the forefront according to Department of Energy (DOE), Renewable Fuels Association (RFA) and other sources found on Wikipedia (EERE, GM, The Center for American Progress).

Flex-Fuel Vehicles

Ethanol or gasohol requires a specially-designed car. A flex-fuel vehicle (FFV) is one that can alternate between sources of fuel, and run on most combinations of petroleum and environmental types. It is this engineering that makes cleaner emissions a reality.

Before the 1980's, imported cars were made with materials that were not-compatible with ethanol, like rubber and aluminum. In addition, the original Brazilian design required a choke device installed in cars that took 100% ethanol in order to start the vehicle during inclimate weather. With denatured ethanol being mixed with a minimum of 10% gasoline, the fuel mixture is automatically detected by ECU sensors to correct the timing and fuel injection. In the U.S., that minimum is 15% because the bio-technology is more corrosive than conventional gas, known as E85 vehicles. American car manufacturers, such as Ford and Chrysler, have perfected the engineering of flex-fuel since 1998. Foreign manufacturers Toyota and Mercedes-Benz are working on engineering their own FFV's for the U.S., but are several years behind the Americans.

Market penetration with FFV's is steadily growing, but the main reason for the delay is that industry leaders are proceeding cautiously (See Flex Fuel Availability following page). These car factories are uneasy about going a break-neck pace, until an economically viable source of fuel is successfully determined. Since 2005, American manufacturers intend on increasing ethanol-based production lines by 1 million each year. There are an estimated 4.5 million E85 cars on the road now in 34 different models in the U.S. This is made possible by a 1988 Corporate Average Fuel Economy law that reduces fuel efficiency standards in exchange for flexible fuel vehicle credits, and thereby increasing average national fuel consumption.

Models of FFV's also exist throughout Europe. Ford Focus is popular in Sweden and Ireland with new models coming to Germany. Volvo is now sold in France as well as Sweden. Saab is also sold in Sweden. Renault (Citroen) and Peugeot were recently introduced in Germany. Alternative fuel availability in Europe is slim, but exact numbers are not known.

In Brazil, 75% of car sales come from flexible fuel vehicles manufactured by Chevrolet, Citröen, Fiat, Ford, Honda, Mitsubishi, Peugeot, Renault, Toyota and Volkswagen. Brazil plans on exporting Obvio! through Zap authorized dealerships in Southern California and Canada. The FFV technology exists and is wide-spread among global auto producers, but reluctance will persist until satisfied that the fuel will reach its market. Just heard on CNN July of 2007, soaring corn prices related to ethanol production has resulted in rising dairy, chocolate, and tortilla prices because of all the markets affected by corn. Corn producers now are saying they can only produce 10% of the American fuel market and fuel suppliers are scrambling for another source. Cellulosic ethanol producers met in Tucson, Arizona in February to discuss the future of ethanol without an effective preprocess and sugar separation mechanism. The introduction of For Fuel Freedom Recycling's solution to the problem is perfect timing.

Europe's Flex-Fuel Vehicle Availability

Ford: Focus FFV, Focus C-MAX.
Koenigsegg: CCX.
Saab: 9-5.
Volvo: S40, V50, XC60 (concept).

United States Flex-Fuel Vehicle Availability

Chevrolet: Avalanche, Silverado, Suburban, Tahoe (all 2007 models, some 2002-2006), Impala 2006 and later 3.5L, Monte Carlo 2006 and later 3.5L, S-10 Pickup.
Chrysler: Sebring, Town & Country, Aspen.
Dodge: Caravan, Durango, Grand Caravan, Ram Pickup, Stratus, Dakota.
Ford: Crown Victoria, 2006 F-150, 1999-2000 Ranger, Grand Marquis, 1999-2001 Taurus, 2002-2004 3.0L Taurus sedan and wagon, 2004-2005 3.0L Taurus sedan and wagon (2-valve), Sport Trac XLT,
Mercury: Grand Marquis, Mountaineer, Sable, Lincoln Town Car.
GMC: Sierra, Yukon, Yukon XL.
Isuzu: Hombre.
Jeep: 4.7L Commander, Grand Cherokee.
Mazda: B3000 (1999, 2001-2002 models).
Mercedes: C230 2.5L(2007), C240 2.6L(2005), C320 3.2L(03-05).
Nissan: Titan.

Brazil Flex-Fuel Vehicle Availability

Chevrolet: Celta, Classic, Corsa, Astra, Vectra, Montana, Meriva, Zafira.
Citroën: C3, Xsara Picasso.
Fiat: Mille, Palio/Palio Weekend/Siena/Strada, Doblò, Idea, Stilo.
Ford: Fiesta, EcoSport, Focus.
Honda: Civic, Fit.
Mitsubishi: Pajero TR4.
Peugeot: 206, 307.
Renault: Clio, Mégane, Scénic.
Toyota: Corolla VVT-i Flex and Fielder [6].
Volkswagen: Gol/Parati/Saveiro, Fox, Kombi, Polo, Golf.

List of E85 vehicles
courtesy of the National Ethanol Vehicle Coalition
http://www.eere.energy.gov/afdc/afv/conversion101.html

United States

A leading source of energy that will reduce environmental impact of petroleum while changing the economic base of a nation, will surely attract some resistance even in the most favorable of conditions. A careful plan up front will help to avoid unnecessary entanglements with political will of bureaucracies, irate advocacy groups, oil refineries, and the terrain of remote locations. A clear path should give rise to set roots until such costs can be absorbed.

Such concerns prompted studies on political boundaries, population density, predatory competition, and placement of mills. Research efforts focused on statistics that easily translate into considerations for location, such as: 2006 Congressional voting demographics, county populations, top producing oil refineries, and remote terrain. This data provided estimations for unfavorable environmentalism, slow waste streams, unforeseen bureaucracy, and added expense.

With the mixture of information being quite complex, priorities were set to the tune of a basic algorithm. The intent was to create a fairly accurate assumption of what locations to pursue in what order, but some data did not fit the design. Concessions were made in reducing the impact of negative externalities. For example, in Santa Barbara, California, there are oil refineries with over half of the county voting districts being Republican, but it is located on the coast where more regulation and waste restrictions occur. The existence of oil refineries sent up a red flag, having automatically placed this site on the list of cautionary demographics. However, the bureaucratic conditions favor environmentalism, so it was manually placed on the primary list. Its overall rank is 294, giving lead time to spy out the land. For the most part though, county population carries the most weight in the sort order, using quantity of Democratic Representative districts as the major key modifier per www.DCPoliticalReport.com, http://Projects.WashingtonPost.com/Elections/KeyRaces, and http://Congress.org databases.

There are four basic reports that comprise this data. The largest collection of data is the primary "Mill Location Considerations" (Sample Below).

Mill Location Considerations

County Population By Favorable Political Demographic

Rank	State	County	Density	Lrgst City	Populatn	EstWaste	Sites	%Favr
1749	Illinois (IL)	Greene	15,012	Carrollton	4,001	3,140	1	100%
1751	Iowa (IA)	Cedar	15,003	Tipton	4,959	3,892	1	100%
1753	Colorado (CO)	Las Animas	15,129	Trinidad	12,512	9,820	1	90%
1755	Illinois (IL)	Lawrence	15,174	Lawrenceville	8,019	6,294	1	80%
1757	Missouri (MO)	Osage	15,957	Linn	8,619	6,765	1	11%
1758	Kentucky (KY)	Simpson	15,940	Franklin	15,940	12,510	1	0%
1760	Kentucky (KY)	Adair	15,569	Columbia	14,395	11,298	1	0%
1762	Texas (TX)	Pecos	15,313	Fort Stockton	14,109	11,073	1	0%
1764	Wyoming (WY)	Park	15,227	Cody	14,377	11,284	1	0%
1765	Louisiana (LA)	Claiborne	15,314	Homer	9,169	7,196	1	0%
1768	Iowa (IA)	Obrien	15,656	Sheldon	6,245	4,901	1	0%
1769	Tennessee (TN)	Morgan	15,171	Wartburg	6,690	5,251	1	0%
1772	Tennessee (TN)	Grundy	15,534	Tracy City	3,965	3,112	1	0%
1773	Colorado (CO)	Alamosa	14,961	Alamosa	14,100	11,066	1	100%
1776	Illinois (IL)	Massac	14,605	Metropolis	11,453	8,989	1	100%
	Totals		212,557,000		108,153,486	84,883,182	1,905	
	Averages		119,683		60,897			54.6%

It is believed a minimum population of 10,000 is most profitable, but slight variation may exist when pursuing synchronized public relations planning. "Future Mill Placement" (Internal Report L2) considers secondary locations for profitability, such as Hawaii, Alaska, and minor population centers where accommodations for smaller mill sizes can be made. Other than non-continental states and smaller cities, its format is identical to the primary report and follows an identical algorithm already discussed. The "Cautionary Mill Locations" (Internal Report L3) includes even more remote locales and sparse populations, with the addition of an "oil refinery" sort key as determined by "Locations of Top Oil Refineries" (www.EIA.DOE.Gov/NEIC/Rankings/Refineries.htm). This fourth and final report defines 144 substitute commodity threats. The column heading "Rank" deviates from potential mill locations, as the report relates to "Barrels per Day" output. Not always was company associated with a particular county, denoted by "– Unknown –" are not captured by the algorithm in the other 3 reports, due to inconsistencies in the source data. However, only 1 out of the 3 missing was considered significant rank at 36 to warrant pulling Allegheny, Pennsylvania from its natural 22nd spot and placing it lower on the primary report as a precaution. Another report deviation was sorting alphabetically by State since population data was not compared here. Oil refineries below 2,000 barrels a day were not considered significant.

The compilation of data leaves a concise representation of how strategic concerns may play out. To be used as a guide, it proves useful in recommending probable locations, both in terms of what counties to look for existence of landfills and where profitability would be likely. Risky scenarios have not been eliminated, but rather have been carefully orchestrated to most likely not occur at inopportune moments.

Foreign Soil

Undoubtedly, the same concerns that exist in the U.S. apply double when taking this technology abroad. What makes this product economically viable, however, is the existence of sufficient infrastructure. What most other countries do not have is the infrastructure, based on personal experience. Mexico being close to the border with the U.S., obviously does not share any equality of living with its neighbor to the North, and that inequality exists at the basic utilities level - affecting any company. The same would be true for any developing nation, although each at their own pace. That leaves Canada, Brazil, and Europe.

Canada

A study of profitability in various climate regions in the U.S. shows organic waste can still be produced in sufficient quantity in colder regions, and the same profitability model can be applied to Canada (per http://www.eia.doe.gov/emeu/cbecs/climate_zones.html). Their political persuasion follows the Westminster System used by former colonies under British rule, and has similar infrastructure as the U.S. in most regions. However, a formal investigation needs to be launched to determine if there are any hidden obstacles to this industry. Due to one climate zone, just one serious setback can halt operations.

Brazil

Of the countries that have sufficient infrastructure, the politics of Brazil tends to take things personally that are not intended to be so. Their political landscape is founded on generations of hurt associated with military coups and the unsuccessful corrupted administrations that followed. So, they view themselves as victims of unfair politicians, that refuse to finish construction projects initiated by former administrations. They hold grudges against American foreign policy, like tacking on extra fees for foreign travelers following 9/11 passport restrictions. They also are not entirely in synch with the American work ethic either, like month-long vacations and shutting all business down during soccer tournaments – any soccer. Similar conditions persist in certain African countries, and profitability would be shaky in such places without a constant eye on the fluctuations of gold ore prices. However, Brazil already has ethanol and it is a fair assessment one administration might resent our intrusion, just because another would be open to it.

United Kingdom

Political parties in England tend to alternate in power between the Labour Party and Conservative Party. The current ruling party is the Labour Party with its left-leaning tendencies, poses little resistance to free trade and economic justice due to its neo-liberal policies stemming from privatization, limited government intervention, and fiscal responsibility. In this case, however, the ruling party in England does not paint the full picture of tensions in the political landscape.

In the aftermath following Princess Diana's tragic death as noted by journalists of the day, the Labour Party helped turn public opinion into a means of softening the monarchy, dethroning tradition since the time of World War I. Had the Queen continued to resist change, the turmoil could have sparked a revolt that would have been spoken of in terms like "generational rebellion" and "societal awakening", and possibly even "English revolution". Instead of a resented political undertow, the Brits as a whole are ready to resolve differences with royals and the monarchy is ready to embrace the change. This is important to note because it speaks to a changing of the generational guard, a precursor signal to an American awakening, the historical delay effect of the "Atlantic divide".

There are two indicators of profitability here. First, with environmentalism gaining popularity in the West and global warming becoming a hot topic, Great Britain will be inclined toward embracing alternative energy sources. Secondly, be prepared to make all the money that can be made in America as rapidly as possible before the next presidential election.

Austria

The terrain in the Danube Valley states, Upper Austria, Lower Austria, Vienna, and Burgenland, are readily accessible. The mountainous communities of the Alps are more difficult to truck equipment to, but not impossible. Their terrain is perfectly suited for light industry with periodic and decentralized consumerism. Accordingly, profitability directives would begin in the metropolis of Vienna (the city-state) and work Southwest toward the Alps. The geographically secluded state of Carinthia may require additional equipment assembly on site. The alpine state of Vorarlberg is not considered accessible.

A better picture of how the landscape affects population is depicted through the following table:

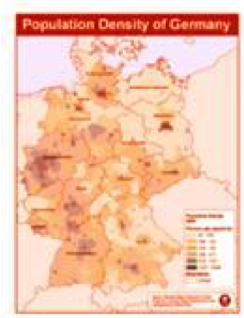
State	Capital	Area (km²)	Population	Density	Cities	Towns
Vienna	Vienna	415	1,660,534	4,001.3	1	0
Lower Austria	Sankt Pölten	19,178	1,588,545	82.8	74	499
Upper Austria	Linz	11,982	1,405,986	117.3	29	416
Styria	Graz	16,392	1,203,986	73.5	34	509

Tyrol	Innsbruck	12,648	698,472	55.2	11	268
Carinthia	Klagenfurt	9,536	560,753	58.8	17	115
Salzburg	Salzburg	7,154	529,085	74.0	10	109
Vorarlberg	Bregenz	2,601	364,611	140.2	5	91
Burgenland	Eisenstadt	3,966	280,350	70.7	13	158

Austria's political landscape is mostly Social Democratic Party of Austria (SPÖ), the ruling party steeped in neo-liberalism. All states, save the capital, share leanings with Austrian People's Party (ÖVP). Theirs is not a dual-party system; Upper Austria, Carinthia, and Vorarlberg entertain The Green Alternative (Die Grünen), Alliance For The Future of Austria (BZÖ), and Freedom Party of Austria (FPÖ), respectively. Basically, these demographics are not out of the ordinary and no political recourse is recommended. However, that is not the only concern, as Austria has a long history.

Austria's biggest economic influence in the world stage has been ceding land at the close of World War I, and its contributions as the nucleus in the Hungarian Empire prior. Its castles and coats of arms are remnants of knightly influence, a time when kings ruled feudal economies. The Empires of old are all gone and so are their monies, but not their traditions. Austria now benefits from close proximity with Germany's economic center, whereas it once was a deficit – militaristically speaking. Even considering availability of German flex-fuel vehicles, the transition to ethanol would not be so tenuous unless Austrians were given opportunity to sell ethanol to Germany or France first. Most likely, Austria would welcome an economic base from beer-making that would work in both Alpine and Valley landscapes. Success in Austria would have a useful side effect: paving the way there could lead to ethanol production in Switzerland.

Germany



Political parties in Germany tend to follow a combination of policies gained by one of two traumatic events: World War I and The Rise of Nazi Germany. The two leading political parties are Christian Democratic Union and Social Democratic Party. The current ruling party CDU, is a blend of Christian Government ideals and Environmentalism, and would welcome alternative fuel. SPD, who wrestles political control whenever the country's pendulum swings in their favor, poses little resistance to free trade and economic justice due to its neo-liberal policies stemming from privatization, limited government intervention, and fiscal responsibility. However, their tradition of upholding working class rights may result in union-based pay rates. The key strategy would be to launch into not just key population centers as shown in dark colors on the map shown, but as many lower-altitude states to the North and gain trade acceptance before the generational transition starts another political cycle.

Germany as a whole will invite hard-working multi-cultural business. Berlin, their capital, is called "the city that never sleeps" and boasts of a "melting pot" of cultures. Hamburg has long been known for its sea trade and civil affairs. Munich provides many economic and leisure opportunities, rich in Bavarian culture. Leipzig is where the Berlin Wall fell first and has experienced the fastest growth due to reconstruction. Cologne, in the Rhineland, is quite open-minded. Frankfurt is the financial district for both the country and the European Union and is considered so business-minded, they ignore tradition and recreation.

Even Germany's population seems to invite foreign investors to expend their resources there:

Germans	75,212,900		Spaniards	108,300		Pakistanis	30,900
Turks	1,764,300		French	100,500		Eritrean	25,000
Kurds (Estimated)	600,000		Iranians	100,000		Tunisians	22,400
Italians	548,200		Americans	96,600		Belgians	21,800

Serbs	507,328		Britons	95,900		Slovenes	21,000
Greeks	370,000		Moroccans	73,000		Ghanians	20,600
Poles	327,239		Macedonians	61,000		Slovaks	20,200
Croats	229,200		Sri Lankans	60,000		Danes	18,000
Vietnamese	183,500		Afghans	57,900		Swedes	16,200
Russians	179,000		Azerbaijani	55,000		Lithuanians	14,700
Austrians	174,000		Hungarians	47,800		Algerians	14,500
Bosnians	156,000		Lebanese	40,900		Finns	13,100
Ukrainians	128,100		Bulgarians	39,200		Albanians	10,500
Romanians	125,651		Indians	38,900		Irish	10,000
Portuguese	116,700		Czechs	38,800		Luxembourgers	6,800
Dutchmen	114,100		Swiss	35,400		Other Foreigners	449,782

However, do not let the multiculturalism fool one into thinking the scars of the past are gone. Any talks should focus on superior German car engineering and what a good neighbor they are.

Italy

The political structure of Italy requires the forming of coalitions, the largest consists of 19 million votes to mostly Socialist-Democratic constituents (49.8%). However, this makeup does not appear stable and demographic mapping may be more difficult than it appears to the eye. Each political party is in a state of internal flux, supposing the generations may be toying with the appeal of / disapproval of communism and the threat of fascism, still fresh in their minds. What is known is that within each party exists factions over some sort of reform verses radicalism. The country is split; even the winning coalition only won by 0.11%. Since they already produce ethanol from durum wheat, it is recommended to offer intent and diplomacy until firm guarantees can be assured. Perhaps it is also wise to interview Sicilians in New York to be briefed in matters of culture prior to any mission. However, thermal energy sources can be mined profitably here using Ireland's steam generators as a model and thereby causing a highly competitive fuel market when hydrogen fuel cells come on the scene.

France

The French are very eco-minded and have emissions free power plants throughout their country. However, this does not mean outside vendors are welcome. They tend to view ex-patriots with great disdain since the increases in unemployment and crime following a wave of Northern Africans. There is also increasing concern of juvenile criminality. And, just because they are eco-minded does not necessarily mean whether progress can be made in similar industry. French politicians hold simultaneous office in more than one level of government, traditionally known as *cumul des mandates*. As a result of their impact, it is suspected that favoritism and corruption will be the next major political issue for voters, and will be a concern until such internal landscape settles. Also, because French corporate law has roots in case law and shifting statutory provisions (according to Triplet & Associés), France's corporate regulation is therefore potentially volatile. Their social-political demographics may be predatory to newcomers and should be handled with extreme caution.

Location Recap

Although For Fuel Freedom has started international patents in several locations, it is important to note that other factors are involved in securing foreign product placement through political, social, legal, and corporate safeguards. English and Germanic cultures would be good starting places to promote this business globally. Insufficient information exists on Canada, Sweden, and Switzerland. Other countries lack the infrastructure, legal-political safety net, sufficient research information, or simply have other economic concerns that require more study or more time to develop what strategy would work best for that particular region. This report provides a starting point and should be modified as new information is made available (garnished from Wikipedia and primary sources).

Competitive Ethanol Technologies Review

The following information is made available by Environment Canada.

Technology Summary

It is difficult to compare the leading technologies that have been evaluated since they are all at different stages of development and thus the level of certainty surrounding each process is different. Table below is a qualitative comparison of the five technologies reviewed with the established grain to ethanol technology. The costs for the grain plant do not include interest, taxes, depreciation or profit, as these are project dependent.

Comparison of Process Economics

Descript	**Grain**	**Iogen**	**BC International**	**Arkenol**	**ACOS**	**Bioengineering Resources**
Develpmnt.. Status	Proven & Commrcl	Building Demonstratn	Building Commercial	Commercial (Japan)	Laboratory	Laboratory/Pilot/Demo
Capital cost	$0.5/l	Higher	Higher	Much Higher	Higher	Similar
Feedstock	Grain	Agricultural residues	Bagasse	Softwood	Softwood	Softwood and Bark
Feedstock cost	$0.3/l	Lower	Lower	Lower	Lower	Much Lower
Co-product value	$0.15/l	Lower	Lower	Lower	Higher?	Lower?
Operating Costs						
Energy	$0.05/l	Higher	Higher	Higher	Same?	Same?
Labor	$0.045/l	Higher	Higher	Higher	Higher	Same?
Chemicls	$0.03/l	Higher	Higher	Higher	Higher	Lower?
Maintnce	$0.025/l	Higher	Higher	Higher	Higher	Higher?
Overhead	$0.04/l	Higher	Higher	Higher	Higher	Same?
Total	$0.34/l	Higher Today	Higher Today	Higher Today	Lower?	Lower?

It can be seen that none of the technologies reviewed are at the same development stage as the proven grain to ethanol technology. The new technologies can not be considered to be commercial today. All of the technologies have substantial room for further development that has the potential to make them competitive in the future. The potential for British Columbia applications is summarized below.

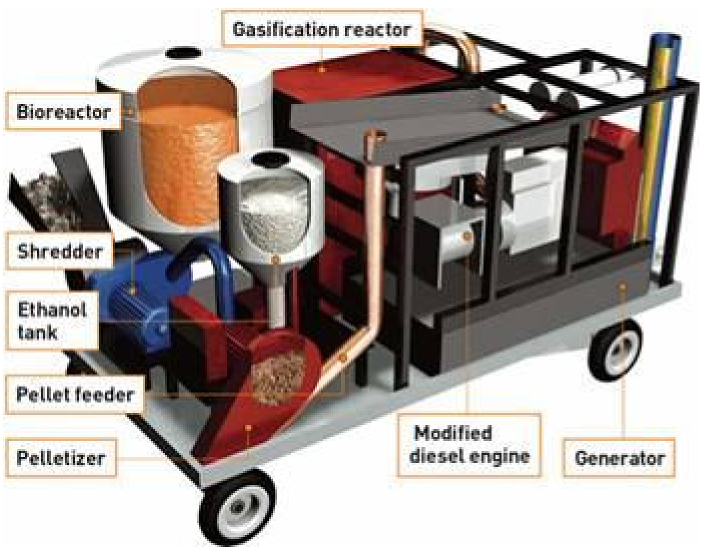
1. **Iogen.** Improvements in enzyme productivity and effectiveness will lower capital costs and operating costs. The demonstration plant being built will help to further define the process. Even more work is required for softwood feedstock, as the higher lignin levels require much higher enzyme use and thus have poorer economics. Lignin is relatively uncondensed and may have a higher value than fuel. Lignin potential requires further work. Pentose sugar fermentation is still to be demonstrated. Clearly a leading technology.
2. **BC International.** Pentose sugar fermentation capability is their strength. Little work has been done to date on softwoods. Two-stage dilute acid hydrolysis is capital and operating cost intensive compared to grain hydrolysis. Unique low capital cost commercial demonstration project underway. Lignin may not be very reactive. Much more work is required on lignin. Also a leading technology.
3. **Arkenol.** Very high capital cost at this time. Cost may come down after the first plant is built and a better understanding of the process is gained. Lignin is not very reactive, it will be difficult to get a high value for it.

4. **ACOS.** Still only at the laboratory stage. Proposed design to produce xylitol and a high value lignin add complexity and cost. The single stage hydrolysis and potentially high value lignin make the process potentially the most cost effective. Question whether the single stage hydrolysis can be effective without degrading the pentose sugars. Could be a very effective pretreatment for softwoods or one of the other processes.
5. **Bioengineering Resources.** Neither the gasification or fermentation stages can be considered proven. Needs a partner to take the combined process to the next stage. Requires detailed engineering to be done on the integration of the two processes. Has the very large advantage of being able to process bark.

"Wood-Ethanol Report", Environment Canada, 1999.

Additional Notes

A more recent technology just announced in the May issue of Popular Science is the Mobile Bioreactor. Purdue University designed a van for the U.S. Army that shreds, palletizes, gasifies, and fuels a small electric generator from trash used by the troops. It uses all aspects of trash to arrive at automation of conversion into various fuel components whose end result powers the generator. The unused plastic encases any unfermentable waste to form pellets used to heat the shredded kitchen scraps in an ethanol bioreactor whose fuel runs the generator. Similar concepts can be employed, but the end product is different than WLM's vehicle goal.



Currently per Wikipedia, several existing ethanol plants in the U.S. are engaged in research and demonstration projects with the U.S. Department of Energy utilizing the existing fiber in their facility that typically goes into the livestock feed co-product. Enzyme companies including Genencor International and Novozymes have led successful research projects with the Department to significantly reduce enzyme cost and increase enzyme life and durability.

Inside chicken dung exists another solution, according to BRI Energy in Fayetteville, Arkansas. Clostridium ljungdahlii is an anaerobic bacterium that produces ethanol from carbon monoxide and hydrogen single-carbon gases found in biomass.

Cellulosic ethanol production currently exists at "pilot" and "commercial demonstration" scale, including a plant in China engineered by SunOpta Inc. and owned and operated by China Resources Alcohol Corporation (CRAC) that is currently producing cellulosic ethanol from corn stover (stalks and leaves) on a continuous, 24-hour per day basis.

According to US Department of Energy studies conducted by the Argonne Laboratories of the University of Chicago, one of the benefits of cellulosic ethanol is that it reduces greenhouse gas emissions (GHG) by 85% over reformulated gasoline. By contrast, starch ethanol (e.g., from corn), which most frequently uses natural gas to provide energy for the process, reduces GHG emissions by 18% to 29% over gasoline. Sugar ethanol is cheaper than corn ethanol. Cellulosic ethanol from sugarcane bagasse, reduces greenhouse gas emissions by as much as cellulosic ethanol. In both cases the waste lignin becomes fuel to provide the energy for the process with some excess to provide electricity for the grid.