ASEMBLON™

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Dear Mr. Ward,

This letter describes a potential recyclable hydrogen carrier technology, HYDRNOL™, that I believe would accelerate the proliferation of hydrogen fueling stations in the State of California.

- HYDRNOL can be created from a renewable resource.
- HYDRNOL creates a safer storage medium for hydrogen allowing distribution of hydrogen fueling stations in urban areas, with a delivery frequency of 6-12 days (based on a usage rate of 40 – 120 kg/day)
- HYDRNOL is an organic liquid carrier, which handles exactly the same as gasoline or diesel. This results in minimum change to the currently understood infrastructure for petroleum fuels and minimum education associated with handling.
- HYDRNOL can be re-charged with hydrogen after the hydrogen is released. In California this would be likely occur at a central facility located on the site of a renewable resource, such as bio-methane, solar fields or wind farms.
- HYDRNOL can be recycled at least 100 times, driving down the economics of implementation

Below is a general summary of HYDRNOL and how I generally envisage this would extend into a program in California.

I look forward to further conversations with you with regard to this opportunity.

Regards

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Accelerating the Hydrogen Economy – Asemblon's HYDRNOL™ Fuel

General Background

Asemblon, Inc. has patented a method for hydrogen storage and transportation using a family of organic liquid hydrogen carriers (HYDRNOL™). HYDRNOL releases hydrogen, on demand, through a catalytic reaction. The spent HYDRNOL can then be re-hydrogenated back to the original HYDRNOL form i.e. recycled; this can occur at least 100 times. This approach delivers a liquid chemical system that offers significant advantages over liquid and compressed hydrogen; the initial, current configuration has the capacity to store 6% hydrogen by weight (US DOE 2010 target for vehicle use) with 12% hydrogen, by weight, carriers under research and scheduled for release in 2011, 4 years ahead of the DOE target of 9% hydrogen, by weight. HYDRNOL can be stored and transported as a liquid at ambient temperatures and pressures (-63 °C to 113 °C), which reduces safety concerns with regard to on-board or urban hydrogen storage. All these advantages allow relatively simple integration into the existing petroleum delivery and use infrastructure (pipelines, trucks and tankers), thus negating a need for a complete new infrastructure for hydrogen transport and storage. In static situations the carrier offers a central or distributed storage system that is as safe as gasoline or diesel for a vehicle network, hydrogen generators or fuel cells.

In a stationary application, such as a hydrogen filling station, a 5,000 gallon tank of HYDRNOL containing the equivalent of 720 kg hydrogen can be placed on-site (the equivalent of a tanker truck delivery frequency of every 6-12 days based on 40 – 120 kg/day usage). The hydrogen can then be released as needed, perhaps via a small buffer tank during high demand, to power a stationary fuel cell, a generator or fill up a compressed hydrogen powered car. The spent HYDRNOL is collected in a second tank, and when the next batch of HYDRNOL is delivered to the station the spent HYDRNOL is loaded onto the empty tanker and returned to the re-hydrogenation facility for recharging. The system is very simply scaled up - the larger the hydrogen demand, the larger the holding tank and more reactors.

In all situations the spent HYDRNOL can be re-hydrogenated on-site in a distributed or remote system, using localized solar or wind power to produce the hydrogen, or returned to a central location for bulk re-hydrogenation using any technology that produces a high volume of hydrogen. It is envisaged that California's potential to produce bio-methane complements the use of hydrogen.

As the HYDRNOL and its derivatives are a liquid at standard temperature and pressure, they handle exactly the same as currently used for gasoline or diesel. This means that the conventional infrastructure design of tanker trucks and riveted pipelines significantly reduces the logistical costs associated with hydrogen delivery and storage for fuel use.

Therefore, it follows that co-location of a bio-methane reformer and the HYDRNOL re-hydrogenation facility would allow the use of a renewable fuel, presenting that fuel in a form that is as safe to handle as gasoline or diesel, which can be handled exactly the same as gasoline or diesel and can be distributed to urban based fuel stations following the petroleum fuel model.

The current HYDRNOL molecule (Molecule 02) delivers a liquid chemical system that, at the least:

1. Has the capacity to store 5.8% hydrogen by weight
2. Can be stored and transported at standard temperature and pressure, reducing the safety concerns with regard to on-board hydrogen storage
3. Is a liquid over the range of -63 °C - 113 °C under ambient conditions, in both its hydrogenated form and its dehydrogenated form, allowing relatively simple integration into the existing infrastructure
4. Releases hydrogen, as needed, using a proprietary catalyst
5. Is recyclable, where a method for adding hydrogen back to the dehydrogenated molecule has been developed
6. Is as safe as gasoline or diesel
7. Offers significant advantages over the estimated cost and weight of the storage systems required of liquid hydrogen, compressed hydrogen and metal hydrides.

Application of the HYDRNOL system to the State of California

Figure 1 demonstrates the HYDRNOL concept for a centralized production and re-hydrogenation system. Virgin HYDRNOL is produced from biomass or low value crude oil by-products at the generation facility. After the hydrogen has been released and used, the spent HYDRNOL is collected, transported to a second facility for reconstitution with renewably produced hydrogen. The reconstituted HYDRNOL is then delivered back into the use circuit.

As mentioned the recyclable nature of HYDRNOL allows 'recharging' with hydrogen generated by any hydrogen production system such as wind, solar, tidal power, steam reforming of on-site fossil fuels, waste material reforming, excess power from nuclear sources or water electrolysis. Of especial benefit is that the recycling of the hydrogen carrier molecule significantly increases usefulness by reducing the economic cost, thus reduces operation expenditure (OpEx). California's renewable energy approach would allow for the HYDRNOL to be regenerated from the solar fields, wind farms and biomethane systems currently being developed.

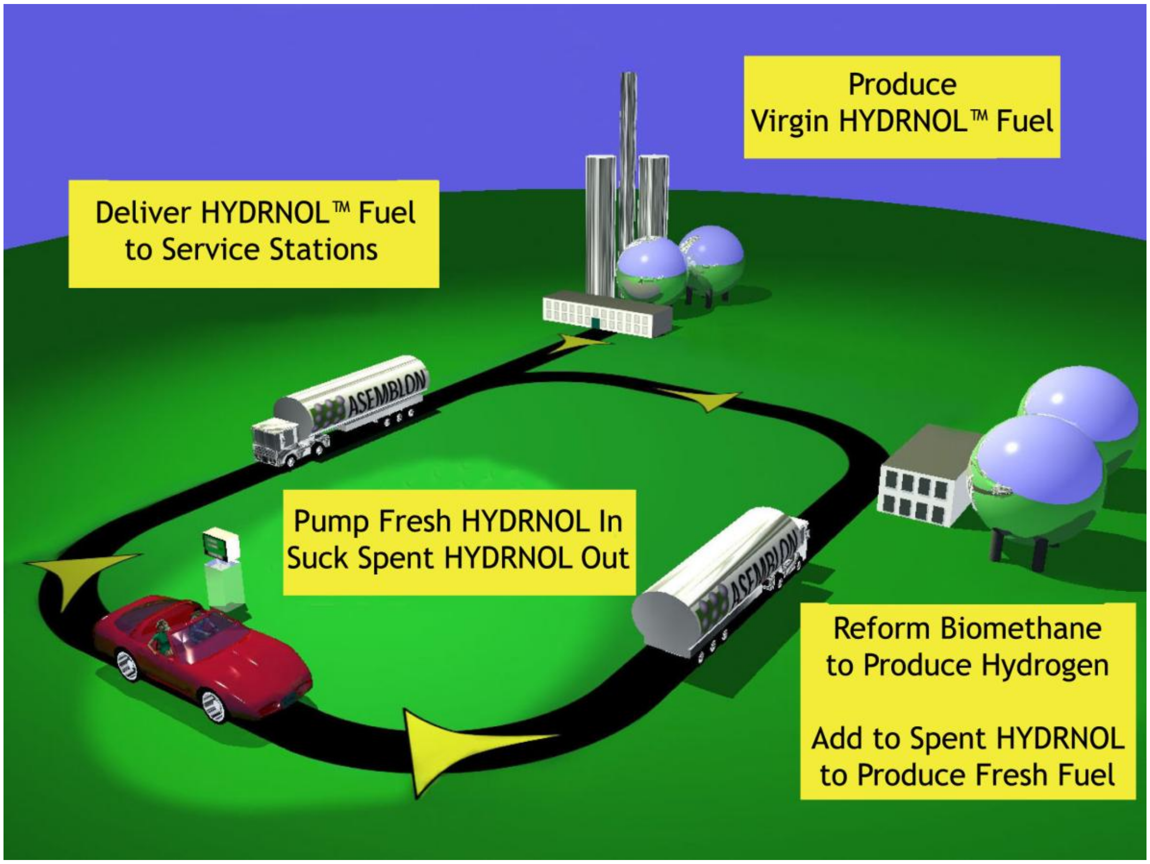

Figure 1 - HYDRNOL, Centralized Use

Asemblon is making considerable headway in to a long-range business plan to bring HYDRNOL to market worldwide. An initial project demonstration is being implemented in North Dakota, designed to demonstrate the advantage of storing electrolytically produced hydrogen where the power for the hydrogen production comes from wind turbines. Figure 2 shows a commercially available electrolyzer on site in North Dakota powered by electricity generated from wind turbines. Currently, the produced hydrogen gas is compressed in to the white 5000 psi tanks, seen in Figure 2, for delivery to existing modified vehicles. In 2009, 400 gallons of HYDRNOL will replace these tanks.

However, it is believed that a California based project would be an ideal place to scale-up the technology to a larger functional level using biomethane reforming or solar and wind derived power. The initial production of HYDRNOL can come from the synthesis of waste biomass derived precursors or low value, crude oil refining by-products. The recyclable nature of the technology results in at least a 100 – 10,000 times use of each batch of produced HYDRNOL.

This would be anticipated to occur initially at pilot-scale using fleet sites for distribution with the expectation of citywide adoption on concept proof and acceptance. Asemblon is already working with various universities, industry leaders and in-house to achieve these goals.

The projected roll-out strategy of HYDRNOL molecules over the next 7 years results in a two molecules in current demonstration, 4% and 6% hydrogen by weight (where the DOE target is 6% hydrogen by weight, in 2010), a third molecule in development, 7% hydrogen by weight and an identified molecule currently in research which would deliver 12% hydrogen by weight by 2015.

Figure 2 – The electrolyzer system in North Dakota to be used for the first HYDRNOL demonstration.

HYDRNOL™ Fuel Cost Comparison for Vehicle Use

The use of hydrogen as a vehicle fuel has large benefits by reducing tailpipe emissions and allowing a transportation fuel from to be made from renewable sources such as biomethane, wind and solar.

Depending on the assumptions made in the model, there are also substantial benefits due to the improved mileage and power associated with hydrogen fuel.

To demonstrate these benefits, three different vehicles are compared:

1. A gasoline internal combustion car or light truck
2. A Ford F-150 light truck modified to run on pure hydrogen
3. A Fuel Cell vehicle, such as the Honda Clarity or Daimler SFCV

Vehicle 1 is assumed to get 27.5 miles per gallon of gasoline, the current Corporate Average Fuel Efficiency (CAFÉ) standard. Higher numbers are being demanded by environmental groups but are being fought by some in government and in court by the US automobile companies.

The amount of fuel is calculated that would be required for each vehicle to go 300 miles, the trip length specified by the US Department of Energy (DOE).

HYDRNOL was considered to be produced from biomass.

The central assumption is the cost to obtain hydrogen to recharge the HYDRNOL molecule. Prices vary over the range from $1.20 to $6.00 per kilogram depending on the source of hydrogen (nuclear is the least expensive and the wind-driven electrolysis of water is the most). For this model, we chose steam-reformed bio-methane at $1.60 per kilogram.

Since HYDRNOL Fuel does not require either compression or cryogenic cooling, the hydrogen cost is not inflated by those post processing steps to prepare it for transport. The hydrogen is incorporated directly onto the spent HYDRNOL molecule

1. Running the model under these assumptions gives the following:

Fuel Efficiency

Gasoline ICE Engine	27	miles/gallon	Current CAFÉ Standard
Hydrogen ICE Engine	45	miles/kg	Ford F150
Hydrogen Fuel Cell	80	miles/kg	Daimler Smart Fuel Cell

Fuel Required to go 300 Miles

Gasoline ICE Engine Vehicle	11.11	gallons
Hydrogen ICE Engine Vehicle	6.67	kilograms H2
Hydrogen Fuel Cell Vehicle	3.75	kilograms H2

Cost ($) to go 300 Miles on Blended HYDRNOL (Current molecule-02)

	$
Gasoline ICE Engine Vehicle	44.44
Hydrogen ICE Engine Vehicle	21.28
Hydrogen Fuel Cell Vehicle	11.96