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April 30, 2004

Dear Dennis Weaver and Others,

**'Butyl-Fuel™' and 'Freedom Fuel' - Tomorrow's Fuels Today**

***Butanol replaces gasoline!***

Not until recently, thanks to an article written by Matthew L. Wald , titled "Questions about a Hydrogen Economy," that appeared in Scientific American, May 2004 issue, did I realize how dynamic a hydrogen-butanol future can be.  The article focused my attention on answering many questions.  I soon humbly realized that no one knows about a hydrogen-butanol standard.  Butanol is the missing link between ethanol and gasoline.

I have been working for 10 years to prove that it is possible to increase the yield of butanol for use as an alternative fuel.   I was astonished by what I found.  Always good and for the sake of me I cannot find a down side.  I am truly in awe of Mother Nature giving so much of an increase in energy per pound from any organic matter.  I only know that others should know the facts about hydrogen and butanol and the natural anaerobic fermentation process involved.  Please take time to understand what is being said about a hydrogen-butanol paradigm.

Let the facts speak for themselves.

- Butanol and Hydrogen yield 42% More energy (Btu's) per bushel of corn !
- Butanol replaces gasoline !
- Butanol is very safe to handle !
- Butanol solves the hydrogen supply problem for fuel cell development !
- Nationally butanol can make us independent from foreign oil !
- Butanol and hydrogen comply with the Clean Air Acts standards – no smog !
- Butanol manufacturing fulfills goals of the U.S. Strategic Chemicals Act's

With respect for the Planet Earth, the people of earth should know about butanol.

David E. Ramey
President

# A Biomass-to-Butanol/Hydrogen Economy
# 'Butyl-Fuel™' & 'Freedom Fuel'

Since the 1970's oil shortage, there has been a need for a safe hydrogen dense liquid that can replace gasoline, which can be produced from things that grow each year on planet earth, can be shipped through existing infrastructures and have no emissions.

Unlike our oil friends to the East, 'Mother Nature' and 'Ole Sol' never cut back on the production of growing things. Natures' living critters (microbes) digest plants and make hydrogen plus another alcohol called butanol, which is different than ethanol because butanol can replace gasoline: one to one and safely power fuel cells, hybrid cars and other forms of transportation at the same time.

Butanol is the other alternative power grade alcohol
that has no public name recognition.

A butanol economy will stabilize the cost of our fuel in the future. Generating agricultural jobs, by producing *hydrogen and butanol* from corn, grass, leaves, kudzu, digestible trash and anything that flourishes on the planet.

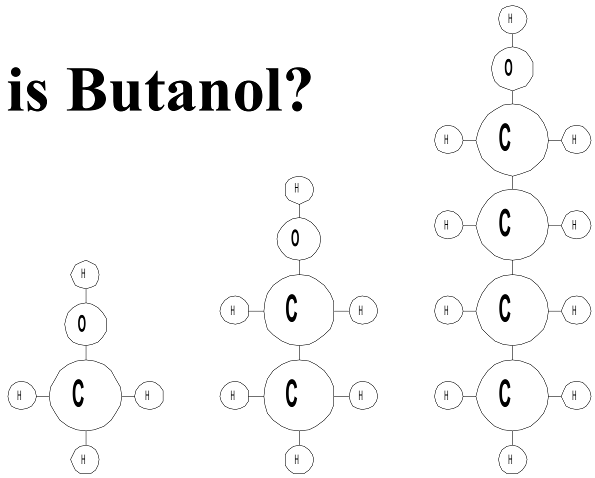
Butanol and hydrogen are 'Green' answers to a future without
high prices at the pump because of a leaned gasoline supply.

The major reason no one knows about butanol as an alternative power grade fuel is that butanol production has never been considered economically feasible. It is an industrial solvent that sells for about three times the price of gas. With the classic and historic ABE[1] (Acetone, Butanol, Ethanol) fermentation a yield of only 1.3 gallons butanol, 0.7 gallons acetone, 0.33 gallons of ethanol and 0.62 pounds hydrogen per bushel of corn is realized – (35 lb sugar). The butanol yield of the ABE fermentation does not even compete with high technology ethanol yields at 2.85 gallons per bushel. Through research grants from the U.S. Dept. of Energy[2] and the Small Business Association's STTR program: a biomass-to-(carbon dioxide, hydrogen and butyric acid) -to-butanol paradigm has proved effective and economically feasible. Environmental Energy's (EEI) US Patent No. 5,753,474 "Continuous Two Stage, Dual Path Anaerobic Fermentation of Butanol and Other Organic Solvents Using Two Different Strains of Bacteria", makes butanol-hydrogen production economical and should be considered in the future. The Company's "Dual Immobilized Reactors with Continuous Recovery" (DIRCR™) process increased the yield of butanol to 2.5 gallons per bushel corn plus an additional 0.6 pounds of hydrogen as a by-product.

Considering the energy yield of 2.5 gallons of butanol and 0.62 pounds hydrogen for every bushel versus the average 2.5 gallons ethanol, the DIRCR™ Butanol-Hydrogen biorefinery will produce 42% more energy.

If 'Mother Nature' and 'Ole Sol' produce such a power grade alcohol as butanol
then let us start making more of it?

# What is Butanol?




| Methanol | Ethanol | Butanol | Gasoline |
|---|---|---|---|
| $CH_3OH$ | $C_2H_5OH$ | $C_4H_9OH$ | Many |
| **Energy Content (per Gallon)** | | | |
| 63 K Btu | 78 K Btu | 110 K Btu | 115 K Btu |
| **Vapor Pressure @ 100 F (Reid V.P.)** | | | |
| 4.6 PSI | 2.0 PSI | 0.33 PSI | 4.5 Psi |
| **Motor Octoane** | | | |
| 91 | 92 | 94 | 96 |
| **Air to Fuel Ratio** | | | |
| 6.6 | 9 | 11.1 | 12 - 15 |

**How Butanol Differs From Other Major Alcohol Fuels**

Butanol is a four-carbon alcohol, double the carbon of ethanol and containing 25% more energy (Btu's).

Butanol is produced by fermentation, from corn, grass, leaves and agricultural waste – anything that grows on the planet.

Butanol with a Reid Value of 0.33 psi. is safer to handle (less evaporative) when compared to gasoline at 4.5 and ethanol at 2.0.

Butanol is an alcohol that can be - but does not have to be - blended with fossil fuels – replaces gasoline one to one.

Butanol can be shipped through existing pipelines. It is far less corrosive than ethanol.

Butanol when consumed in an internal combustion engine yields no $SO_X$, $NO_X$ or carbon monoxide; the $CO_2$ is 'Green'.

Butanol solves the safety problems associated with the infrastructure for hydrogen supply. Reformed butanol has four more hydrogen atoms than ethanol, resulting in a higher energy output (10 watt-hr/gram vs. 8 for ethanol).

Butanol is currently an industrial commodity, with a 2.4 billion pound per year market selling for more than gasoline at $3.38 per gallon.

Hydrogen generated during the butanol fermentation process is easily recovered, increasing the energy yield of a bushel of corn by an additional 18% over the energy yield of ethanol produced from the same quantity of corn.

## NEED

Nationally there is a need to become independent from foreign oil and to comply with the U.S. Strategic Chemicals and Clean Air Acts. There is a need to replace ethanol and gasoline with a safer less evaporative power grade alcohol fuel. There is a need to find a biomass source of hydrogen, and a safe high energy density liquid fuel for fuel cell power generation and distribution. There is a need to revitalize the agricultural sector by developing new value added products that will have a high commercial and industrial demand well into this century, while at the same time creating jobs in depressed areas such as Ohio's Appalachian Region.

National security is addressed by the creation of biorefineries supplying the country's fuel needs while being disseminated throughout the country's Corn-Belt and other biomass source regions –'Bio-Belt'. Locally generated fuel and electricity makes more sense than having our refineries located on coastal regions. Local production makes it harder for acts of God and terrorist to disrupt entire sections of the electric grid and thus directly improves homeland security. Supplies are local thereby reducing the possibility of transportation sabotage.

State wise (Ohio) can expect to see not only jobs at the envisioned BioRefinery Campus but also in the development of BioCottage industries, which consume the various raw products produced at the Bio-Campus. A biorefinery campus is intended to be located in Junction City and New Lexington, Ohio and will impact some 25 local towns on the way to the Ohio River. Towns such as Glouster, The Planes, Albany, Athens, Diesville, Dexter, Hobson's Junction and Pomeroy can be developed into a new 21st and 22nd century plastics industry guaranteeing secure jobs.

## THE HISTORY OF BUTANOL AND ETHANOL

Production of industrial butanol and acetone, via ABE (Acetone, Butanol, Ethanol) fermentation, using *Clostridia acetobutylicum* started in 1916 during the First World War. Chime Weizmann [1](US Patent No. 1,315,585) a student of Louie Pasture isolated the microbe that made acetone. England approached the young microbiologist and asked for the rights to make acetone for cordite – a smokeless powder used to win World War One. Under one condition – Israel would have a homeland after the war and so it was. Up until the 1920s acetone was the product sought, but for every pound of acetone fermented two pounds of butanol were formed. Finally someone took cotton nitrate and mixed it with butanol creating a fast drying lacquer and in three years the automotive industry turned the market around so by 1927 we could not make enough butanol and acetone became the byproduct. Indeed butanol was used to make synthetic rubber and helped win WWII.

The ABE fermentation by *Clostridium acetobutylicum* is one of the oldest known industrial fermentations. It was ranked second only to ethanol fermentation by yeast in its scale of production, and is one of the largest biotechnological processes ever known. These anaerobic microbes were hardy enough to have created the first microbiological industry in the world. One of the world's largest facilities, Commercial Solvents International, was located in Terre Haute, Indiana[3]. However, the actual fermentation has been quite complicated and difficult to control until EEI's patent[4] was recently applied.

Since the 1950's ABE fermentation declined continuously, and almost all butanol is now produced via petrochemical routes[5]. The production of butanol by fermentation declined mainly because the price of petrochemicals dropped below that of starch and sugar substrates such as corn and molasses. The labor-intensive batch fermentation system's overhead combined with the low yields of 1.3 gallons butanol and 0.75 for acetone per bushel corn and a low concentration of only 1 to 1.5 percent butanol before the microbes died was also a reason. Truly a brew masters art. The loss of our cheap molasses supply from Cuba under Castro's control in the mid 1950's, put together with the expensive distillation recovery process and cheap foreign oil, acetone and butanol production from fossil fuel became more popular and sealed the fate of ABE fermentation in the United States. Currently in response to the rising cost of petrochemicals and pollution, industries in many countries are reexamining fermentation as a source of butanol[6].

In the 1970's the primary focus for alternative fuels was on ethanol, people were familiar with its production and did not realize that dehydration (a very energy consuming step) was necessary in order to blend ethanol with fossil fuels. Nor did we realize the difficulty of distribution of ethanol since ethanol cannot be transferred through the existing pipeline infrastructures in any practical concentration without corrosion and damage to rubber seals. The selection of ethanol, a lower power grade alcohol, that is corrosive, hard to purify, very evaporative, and dangerously explosive is the result. Ethanol is still subsidized today by the government since it is not profitable enough to compete with gasoline. The laws should be changed in the future to say power grade alcohols such as ethanol and butanol or poly-carbon alcohols. The laws were written to exclude methanol (mono-carbon) a very low-grade alcohol that is dangerously evaporative and invisible when burning.

For the past thirty years the very energy intensive ethanol process still has not solved our fuel, power or clean air requirements. Ethanol is used predominately as an oxygenate in gasoline at only 10% for all these years and only recently at 85% ( E-85) in highly modified vehicles. Even in some states which require very specialized seasonal gasoline formulas when used in such places a Phoenix, Arizona and Cleveland, Ohio. Ethanol still only yields 2.5 to at best 2.8 gallons per bushel corn. Much of the research stimulated by the biomass ethanol industry has done wonders for consuming hard to digest lignocellulosic (waxy – corn stalks, switch grass) biomass and converting it into simple sugars for yeast fermentation. Any front-end (material handling) technology that is applicable to present sugars to an ethanol facility can be used by a butanol biorefinery. Only the fermentation parlor is modified.

Butanol is an important industrial solvent and is a better fuel extender/oxygenate than ethanol and a 100% replacement for gasoline, as proven by EEI's trip across the nation July – August 2005. Current Industrial Grade butanol prices as a chemical are at $3.35 per gallon with a worldwide market of 350 million gallons per year. The market demand is expected to increase dramatically if 'Green' butanol is produced economically. India, China, Japan and other developing countries need butanol for their burgeoning industrial growth.

In a typical ABE fermentation, butyric, propionic, lactic and acetic acids are first produced by *C. acetobutylicum* (*acidogenesis*) the culture pH drops and then undergoes a metabolic shift (*solventogenesis*) and butanol, acetone, iso-propanol and ethanol are formed[7]. Increasing butyric acid concentration to >2 g/L and decreasing the pH to <5 usually are required for the induction of a metabolic shift from acidogenesis (*acid producing stage*) to solventogenesis (*solvent producing stage*). In conventional ABE fermentations, the butanol yield from glucose is low, typically at ~15% (w/w) and rarely exceeds 25% (1.3 gallons per bushel). The production of butanol is limited by severe product inhibition. Butanol at a concentration of 1.0 – 2.0% can significantly inhibit cell growth and the fermentation causing the fermentation to cease. Consequently, butanol concentration in conventional ABE fermentations is usually lower than 1.3 %.

In the past 20+ years, there have been numerous engineering attempts to improve butanol production in ABE fermentation, including using cell recycle and cell immobilization to increase cell density and reactor productivity and using extractive fermentation to minimize product inhibition. For example, ABE fermentation with cell recycle using a spin filter perfusion bioreactor, 49 g/L of cell mass was achieved and the process gave a butanol productivity of 1.14 g/L/h (grams butanol produced per liter of reactor volume per hour). Cell immobilization benefits ABE fermentation by increasing cell density and producing cell-free product streams that are easier for product recovery.

Also, extractive fermentation with *in-situ* butanol removal from the fermentation broth has been shown to improve the fermentation productivity by twofold as well as butanol yield[8]. Despite all these efforts, the best results ever obtained for ABE fermentations to date are still less than 2.0 % in butanol concentration, 4.46 g/L/h productivity, and a yield of less than 25 % (w/w) from glucose. Optimizing the ABE fermentation process has long been the aspiration of over a century of research. Producing butanol via butyric acid converted from carbohydrates has been proven to increase yield, volumetric productivity and final concentration very efficiently.

Environmental Energy's work with continuous immobilized cultures of *Clostridium tyrobutyricum* [9,10,11,12,13,14]and *Clostridium acetobutylicum* [15] has an optimal butanol productivity of 4.64 g/L/h and yield of 42% (w/w) from glucose or 2.5 gallons per bushel corn (35 Lb starch/lactose/sugar).

| Description | ABE historic | EEI process |
|---|---|---|
| Yield (w/w) | 22% ABE | 42% butanol only |
| Volumetric Productivity | 4.46 g/L/h | 4.64 g/L/h |
| Gallons Butanol per Bushel corn | 1.30 | 2.50 |
| Gallons Acetone per bushel corn | 0.65 | - |
| Gallons Ethanol per bushel corn | 0.22 | - |
| Percent acids left by weight of corn | 0.01 | - |

**Table 1**. **Comparison of EEI technology to historical routes of butanol**

**The Company's Technology Compared to Historic ABE Fermentation**

Compared to the conventional acetone-butanol-ethanol (ABE) fermentation, the company's patent eliminates unwanted products such as acetic, lactic, propionic acids, acetone, iso-propanol and ethanol production, thereby saving the carbon atoms in the feedstock to produce only carbon dioxide, hydrogen, butyric acid and butanol. This process doubles the yield of butanol from a bushel of corn from 1.3 gallons per bushel to 2.5 gallons per bushel – matching the average ethanol yield that is generally achieved through ethanol fermentation. Since each process develops 2.5 gallons per bushel the process that converts sugars to butanol yields 24% more energy (Btu's) per bushel. Since the ethanol route does not produce hydrogen as in the Companies anaerobic path, we gain another 18% Btu's from the hydrogen. (see Table 2)

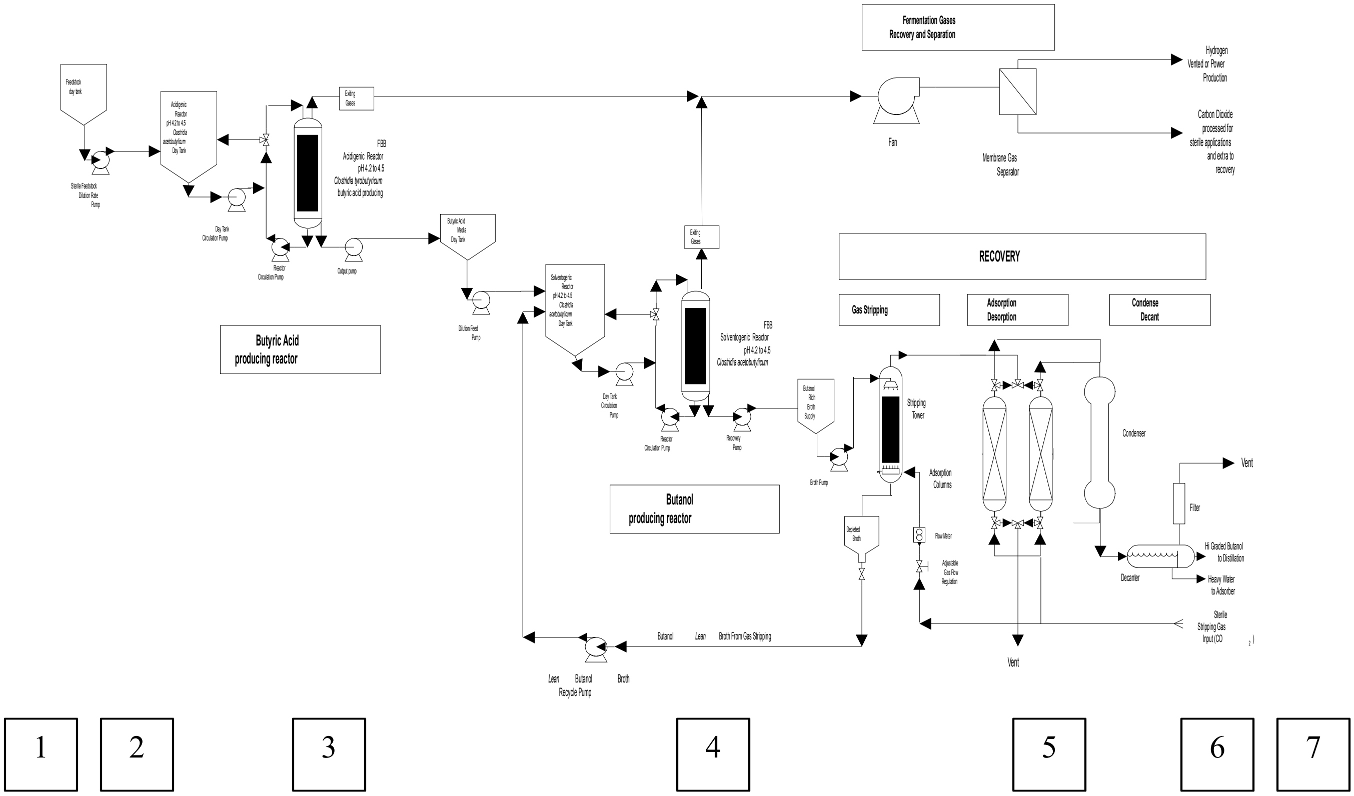



**Figure 1. The Dual Immobilized Reactors with Continuous Recovery (DIRCR™) process.**

The production of butanol consists of a seven-stage process:

1. Dry or wet milling
2. Conversion of biomass into usable sugars
3. Butyric acid and hydrogen fermentation (acidiogenic)
4. Butanol fermentation (solventogenic)
5. High grading: gas-stripping/adsorption/desorption/condensing/decantation
6. Distillation: high purity
7. By-product recovery

The dual process takes advantage of the separate natures of two distinct anaerobic bacteria. One produces butyric acid (3) and the other converts that acid into butanol (4). During the process carbon dioxide and hydrogen are given off and are separated via a membrane.

Butanol is an alcohol and is stripped from the broth in a stripping tower with counter current flows of broth and sterile carbon dioxide (5). The broth falls gravitationally while warm sterile carbon dioxide passes upward, removing small amounts of butanol and then passes into an activated carbon adsorption bed where the butanol is adsorbed from the vapors and leaned water is recycled. Full of adsorbed butanol this canister is exchanged for another recharged (empty) one and the butanol full canister is stripped (desorbed) by another stream of warmed carbon dioxide. This butanol rich vapor stream is then condensed. The condensate is allowed to settle - decant. Butanol will separate at above 10% concentration – which the stripping of the adsorption media yields very easily. The floating portion is then enriched in butanol concentration by gravitational influences to 90% butanol and only contains 10% water and that can be effortlessly removed by distillation (6).

## Compared to Ethanol What Does Butanol Cost to make?

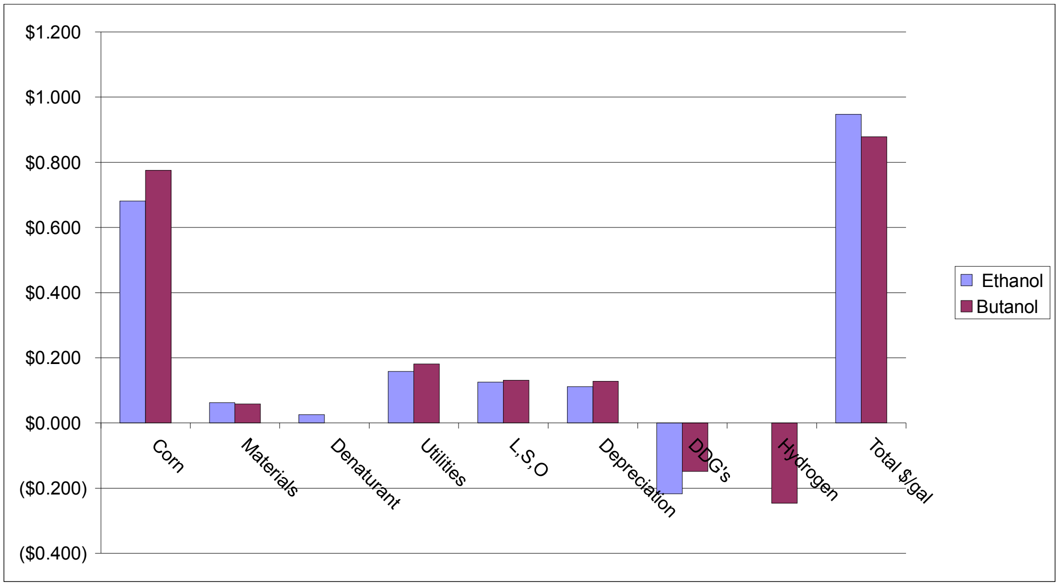



**Figure 2. Over-Head manufacturing Cost Comparison between Ethanol and Butanol**

(An NREL & DOE study October 2000 *"Determining the Cost of Producing Ethanol from Cornstarch and Lignocellulosic Feedstocks" was* used for an Excel boilerplate to determine butanol production costs)[16]

It can be seen in Figure 2, that corn costs more for butanol than ethanol since ethanol yields are higher 2.85 vs. 2.5 for butanol. Materials are just about the same. Unlike ethanol butanol does not have to be denatured in accordance with the US Department of Alcohol, Tobacco and Firearms laws and therefore does not require gasoline for denaturing. Utilities are higher for butanol-hydrogen process due to the fact that biorefinery operates continuously 365 days a year and the ethanol facility for only 330 days a year. Labor and other overheads are similarly higher because of the days of operation. However because of the continuous process for butanol productin labor should prover to be less when pilot plant studies are performed. Depreciation is higher for the butanol-hydrogen biorefinery since a similar size manufacturing plants' capital costs are about 15-25 percent higher than a comparable ethanol facility – only the fermentation parlor is changed. Dried Distillers Grain credit comes from the waste stream of each process and it can be seen that the butanol-hydrogen process gets less credit. This is due to the fact that the butanol-hydrogen process digests more of the incoming carbohydrates and is more efficient in converting them to fuel. Therefore less DDG's are created for sale in the butanol-hydrogen operation. However the anaerobic fermentation does get a credit for the hydrogen produced whereas the ethanol path produces none. Not needing a denaturant and the credit for hydrogen makes the cost of production for butanol the same or just a little less than ethanol.

## The real strength of the DIRCR™ butanol-hydrogen process is in the amount of energy in those 2.5 gallons of butanol plus the hydrogen.

| | Corn | Ethanol | Butanol | Hydrogen |
|---|---|---|---|---|
| Btu per Pound | | 12,790 | 15,511 | 61,000 |
| Btu per gallon | | 84,246 | 104,822 | |
| Gallons per bushel corn | | **2.5** | **2.5** | |
| Pounds per gallon | | 6.59 | 6.76 | |
| Pounds per bushel | 56 | 16.47 | 16.90 | 1.10% |
| Btu's per Bushel Corn | | 210,616 | 262,056 | 37,576 |
| Percent total Btu increase of butnaol and hydrogen over ethanol | | | **24%** | **18%** |
| Total Btu's EEI's process vs Ethanol per Bushel Corn | | **210,616** | **299,632** | |
| Percent total Btu increase of butnaol plus hydrogen process over ethanol | | | **42%** | |

**Table 2. 42% More Energy From a Bushel of Corn**

We see the different Btu values for ethanol, butanol and hydrogen per pound and gallon in Table 2. It is assumed that hydrogen is produced from the same bushel of corn that produced butanol and accounts for 0.6 pounds per bushel corn. Ethanol at 6.56 pounds per gallon yields 211 Kilo Btu's per bushel while the butanol-hydrogen process yields 260 Kilo Btu's with butanol at 6.76 pounds per gallon and another 38 Kilo Btu's for hydrogen. Or almost 300 Kilo Btu's more. That is 42 % more energy from the same bushel of corn when making butanol and hydrogen versus ethanol.

## What about fuel cell applications?

In a 25,000,000 gallon per year butanol-hydrogen biorefinery capable of converting butanol and hydrogen into electricity via fuel cells we might expect to see the following: 750 thousand megawatt-hours per year versus ethanol at 525. (see Table 3.)

**Table 3. Butanol-Hydrogen to Fuel Cell Electricity**

| **Gallons Per Year 25,000,000** | | | |
|---|---|---|---|
| **Income for electricity at 85% conversion** | | | |
| | Hydrogen | Butanol | Ethanol |
| Btu per pound | 61,000 | 15,511 | 12,790 |
| Btu's per gallon | 15,030 | 104,822 | 84,246 |
| $ per kilowatt-hour | $0.04 | $0.04 | $0.04 |
| Btu per kWh | 3,414 | 3,414 | 3,414 |
| kWh per gallon | 4 | 31 | 25 |
| $ per gallon | 0.18 | 1.23 | 0.99 |
| kilowatt-hours per year | 110,050,579 | 767,495,109 | 616,839,546 |
| Electricity Converted - Kilowatt-hours per year | 93,542,993 | 652,370,843 | 524,313,614 |
| Annual income all Electric output | $3,741,720 | $26,094,834 | $20,972,545 |
| Total all electric Gross income | | $29,836,553 | $20,972,545 |
| Overheads - hydrogen a byproduct no costs | $0.00 | | |
| cost to produce a gallon | | $21,969,085 | $23,672,806 |
| Net Income | | $7,867,469 | ($2,700,261) |

Producing electricity would allow us to take advantage of fuel cell efficiencies, which are a factor of two over gasoline turbine generator systems.[17]

Many research facilities have investigated the ability to reformed hydrogen from methanol, ethanol, methane, butane, iso-octane, synthetic diesel, and other hydrocarbons such as gasoline, but no butanol. Butanol is not even thought of as a power grade alternative fuel because of low yields in historic ABE fermentations. However, the success of reforming the aforementioned fuels and experiences in a broader array of chemical process application gives a very high level of confidence that reformed butanol with technology very similar to what is already developed will be successful. Of course, as with any specific fuel application, some additional confirmatory development and optimization is envisioned with little doubt as the success of such efforts.

## What If Butanol-Hydrogen Are Sold for Btu Content?

It can be seen in Table 4 that if butanol and hydrogen are not converted into electricity but sold relative to their respective Btu contents, as is ethanol ($1.65 per gallon - 84 KBtu) then we see an income for butanol (105 KBtu per gallon), which has 25% more Btu content will be about $2.03 per gallon. Therefore, in a 25 MM gallon per year facility we might see the following differences:

| **Gallons per Year** | **25,000,000** | | |
|---|---|---|---|
| **Income From Btu Content relative to Ethanol includes equal subsidy** | | | |
| | Hydrogen | Butanol | Ethanol |
| Pounds per Gallon | 0.25 | 6.76 | 6.59 |
| Pounds per year | 6,160,000 | 168,950,599 | 164,673,632 |
| Market Value per Pound | 1.00 | 0.30 | 0.25 |
| Market Value per gal | 0.25 | 2.03 | 1.65 |
| Ethanol Subsidy | | 3,750,000 | 3,750,000 |
| Total Gross Income | $6,160,000 | $54,435,180 | $45,000,000 |
| | | $60,595,180 | $45,000,000 |
| Overheads - hydrogen a byproduct no costs | $0.00 | | |
| cost to produce a gallon | | $21,969,085 | 23,672,806 |
| Net Income | | $38,626,095 | 21,327,194 |

**Table 4. Butanol-Hydrogen marketed for its Btu content**

Comparing the Btu's per gallon of fuel ethanol to butanol-hydrogen we see an extra income of $17 million. The hydrogen can also be used to off set over 17% of the energy load for the biorefinery and still see a $11 million difference. (Both receiving subsidies)

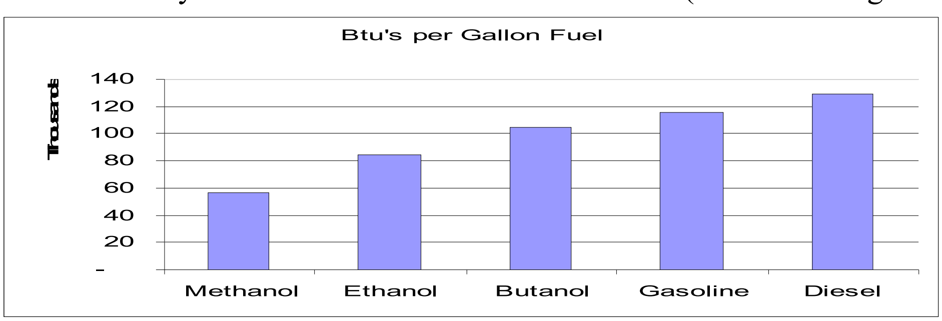



**Figure 3. Various Fuels and their Btu's per gallon content.**

**Where has butanol been in all the alternative fuel studies?**
**It fits so well!**
**It is the missing link.**

## What If Butanol Were Sold As An Industrial Commodity?

Butanol has a market value between $0.45 and $0.50 per pound that is around $3.38 per gallon. The open Commodity Market that exists today requires barge loads shipped to distributors. There are over 2 billion pounds of butanol sold each year for paint thinner, brake-fluid and perfumes. With this in mind we might see from Table 5 the following profit of about $47 million more than a similar ethanol facility:

| Gallons Per Year | 25,000,000 | | |
|---|---|---|---|
| Income as Industrial Commodities | | | |
| | Hydrogen | Butanol | Ethanol |
| Pounds per Gallon | 0.25 | 6.76 | 6.59 |
| Pounds per year | 6,160,000 | 168,950,599 | 164,673,632 |
| Market Value per Pound | 1.00 | 0.50 | 0.25 |
| Market Value per gal | 0.25 | 3.38 | 1.65 |
| Ethanol Subsidy | | | 3,750,000 |
| Total Gross Income | $6,160,000 | $84,475,299 | $45,000,000 |
| | | $90,635,299 | $45,000,000 |
| Overheads - hydrogen a byproduct no costs | $0.00 | | |
| cost to produce a gallon | | $21,969,085 | $23,672,806 |
| Net Income | | $68,666,214 | $21,327,194 |

**Table 5. Butanol-Hydrogen Sold as Industrial Commodity.**

The commodity market would take ten 50 million gallon per year butanol biorefineries to reach saturation.

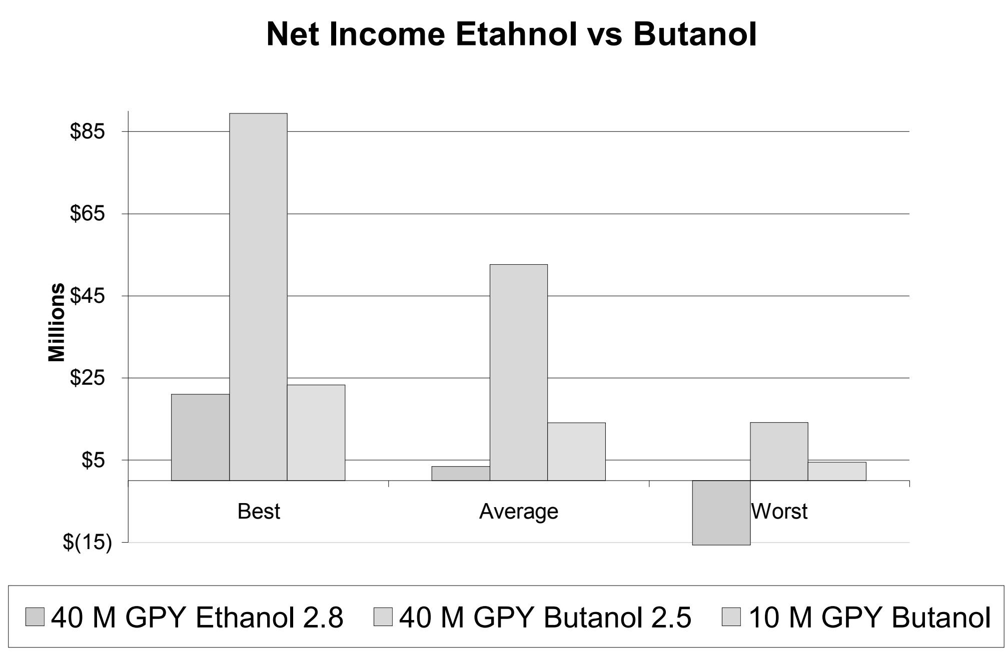



**Figure 4. Profitability of an Industrial Grade Butanol Biorefinery**
(Not including hydrogen)

NOTE: The worst-case scenario 10 mgpy butanol biorefinery will still gross approximately $2 million more than a 40 mgpy average ethanol manufacturer. This ability to obtain a higher income is due to the difference in current spot market value of butanol and ethanol ($3.38 - $1.54 respectively).

## Butanol Commercial or Military Application

In a commercial or military application, butanol could be used as a fuel for fuel cell power stations supplying local electricity such as in Westerville, Ohio[18]. Supplying electricity for computers and other portable hardware is another commercial package. Butanol will prove to be exceptional because it is a safe hydrogen dense liquid (10 watt-hr / gram, versus ethanol at 8.

A Tactical Butanol-Hydrogen BioRefinery Platform application will be a cost-effective means for providing fuel and energy during forced entry or expeditionary operations and is a critical requirement, similar to the current reverse osmosis water treatment platforms. Further, with the increasing importance of electronics in the Objective Force Warfighter effort, cost-effective and lightweight means for producing electricity in the field is important. The logistics of delivering fuel where local sources are not readily available incur high costs, time, and opportunity. Forward positions have critical and significant uses for fuel in stationary equipment (mess halls and operations centers), as well as for combat vehicles. The value of a safe liquid fuel to be carried in a biodegradable canister that can be buried on site and continually reformed by a small, heatless, lightweight, fuel cell units that generates power for body held counter electronics, camouflage, body temperature signature control, night vision equipment and other computer hardware units is achievable, with out batteries.

A quart of butanol (1.7 pounds produces 7,600 watt-hours), depending upon the electrical loads, the quart of butanol might yield several weeks or more of deployment without the need to return or lose mission critical functions for lack of electrical power. All movement incurs risks, and to return or otherwise be re-supplied presents risks: positions may be disclosed, operations may be delayed, or goals may not be achieved. Using the butanol-fuel cell paradigm would guard concealment and save time. Individual combatants could remain onsite longer for reconnaissance and communication activities.

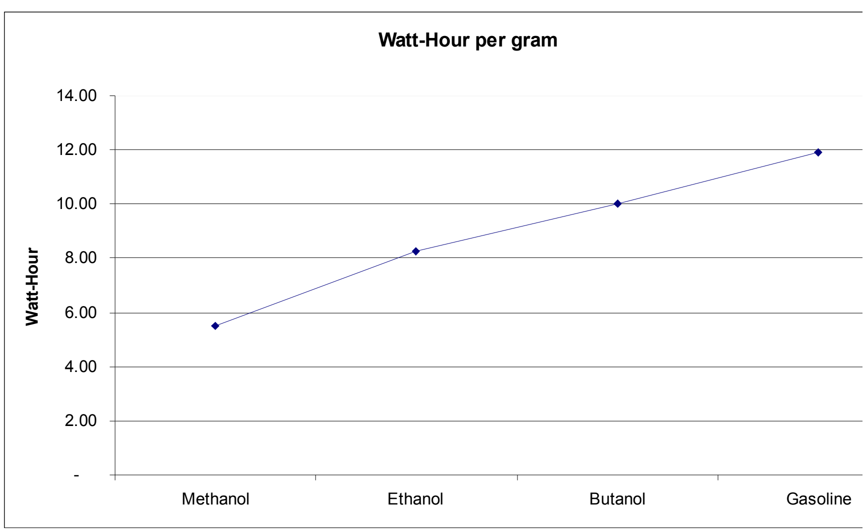



**Figure 5. Watt-Hours per grams for Alternative Alcohol fuels**

## Butanol-Hydrogen BioRefinery Platform Application

The use of the Pilot Plant platform units can solve small agro-businesses waste stream disposal problems. Many manufactures pay dearly for the amount of sugars or bio-constituents that demand oxygen (BOD) before disposal into our streams or local community waste management systems.

These smaller units can address many of these problems such as the cheese industries whey disposal problem, the corn milling industries corn steep liquor problem and many other small local community restaurants, produce prepping, potato chip and distributors, all with unusable starch by-products that contain sugars but which present a financial yoke on their companies for disposal. These companies now have the ability to turn those waste streams into marketable products, by turning an economic drain on the company into a profit, by becoming part of this century's bio-solutions to business problems – fuel for you car.

## Jobs In Appalachian Regions and Throughout the 'Bio-Belt'!

Starting in Perry County, Ohio, a biorefinery campus is envisioned, producing hydrogen/electricity, acids such as lactic, butyric, acetic, propionic and solvents such as acetone, butanol, and propanol. Biomass converters of woody items, bales of hay, leaves and grass, appropriate landfill wastes and corn or sugar beets could be brought to a BioCottage Material Handling Co-Operative, converted to sugars and fed to the local BioRefinery's input. This will enable many untillable but mowable acres of Appalachia to contribute feedstock to the local co-op. Corn and other biomass feedstock would have to come from Knox, Licking, Franklin, Fairfield and other counties south, north and west of Junction City and New Lexington, Ohio. The output products of the biorefinery such as ethyl-lactate, calcium lactate, butyl lactate and various forms of poly lactic acids (biodegradable plastics) will be shipped as raw materials either to barges on the Ohio River or to entrepreneurial BioCottage industries located in some 25 towns with rail sidings on the way to the river.

These BioCottages can use these precursor chemicals and make many value added end products for the industrial, commercial and retail markets. Bio-products manufactured in these towns are transported via rail inland or to Hobson's Junction on the Ohio River. All while creating jobs in a very beautiful but needy area of the United States.

BioCottage industries can produce biodegradable auto parts, disposable sanitary products, picnic ware, garbage bags, fishing nets and line, etc., all to be used by the public and then composted. These products will have high demand well into this and the next century. It will be great to be around in December some year and see if more Christmas lights are up and more community functions gather people together in the warm golden glowing lodges of the valleys and towns in the Appalachian Region.

## FUTURE

Butanol, a pure alcohol with 90% the punch (Btu's) of gasoline but more torque qualities is an answer to solving global warming and gaining our independence from foreign oil. In the future people might even mow their yards and collect some of the grass and all the leaves, putting them in a solar powered dryer in the garage in order to immediately preserve the sugars, inhibit bacterial growth and reduce the weight, prepping for collection, used in their local fuel cell electric grid and given a credit for each pound. Local departments of transportation (DOT's) might look for a grass they could plant along freeways that they could cut three or four times a year instead of once. Using the grass to create fuel for their operations and reducing the tax load on the public.

This might help answer the question: “Is there enough biomass to go around?”. How many acres of grass mowed 4 to 6 times annually are necessary to give a person a good agricultural livelihood? A butanol, hydrogen, Polylactic acid economy will move people back to the land supplying our food, fuel and biodegradable fibers and plastics of the future.

A butanol-hydrogen economy overcomes the problems faced with ethanol and the other alternative fuels: 1) Butanol does not have to be stored in high-pressure vessels like natural gas. 2) Butanol can be transported through existing pipelines for distribution. The filling station of the future could service regular automobiles, hybrids, and fuel cell vehicles all at one stop, all with one renewable fuel made locally. 3) The application of fuel cell technology is held up by the safety issues associated with hydrogen distribution, since butanol is safe and can be very easily reformed, as is methanol and ethanol, for its hydrogen content butanol solves another problem. 4) Since butanol can be blended with gasoline or diesel (oxygenate), it can be slowly introduced into the fuel grid as more and more biorefineries are built throughout the ‘Bio-Belt’. 5) Jobs created in this burgeoning industry will stay in America and cannot be sent overseas – fuel generation will be a local activity. 6) Further, because butanol is very safe, it solves many of the inherent dangers with transporting fuels, natural gas and hydrogen.

New demands for cleaner burning fuels resulting from the U.S. Clean Air Act adds more immediate importance for all forward looking projects relative to alternative fuels. Demands for fuel, improved technology and reduced feedstock costs through the use of biomass and energy generated by the hydrogen output will make it economically favorable to sell hydrogen and butanol at competitive prices with gasoline and diesel once the industrial solvents and chemicals market are satisfied.

Environmental Energy is combining vigorous strains of bacteria with decades of proven technology and applying U.S. Patent No.5,753,474, “Continuous Two Stage, Dual Path Anaerobic Fermentation of Butanol and Other Organic Solvents Using Two Different Strains of Bacteria” to place other biomass derived gases, chemicals, acids, solvents, ethers and esters on the market. In turn, these chemicals can be used by the local ‘BioCottage’ industries to create even more ‘Green’ friendly products and jobs.

Growing consumer acceptance, name recognition, incentives to agriculture and industry, falling production costs, increased prices and taxes for fossil fuels and the desire for cleaner burning source of energy will increase butanol production and use.

Building new smaller turnkey Biorefineries of 5 to 30 million gallons per year for small municipalities and the surrounding farming communities will introduce state-of-the-art technologies at a faster rate than has been adopted in the past for ethanol. This acceleration will improve the butanol-hydrogen industry's overall efficiency and address many overwhelming problems associated with the environment.

By disseminate fuel generation and generation of electricity throughout the ‘‘Bio-Belt’’, disruption by terrorism is made more difficult thus improving ‘Home Land Security’. Cooperatively owned BioRefinery will allow the agricultural sector to employ more people and dollars made in a community stay and multiply seven fold.

Laws should be modified to read not only ethanol but also “***any power grade alcohol such as ethanol or butanol: or: Polycarbon alcohols.***”.

## Where's the Down Side:

We can't produce butanol-hydrogen fast enough because of the infancy of the technology: by 2010 the first 30 MM gallon per year butanol biorefinery is expected to be online in the Appalachian Region of Ohio. The next few years are necessary to methodically development and scale the DIRCR process. First of a kind system costs will be incurred just as they did for the ethanol industry (1970-1990).

As with any other new power grade fuel or chemical to be placed in common use, butanol has to be investigated by everybody since it has never been thought of as an alternative fuel. The EPA, automakers, fuel cell proponents and many other civilian and political bodies will determine if butanol is what it is. A fuel that replaces gasoline today in your car without having to be modified is what they will find. Many jobs will be generated to prove what has already been demonstrated.

Until butanol is sold as an alternative fuel, it can continue to be sold as a 'Green' industrial commodity that will create new uses and power the new fledgling butanol-hydrogen bio-industry.

Please, if there is any down side, let us know. I have been looking for it for years. Even if we found a problem I am sure that the scientific community can solve it. Especially if we can make catalytic converters that withstand ethanol blends and solve the many other problems we have faced with ethanol, soy diesel, natural gas and gasoline in our approaches to stop 'Global Warming'.

# www.butanol.com

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