h2technologies

AlohaFuels Division
www.AlohaFuels.pbworks.com

Hawaii Gateway Energy Center
73-4460 Queen Kaahumanu Hwy #131
Kailua-Kona, HI 96740
www.h2-techs.com
9 September 2011

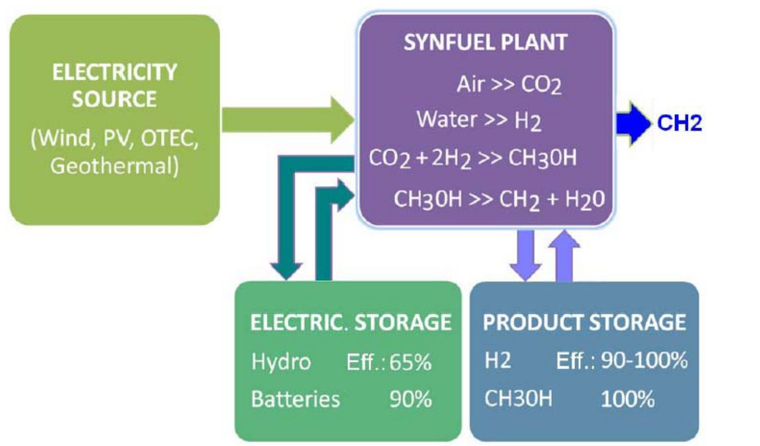
Proposal Title: Aloha gasoline from air and electricity

The Problem: Hawaii's transportation fuel security is dependent on 100% imported, uncertain availability and highly volatile but rising World crude oil prices

Our Mission: Long-term, to help Hawaii to become self-sustaining on fuel and food
Near-term, to produce part of Big Island fuels with renewable energy

Objectives:
1. Build and operate a 0.2 MGGE/y (Million Gal. Gasoline Equivalent per year) pilot demonstration plant and sell such gasoline locally, wholesale or retail. Such production would about meet the average fuel needs of 500 passenger cars averaging 30 MPG.
2. Expand above pilot plant 100x to produce 20 MGGE/y and offer to help replicate such mini-plants at additional sites on Hawaii, Oahu, Maui and other islands.

Definitions: The Aloha plant captures CO2 and water from air and extracts H2 from water (H2O) using renewable electricity. To enable variable power inputs w/o disturbing the steady operation of the subsequent catalytic reaction of CO2+3H2 to gasoline (~CH2) and some water, H2-storage is provided. This process converts about 1.5 MW into 0.2 MGGE/y or 100 MW into 20 MGGE/y, at an overall energy conversion efficiency approaching 70%.



Block diagram of synthetic fuel plant, showing *round-trip" energy storage efficiency options of 65 to 100%.

Specifications:
- Preferred **energy source**: Geothermal, because of its steadiness; however, means to use variable, off-peak wind energy will be provided
- Preferred **pilot plant location**: NELHA in Kailua-Kona, on the Big Island
- The estimated **real-estate space** needed for the above plants is less than 0.3 and 5 acres, respectively. **Max height** of plant units: 40 feet of the CO2 absorbers.
- The **electricity cost** needed to enable gasoline production for **sale at 3 $/gal** (wholesale) before taxes and distribution is between 4 and 5 c/kWh, for electricity availability capacity factors between 50 and 100%[1]. Retail price would be **4 $/gal**. A short analysis summary of the economics of H2 storage[1] is provided below.
- **Gasoline quality certification** (87- and 95-octane) via ASTM D4814, etc
- **Funding** needs: 10 ±2 M$ for the pilot and 125 M$ for the mini-plant

Schedule:
- **Pilot plant**, incl. permits, site prep., installation and perform. evaluation – 4-5 yrs;
- **Mini-plant**, to grow in modular steps of ~ 2 MGGE/y in synch with the geothermal additions of 10-MW PowerTubes[4] – 3-4 years, for a combined **total of 7-9 years**

Economics: To achieve the above competitive price and associated cash flow, we assumed a 30-year service life, a maximum **payback period** of 7.5 years and for equity holders a levelized **30-year ROI** of 10 %/year. Additional assumptions[1]:

- Bank loan **interest rate** of 6 %/year
- **Operations and Maintenance** costs: 2-3 % of capex/year, excluding energy costs, but including LB&M, insurance costs, and 0.5 %/y property tax
- Zero profit during payback period
- Energy cost bonus for steady power: Increasing the electricity availability capacity factor (CF) reduces H2-generation and storage costs, so that for example, it would allow us to pay 0.5 c/kWh more when increasing CF from 0.5 to 1[1].

Approach:

- The **design, installation, commissioning and operation** of the two plants, and their interface with the power supply, will be managed by GT and its partners (primarily: SummitPower (Program Manager), Corning, BASF and The Linde Group). The PowerTubes(PT) are monitored and maintained by PT[4]
- **Certification** of the produced gasoline and administering ASTM D4814 etc tests will be completed by Inspectorate in S.Fransisco, CA (a Bureau Veritas company)
- **Financing** the project, after appropriate endorsements by Linde, BASF and others, will be part equity by capital investors; government grants and bank loan, with H2 Techs as majority owner

Risk: The inherent risks of being the first to install and operate above synthetic gasoline plants are mitigated by the demonstrated operation of the key units 1-4 below; and by similar quests today in the US[5] and ones using coal as feedstock by BASF in WW-II:

1. A **CO2-from-air** capture unit by GT at SRI (Stanford Research Inst.) producing 750 tons-CO2/year at 95% purity[2], i.e. enough for a 0.1 MGGE/y pilot plant
2. **H2-generation** modules via water electrolysis have been in use for over 100 years. The recent models strive to increase efficiency and reduce capex[3].
3. **Hydrogenation of CO2** to make methanol and Exxon's MTG (Methanol-to-Gasoline) process are well documented processes. The MTG process is available and can be licensed from ExxonMobil
4. **Geothermal generators** (GG) of 1, 5 and 10 MW are available from the manufacturer. A first installation, presently under development in Guatemala, will use 100 10-MW units[4]. Also underway is a third-party certification involving the DoD. This type of GG are fully integrated systems, with heat exchanger and in-line, sealed turbine housed in a single, sealed well (under ground & thus low-noise); because no geothermal steam is required, there are no gaseous emissions or liquid discharges.

There is uncertainty about HELCO's ability & price to transport power between the geothermal source and the fuel plants, if they are not co-located.

References:

[1] U. Bonne,"Influence of variable electricity supply on synth. fuel price." 10 Aug. 2011, http://AlohaFuels.pbworks.com/f/PB-11-Variable-ESource-vs-Fuel-Price.pdf

[2] Peter Eisenberger et al, Global Thermostat, Inc., "Innovation and abuse," http://globalthermostat.com/news/innovation-and-abuse 10 July 2011

[3] Norsk Hydro Electrolysers AS, "Hydro PEM electrolyser," Notodden Næringspark, N-3674 Notodden, Norway, electrolysers@hydro.com, www.hydroelectrolysers.com

[4] K.Kubat, MokuPower, Hilo, HI, licensee of PowerTube Inc., with headquarters in Houston, TX, www.PowerTubeInc.com

[5] David Doty, Doty Energy, Columbia, SC, www.dotyenergy.com

H2 Storage & Load Following

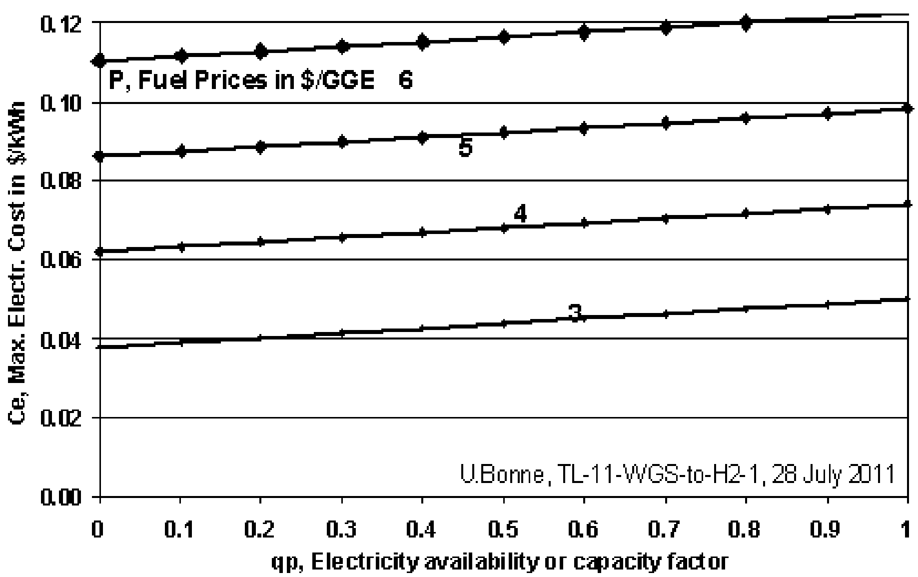
The synergistic operation of a steady geothermal electricity source and a large but flexible-load electricity user, such as our industrial synthetic fuel plants, in a typical community setting, enables

(1) Full use of steady, 24/7 geothermal power,
(2) Leveling of the total variable residential, commercial and industrial loads, and
(3) Feeding the maximum possible amount of that remaining but variable electricity to the load-flexible industrial fuels plant, at a cost of only a small discount in the electricity rate.

and thereby achieving an **unprecedented grid load balance** and win-for-all in terms of simultaneous maximum profits for the electricity and fuel suppliers as well as minimum costs to the industrial, commercial and residential electricity users and synthetics fuels, because the invested capital equipment is in maximal use.

Analysis

As a way to support the above attractive scenario, we determined how much variable, renewable (from wind, geo, or any other source) electricity cost would have to drop to compensate for the cost of in-plant electricity storage (battery or hydrogen) to achieve an effectively 24/7 steady downstream plant operation, and steady fuel output.
For one example involving an electricity availability capacity factor of 50%, using popular lead-acid batteries, electricity cost would have to drop by over an unfeasible 5 ¢/kWh to compensate for the battery cost, and enable synfuel to be priced at the same level as with a 100 % capacity factor. However, an enlarged H2 front-end plant production system with appropriate H2 tank storage, turned out to be much more economical than battery storage. In this case, a capacity factor of 50% may only require a decrease of 0.6 ¢/kWh in the maximum cost of electricity, in order to still meet the same fuel price goals (4 $/gal retail)[1]. We also quantified what effect profit goals can have on the maximum allowable electricity cost: For example a 5% drop in the 30-year-levelized ROI was equivalent to a 1 ¢/kWh of allowable increase in the cost of electricity, as shown by the data plotted below from ref.[1].
Note that 1. By not including the effects of CPI (consumer price index) and fuel price escalations, the results are more conservative than if those effects had been included, and 2. The advantageous economics of H2 storage uniquely apply here because H2 is used in the process and not reconverted to electricity via fuel cell or engine generator.



L =	30	years plant life.
Ft =	95	% Plant up-time
Fg =	0	% capex gov. cl
Fl =	100	% loan for
nl=	7.5	yrs payback
il=	6	%/y interest
Fe=	100	% equity stake
ne =	30	years at
ie=	**4.6**	%/y ROI, leveliz
Cso=	0.034	M$/MW capex-s
Cse=	0.03	M$/MWh for ea
Es=	100	% storage batte
Ep=	70	% overall plant e
Cp=	1.71	M$/MW(out) = c
Mp =	2	% capex/y for p
Ls=	20	years before bat
Output	20	MGGE/y

Fig. 4. Electricity cost to produce fuel between 3 & 6 $/GGE wholesale before taxes (~4 to 8 $/GGE retail), with front- end H2-byproduct storage, but instead of a 10%/y 30-year-levelized ROA, the profit is 10% of sales, equivalent to 4.6%/y ROA.