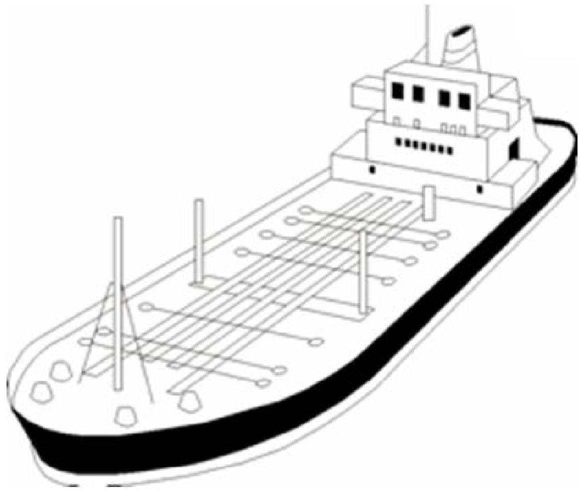
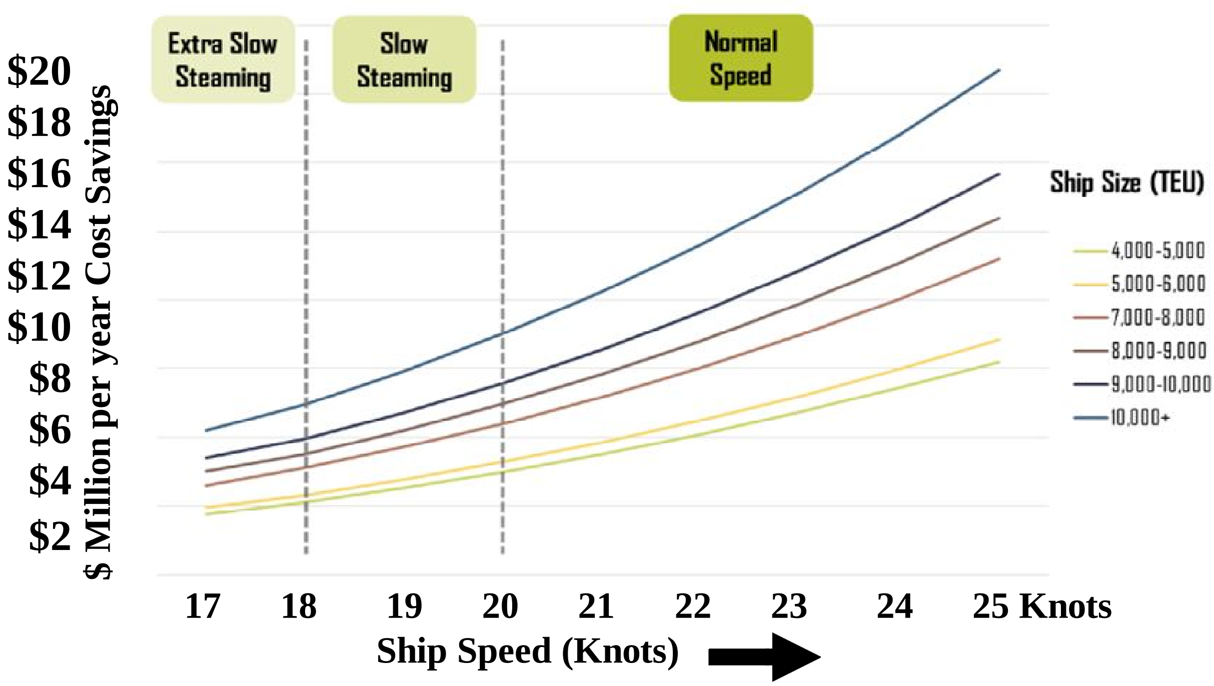


Annual Cost Savings

Fuel cost reduction when hydrogen is used to supplement diesel for a single ship (estimated)

This is an engineering concept document.



Calculations by Phillips Company
April 2013 -- Updated August 2013

Contents

Section 1 -- Introduction

Hardware Feasibility Study
- Formulation
- Trade secrets and/or
- Patent applications
(Use NDAs to allow CC shipment to evaluators until patent application work is completed.)

} TBD

↑

Concept (This document)
- Fuel cost savings preliminary analyses
- Cost of aluminum (rate of use)
- Rate of hydrogen (LPM) needed for BOOST mode operation for large engine, based on extrapolation of data from small engines.

} This document

Introduction

This document contains calculations showing that for a ship, CC-HOD technology can be used to produce hydrogen at the rate needed to obtain a 30% fuel cost savings. The fuels needed to produce hydrogen using this method are only aluminum and water. The good news is that this can be sea water. Distilled water is not needed for the CC-HOD method of producing hydrogen. The following will be calculated in this document:

Net Fuel Cost Savings = ($26,738 per day) x (300 days per year) = $8.021 million USD per year = approximately $8 million USD per year.

The fuel cost calculations summarized above assume a ship described as follows: 21 knots; 8000 TEU ship size; diesel fuel consumed = 150 tons/day; ship in route 300 days per year.

Section 2 -- Data used for the calculations in this document

Fuel cost calculations in this document are based on these assumptions: 21 knots; 8000 TEU ship size; fuel consumed = 150 tons/day.

What kind of fuel is used for cargo ships?

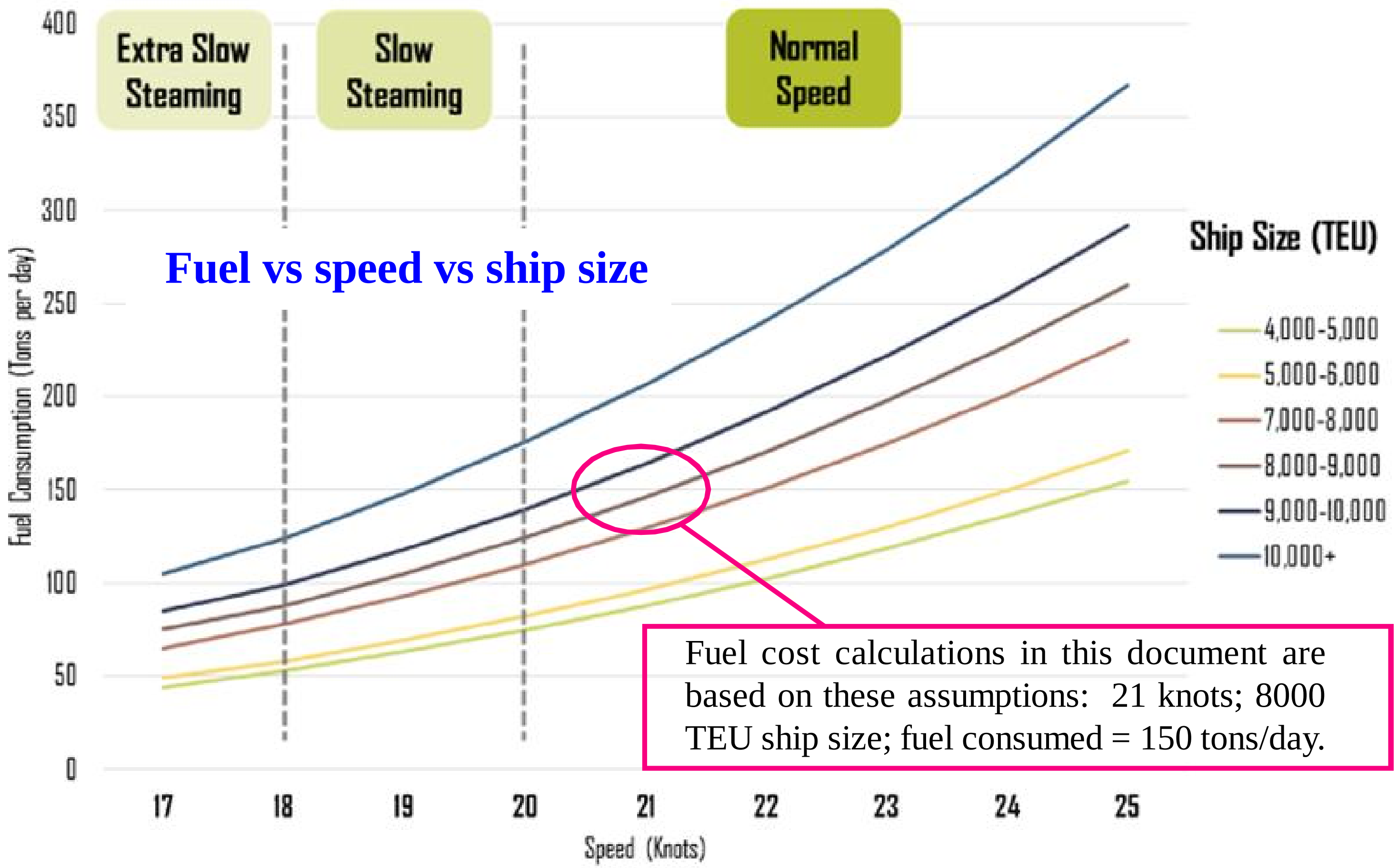
Different ships use different fuels according to their needs. Most large cargo ships use bunker fuel which is a form of crude oil. Some ships use diesel fuel.
Ref: http://wiki.answers.com/Q/What_type_of_fuels_do_ships_use

Fuel use assumptions used for calculations in this document

Common practice is for a ship to use bunker oil (a form of crude oil) in open water, then switch to diesel when near port, or in territorial waters. This is because of agreements established to minimize air pollution on shore, since prevailing winds usually come from open water to the shoreline.

The calculations in this document focus on diesel fuel.

Important point: Although the $$$ savings will be different for diesel vs bunker fuel, these calculations in percent savings are the same for either/both kinds of fuel. In other words, using CC-HOD to provide hydrogen as a fuel additive, we expect a 30% cost reduction for bunker fuel and/or a 30% cost reduction for diesel fuel.



Source: adapted from Notteboom, T. and P. Carriou (2009) "Fuel surcharge practices of container shipping lines: Is it about cost recovery or revenue making?". Proceedings of the 2009 International Association of Maritime Economists (IAME) Conference, June, Copenhagen, Denmark. Fuel Consumption by Containership Size and Speed Fuel consumption by a containership is mostly a function of ship size and cruising speed, which follows an exponential function above 14 knots. For instance, while a containership of around 8,000 TEU would consume about 225 tons of bunker fuel per day at 24 knots, at 21 knots this consumption drops to about 150 tons per day, a 33% decline. While shipping lines would prefer consuming the least amount of fuel by adopting lower speeds, this advantage must be mitigated with longer shipping times as well as assigning more ships on a pendulum service to maintain the same port call frequency. The main ship speed classes are:

- **Normal** (20-25 knots; 37.0 - 46.3 km/hr). Represents the optimal cruising speed a containership and its engine have been designed to travel at. It also reflects the hydrodynamic limits of the hull to perform within acceptable fuel consumption levels. Most containerships are designed to travel at speeds around 24 knots.
- **Slow steaming** (18-20 knots; 33.3 - 37.0 km/hr). Running ship engines below capacity to save fuel consumption, but at the expense a additional travel time, particularly over long distances (compounding effect). This is likely to become the dominant operational speed as more than 50% of the global container shipping capacity was operating under such conditions as of 2011.
- **Extra slow steaming** (15-18 knots; 27.8 - 33.3 km/hr). Also known as super slow steaming or economical speed. A substantial decline in speed for the purpose of achieving a minimal level of fuel consumption while still maintaining a commercial service. Can be applied on specific short distance routes.
- **Minimal cost** (12-15 knots; 22.2 - 27.8 km/hr). The lowest speed technically possible, since lower speeds do not lead to any significant additional fuel economy. The level of service is however commercially unacceptable, so it is unlikely that maritime shipping companies would adopt such speeds.

Ref: http://people.hofstra.edu/geotrans/eng/ch8en/conc8en/fuel_consumption_containerships.html

What is a TEU?

Standard unit for describing a ship's cargo carrying capacity, or a shipping terminal's cargo handling capacity. A standard forty-foot (40x8x8 feet) container equals two TEUs (each 20x8x8 feet).

Ref: http://www.businessdictionary.com/definition/twenty-foot-equivalent-unit-TEU.html
Read more: http://www.businessdictionary.com/definition/twenty-foot-equivalent-unit-TEU.html#ixzz2Sp2JVaJs

Typical fuel consumption rates

While a container ship of around 8,000 TEU would consume about 225 tons of bunker fuel per day at 24 knots, at **21 knots this consumption drops to about 150 tons per day**, a 33% decline. While shipping lines would prefer consuming the least amount of fuel by adopting lower speeds, this advantage must be mitigated with longer shipping times.

Savings if hydrogen is used in boost mode to power a typical ship

Savings = 30% x 150 tons per day = 45 tons per day.

The current price for D2 diesel is around the $650 USD per metric ton, depending on the quantity ordered. This is an international price "CIF". Ref: http://wiki.answers.com/Q/How_much_does_1_metric_ton_of_D2_diesel_cost
The above cost is called the CIF cost. Definition of 'Cost, Insurance and Freight - CIF'
A trade term requiring the seller to arrange for the carriage of goods by sea to a port of destination, and provide the buyer with the documents necessary to obtain the goods from the carrier.

Savings = (45 tons per day) x ($650USD per ton) = $29,250 per day.

Assuming the ship is operated 300 days per year, the annual cost savings will be:
Savings = ($29,250 per day) x (300 days per year) = $8.775 million USD per year.

Section 3 -- Boost Mode and Fuel Replacement Mode are different

Fuel conversion efficiency

A measure of how effectively fuel is transformed into usable energy. Each type of fuel is deemed to have a specific energy-producing potential per unit of weight, but some or most of that potential is lost during production or refining.

While 100% efficiency is always the goal, in practice the fuel conversion efficiency of a typical commercial steam turbine generator is only about 30 percent efficient. Household natural gas furnaces typically achieve only about 70% efficiency. Automobiles rarely boast better than 20% fuel conversion efficiency.
Ref: http://www.energyvortex.com/energydictionary/fuel_conversion_efficiency.html

Confusion is common

Confusion is common when considering the use of hydrogen as a fuel for engines.

Fuel Replacement Mode is when hydrogen is used as a **primary fuel**, either mixed with petrol or when hydrogen is used as the ONLY fuel for an engine.

Boost Mode is when hydrogen is used a **fuel supplement**, introduced into the engine via the air-intake manifold. This is a much more efficient and cost-effective way to use hydrogen. The expected effect is to increase the **conversion efficiency of the fuel**, thereby achieving a fuel cost savings.

This concept paper does NOT analyze the use of hydrogen in the fuel replacement mode.

This concept paper DOES analyze the use of hydrogen in the Boost Mode.

Introduction to HYDROGEN BOOST MODE fuel cost savings

Let me tell you about one of my friends. When he wants to make a point, he screams at me. **Here is what he said in a recent screaming phone call:**

- **Use hydrogen in the BOOST mode, if you are smart!**
- **Forget about using hydrogen from CC-HOD for fuel cells! Maybe later, but not now. Save fuel costs by using hydrogen in the BOOST mode, if you are smart!**
- **Forget about using HHO! Pure hydrogen is better!**
- **Forget about using electrolysis! Electrolysis produces HHO! CC-HOD produces hydrogen! CC-HOD is better! Forget about talking to people who think HHO is the same as pure hydrogen (no oxygen) generated with CC-HOD.**
- **Forget about talking to people who do not understand the technical aspects of FUEL CONVERSION EFFICIENCY. It is a waste of time talking to them. They will NEVER understand this simple way to obtain fuel cost savings.**
- **There are currently more than 1 billion cars in the world. Ref: Huff Post, 8/28/2013, "Number Of Cars Worldwide Surpasses 1 Billion" About 20% of the world's cars use diesel fuel. There are an estimated 280 million diesel engines in the world.**
- **When engineers realize that you can use CC-HOD to produce hydrogen at ANY rate, from WATER, and get more energy from the hydrogen than the energy used to extract the hydrogen from water, you will be trampled by every company that wants to decrease fuel costs.**
- **You don't know anything about ships; or energy. PC is a pharma company. PC is an engineering chemistry company. Find a partner! Find a consultant! Pass this to another company that knows about hydrogen!**

What is BOOST mode, and why does it increase fuel efficiency?

Addition of hydrogen to the air intake of a combustion engine can dramatically cut the pollutants in the engine's exhaust. Reductions up to 50% have been observed in studies, some dating back into the 1950's.
Ref: http://gogreenfuel.biz/docs/
Cleaning%20up%20Diesel%20and%20Automotive%20Exhaust%20with%20Hydrogen.pdf

Hydrogen burns more fiercely, propagating the flame front faster, increasing the efficiency of combustion, and burning the fuel more completely. In the Hydrogen Generator, distilled water was converted by electrolysis into hydrogen and oxygen gas, which is then pulled into the engine through the air intake. This uses some of the engine's power, but the return from increased efficiency in a lot of cases is more than the cost of the electricity. **The new breakthrough, using CC-HOD, makes possible, for the first time, increased efficiency MUCH more than the cost of the power used to generate the hydrogen.**

Fuel efficiency can increase, as stated in both customer letters and formal test results. Another benefit is a reduction in exhaust emissions, which is becoming important to independent truckers. Several states, California and New Jersey for example, are heavily fining truckers for smoky exhaust, thereby possibly making a BOOST-mode device valuable. This has resulted in the production of electrolyzer (HHO) devices which are becoming available to reduce emissions and, more importantly, increase fuel efficiency for commercial trucks. **CC-HOD, makes possible, for the first time, increased hydrogen production at rates (LPM) MUCH greater than the production rates achievable from electrolysis; thereby making possible the use of hydrogen to increase fuel efficiency for engines much larger than commercial trucks.**

Many studies have shown benefits when hydrogen added to the fuel.
(Ref: http://gogreenfuel.biz/docs/
Cleaning%20up%20Diesel%20and%20Automotive%20Exhaust%20with%20Hydrogen.pdf;
references 1,2,3,4,5,6) In reference 6, Hoehn and Dowdy of the Jet Propulsion Laboratory performed a feasibility demonstration of a road vehicle fueled with gasoline, with hydrogen added to the air-fuel mixture.

> *"The addition of hydrogen to combustion mixtures can provide additional thermal energy release, lower ignition temperatures, advance flame speeds, reduce the undesirable emissions of nitrogen oxides and carbon monoxide and generally affect a more efficient combustion".* (1)

Confidential Information -- Phillips Company

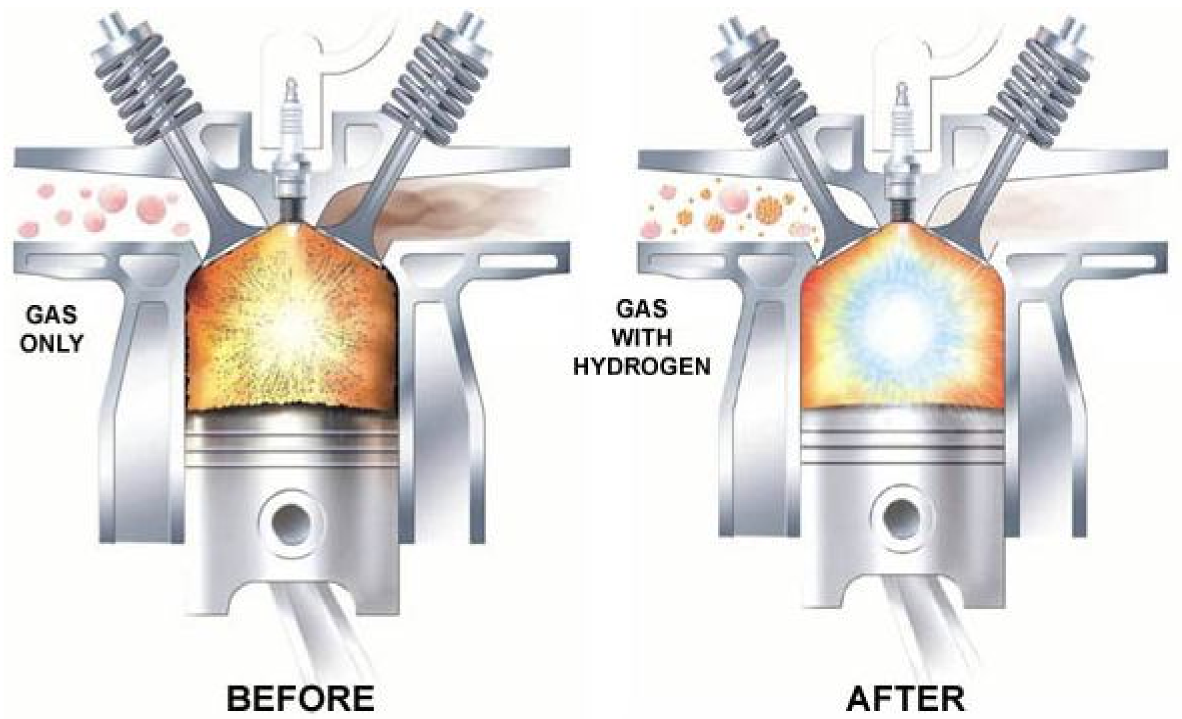
The key factor in adding hydrogen is the increased flame speed. The flame front speed for hydrogen is four times the speed of most other fuels.

Fuel	Flame Velocity (cm/sec)
Hydrogen	225
Ethylene	42
Methane	39
Ethane	38
Propane	43
Butane	70

Increasing the flame speed in the combustion chamber has a distinct advantage. More fuel is burned in a smaller volume, increasing the thermal efficiency of the engine (7,8,9,10). Increased efficiency translates into better utilization of the primary fuel.

BOOST mode is better -- A good way to use hydrogen is to use it not as a primary fuel, but as a booster in combustion. Francois Isaac de Rivaz in 1806 designed the first internal combustion engine, which ran on a hydrogen/oxygen mixture. Paul Dieges patented in 1970 a modification to internal combustion engines which allowed a gasoline-powered engine to run on hydrogen. Recently, BMW tested a supercar, powered by a hydrogen ICE (internal combustion engine), which achieved 187 mph (301 km/h) in tests. At least two of these concepts have been manufactured.
Source: http://www.defence.pk/forums/social-issues-current-events/202020-water-last-hope-future-energy-needs.html#ixzz2TNCQNrKd

A hydrogen-boosted engine has much greater fuel combustion efficiency and combustion quality. This system is expected to provide a cost-effective alternative to fuel-cell technology and traditional gasoline- and diesel-combustion engines. This promising new technology saves energy by reducing fuel consumption and also burns fuel more cleanly. A vehicle running on a mixture of hydrogen, gasoline and air can expect to achieve up to 30 percent better mileage than one with a traditional engine. The hydrogen-boosted engine runs cleanly, boosts fuel efficiency and does not require any special equipment for controlling harmful nitrogen oxide (NOx) emissions.
Source: http://www.defence.pk/forums/social-issues-current-events/202020-water-last-hope-future-energy-needs.html#ixzz2TNCQNrKd



"It's likely that we'll hear a lot more about the hydrogen-boosted engine in the future."

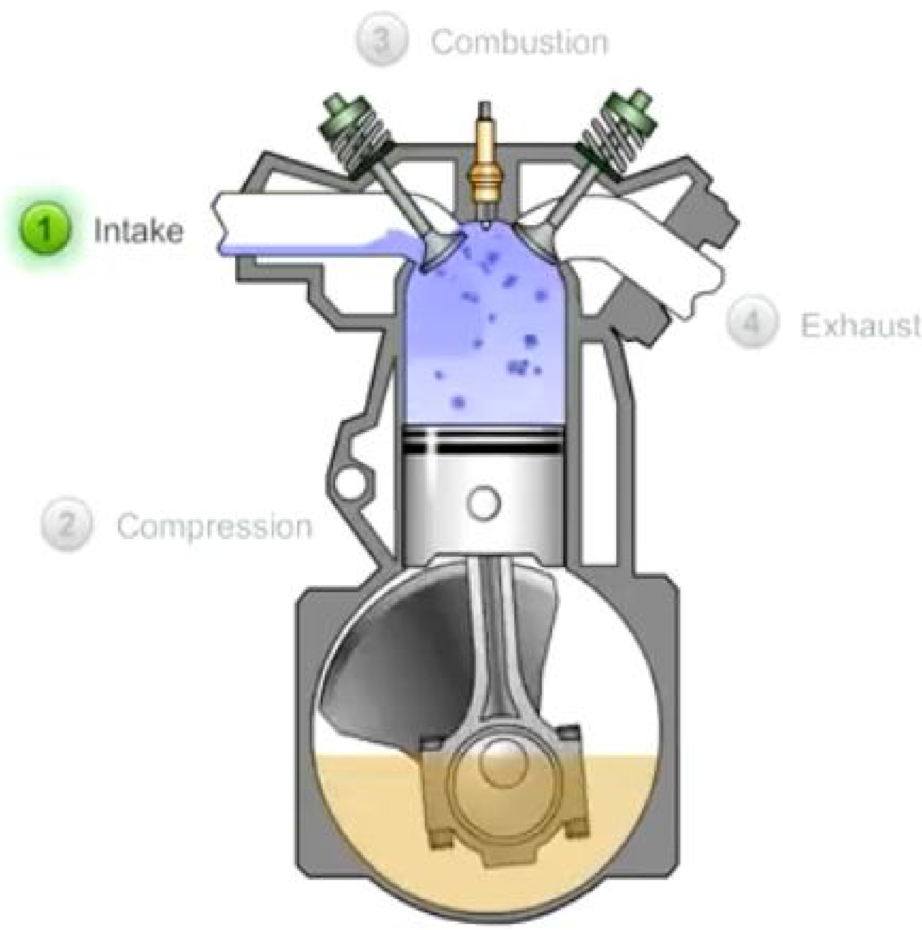
http://www.defence.pk/forums/social-issues-current-events/202020-water-last-hope-future-energy-needs.html#ixzz2TNCQNrKd

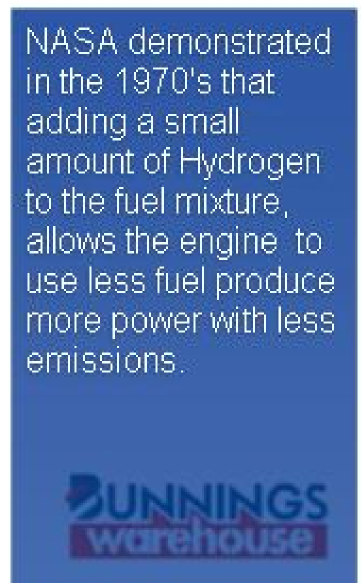
CC-HOD, makes possible, for the first time, increased hydrogen production at rates (LPM) MUCH greater than the production rates achievable from electrolysis; thereby making possible the use of hydrogen to increase fuel efficiency for engines much larger than commercial trucks.

The CC-HOD Hydrogen Generator system proposed is based on proven engineering methods for reducing emissions, which date back several decades. Test results confirm this, and also show that the technique can increase fuel economy. The equipment is simple and relatively easy to install and operate, which should result in increased reliability for engines of any size. All it takes is water, aluminum and catalytic carbon (CC).

Boost mode operation and fuel economy benefits are described online:

http://www.youtube.com/watch?v=7NTNVpdON00





BOOST mode is cheap; here is the reason why

The amount of hydrogen required to increase flame velocity is less than 1 % of the inducted air volume.

(Ref: http://gogreenfuel.biz/docs/Cleaning%20up%20Diesel%20and%20Automotive%20Exhaust%20with%20Hydrogen.pdf; references 2,3,4,7)

You would think this small amount of hydrogen could be easily supplied, but herein lies the main problem. Laboratory techniques have generally used bottled hydrogen, which isn't an option for anyone driving a truck or car. Over the years many attempts have been made to crack a portion of the primary fuel to get the hydrogen (3,5) including MIT with their Plasmatron (12). Trying to crack the fuel requires extensive modifications to the engine, or draws so much power from the engine like the Plasmatron does, that it becomes impractical. Another technique has been to crack the fuel using a simplified steam reformer, which also has proven bulky and impractical since steam isn't readily available onboard most vehicles.

HHO (produced by electrolysis) is not the same as hydrogen-only (produced by CC-HOD)

Hydrogen used as a BOOST fuel -- It has been firmly established that hydrogen can be used to boost MPG in vehicles using internal combustion engines. Fuel reduction of 30% or more has been experimentally proven by many workers, including individual experimenters. A web site devoted to hydrogen used in this manner has a growing membership. www.HODinfo.com now has a membership exceeding 3000 members. The requirement for hydrogen is about 6 LPM for large 18-wheeler trucks, and less than 1 LPM for typical automobile engines.

Electrolysis produces both Oxygen and Hydrogen

CC-HOD produces only hydrogen; no filtering; no separator cells.

Test vehicle results have shown a mileage improvement of 32%. These test results are documented online at www.PhillipsCompany.4T.com/CT.pdf

A major advantage of BOOST mode use of hydrogen is that it is cheap. That is because the hydrogen is NOT used as a substitute for the main fuel (bunker fuel for ships, diesel fuel for GENSETs, trucks and automobiles). For this reason, BOOST mode hydrogen is not used because it is cost competetive vis-a-vis conventional hydrocarbon fuels. This point is almost always overlooked in simple cost-saving analyses for applications where hydrogen is contemplated as a fuel supplement used in BOOST mode. Test vehicle results have shown a mileage improvement of 32%. These test results are documented online at www.PhillipsCompany.4T.com/CT.pdf

ENGINEERING ANALYSES: Cost analyses and engineering data are available that show the commercial advantages of using CC-HOD for use in fuel cost reduction for 18-wheeler commercial trucks; for diesel-electric generators used to generate electricity for either emergency-power applications or to generate electricity in off-grid locations; for diesel-electric generators used to power locomotives; for use in fuel cost reduction for diesel engines used to power ships. Any of these documents are available by request from Phillips Company. **The following analysis uses data obtained for trucks, and extends this to possible applications of BOOST mode CC-HOD for use in fuel cost reduction for diesel engines used to power ships.**

<u>Summary of the analyses in this document</u>:

If CC-HOD hydrogen is used as a fuel supplement for fuel in a typical cargo ship, the cost savings for fuel will be approximately:

Savings = (45 tons per day) x ($650USD per ton) = $29,250 per day.

Savings = ($29,250 per day) x (300 days per year) = $8.775 million USD per year.

The above = gross savings. The NET SAVINGS will be calculated later in this document.

Looking for the weak point in this paper? Here it is...

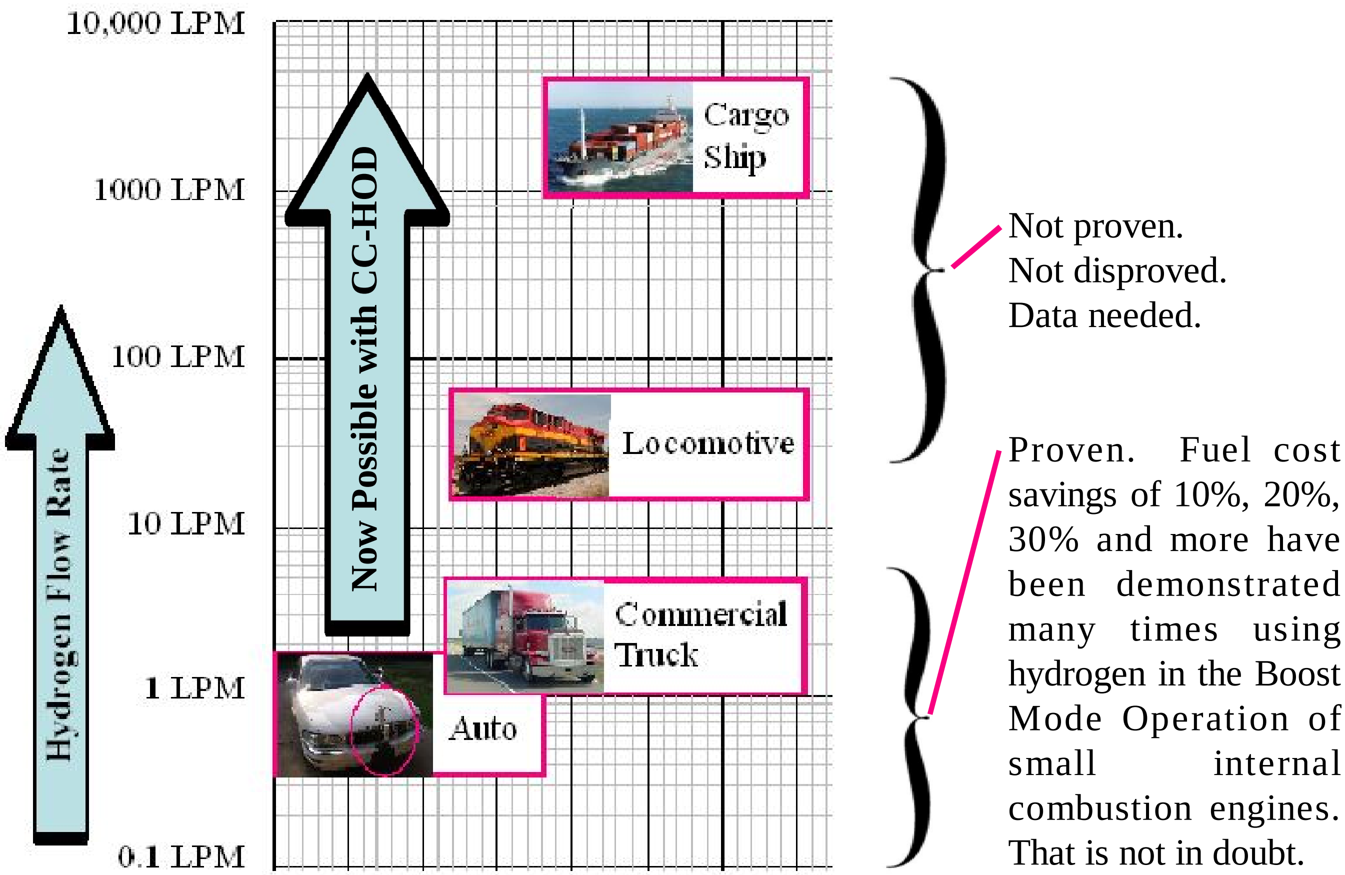
The focus of this paper is on fuel conversion efficiency improvement. Accordingly, the focus is on fuel.

Fuel cost savings of 10%, 20%, 30% and more have been demonstrated many times using hydrogen in the Boost Mode Operation of small internal combustion engines. That is not in doubt.

But, this paper extrapolates from smaller auto and truck engines to much larger engines. That extrapolation is the weak point, because it has not been proven that the same fuel cost savings (in percent) has been obtained for cargo ship engines using hydrogen in the Boost Mode Operation. There is simply no known data.

This concept paper outlines a path forward, but data is needed to validate the (unproven) expectation that known fuel conversion efficiency for small engines will be approximately the same for large (cargo ship) internal combustion engines.

This is the extrapolated hydrogen flow rate needed for boost mode operation.



Fishing boat shows 29% fuel cost reduction using hydrogen

The hydrogen used in the demonstration is in the form of HHO. HHO is 66.67% hydrogen and 33.33% oxygen. HHO is not the same as pure hydrogen, but we reference this data because it is indicative of what can be done using hydrogen, when hydrogen is added to the air-intake for an engine (oxygen supplied by the air).

ZCLC on Traditional Fisherman's Boat Day #1 with 30 HP Diesel Engine

Using 2 Tiny ZCLC to feed 30 HP Diesel Engine. Without HHO it is 21 minutes and 55 seconds for 1.5 liters diesel fuel. With HHO it is 31 minutes and 20 seconds.
Ref: http://hodinfo.com/video/zclc-on-traditional-fisherman-s-boat-day-1-with-30-hp-diesel

The HHO generator is shown online at http://www.youtube.com/watch?v=h5HKiOfD7U4
The production of HHO for this system is believed to be about 0.5 LPM.

Analysis

Without HHO: Diesel consumption rate = 1.5 liters / 21.92 minutes = 0.07 LPM.
With HHO: Diesel consumption rate = 1.5 liters / 31.33 minutes = 0.05 LPM.
Fuel savings = (0.07 - 0.05) /0.07

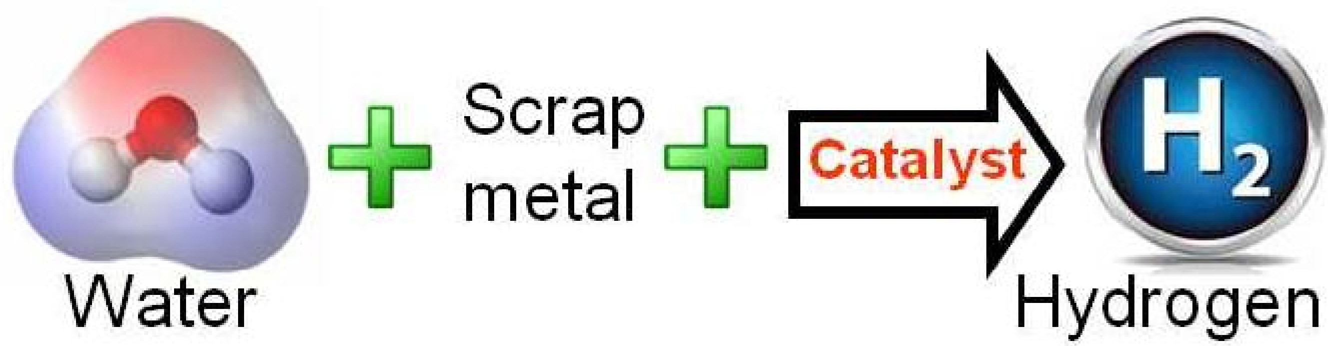
Fuel savings = 29%.

Section 4 -- Calculations

This document is an engineering concept paper. A concept paper may have calculations, hypotheses, and plans. Seldom does a concept paper have a great deal of technical data or proof. "Proof of concept" is important but almost always occurs at a later time, and the "proof of concept" work is usually guided by the ideas initially described in the concept paper.

A concept paper with a lack of extensive technical data does NOT mean that the concept is flawed (although it may be). I acknowledge and understand your demand for "technical data" for fuel cost reduction for large ships using hydrogen as a fuel additive to improve combustion and fuel efficiency.

MORE WORK NEEDED: An argument against using CC-HOD to generate hydrogen is that there is a growing demand for large, coherent, repeatable data sets to support an underlying theory, regardless of the field of study. It is stretching the proof of technology to use the data from a limited set of conditions and extrapolate it to entirely different vehicles, engines and fuels that are orders of magnitude apart. Going from a 3.8 liter gasoline automobile engine to a marine diesel that displaces 1821 liters per cylinder (6-14 per engine!) requires quite a bit more effort, much more so than simply saying the results are fungible. This is a valid argument. This argument applies to all new technologies -- especially so-called “game changer” technologies. What is new? The ability to generate hydrogen at unlimited high rates, on demand, economically, using CC-HOD. More work, leading to product development and demonstrations will be required. Summary: This is a valid argument.



Can we estimate how much hydrogen is needed?

An 18 wheeler requires about 6LPM at 60 MPH to obtain a good cost savings, according to one source, who makes and sells electrolyzer-based hydrogen systems for this purpose.

At 6 MPG, a diesel 18-weeler truck consumes about 10 gallons per hour at a speed of 60 MPH. From this, we can calculate a useful conversion factor:

6 LPM per 10 gallons/hour

This is about how much hydrogen (6 LPM) is needed to obtain a cost savings of about 30% for a diesel fuel use rate about 10 gallons per hour. From this, we can calculate a useful conversion factor:

(6 liters per minute) x (1 hour per 10 gallons) x (60 minutes per hour) = 36 liters/gallon

From this, we know how much hydrogen is needed per gallon of diesel to obtain a 30% cost savings:

36 liters of hydrogen per gallon of diesel
is needed to obtain a 30% fuel cost savings.

How many gallons of diesel in a metric ton?

From an on-line calculator, taking density of the liquid into account,

Diesel Fuel & Heating Oil Conversion Calculator				
Gallons	Btu	Megajoules	Metric Tons	Clear
313.283208	43449248.1	45842.7318	1	Calculate

For our calculations, we will assume there are 313 gallons of diesel in a ton of fuel.

From this, we know how much hydrogen is needed per ton of diesel to obtain a 30% cost savings:

36 liters of hydrogen per gallon of diesel is needed to obtain a 30% fuel cost savings multiplied by 313 gallons per ton. So the answer is:

11,268 liters of hydrogen per ton of diesel is needed to obtain a 30% fuel cost savings

How much hydrogen is needed?

Fuel cost calculations in this document assume the following: 21 knots; 8000 TEU ship size; fuel consumed = 150 tons/day.

150 tons of diesel per day x 11,268 liters of hydrogen per ton of diesel = 1,692,900 liters of hydrogen per day is needed to obtain a 30% fuel cost savings. We know that

1	=	1440
Day		Minute

Therefore, we can calculate the hydrogen (LPM) required to obtain a 30% fuel cost savings when fuel is consumed at a rate of 150 tons/day.

1,692,900 liters of hydrogen per day = 1176 LPM

From data developed for the generation of hydrogen using the CC-HOD method, we know the following:

Interpolation from scale-up data

Interpolation from scale-up data in www.PhillipsCompany.4T.com/SU.pdf

A	B	C	D	E	F	G	H
690	1382	1995	77	1024	1.4		
1380	2764	3989	155	2048	2.8		
690	1382	1995	77	1024	1.382		
1177/1024 =		1.148438	This is the interpolation multiplication constant.				
792.4	1587.141	2291.133	88.429688	1176	1.5871406		

Which gives the following simplified data:

Aluminum (g/min)	Water (g/min)	AH (g/min)	Hydrogen (g/min)	Hydrogen (l/min)	Water (l/min)
793	1587	2291	88.4	1176	1.59

The aluminum use rate required for the hydrogen flow rate we need.

The hydrogen flow rate we need

The water use rate required for the hydrogen flow rate we need.

Aluminum (g/min)	Water (g/min)	AH (g/min)	Hydrogen (g/min)	Hydrogen (l/min)	Water (l/min)
793	1587	2291	88.4	1176	1.59

This above data is interpolated from a more complete set of data, online at www.PhillipsCompany.4T.com/SU.pdf

The above data gives the answer we need. This says that CC-HOD can be used to produce hydrogen at a rate of 1178 LPM.

How much water is needed to produce hydrogen at the required rate?

All the hydrogen would come from water (not from aluminum, AH or any other source). The water consumption rate = 1.59 LPM.

1	=	3.78541
US gal		Liter

This gives the consumption rate of water, needed to make hydrogen at the rate needed. The consumption of water is:

1.59 LPM x (1 gallon per 3.78 liters) = 0.42 gallons per minute = 25.2 gallons per hour = 604 gallons per day.

How much aluminum is needed to produce hydrogen at the required rate?

Aluminum (g/min)	Water (g/min)	AH (g/min)	Hydrogen (g/min)	Hydrogen (l/min)	Water (l/min)
793	1587	2291	88.4	1176	1.59

To produce hydrogen at the required rate, the CC-HOD process will consume aluminum at a rate of 793 g = 0.793 Kg per minute.

0.793 Kg per minute x 1440 minutes per day = 1142 Kg per day

1142 Kg per day x 2.2 pound / Kg = 2512 pounds of aluminum per day = 105 pounds of aluminum per hour. This is the aluminum consumption rate required to produce hydrogen at the rate needed to obtain a 30% fuel cost savings.

Summary:

105 pounds per hour of aluminum is needed to produce hydrogen at the rate needed to obtain a 30% fuel cost savings. The good news is that this can be scrap aluminum (low purity; and therefore lower cost than the commodity spot price for >99% pure aluminum).

25.2 gallons per hour of water is needed to produce hydrogen at the rate needed to obtain a 30% fuel cost savings. The good news is that this can be sea water. Distilled water is not needed for the CC-HOD method of producing hydrogen.

What is the cost of aluminum needed to produce hydrogen at the required rate?

2512 pounds of aluminum per day is the aluminum consumption rate required to produce hydrogen at the rate needed to obtain a 30% fuel cost savings.

Aluminum can be purchased for less than $1/pound. (Ref: data from B. Coger and DEW, April 2013). This document is not an in-depth ‘source and price” document for aluminum, so for the following cost analysis, we will simply use a price of $1/pound for aluminum.

This is the aluminum cost required to produce hydrogen at the rate needed to obtain a 30% fuel cost savings. This is a minor cost when compared to the approximate fuel cost savings when hydrogen, in boost mode, is used as a fuel additive to diesel for our ship. The approximate fuel cost savings calculated previously in this document is: **Savings = (45 tons of diesel per day) x ($650USD per ton of diesel) = $29,250 per day.**

Cost Saving Summary:

$2512 per day is the aluminum cost required to produce hydrogen at the rate needed to obtain a 30% fuel cost savings.

The cost of sea water (25.2 gallons per hour) is considered negligible.

Fuel Cost Savings = (45 tons of diesel per day) x ($650USD per ton of diesel) = $29,250 per day.

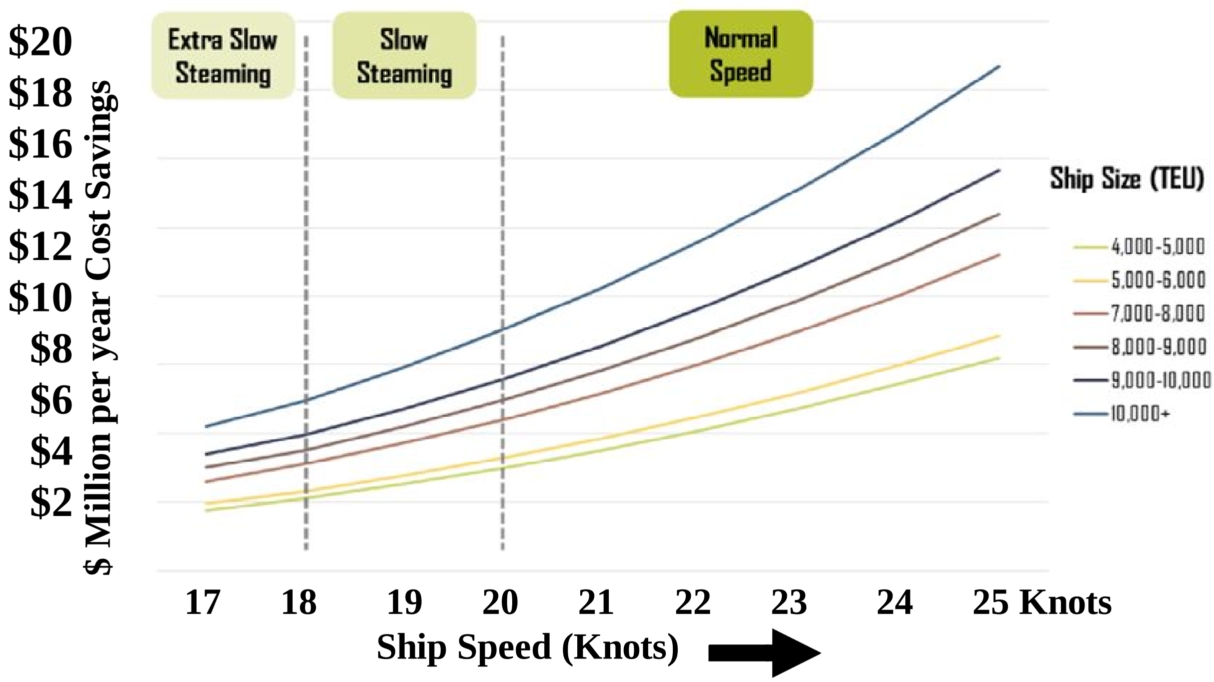
Net Fuel Cost Savings = $29,250 per day - $2512 per day = $26,738 per day.

Net Fuel Cost Savings = ($26,738 per day) x (300 days per year) = $8.021 million USD per year = approximately $8 million USD per year.

The fuel cost calculations summarized above assume a ship described as follows: 21 knots; 8000 TEU ship size; diesel fuel consumed = 150 tons/day; ship in route 300 days per year.

Annual Cost Savings

Fuel cost reduction when hydrogen is used to supplement diesel for a single ship (estimated)



Why hasn't hydrogen been used to obtain this large fuel savings?

The reasons are:

* Hydrogen on demand (HOD) is much preferred, compared to the use of hydrogen stored in a tank. Storage of large volumes of hydrogen is neither practical nor is it safe. The use of HOD eliminates the cost and need for storing hydrogen in tanks. Generating the hydrogen at the rate needed, when and only when needed (HOD), has been a requirement for all system engineering studies based on the use of hydrogen to obtain fuel cost reduction.

* **THERMOFORMING** -- Until the development of CC-HOD, no hydrogen generation technology existed to do this job. **Thermoforming is not practical for many locations where large-engine equipment is operated.** The input fuel for producing hydrogen using thermoforming is typically natural gas. Natural gas pipelines are not available for many locations where large-engine equipment is operated. Storage of large volumes of natural gas (even in the form of CNG) is not cost effective.

* **ELECTROLYSIS -- It is virtually impossible to generate hydrogen at the required rate using electrolysis**. If electrolysis were used, the electric current required to produce hydrogen at the rate needed for our ship would be more than 11,000 Amperes. This is totally impractical -- and virtually impossible.

Obtaining hydrogen from electrolysis requires a LOT of electrical power, making it too expensive for our application

The following is an excerpt from http://forum.onlineconversion.com/showthread.php?t=7218

The molar volume at temperature and pressure is 24.46 L/mol at 25 °C, 1 atm. That figure is used in the calculation below. At other conditions, it is 22.414 L/mol x 101.325 kPa/P x (273.15 + T)/273.15 K, where P is pressure in kPa, and T is temperature in °C.

To generate 1 mol/min of H_2 at 100% efficiency, 237.1 kJ of electricity must be supplied in 1 minute (60s). 237.1 kJ/60 s = 3.95 kW.

At 3.95 kW and 100% efficiency, you should produce 1 mol/min, that's 2.016 g/min, or 24.46 L/min at 25 °C.

Hydrogen production using electrolysis: 24.46 LPM per 3.95 kW at 25 °C This is best case, assuming 100% efficiency which can not be obtained in practice. A simplified conversion factor is:

6.19 LPM per killowatt of electricity used [100% efficiency, at 25 °C].

It can not be over emphasized that the 24.46 L figure is temperature dependent. Because of that, it is recommended that in experiments, it is better to measure volume (liters), correct for temperature and pressure, and convert to moles of production (grams). It will greatly simplify comparison of performance at different conditions, although it obviously adds a layer of complexity.

If Molar Volume is MV, (LPM/MV) x (3950 W·min/mol) / (Watts used) x 100% = efficiency in %.

For more discussion on the efficiency and electrochemistry of electrolysis, please see the online discussion at http://forum.onlineconversion.com/showthread.php?t=7218

Best case, assuming 100% efficiency -- Electrolysis produces HHO, which is 2/3 hydrogen and 1/3 oxygen. The two gas elements can be separated using a special cell design called a separator cell. For simplicity, we will assume all the gas produced by electrolysis will be hydrogen (the desired gas), since this is a best, best case calculation presented for reference only.

The hydrogen (LPM) required to obtain a 30% fuel cost savings when fuel is consumed at a rate of 150 tons/day is approximately 1,692,900 liters of hydrogen per day = 1176 LPM.

The electrical power required to produce hydrogen at this rate is

1176 LPM / 6.19 LPM per kW = 190 kW.

The Gibbs free energy of 237.1 kJ/mol of H2 can be expressed as a voltage by noting 2 mol of electrons are required to produce x 96485 C/mol, thus this is 237.1 kJ/193 kC = 1.23 V approximately. At negligible current, the reaction would proceed infinitely slowly in either direction at this voltage. Typically, a cell voltage in the range 1.5-2.0 V is used as a minimum practical voltage for electrolysis. So, in this best-case calculation, (cell voltage = 2 volts), the current required to produce 1176 LPM of hydrogen would be 190 / 2 = 95 Amperes.

95 Amperes, at 2 volts, best case

Practical application of electrolysis to produce hydrogen

In practice, 2 volts is too low to produce HHO at a desirable rate (LPM).

The real world wants hydrogen production at a faster rate, so we force the hydrogen production rate up with overvoltage in electrolysis.

The hydrogen (LPM) required to obtain a 30% fuel cost savings when fuel is consumed at a rate of 150 tons/day is approximately 1,692,900 liters of hydrogen per day = 1176 LPM. In practice, various methods exist for producing hydrogen (or HHO) using electrolysis, typically requiring a few Amps per liter of HHO produced. As a rough calculation, let's assume electrolysis might be used to produce HHO (or hydrogen, using a separator cell), at a rate of 1 LPM per 5 Amps of electrical current.

In practice, the production of hydrogen using electrolysis at a rate of 1176 LPM would require more than 5,000 Amperes.

Wow! Repeat: This is totally impractical -- and virtually impossible. That is the primary reason why hydrogen has not been used successfully to reduce fuel costs for large engines. Until the development of CC-HOD, no HOD hydrogen generation technology existed to do this job. Now, for the first time on earth, a new hydrogen production technology exists that do the job. CC-HOD can produce hydrogen at any desired rate, limited only by hardware design.

Using CC-HOD, how much current is required to generate hydrogen at the required rate?

The production of hydrogen, using CC-HOD has been demonstrated at a rate of 30 gallons per minute. Ref: www.PhillipsCompany.4T.com/CD.pdf

30 gallons per minute = (3.785 liters per gallon) x (30 gallons per minute) = 113.55 liters per minute. This demonstration required only 0.1 Amperes of electrical current, used to prevent buildup of aluminum hydroxide on the aluminum fuel.

To provide enough hydrogen, at the right rate for our ship, we will produce hydrogen at a rate of 2048 liters per minute (from earlier in this document). Using direct proportion in our design, we can determine that hydrogen production at a rate of 2048 liters per minute and will require an electric current of I = (2048 / 113.55) x (0.1 Ampere) = 1.8 Amperes. A comparison shows the dramatic advantage of using CC-HOD to produce hydrogen at the rate needed to obtain a 30% fuel cost savings for our ship:

	Electrolysis	**CC-HOD**
Electric current required	>5,000 Amperes	1.8 Amperes

Summary

The use of electrolysis would require more than 27,000 times the electrical current than if CC-HOD is used to generate hydrogen at the rate needed to obtain a 30% fuel cost savings for our ship.

If electrolysis were used, the electric current required to produce hydrogen at the rate needed for our ship would be more than 5,000 Amperes. This is totally impractical -- and virtually impossible.

CC-HOD is the only technology, worldwide, that uses only aluminum and water for fuel, and can easily generate hydrogen at the rate needed to obtain a 30% fuel cost savings for our ship.

Section 5 -- Is this fuel-saving concept worth additional consideration?

There seems to be a "demand pull" for methods to increase fuel efficiency

ADMIRALTY

In the news

Date: March 15, 2013

Fuel efficiency tops list of shipping concerns –Fuel efficiency has emerged as the leading strategy for shipping companies to meet the challenges posed by tough market conditions, according to a new survey from law firm Norton Rose. As Lloyd's List reports, 69% of shipping businesses believe that the industry should concentrate on developing more cost-effective means of managing fuel consumption in order to cope with the challenging economic conditions that Norton Rose describes as the "new normal", with 42% identifying increased financial restraint as the most significant change to their business over the past two years.

Ref: http://blog.admiralty.co.uk/tag/fuel-efficiency/

Press editorial

May 2012

How much would you save in a year if you cut your fuel costs by 2%?

ht W

high oil prices, bunker fuel oil accounting for around 60% of a vessel's operating costs, and increasingly stringent emission controls, a fuel strategy and ways to cut fuel bills are at the top of the agenda for most ship owners and operators today. In addition to looking at technical measures to cut fuel bills, such as exhaust gas cleaning and other technologies, shipowners are being compelled to reduce speed, remove destinations from their itineraries, and so on.

However, it is now permissible to re-use waste fuel and, according to Alfa Laval, for the first time there is a technically and economically efficient method of recovering waste fuel from fuel oil residues. With waste fuel recovery, WFR, a direct saving of up to 2% on fuel bills can be achieved with an investment that pays for itself and gives a healthy profit in the first year.

Important point: Although the $$$ savings will be different for diesel vs bunker fuel, these calculations in percent savings is the same for either/both kinds of fuel. In other words, using CC-HOD to provide hydrogen as a fuel additive, we expect a 30% cost reduction for bunker fuel and/or a 30% cost reduction for diesel fuel.

Maersk to save $35 million with Retrofit Program
-- News: May 27, 2013

Ref: http://www.vesselfinder.com/news/1147-Maersk-Line-to-Save-35-million-with-Retrofit-Programme?goback=%2Egde_1803841_member_244673415

Maersk Line to Save $35 million with Retrofit Programme

Maersk Line is planning to spend up to $35 million as it pushes ahead with a fuel saving retrofit project for its tanker ships. One of the Maersk Line's "I-class" VLCCs is being fitted with fuel saving devices, which include Becker Mewis propeller ducts and propeller boss cap fins on a range of owned tanker ship. In the programme is included screening and retrofitting around 70 tanker vessels of Maersk Line over the next 2 to 3 years.The Maersk Line's drive to raise fuel efficiency is going to focus on as many as thirty-five separate measures, which are all going potentially to contribute to fuel savings across the fleet. Maersk Line believes that retrofitted tonnage could yield fuel savings of as much as 8-10 per cent. Company naval architects are carefully going to assess each class of ship in the Maersk Line's fleet and professionals from the group's technology firm, Maersk Maritime Technology, to **determine which retrofits would be the most effective.** Maersk Line's view is that existing ships may give fuel savings of between 8-10% at a relatively low cost, rather than ordering new vessels against the current backdrop of substantial overcapacity. Cutting fuel consumption by 8% would translate into savings of around $8,000 a day, or $30 million per year, for each VLCC

Read more at: http://www.vesselfinder.com/news/1147-Maersk-Line-to-Save-35-million-with-Retrofit-Programme?goback=%2Egde_1803841_member_244673415

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The problem with this engineering concept paper is that Phillips Company is a pharmaceutical company and we have no connection, and thereby no credibility, with Maersk Maritime Technology.

Commercial offerings include hydrogen from electrolyzers

www.youtube.com/watch?v=uaIRHhiV8mI

Fuel Cell Comments:

- DRIVE-H2O PRO systems are producing pure hydrogen. It's purity is 99.99%.
- This method works well for smaller engines, but may be limited because of the electrical power required for generation of hydrogen for larger engines.

CC-HOD Comments:

- The CC-HOD technology can output hydrogen, directly from the cell, at ANY rate (LPM), limited only by the hardware design.
- The CC-HOD technology can produce the hydrogen ON DEMAND, or "HOD."

U.S. Navy wants to run its ships on seawater

U.S. Navy wants to run its ships on seawater

Michael Trei Friday, September 28, 2012 - 11:15am

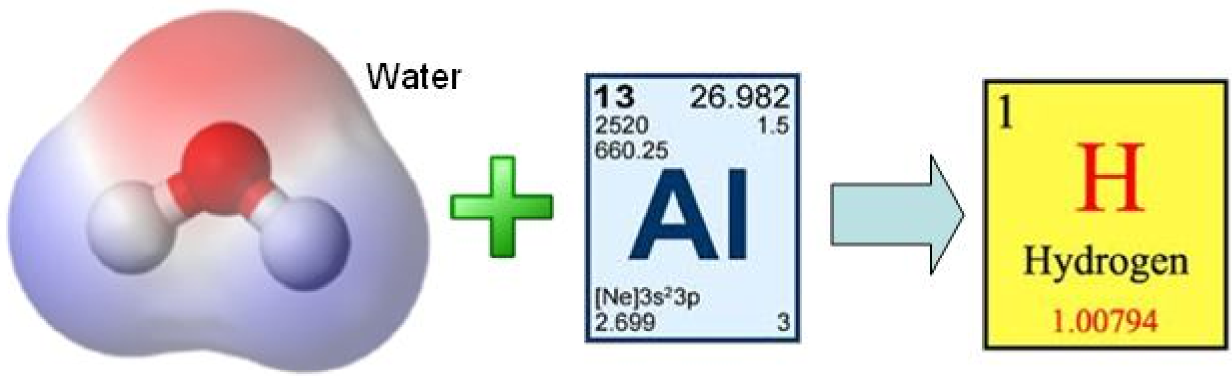
http://www.dvice.com/archives/2012/09/us_navy_wants_t.php

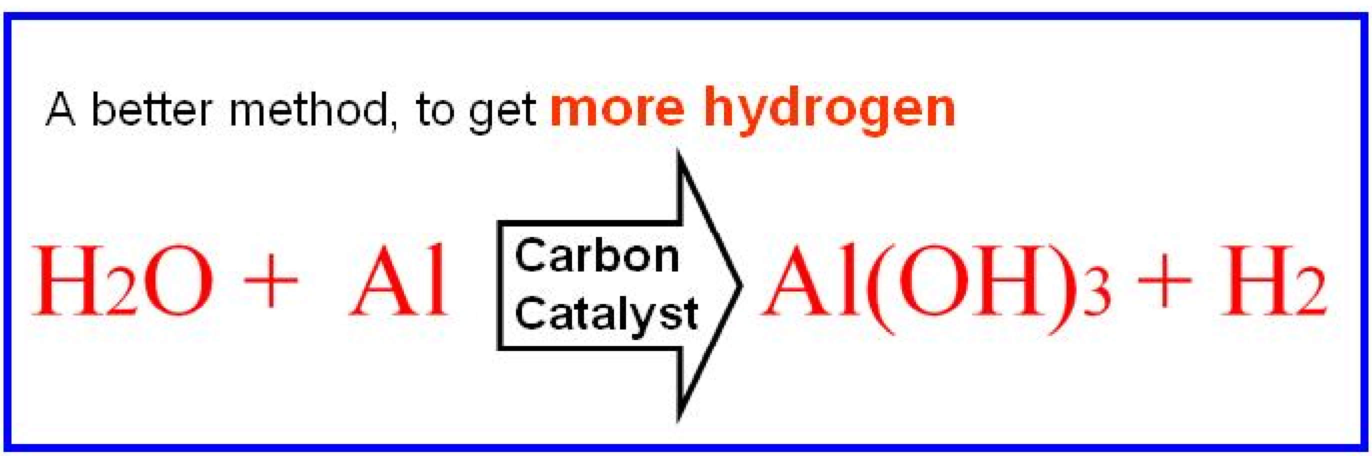
The U.S. Navy needs a lot of fuel to keep running. That's especially a problem if you're thousands of miles from home or in hostile waters. But what if you could simply make your own fuel using the seawater that surrounds you? That's what the U.S. Navy wants to do, using a two-step process that turns seawater into jet fuel.

Scientists at the U.S. Naval Research Laboratory are developing ways to extract both carbon dioxide (CO_2) and hydrogen (H_2) from regular seawater, and then feeding these two components into a catalytic converter that converts them into what is essentially JP-5 jet fuel that can power the ships' engines. Of course, the process is actually way more complicated than that, but the upshot is that they believe it should be possible to generate sufficient fuel to keep the ship running. Luckily, seawater is one potential fuel supply that isn't exactly in short supply when you're at sea.byproducts than using regular diesel fuel.

Section 6 -- What are the PROS and CONS?

Hydrogen can be extracted from water at rates (LPM) never before possible, because of a new catalyst, called Catalytic Carbon. The water-splitting reaction is simple, straightforward, and it uses materials that are environmentally friendly and affordable.





Catalytic Carbon technical information

Catalytic Carbon technical information is available online at
www.PhillipsCompany.4T.com/HYDROGEN.html
and
www.PhillipsCompany.4T.com/AHA.pps

Hydrogen-generation technology breakthrough

World organizations and international agencies, including the IEA, are concerned about the environmental impact of burning fossil fuels, and coal in particular.
Ref: http://en.wikipedia.org/wiki/Fossil-fuel_power_station

	Fossil Fuels					Hydrogen
Pollutant	Hard coal	Brown coal	Fuel oil	Other oil	Gas	Hydrogen
CO_2 (g/GJ)	94600	101000	77400	74100	56100	0
SO_2 (g/GJ)	765	1361	1350	228	0.68	0
NO_x (g/GJ)	292	183	195	129	93.3	0
CO (g/GJ)	89.1	89.1	15.7	15.7	14.5	0
Non methane organic compounds (g/GJ)	4.92	7.78	3.70	3.24	1.58	0
Particulate matter (g/GJ)	1203	3254	16	1.91	0.1	0
Flue gas volume total (m^3/GJ)	360	444	279	276	272	0

Game changer

Before CC-HOD became available, it was not possible or practical to produce hydrogen on demand (HOD) at the rate needed to obtain a 30% fuel cost savings for cargo ships, diesel-electric generators sometimes called GENSETs, locomotives and trucks, including the common 18-wheeler commercial truck.

Now and for the future, the situation will be different. The new technology, CC-HOD, makes it possible and practical, for the first time on earth, to produce hydrogen on demand (HOD) at the rate needed to obtain a 30% fuel cost savings for large engines.

The CC-HOD technology is available to any company that wants to commercialize this technology. We want to take this new hydrogen-generation technology to the people of the world.

We call it Catalytic Carbon, Hydrogen On Demand — CC-HOD. This simple, straightforward hydrogen-generation approach is the only technology, worldwide, that combines all of the following features and advantages:

CC-HOD CHARACTERISTICS

1 CC-HOD results in more energy when the hydrogen is used (combusted, burned) than the energy required to generate the hydrogen. CC-HOD is the only technology, worldwide, that can generate hydrogen at any rate desired (high LPM) using less energy than the useful energy released when the hydrogen is used (combusted, burned).

If the hardware is designed to operate at thermal equilibrium, input power is needed only during the start-up phase, as the hydrogen-producing cell is heated to approximately 180F. After that, hydrogen can be produced at any rate desired, with no more input power required to operate the cell. The chemical reaction is exothermic (produces some heat) and that can be used to offset the heat lost as a result of cooling of the cell during operation.

2 CC-HOD does not produce HHO. HHO is produced by electrolysis. CC-HOD produces hydrogen; with no oxygen in the output. When water is split, the oxygen is bound through the formation of aluminum hydroxide, which is retained in the water.

3 CC-HOD uses only low-cost and friendly materials (carbon and fuel).

4 CC-HOD uses only two fuels — aluminum and water. All the hydrogen produced comes from water. The process uses about 3 times more water than aluminum. The water does not need to be distilled. Any water will work. Sea water can be used to generate hydrogen. Dirty water can be used to generate hydrogen using the CC-HOD process.

5 The aluminum does not need to be of high purity. Scrap aluminum will work. Recycled aluminum can be used to generate hydrogen using the CC-HOD process. The result is that lower-cost aluminum will lead to a cost advantage for hydrogen production using the CC-HOD process.

6 Scrap aluminum exists in abundance. An online video shows how scrap aluminum is recovered from the trash you throw away every day. Pay close attention to the video at the 3 min : 50 second mark in the video. That's where the company says they recover the amount of aluminum required for 1 billion beverage cans -- and they do that every year. This amount of aluminum is recovered by just this ONE company! This is the kind of aluminum we need for CC-HOD production of hydrogen. We do not need high-purity aluminum. Here is the link to the video: http://www.youtube.com/watch?feature=player_embedded&v=sS60ND1FkBI

7 CC-HOD produces hydrogen, with no oxygen. This is done with no filters and no separator cell design requirements.

8 CC-HOD produces hydrogen that is 93% pure, based on independent test laboratory results, available online at www.PhillipsCompany.4T.com/PUR.pdf

9 Because the hydrogen is generated from water, the output gas is about 7% water vapor. The remainder is 93% pure hydrogen, as noted above.

10 The CC-HOD process is based on catalytic chemistry which is well understood. See the online description of CC-HOD at www.PhillipsCompany.4T.com/CCS.pdf

11 Catalytic Carbon is a non-stoichiometric heterogenous surface-activated catalyst. Complete activation process details are provided to anyone who licenses the CC-HOD technology.

12 Test vehicle data has shown a mileage improvement of 32%. These results are not in dispute. This amount of MPG improvement has been obtained by many other workers using both HHO (separator cell operation) and pure hydrogen -- including hydrogen produced using the CC-HOD method. A mileage improvement of 32% using CC-HOD is documented online at www.PhillipsCompany.4T.com/CT.pdf

13 CC-HOD can generate hydrogen at ANY rate (LPM, GPM), limited only by the hardware design.

14 The production of hydrogen using the CC-HOD technology has been publicly demonstrated, at a rate of 30 gallons per minute. The public demonstration (hydrogen production at 30 gallons/minute) is documented online at www.PhillipsCompany.4T.com/CD.pdf

15 The CC-HOD technology has been verified. It has been successfully used to produce hydrogen by workers worldwide. The technology verification and the countries where CC-HOD was evaluated are documented online at www.PhillipsCompany.4T.com/AHA.pdf

16 The CC-HOD technology has been endorsed by the American Hydrogen Association. This endorsement is documented online at www.PhillipsCompany.4T.com/ROY.pdf

17 The CC-HOD technology can produce the hydrogen ON DEMAND, or "HOD."

18 STORAGE TANKS: Because CC-HOD can be used to generate hydrogen at any required rate (LPM), there is no need for hydrogen storage tanks for most applications. This is a major system-design cost savings. In particular, this advantage supports the future development of hydrogen fuel applications, because CC-HOD can be considered as a technology that can eliminate the now-unnecessary requirement for a hydrogen infrastructure involving hydrogen refueling stations.

19 The CC-HOD technology can output hydrogen, directly from the cell, at ANY pressure, limited only by the hardware design. For the few system-design applications requiring a storage tank, the tank can be refilled, directly from the CC-HOD cell, to ANY pressure.

20 The CC-HOD technology produces only TWO products — hydrogen and aluminum hydroxide (AH).

21 Aluminum hydroxide is a valuable and safe industrial material. After harvesting the hydrogen, the AH by-product is both environmentally safe, not controlled by EPA, and can be either discarded or recycled. More info online at www.PhillipsCompany.4T.com/AHU.pdf

22 CORROSION CHARACTERISTICS: The CC-HOD hydrogen production process can operate as a water mixture that is pH neutral. The mixture is not required to be either acid nor is it required to be alkaline. Operation under pH neutral conditions reduces corrosion normally associated with electrolysis cells, because of the use of strong electrolytes and high electric currents required for electrolysis.

23 A comparison between CC-HOD and electrolysis is online: www.PhillipsCompany.4T.com/CT.pdf

24 SAFETY: The CC-HOD process offers the advantage of a chemical mixture that is more safe than electrolysis. As noted above, the mixture is pH neutral and contains no harsh chemicals. Literally, a person can wash their hands in this mixture. The safety cautions are associated with either pressure buildup or thermal burns because the cell operating temperature may be in the range of 180F.

25 The CC-HOD process offers the advantage of operation at atmosphere pressure. Most prototype cells have been designed to operate at a pressure of approximately 1 ATM. The process CAN produce high pressures if pressure-seal containment is employed in the design, but doing so is not necessary and not required for producing hydrogen at any desired rate (LPM), limited only by hardware design.

26 The CC-HOD technology can produce hydrogen with no critical parameter control required, leading to a hydrogen manufacturing process that is said, by manufacturing engineers, to have a WIDE PROCESS LATITUDE which leads to easy control and therefore low cost for hardware used to produce the hydrogen.

27 CC-HOD is believed to be best suited for many commercial applications that are part of a $150 Billion/year market for hydrogen and hydrogen products. Market size and forecasts: www.PhillipsCompany.4T.com/HM.pdf

28 CC-HOD may be the best technology that can help the trucking industry meet the new standards being imposed by the Obama administration. The announcement says: "**New big rigs— tractor-trailers we see on the road every day— will have to cut emissions and fuel consumption by a minimum of 20% by 2018. Given, with your average semi pulling about 6 mpg, the rise might seem pretty modest. But when you consider that the average long-haul freight-liner travels about 100,000 miles a year, and that heavy-duty vehicles account for 20% of all fuel consumption in the US, it's clear the effects will really add up over time**." For more, please see http://blog.uship.com/us/2010/11/obama-announces-fuel-economy-standards-for-heavy-vehicles-trucks.html

29 TRUCK FUEL COST REDUCTION -- Cost analyses and engineering data are available that show the commercial advantages of using CC-HOD for use in fuel cost reduction for 18-wheeler commercial trucks. For more information about this engineering study, contact Phillips Company.

30 RAILROAD LOCOMOTIVE FUEL COST REDUCTION -- CC-HOD is the focus of a cost-benefit engineering study showing how this new technology can provide a 30% increase the MPG efficiency of railroad locomotives. For more information about this engineering study, contact Phillips Company.

31 GENSET AND LARGE DIESEL-ELECTRIC GENERATOR FUEL COST REDUCTION -- Cost analyses and engineering data are available that show the commercial advantages of using CC-HOD for use in fuel cost reduction for diesel-electric generators used to generate electricity for either emergency-power applications or to generate electricity in off-grid locations. For more information about this engineering study, contact Phillips Company.

32 CARGO SHIP FUEL COST REDUCTION -- Cost analyses and engineering data are available that show the commercial advantages of using CC-HOD for use in fuel cost reduction for diesel engines used to power ships. For more information about this engineering study, contact Phillips Company.

33 The CC-HOD technology was the primary focus of the world's first CC-HOD Hydrogen Cell Design Conference, held April 8, 2013. Conference info: www.PhillipsCompany.4T.com/HDC1.pdf

34 CC-HOD was developed by Phillips Company, an FDA-registered pharmaceutical manufacturing company. The Company operates as a not-for-profit business. We are not a hardware company. Accordingly, we plan to make the technology widely available for commercialization by company operations worldwide. The Company CC-HOD business model is online at www.PhillipsCompany.4t.com/bmH.pdf

35 PATENT PENDING -- CC-HOD is a patent-pending technology.

36 LICENSING PROGRAM -- The CC-HOD technology can be licensed for use by any company. The licensee can then manufacture or produce catalytic carbon for use in commercial products; and market/sell those products with full encouragement from Phillips Company.

37 This simple, straightforward hydrogen-generation approach is the only technology, worldwide, that combines all of the characteristics, features and advantages listed above.

ARGUMENTS AGAINST USING ALUMINUM-WATER

1 An argument against using aluminum is that it takes a lot of energy to mine, refine and smelt aluminum. That is true, but not a valid argument if scrap aluminum is used to generate hydrogen. Even with the recent growth of aluminum reclamation and recycling programs (a good thing), the fact is that most scrap aluminum is discarded into landfills where it is lost to the benefit of mankind. When it is lost to mankind, the "energy-to-make-it" argument becomes an argument akin to a bankrupt notion because that argument actually SUPPORTS the idea of using scrap aluminum for something good, including its use in making hydrogen.

2 An argument against using aluminum is that there is not enough of it. That is not a valid argument. Scrap aluminum exists in abundance. An online video shows how scrap aluminum is recovered from the trash you throw away every day. Pay close attention to the video at the 3 min : 50 second mark in the video. That's where the company says they recover the amount of aluminum required for 1 billion beverage cans -- and they do that every year. This amount of aluminum is recovered by just this ONE company! This is the kind of aluminum we need for CC-HOD production of hydrogen. We do not need high-purity aluminum. Here is the link to the video: http://www.youtube.com/watch?feature=player_embedded&v=sS60ND1FkBI

3 An argument against using aluminum is that it costs money. That is a valid argument. We believe the cost of aluminum for making hydrogen is continuing to decrease. When CC-HOD R&D first began, we were paying about $10 per pound for 30-micron aluminum. Now (2013), it can be obtained for $3 per pound, in commercial volumes from suppliers in the USA. From international suppliers, aluminum is available for **less than** $1 per pound. New business ventures are being considered to provide aluminum for CC-HOD at costs that will continue to decline. For those interested in this activity, ask Phillips Company for the contact information for Butch Coger. He attended the world's first Hydrogen Design Conference, and he is in discussions regarding a possible new business initiative to provide low-cost-aluminum for CC-HOD.

4 SAFETY: An argument against using hydrogen is that it is not totally safe. That is a valid argument, which applies also to all other high-energy fuels. Phillips Company stresses safe-equipment design an safe operating practices. A major safety advantage: Because CC-HOD can be used to generate hydrogen at any required rate (LPM), there is no need for hydrogen storage tanks for most applications.

5 START IT: An argument against using CC-HOD to generate hydrogen is that input energy (heat) and heat-up time are required to bring the hydrogen output to full value, using the CC-HOD method for generating hydrogen. This is a valid argument. Our prototype systems typically require a few minutes for heat up, from room temperature to about 180F, after which the heater can be turned off. The reaction is exothermic, and generates heat. With proper cell design, the system can be made to operate in thermal equilibrium, so that the heat lost is equal to the heat provided by the continuing reaction during the generation of hydrogen.

6 STOP IT! An argument against using CC-HOD to generate hydrogen is that the hydrogen can not be stopped instantly. This is a valid argument. Four things are needed to sustain the reaction -- heat, water, aluminum and catalytic carbon (CC). To slow the reaction, cooling can be used. Every temperature drop of 18 to 20 degrees F, the hydrogen output will drop to half of the value before the temperature reduction. To stop the hydrogen reaction, any of the following can be done: water starvation, aluminum starvation, or CC starvation. Recent CC cell prototype designs (DW designs) have used continuous-feed apparatus to feed aluminum fuel into the cell. This concept is similar to carburetor or fuel injection designs for internal combustion engines. Shutting down the reaction to stop the hydrogen production simply involves control to stop the continuous supply of aluminum to the cell. In addition, some prototype designs have provided for venting hydrogen when a solenoid valve instantly stops the delivery of hydrogen from the cell to the engine. This works well, because hydrogen dissipates rapidly and rises (in air) very rapidly, at the rate of about 10 feet per second.

7 Hydrogen used as the ONLY fuel -- An argument against using aluminum is that it may be too expensive to make the aluminum-water reaction cost competitive vis-a-vis conventional hydrocarbon fuels for applications where ONLY hydrogen is contemplated as a fuel. Cost analyses regarding this matter were first carried out by Russel Phillips (American Hydrogen Association) and later by Jim Chatterly (Consultant). These analyses established and confirmed that aluminum may be too expensive to make the aluminum-water reactions cost competitive vis-a-vis conventional hydrocarbon fuels for applications where ONLY hydrogen is contemplated as a fuel for some applications currently. Hydrogen fuel enjoys no government subsidy (such as has been the case for ethanol and petroleum). But the cost for aluminum (low purity, low cost) is decreasing because of the initiative regarding low-cost-aluminum new business venture, described above. This argument does not apply to the use of hydrogen for "BOOST mode" operation of existing gasoline and diesel engines.

8 Hydrogen used as a BOOST fuel -- It has been firmly established that hydrogen can be used to boost MPG in vehicles using internal combustion engines. Fuel reduction of 30% or more has been experimentally proven by many workers, including individual experimenters. A web site devoted to hydrogen used in this manner has a growing membership. www.HODinfo.com now has a membership exceeding 3000 members. An argument against using aluminum is that it may be too expensive to make the aluminum-water reactions cost competitive vis-a-vis conventional hydrocarbon fuels for applications where hydrogen is contemplated as a fuel supplement used in BOOST mode. This argument seems to have no merit, primarily because hydrogen consumption rates are much lower when BOOST mode is used to increase MPG for automobiles and trucks. The requirement for hydrogen is about 6 LPM for large 18-wheeler trucks, and less than 1 LPM for typical automobile engines.

9 Hydrogen used as a BOOST fuel -- We believe a bankrupt notion is the best way to describe the argument against using aluminum because it is too expensive to make the aluminum-water reactions cost competitive vis-a-vis conventional hydrocarbon fuels for applications where hydrogen is contemplated as a fuel supplement used in BOOST mode. As noted above, test vehicle results have shown a mileage improvement of 32%. These test results are documented online at www.PhillipsCompany.4T.com/CT.pdf

10 CC COST: An argument against using CC-HOD to generate hydrogen is that CC costs money. CC is not consumed in the CC-HOD process. It is a catalyst, and continues to function as a catalyst even as fuels (water + aluminum) are added to the hydrogen-production process. Replacement of the CC is needed only if the user wants to discard it for some reason. The cost of CC is expected to decrease to about 1/3 of the current cost when the demand for CC grows to more than 1 metric ton per year. CC is manufactured and provided, without restriction, to anyone in the world who wants it. It shipped to USA addresses, because the manufacturer is not an exporter. It is sold at the cost of manufacturing, with no profit added. For more information and to obtain Catalytic Carbon (CC): www.PhillipsCompany.4T.com/CT.pdf Because of these reasons, the argument against using CC-HOD to generate hydrogen is that CC costs money -- seems like a weak argument without merit. .

11 MAKING CC AT HOME: An argument against using CC-HOD to generate hydrogen is that a manufacturer can not control the production of the CC it needs for commercial hardware. Not true. Any company can license the use of the CC technology for use commercially, and obtain both trade secrets and IP rights to manufacture CC. A licensing program has been established for this purpose. Because of these reasons, the argument that a hardware manufacturer can not control the production of the CC -- seems like an weak argument without merit.

12 COST ANALYSES: An argument against using CC-HOD to generate hydrogen is that no cost analyses exist to show that CC-HOD use can be commercially attractive. Not true. CC-HOD can generate hydrogen sufficient to boost fuel economy when the hydrogen is combined with diesel to power a ship. Engineering calculations show a Fuel Cost Savings = ($29,250 per day) x (300 days per year) = $8.775 million USD per year, assuming a ship described as follows: Speed = 21 knots; 8000 TEU ship size; fuel consumed = 150 tons/day; ship in route 300 days per year. If interested in the details, please contact Phillips Company.

13 ENGINEERING ANALYSES: Cost analyses and engineering data are available that show the commercial advantages of using CC-HOD for use in fuel cost reduction for 18-wheeler commercial

trucks. Cost analyses and engineering data are available that show the commercial advantages of using CC-HOD for use in fuel cost reduction for diesel-electric generators used to generate electricity for either emergency-power applications or to generate electricity in off-grid locations Cost analyses and engineering data are available that show the commercial advantages of using CC-HOD for use in fuel cost reduction for diesel-electric generators used to power locomotives. Cost analyses and engineering data are available that show the commercial advantages of using CC-HOD for use in fuel cost reduction for diesel engines used to power ships. These documents are available by request from Phillips Company.

14 It seems that there is no valid argument against using CC-HOD to generate hydrogen if the argument is that no cost analyses exist to show that CC-HOD use can be commercially attractive.

15 MORE WORK NEEDED: An argument against using CC-HOD to generate hydrogen is that there is a growing demand for large, coherent, repeatable data sets to support an underlying theory, regardless of the field of study. It is stretching the proof of technology to use the data from a limited set of conditions and extrapolate it to entirely different vehicles, engines and fuels that are orders of magnitude apart. Going from a 3.8 liter gasoline automobile engine to a marine diesel that displaces 1821 liters per cylinder (6-14 per engine!) requires quite a bit more effort, much more so than simply saying the results are fungible. This is a valid argument. This argument applies to all new technologies -- especially so-called “game changer” technologies. What is new? The ability to generate hydrogen at unlimited high rates, on demand, economically, using CC-HOD. More work, leading to product development and demonstrations will be required. Summary: This is a valid argument.

16 TECHNOLOGISTS NEEDED: An argument against using CC-HOD to generate hydrogen is that the current state of the art of hydrogen fuel supplementation is still in its infancy and will require interdisciplinary teams of manufacturers, entrepreneurs, engineers, chemists, and scientists to help it achieve its potential. More work, leading to product development and demonstrations will be required. Summary: This is a valid argument.

17 CELL DESIGNS NEEDED: An argument against using CC-HOD to generate hydrogen is that cell designs are not available for company operations desiring to develop hydrogen-fueled commercial hardware. That is valid and true. Phillips Company is a pharmaceutical company -- not a hardware company. The commercial hardware designs will be developed by company operations who want to commercialize this technology. Phillips Company will assist any company in the understanding and use of the CC-HOD engineering chemistry needed for various commercial hardware designs. The CC-HOD technology can be licensed for use by any company. The licensee can then manufacture or produce catalytic carbon for use in commercial products; and market/sell those products with full encouragement from Phillips Company.

18 MORE CELL DESIGN INFORMATION NEEDED: The CC-HOD technology was the primary focus of the world’s first CC-HOD Hydrogen Cell Design Conference, held April 8, 2013. Conference info: www.PhillipsCompany.4T.com/HDC1.pdf   The next Hydrogen Design Conference will be scheduled soon. Attendance will be limited so that individual attention can be given to specific commercial designs and demonstrations of CC-HOD prototype cells, if requested. For info, please contact Phillips Company.

Section 7 -- Public reviews and feedback from reviewers

This engineering concept paper was reviewed based on a post in a public forum, in May, 2013. This was my post that invited reviewers.

Howard Phillips
Active Contributor

Join Date: May 2013
Location: Oklahoma -- Choctaw Nation of Oklahoma
Posts: 16

30% Increase in Fuel Economy for Large Ships
05/10/2013 10:19 PM

Are you a "greener energy" expert? I am searching for an expert to look over a short engineering concept paper that explains how to increase the fuel economy for large ships. The concept seems technically valid, and ready for implementation without large expense or R&D delays. I am searching for a "doubting Thomas" who is an "open-minded skeptic" who can spend 10 minutes reading the concept paper, and then provide CRITICAL technical comments. Please contact me both here (CR4) and also at my direct email address, hp (at) valliant.net

Kind regards,

Howard; Registered Professional Engineer; Phillips Company

Some reviews were lacking in quality

Most people made comments in the forum without having read the concept paper. Those reviews tended to be, as expected, rather uninformed and ranged from 'humorous' to "venomous."

A common problem seemed to be that commenters and reviewers tended to assume things which were not accurate:

1. Some reviewers seemed to think this concept paper was based on the need for recycling aluminum hydroxide (a product of the CC-HOD process), so that the AH could be formed into aluminum to complete the cycle. Although possible, and laudable, this is not what is discussed (or required) for the cost-saving analyses in this concept paper.

2. Some reviewers assumed that this concept paper was developed around using hydrogen as a FUEL REPLACEMENT to offset the use of bunker fuel and/or diesel fuel. That is NOT the basis of this engineering concept paper. Even when the difference was pointed out to these reviewers, they simply could not distinguish between FUEL REPLACEMENT MODE and BOOST MODE regarding the use of hydrogen with engines; and they continued to offer "counter arguments" where their (erroneous) cost-analyses continued to assume that this concept paper was based ONLY on hydrogen to be used as a fuel in the FUEL REPLACEMENT MODE. For these few commenters/reviewers, I was never successful in explaining the difference between FUEL REPLACEMENT MODE and BOOST MODE.

3. Some commenters and reviewers seemed to NOT understand <u>fuel conversion efficiency</u>. Fuel conversion efficiency is a measure of how effectively fuel is transformed into usable energy. While 100% efficiency is always the goal, in practice the fuel conversion efficiency of a typical commercial steam turbine generator is only about 30 percent efficient, and automobiles rarely boast better than 20% fuel conversion efficiency. This concept paper is all about using hydrogen to improve fuel conversion efficiency, but this seemed to be difficult for some of the commenters/reviewers to fully understand.
Ref: http://www.energyvortex.com/energydictionary/fuel_conversion_efficiency.html

4. Some commenters/reviewers could find “nothing new” in the concept paper. Before CC-HOD became available, it was not possible or practical to produce hydrogen on demand (HOD) at the rate needed to obtain a 30% fuel cost savings for cargo ships, diesel-electric generators sometimes called GENSETs, and locomotives. Now and for the future, the situation will be different. The new technology, CC-HOD, makes it possible and practical, for the first time on earth, to produce hydrogen on demand (HOD) at the rate needed to obtain a fuel cost savings for large engines. This new technology was not seen by some of the commenters/ reviewers as “new.” One reviewer maintained that is was just the “same old HHO” all over again.

5. Some commenters and reviewers displayed a seemingly-irrational demand for "technical data" for fuel cost reduction for large ships using hydrogen as a fuel additive to improve combustion and fuel efficiency. These reviewers seemed to not understand the nature of a concept paper (such as this document). A concept paper may have calculations, hypotheses, and plans. Seldom does a concept paper have a great deal of technical data or proof. "Proof of concept" is important but almost always occurs at a later time, and "proof of concept" work is usually guided by the ideas initially described in the concept paper. In the field of engineering, a concept paper with a lack of extensive technical data does NOT mean that the concept is flawed (although it may be).

6. Racial comments were among responses from some commenters. Here, from one of the public comments in the forum:

> I'm thinking that because Howard is on a reservation he might not be subject to the same rules as the rest of us. I'd certainly hate to depend on some ointment cooked up out of herbs and dirt to keep me alive if bitten by any venomous snake.

That commenter has a point. I must admit that I am a Native American, and our company is located within the Choctaw Nation of Oklahoma. But, I considered this as a racist comment -- not a good comment relating to the topic. So, I didn’t reply to this and some of the other public comments that seemed, to me, inappropriate.

7. Some commenters and reviewers seemed to believe that the reviews were sought to provide endorsements, which was completely counter to my original post asking for reviewers. The original post (see previous page), said, **“I am searching for a "doubting Thomas" who is an "open-minded skeptic."**

Confidential Information -- Phillips Company

8. Some commenters and reviewers seemed to believe that the purpose of the reviews was for Phillips Company to attract investors. Those commenters seemed to not realize that Phillips Company operates as a not-for-profit company, and that we are simply trying determine if the fuel saving concepts described in this paper can be useful to the world. And, if so, as explained in our public press releases, we expect other company interests to take the CC-HOD technology and commercialize it -- and in so doing, make money for THOSE companies and ‘take it to the people.”

Even so, the comments and reviewers provided helpful insight into how improvements can be made to this concept paper; and those improvements will be incorporated into future versions of this document.

Some reviews were competent and of good quality

Some reviews were competent and of good quality. These reviews were critical, and therefore helpful. These reviewers searched for calculation errors and provided helpful insight into how improvements can be made to this concept paper. Those comments were much appreciated, and based on those comments, improvements will be incorporated into future versions of this concept paper.

An example of an excellent review, recommending a path forward is given below:

Public comments (excerpts):

... By simply reducing the fuel consumption, Maersk designers have made a massive impact on emissions. Many of the hull design techniques are common is modern ship building but they have been combined and optimized to become a set of best practices for large ship design. ... ... Cited from this article:http://maritime.about.com/od/Vessel_Profiles/p/Maersk-Eee-Class-Of-Green-Container-Ships.htm

Subject RE: Hydrogen BOOST mode engineering concept paper -- Hi Howard,
I did receive and read your concept paper. I gathered from the paper that you are expecting a similar increase in engine efficiency when applying it to large ship engines, the ones that use internal combustion. The ships I am most familiar with are

Navy vessels, since I was a submarine officer. Those ships were all steam boilers or aircraft-like turbine engines which your concept would not work on. Flame front speed is not a factor in firing a boiler where combustion is continuous. I'm not familiar with the types of engines used in merchant ships and oil tankers, I believe they use large diesel engines. Has someone tested the technique on a large diesel engine? Regards, Thor

> This reviewer has a good point. The fuel cost savings method discussed in this concept paper (BOOST mode operation) does not apply to EVERY kind of ship -- only to ships that use internal combustion engines.

And in a separate comment from another reviewer:

I understand that what you have put out thus far is a fleshed out theory that sounds good. The next step is to see if it really is as good as it sounds. That is where the numbers come in. So please, humor us.

Pick a ship, any ship. Panamax, Chinamax, or even the triple E, and get these numbers together.

Fuel capacity

Fuel consumption per hour at ideal hull speed.

Cost of fuel.

Length of transit (one trip) in hours.

These are easy. Now the tough stuff. You have to scale up your calculations. You need to figure out exactly, based on this ships fuel consumption, just how much of all this other stuff you will need for a single transit.

First, how big is the equipment needed for this scale of conversion?

How much does it weigh?

How much will it cost to buy and maintain, and how much will it cost in terms of lost freight fees to carry onboard?

How much aluminum is it going consume per hour at ideal hull speed.

How much aluminum (in tons) are you going to have to carry for a single transit?

How much is that going to cost outright and in lost freight fees?

How much catalyst (in Tons) costing again as before for both out of pocket and lost fees.

> Now here is a sticky point with me as water is heavy and bulky. And carrying water is very inefficient. Just ask the Navy.
>
> Are you sure about using sea water in this reaction? Has it been done and is it as efficient as fresh water or DI water?
>
> How does this change the calculations if the reaction is less efficient?
>
> What are the by products and can they be discharged into the sea or do they have to be carried and disposed of properly.
>
> If you have to carry waste and pay for its disposal what will it cost to dispose of and of course lost freight fees as it is taking up weight that could be better used by paying freight? ... ...

The above comment is viewed as very helpful. It points the way from a concept paper to some better level of (calculated) performance and potential cost saving consideration.

Section 8 -- Where do we go from here? What's next?

Here is a direct quote from our initial press release, following the development of catalytic carbon for use in harvesting hydrogen from water:

> Equipment development and manufacturing is the next step toward commercialization. The new carbon catalyst was developed by Phillips Company, an Oklahoma-based FDA-registered pharmaceutical manufacturing company. Phillips is not an energy products company. Accordingly, the development and commercialization of hardware products will be done by other companies.
>
> Phillips is searching for companies that can produce hardware and commercialize the technology in the form of fuel for vehicles, hydrogen fuel for heating, and hydrogen fuel for water distillation.

As noted earlier in this document, Phillips Company operates as a not-for-profit company. We are simply trying determine if the fuel saving concepts in this paper can be useful to the world. And, if so, as explained in our public press releases, we expect other company interests to take the CC-HOD technology and commercialize it -- and in so doing, make money for THOSE companies and 'take it to the people."

Phillips Company is a pharmaceutical manufacturing company, not an alternative fuel company. <u>We will form connections with people in the shipping and energy business sectors, so that people from those sectors can consider whether fuel savings for large ships is desirable and if this new technology and engineering concept should be commercialized.</u>

Our business model for this new hydrogen-generation technology has been posted online since 2012.

HYDROGEN Fuel Cost Savings R&D

Phillips Company is an FDA-registered pharmaceutical manufacturing company; the world's only not-for-profit pharmaceutical company. We have licensed 21 new pharmaceutical products to other companies since 2009. We are not an energy company. We are not a hardware-products company. We plan to encourage other companies to take this CC-HOD hydrogen fuel technology to the world.

Hardware Commercialization

- Phillips Company is not a hardware-product company.

- Invite consultants and other companies to evaluate and develop CC-HOD technology.

↑

Hardware Prototype
- Design
- Fabrication
- Test and optimize

↑

Hardware Feasibility Study
- Formulation
- Trade secrets and/or
- Patent applications
(Use NDAs to allow CC shipment to evaluators until patent application work is completed.)

} TBD. Phillips company will invite other companies and consultants to evaluate and develop the CC-HOD technology.

↑

Concept (This document)
- Fuel cost savings preliminary analyses
- Cost of aluminum (rate of use)
- Rate of hydrogen (LPM) needed for BOOST mode operation for large engine, based on extrapolation of data from small engines.

} This document

HYDROGEN Value-Add Business Model

Phillips Company is an FDA-registered pharmaceutical manufacturing company; the world's only not-for-profit pharmaceutical company. We have licensed 21 new pharmaceutical products to other companies since 2009. We are not an energy company. We are not a hardware-products company. We plan to encourage other companies to take this CC-HOD hydrogen fuel technology to the world.

Commercialization

- Invite selected companies to develop products using CC-HOD technology.
- Provide an easy-to-license business environment.
- Allow commercialization by other companies to "take it to the world."

Establish strategic alliances

- Phillips Company is not a hardware-product company. Invite consultants and other companies to evaluate and develop CC-HOD technology.

Value added

Field testing
- Buick test vehicle.
- Prove higher MPG

Independent tests
- 45 evaluators, world wide
- Hydrogen purity tests

Discovery and Development
- Formulation
- Trade secrets and/or
- Patent applications

(Use NDAs to allow CC shipment to evaluators until patent application work is completed.)

Concept
- Application, opportunity, SWOT
- Improvement on SOTA
- Need for catalyst to obtain hydrogen fuel from water, using no energy, once heated to start the reaction.

Our main business is pharmaceuticals. Business plan information for that segment of our company:

http://www.phillipscompany.4t.com/BM.pdf
http://www.phillipscompany.4t.com/Plan.html

Email: hp@valliant.net
Tel. 580 746 2430

More information

RECENT NEWS (2013)

1. **Employment opportunity: www.PhillipsCompany.4t.com/HFC.pdf**
2. Hydrogen Newsletter: www.PhillipsCompany.4T.com/AHANL.pdf
3. New antibiotic announced: www.PhillipsCompany.4T.com/PR10.pdf
4. Hydrogen Cell Design Conference was held April 8, 2013
5. Conference info: www.PhillipsCompany.4T.com/HDC1.pdf
6. CC-HOD #1: www.PhillipsCompany.4T.com/PatHHO.pps
7. CC-HOD #2: www.PhillipsCompany.4T.com/GabeHHO.pps
8. H2 = 30 GPM & Cell design: www.PhillipsCompany.4T.com/CD.pdf
9. H2 = 45 liters/minute: www.PhillipsCompany.4T.com/45LPM.mp4
10. $150 Billion/year market: www.PhillipsCompany.4T.com/HM.pdf

HYDROGEN DIVISION

AHA newsletter: www.PhillipsCompany.4T.com/HT.pdf
AHA talk: www.PhillipsCompany.4T.com/AHA.pps
CC Endorsement www.PhillipsCompany.4T.com/ROY.pdf
Hydrogen tech business model: www.PhillipsCompany.4t.com/bmH.pdf
Car test results: www.PhillipsCompany.4T.com/CT.pdf
Hydrogen and CC licensing: www.PhillipsCompany.4t.com/LIC.pdf
Hydrogen and CC: www.PhillipsCompany.4T.com/HYDROGEN.html
How to obtain Catalytic Carbon: www.PhillipsCompany.4T.com/MCC.pdf
How to obtain Catalyzed Aluminum: www.PhillipsCompany.4T.com/MCA.pdf
Hydrogen News: www.PhillipsCompany.4T.com/PRH6.pdf
Catalyzed Aluminum (CA)info: www.PhillipsCompany.4T.com/CA.pdf
What the Government says: http://www.ndep.us/Just-Add-Water
Introduction to hydrogen:
http://www.igem.org.uk/media/232929/Hydrogen-Report-Complete-web.pdf
Water science (link below this line):
http://www.youtube.com/watch?v=sRKN0EymiHA&feature=endscreen%20%3E
What other companies are saying about hydrogen:
http://www.youtube.com/watch?v=hFxxhI0_vbE
More info about CC-HOD: www.phillipscompany.4t.com/INDEX%20H2.pdf

COMPANY INFORMATION

Phillips Company web site: www.PhillipsCompany.4T.com
Company highlights: www.PhillipsCompany.4t.com/accomplishments.pdf
Not-for-profit business model: www.PhillipsCompany.4t.com/bm.pdf
Biographical information: www.Phillips.8K.com