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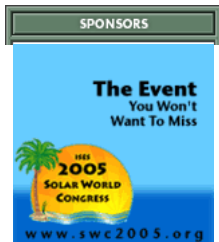
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Today's marketplace is all about renewables. Biodiesel is an important new player with significant promise.



**THE PROBABLE ONLY FUEL OF THE FUTURE,
RENEWABLE OR OTHERWISE**

by C. G. (Chuck) Steiner President and CEO
WaterSmart Environmental, Inc.

It's not fun to think about but when our earth's natural and mostly free resources diminish they must be gradually replaced with sustainable manufactured or produced products in order to continue our successful habitation of this planet. Ocean fish populations, for example, have been greatly diminished because of increased worldwide consumption. Consequently, fresh and seawater fish production are now gradually replacing former ocean fish inventories. The southern half of Florida is now experiencing initial seawater intrusion of its massive freshwater underground aquifers due to excessive groundwater pumping. Over time these groundwater resources will have to be gradually augmented with sustainable manufactured freshwater such as that produced by desalination technology. The fossil fuels of coal, crude oil, and natural gas represent additional examples of gradually diminishing resources which must eventually be completely replaced with sustainable manufactured products. Fossil based products produce electricity, transportation fuels, heating oils, lubricants, and petrochemicals.

So what's going to replace fossil based fuels and when? Let's review the several existing options from the combined purviews of science and cost.

Sustainable Resource	Can Produce	Comments
Wind	Electricity	Up to maximum of 2% electricity replacement possible due to limited wind availability.
Hydroelectricity	Electricity	Up to maximum of 2% electricity replacement due to limited eligible water.
PV Solar	Electricity	Excellent for special applications but otherwise considered far too expensive for massive application.

Tidal Waves	Electricity	Potentially excellent technology for distributed generation on small scale bases. Not possible for massive generation due to limited qualifying tides.
Ethanol	Transportation Fuel	Its existing use as a gasoline fuel oxygenate is frequently challenged as uneconomical because of the significant Governmental subsidies which underwrite the market.
Hydrogen Gas	Transportation Fuel	According to the USDOE, hydrogen requires twice as much energy as electricity, or twice the tonnage of coal, or twice the number of nuclear plants, or twice the field of PV panels to perform an equivalent unit of work. Its future general use appears to be scientifically challenged and its infrastructure must yet be built. The National Academy of Sciences concluded in a report dated February 4, 2004, that it will be "...many decades at best before hydrogen technology can contribute significantly to fixing America's

		oil import and global warming problems.”
Methane Gas	Electricity and Transportation Fuel	Can be produced from anaerobic digestion of organic matter and organic wastes. CNG and LNG are quite excellent transportation fuels environmentally but somewhat costly because of their inherently low Btu value. Their infrastructure is now under construction.
Biodiesel	Electricity, Transportation Fuels, Lubricants, and Greases	Highly suitable for cars, trucks, airplanes, ships, and trains. No oxygenate required. May also be further refined into biolubricants and biogreases. The infrastructure for biodiesel already exists.

Hydrogen gas has received enormous attention recently because of the believed potential of Solar Hydrogen. Solar hydrogen refers to any method of production that uses the power of the Sun to produce and collect usable hydrogen. The most likely approach proposed is:

1. Energy collection utilizing parabolic solar collectors that focus and concentrate the light energy of the Sun.

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2. Applying the collected energy to a Stirling-cycle heat engine which, in turn, drives an electricity-producing generator to power an electrolysis system.

3. Electrolysis systems use electricity to chemically decompose water into its component elements of hydrogen and oxygen. Free hydrogen doesn't exist in sufficient quantities

to support a hydrogen based transportation fuel.

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4. The solar hydrogen is then used as an environmentally clean fuel to power transportation equipment.

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While technically possible, Solar Hydrogen technology still must have its infrastructure developed and thereafter compete competitively with other biofuels such as biodiesel. A hydrogen fueled car currently costs the equivalent of \$4.00/gallon gasoline. Lowering this cost significantly appears to be scientifically difficult. Biodiesel, by comparison, is currently in the \$1.50/gallon range and heading lower.

A gasoline engine is about 25% efficient in converting Btus into work (joules). A diesel engine, by comparison, is about 43% efficient. When converted into actual distances, each and every 100 gasoline miles is the near equivalent of 172 petroleum diesel (petrodiesel) or biodiesel miles. These facts are ever present driving forces which favor the use of far more efficient diesel engines.

As a diesel engine fuel, biodiesel is an environmentally preferred and a performance equal to petrodiesel. If refined from waste vegetable oils and fats, it is price competitive with petrodiesel and consequently now being sold in the marine, transportation, and mining industries as well as for heating oil. If refined from virgin vegetable oils, however, it is not price competitive and therefore not being sold as a 100% replacement of petrodiesel. It is, however, currently being sold as a blend component of petrodiesel because of its extremely favorable influence on environmental emissions. A blend as low as 2% biodiesel provides a dramatic positive effect on the overall performance of a diesel engine which is strong evidence of its excellent fuel characteristics.

The production cost of biodiesel consists of the cost of vegetable oil acquisition or production plus the cost of its subsequent refining. There isn't a great deal of improvement possible with vegetable oil acquisition or production as most of the some 50 vegetable oils marketed are already fully established worldwide commodities. The cost of biodiesel refining, however, is susceptible to significant improvement if the associated refining biowastes are converted into energy through anaerobic digestion technology. The energy produced has significant value which, when credited to the biodiesel refining process, greatly reduces the bottom line cost of biodiesel production.

Biodiesel is efficiently produced by a chemical process called transesterification whereby raw glycerine is removed from vegetable oils. Raw glycerine must then be further purified before it can be marketed. Because of a continuing worldwide glycerine glut, raw glycerine may be far better managed as a biowaste residual of biodiesel refining rather than a salable commodity. And

whether the vegetable oils are obtained by crushing or steam extraction there are always additional biowaste residues all of which may be anaerobically digested to produce methane gas. Methane gas can be efficiently converted into steam and electricity, both of which can be holistically and beneficially used in the refining of biodiesel. In addition to methane gas, anaerobic digestion systems can generate carbon dioxide gas, organic fertilizer, liquid fertilizer concentrate, and reverse osmosis permeate water, all of which are salable commodities and therefore added value co-products in the refining of biodiesel.

Biodiesel is a pure 100% fuel conforming to ASTM Specifications D 6751. It is referred to as B100 or "neat" biodiesel. A biodiesel blend is pure biodiesel blended with petrodiesel. Biodiesel blends are referred to as BXX. The "XX" indicates the amount of biodiesel in the blend. A B20 blend, for example, is a 20% volumetric blend of biodiesel with 80% petrodiesel. B20 easily meets ASTM Specifications D 975. Biodiesel and biodiesel blends have excellent solvent properties. In some cases, the use of petrodiesel, especially No.2 petrodiesel, leaves a deposit in the bottom of fuel lines, tanks, and delivery systems over time. The use of biodiesel can remove these deposits and sediments. This results in the need to change filters more frequently when first using biodiesel until the entire fuel delivery system has been cleaned. This same phenomenon is frequently observed when switching from No.2 to No.1 petrodiesel.

B20 raises the pour point, cloud point, and cold filter plugging point (CFPP) cold weather properties of petrodiesel at least 1.67°C (3°F). Biodiesel anti-gel products are available that can efficiently and effectively lower the CFPP of B20 as low as -40°C (-40°F). Fuel filter and line heaters can also be used to lower the CFPP even further. Neat biodiesel should be transported and stored at temperatures above 10°C (50°F) to guard against gelling.

Biofuels include ethanol, hydrogen, methane, and biodiesel. All are derived from renewable biological sources. All directly support local agricultural economies on a sustainable basis. All generate less pollution than petroleum based fuels. Compared with petrodiesel, biodiesel:

1. Is cleaner burning,
2. Is odor free, non-toxic, and biodegradable,
3. Is free of sulfur, ,
4. Is safer for people and the environment,
5. Reduces EPA targeted emissions,
6. Achieves more complete fuel combustion,
7. Is safer to handle, transport, and store,
8. Has higher lubricity,
9. Reduces black smoke,
10. Eliminates the nauseating smell,
11. Has a flash point above 150°C (302°F) and therefore exhibits a lesser potential for explosion,
12. Reduces greenhouse emissions, and

13. Is a plant-based fuel replacement.

According to the USEPA, biodiesel has additional and multiple benefits as follows:

Emission benefits	Biodiesel reduces particulate matter, carbon monoxide, sulfur dioxides, and total hydrocarbon emissions.
Engine power	Is virtually the same as petrodiesel (128,000 vs. 130,500 Btus/gallon). Engine torque and horsepower therefore remain virtually the same.
Conversion and engine adjustments	None required. A changeover to biodiesel or biodiesel blends does not require any engine conversion or adjustments.
Cetane number	Higher than petrodiesel (49-62 vs. 42 for No.2 diesel fuel). Higher cetane values contribute to reduced engine knocking and smoother running.
Fuel consumption	Similar to petrodiesel.
Lubricity	Much higher and when blended with petrodiesel compensates for the loss of lubrication with the new low-sulfur and CARB (California Air Resources Board) petroleum diesel fuels.
Winter conditions	Existing diesel fuel winterizers can be used with biodiesel and biodiesel blends.
Handling and storage	Is safer than petrodiesel to handle and store. Biodiesel does not produce dangerous vapors at normal ambient temperatures, and can be stored in the same containers and tanks as petrodiesel.
Environmental considerations	Is safer for the environment than petrodiesel. Is also less toxic than table salt, is as biodegradable as sugar, and contains no carcinogenic aromatics.
Availability and supplies	Biodiesel is available now. Currently, North America produces a surplus of 22 billion total pounds of vegetable oils, lard, and tallow that is available for biodiesel production.
Lifecycle carbon dioxide	Is reduced by 78%.
Energy security	Biodiesel produced from domestic renewable resources supplements the world's petroleum supplies and helps

| ensure America's energy security. |

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Politically, The Energy Policy Act (EPAAct) of 1992 requires most federal, state, and public utility companies to have certain percentages of alternative fuel vehicles (AFVs) in their fleets. Since biodiesel works in any diesel engine with few or no modifications, EPAAct was amended in 1998 to allow fleets to gain AFV credits through biodiesel use. Every 450 gallons of biodiesel purchased counts as one AFV credit. Fleets are, however, limited to using biodiesel for 50% of their credits. This 50% restriction is now under review. In addition to the EPAAct provision, the Senate's energy package includes a provision that would give a one cent reduction in the fuel excise tax for every one percent of biodiesel blended into standard diesel fuel up to a B20 blend for three years.

Biodiesel would also be an eligible fuel to participate in a program that calls for the nation to increase use of renewable fuels. This provision calls for the United States to use 5 billion gallons of renewable fuels by the year 2010. There exists a strong petroleum industry lobby opposed to the promotion and usage of alternative fuels. Despite this, use of biodiesel in the United States is increasing, particularly in urban bus fleets. Production costs for biodiesel are currently about 2.5 times that of petrodiesel.

Fuels derived from renewable biological resources for use in diesel engines are known as biodiesel fuels. Animal fats, virgin and recycled vegetable oils derived from crops such as soybeans, canola, corn, sunflower, and some 30 others can also be used in the production of biodiesel fuel. Tall oil produced from wood pulp wastes is yet another possible feedstock source. Biodiesel was used as a diesel fuel as early as 1900 when Rudolf Diesel demonstrated that a diesel engine could be run on peanut oil. Chemically, biodiesel is the methyl or ethyl alkyl esters of long chain fatty acids derived from renewable lipid sources. It is generally produced in a several stage batch process. The process begins by dissolving the catalyst (sodium or potassium hydroxide) with methyl or ethyl alcohol using a standard agitator. The alcohol/catalyst mixture is then added to a closed reaction vessel and the vegetable oil (or fat, or beef tallow, or pork lard) is/are then added. The reaction process from this point on is closed from the atmosphere and kept around 71°C (160°F) for 1-8 hours. Once the reaction is considered complete, two major products exist namely biodiesel and glycerine. Each has an excess amount of alcohol previously used in the reaction phase. The glycerine phase is much denser than the biodiesel phase. After these two products are separated the alcohol is removed by distillation. The glycerine is neutralized with an acid and

sent to storage as crude glycerine. Once separated from the glycerine the biodiesel is purified by washing with warm water (referred to as the methyl ester wash) to remove residual catalysts or soaps, dried, and then sent to storage.

The National Biodiesel Board (NBB) is a trade association of the soybean industry located at PO Box 104898, Jefferson City, MO 65110-4898, Phone: 800.841.5849, Fax: 573.635.7913, URL: www.biodiesel.org. NBB serves as the product development team for biodiesel within the United States coordinating the research, regulatory, and market development programs needed to commercialize biodiesel. Its membership base includes fuel marketers and related feedstock producing and marketing associations. NBB's research is focused on biodiesel fuel, its characteristics, its economics, and diesel engine testing for emissions and non-emissions work. NBB's market development program is focused on federal and state regulatory work and market development through the education of the industry and end users. The United States, Europe, New Zealand, and Canada have conducted tests of biodiesel on trucks, cars, locomotives, buses, tractors, and small boats. Testing has included the use of pure biodiesel and various blends with conventional diesel engines. Results indicate significantly reduced engine wear while performance remains virtually unchanged. Many tests have concluded that the best overall results are obtained with a B20 blend.

Economics of Biodiesel and Petrodiesel Production

The prices of feedstock used in the production of biodiesel relative to petrodiesel is a key determinant in the price competitiveness of biodiesel. The economics of biodiesel production have deteriorated since 1994 for two main reasons:

First, low agricultural commodity inventories (notably corn and wheat), drought conditions in some production areas and increasing demand for grains and oilseeds has resulted in a significant increase in commodity prices in the last few years. While there is expected to be some price moderation in the short-run, it is not anticipated that grain prices will decline in the foreseeable future to the levels prevailing a few years ago.

Second, petroleum prices have declined several dollars per barrel in late March 1996 to just under US\$16/bbl. Much of the impetus for the decline resulted from the recent agreement between the United Nations and Iraq, which allows that country to reenter the market as a supplier. Other petroleum producing nations have indicated they will not be reducing their output to compensate for Iraq's production. Therefore, total oil market supply will increase and prices could decline even further. Over the long term, however, agricultural inventories and the price of petroleum will both likely increase because the ongoing trend for both points

upward. Currently, biodiesel is a technically acceptable substitute, replacement, or blending stock for conventional petrodiesel, but that its cost may only make economic sense where alternative fuel vehicle purchases are required by federal law and where alternative fuels are required by law to be used by certain regulated fleets. The cost of using biodiesel is quite economical when compared to the total cost to use other alternative fuels.

For all practical purposes, the performance of the virgin and recycled oil biodiesel products are identical. The marketplace price of the recycled oil is, however, significantly less than the virgin oil product. If all the existing production of virgin and recycled oil were made into biodiesel and sold, the sales would replace less than 2% of petrodiesel sales. Virgin soy oil costs about 20¢/lb which translates into a soy biodiesel price of about \$2.00/gallon whereas virgin mustard seed oil, a low value waste product, costs about 10¢/lb which translates into a mustard biodiesel price of about \$1.00/gallon. If the waste or recycled oil is free to the producer, the final price of the biodiesel is about \$0.83/gallon utilizing existing technology.

Many Crops Yield Vegetable Oils As Follows:

Crop	kg oil/ha	L oil/ha	lbs oil/acre	gal oil/acre
corn	145	172	129	18
cashew nut	148	176	132	19
oats	183	217	163	23
lupine	195	232	175	25
kenaf	230	273	205	29
calendula	256	305	229	33
cotton	273	325	244	35
hemp	305	363	272	39
soybean	375	446	335	48
coffee	386	459	345	49
linseed	402	478	359	51
hazelnuts	405	482	362	56
euphorbia	440	524	393	57
pumpkin seed	449	534	401	57
oriander	450	536	402	57
mustard seed	481	572	430	61
camelina	490	583	438	62
sesame	583	696	522	74
safflower	655	779	585	83
rice	696	828	622	88
rung oil tree	790	940	705	100
sunflowers	800	952	714	102
cocoa	863	1026	771	110
peanuts	890	1059	795	113
opium poppy	978	1163	873	124
rapeseed	1000	1190	893	127
olives	1019	1212	910	129

castor beans	1188	1413	1061	151
pecan nuts	1505	1791	1344	191
jojoba	1528	1818	1365	194
jatropa	1590	1892	1420	202
macademia nuts	1887	2246	1685	240
brazil nuts	2010	2392	1795	255
avocado	2217	2638	1980	282
coconut	2260	2689	2018	287
oil palm	5000	5950	4465	635

Vegetable oil yields x 0.8 = approximate biodiesel yields

Biodiesel NOx Control Technology already exists with more under development. In the fossil fuel power industry ammonia is added to the hot discharge gas under catalytic influence to convert NOx to Nitrogen Gas and Water. In a worst case scenario the same technology can be successfully used to reduce biodiesel NOx emissions to acceptable levels. One can also retard the timing to achieve acceptable NOx results at the expense of diesel engine performance if absolutely necessary.

Current Biodiesel Production Plants have directed their marketing efforts at the blend business with some B100 from used vegetable oil (with lard, fat, and tallow sometimes added) being sold to the marine and mining industries. The blend business plants are focused almost entirely on existing commodity crops of soybean and rapeseed (canola in Canada) for their feedstock. It is common practice to crush the crop to separate as much vegetable oil as is possible. The remaining pellets and/or mash is then beneficially used as animal feed. On the surface, these practices seem efficient but from chemical engineering and nutrition standpoints are highly inefficient. Far too much oil is left in the crop and the utilization of crop residuals as animal feed, or feed supplements, in fact represents but a solid waste disposal activity rather than a scientifically preferred animal nutrition diet. Additionally, virtually all existing vegetable oil crops are commodities in the marketplace subject to ever present intermittent droughts, diseases, and governmental subsidy influences. Consequently, the marketplace prices of the produced biodiesel are weather and plant disease dependent. Lastly, the majority of existing biodiesel production facilities are rather small which adds another level of marketplace price sensitivity.

As biodiesel begins to replace petroleum diesel (and other kerosenes) and as the political pressure to increase the miles-per-gallon efficiency of automobiles, gasoline and gasoline engines will both disappear as diesel engines are far more efficient than gasoline engines.

The use of biodiesel will permanently and completely eliminate foreign oil imports and therefore maximize our

national security. The fuel has no technical, political, or environmental downside. Agricultural job creation is fantastic. American dollars will stay here as all associated production requirements of this fuel are accomplished domestically. The Kyoto requirements will automatically be achieved as the biodiesel refining process as well as the fuel itself both reduce carbon dioxide emissions. One can actually end up selling CO2 credits to other countries, including Japan, which has no oil or coal of its own.

Total time to accomplish the dominance of biodiesel – perhaps 20 years, maybe sooner, depending on the success of its technology providers.

Somewhat amazingly, neither governmental subsidies nor petroleum industry cooperation are even necessary. Other biofuels of hydrogen, CNG, LNG, and ethanol cannot effectively compete because of the much greater inherently high Btu content of biodiesel. Because the B100 production technology is so strong, downstream petroleum industry participation would be expected, welcomed, and even encouraged.

Approximate annual size of the United States and European market for B100 is \$300 billion each when one includes all of the refined products of biodiesel transportation fuel, biodiesel jet fuel, biodiesel heating oil, biodiesel lubricating oils, and biodiesel greases.

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