Hydrogen & Oxygen

HyOx™

Engine Technology

Presented to the National Hydrogen Association

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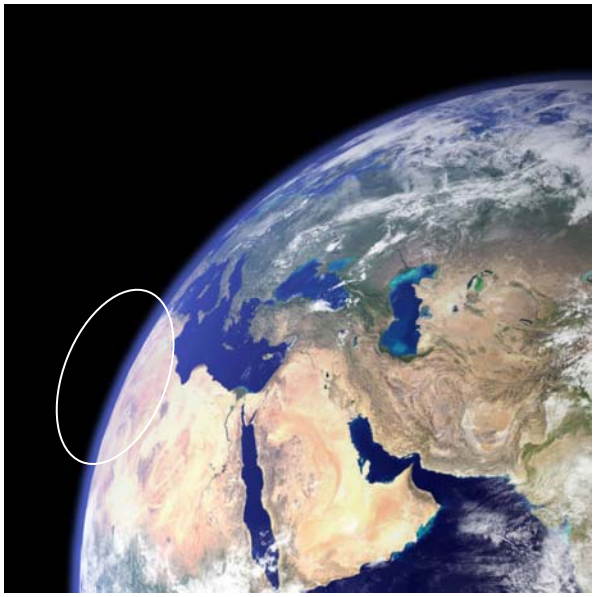
Earth – 2/3 Water

Our bodies are nearly 2/3 water; similarly, the Earth's Surface is nearly 2/3 water. This is while water is required for all life. As a major component of and supporting all life, our atmosphere manages the water cycle with evaporation, clouds and precipitation. As a part of the water cycle, our rivers, lakes and oceans move water across the Earth's Surface. All of this water and movement of water in the air and on the surface are important to our climate, our health and our world. Unfortunately, over the past century, humanity unknowingly created a support system which affects our water, our air and thereby the water cycle of our world. These affects are negatively affecting Earths' ability to support life.

Today, we know of past mistakes. We have the opportunity to improve upon our support system before irreparable harm is done to our home.

ClearValue's Vision has been that pure water and clean energy will become more important to humanity than oil. It is ClearValue's Mission to bring forth innovations to improve our water, our air, our health and our world. It is ClearValue's direction to bring forth innovations in the context of intellectual property so that capitalism will have an interest to implement ClearValue's innovations, thereby driving change to improve our water, our air, our health and our world. As profit is a great motivator, capitalism can be a great motivator to make improvements for all of humanity.



Earth's atmosphere, compared to the size of our planet, is comparatively as thin as the skin of an apple. This atmosphere, again, supports all life.

A Most Significant Challenge to Humanity

While humanity has been rather creative in the use of fossil fuels, it is without question that excessive fossil fuel use leads to environmental consequences which may be of biblical proportions. As the Earth warms, due to CO_X and NO_X in the Earth's atmosphere, the Earth adapts. Adaptation is causing changes in weather patterns, including record hurricane and tornado events, along with flooding and drought, depending upon location. Drought causes wildfires, while drought and flooding destroy personal property. These events are seen with only a 1 °C increase in the average Earth Surface Temperature. Computer models predict a 5 to 7 °C increase in the Earth's Average Surface Temperature within the next 50 - 100 years; only a 3 - 5 °C increase will melt glaciers and polar ice caps. Such a melting and thereby dilution of the oceans may stop the oceans' warm water conveyance systems. Should this come to pass, we should remember how cold it is just outside our atmosphere, Space, where the temperature is only 100 K, e.g. – 260 °F. With Space having such an immense capability to adsorb heat, it is not hard to imagine that if the northern and southern portions of Earth are not heated via tropical warm waters, as today, that those northern and southern portions of Earth would cover with ice. Therefore, humanity may cause the next ice age. And, should the ice age scenario not come to pass, that same melting of the glaciers and polar ice caps will raise Earth's oceans by over 200 feet placing many coastal cities under water. The worst case scenario is a rising of the oceans followed by an ice age; as, humanity would have left the oceans for higher altitudes. Once located in the higher altitudes, an ice age would be horrific.

Answering a Critical Need

Today, the combustion engine is under attack due to high operating costs and global warming. There is an urgent need to commercialize cleaner and more efficient engines. However, several obstacles have remained:

1. The cost of retooling machinery and altering production techniques has historically been prohibitively expensive in time and training required, e.g. fuel cells.
2. There have been difficult challenges with storage, distribution and cost of alternative energies.
3. Consumer demand previously lagged due to the historically low price of gasoline.

ClearValue's proprietary HyOx™ combustion technology provides a totally clean solution, combusting pure hydrogen (H_2) with pure oxygen (O_2) thereby producing pure water (H_20), while solving each obstacle:

1. HyOx™ drastically reduces time, training and new machinery costs; as, HyOx™ is an improvement upon combustion engines of today.
2. HyOx™ minimizes hydrogen (H_2) storage challenges while reducing operating cost to less than that of hydrocarbon. HyOx™ stores H_2 fuel at cryogenic temperatures and low pressures, thereby providing excellent energy storage density and 500 miles of operation prior to refueling. HyOx™ can be refueled at any electrical power source; while, H_2 can be supplied to any service station via a gas line or electricity and water. HyOx™ is more economical than hydrocarbon combustion or fuel cells; as, HyOx™ has 3 to 4 times the operating efficiency of hydrocarbon engines (HyOx™ is 50 to 60% Carnot Efficient). And, HyOx™ has power, compared to hydrocarbon ICE, HyOx™ provides up to 10 times the power per displacement.
3. HyOx™, a variant of the familiar combustion engine, uses familiar performance metrics, provides additional power, adds less than 20% to vehicle price, lowers fuel operating cost, increases engine life and presents fewer obstacles to consumer acceptance than alternatives.

HyOx™ Technology

HyOx™ triples performance efficiency while capable of 10 times the power per displacement. HyOx™ also has no carbon, nitrogen or sulfur footprint. This is because H_2 can be easily produced via electrolysis of water with either: wind, water, nuclear or photovoltaic energy sources.

The combustion of fossil fuels is the combustion of HYDRO-carbons. HyOx™ is the combustion of HYDRO-gen. The processes are chemically very similar while H_2 is very light compared to hydrocarbons, e.g. gasoline is 112 pound/mole, natural gas is 16 pound/mole and H_2 is only 2 pound/mole. (In chemistry, a mole is measure of atomic matter.) On a molar basis, combustion and energy output from each fuel source:

Combustion of HYDRO-carbons	Combustion of HYDRO-gen
$C_nH_{2n+2} + (2n+1)O_2 \rightarrow nCO_2 + (n+1)H_2O$ + energy	$2H_2 + O_2 \rightarrow 2H_2O$ + energy
gasoline + 12.5 $O_2 \rightarrow 8CO_2 + 9H_2O$ + 1,300 kcal	$2H_2 + O_2 \rightarrow 2H_2O$ + 137 kcal
nat. gas (CH_4) + $2O_2 \rightarrow CO_2 + 2H_2O$ + 213 kcal	H_2 has 3X the energy per pound

(Note: 112 lbs of gasoline converts to 1,300 kcal while 4 pounds of H_2 convert to 137 kcal. In comparison, then, 112 lbs of gasoline results in 1,300/112 = 11.6 kcal per pound while 4 pounds of H_2 (2 X 2) results in 137 kcal $\Rightarrow$ 34.2 kcal per pound. And, 34.2/11.6 = 3.0.)

In all, O_2 is the oxidant and H_2O is a combustion product. In hydrocarbon combustion, though, carbon forms CO_2, a greenhouse gas. (During incomplete combustion, carbon monoxide (CO), a poisonous gas is formed.) To complicate matters, also, hydrocarbon combustion is performed with air instead of O_2. While air is 20% O_2, air is 80% Nitrogen (N_2). A portion of the N_2 then combusts endothermically (adsorbing energy) to produce oxides of nitrogen, NO_X (NO, NO_2 and NO_3). While NO_X is toxic to all life, NO_X also catalyzes the conversion of O_2 to ozone (O_3), which is also toxic to all life. NO_X and O_3 inhibit nature's ability to complete photosynthesis (photosynthesis is the biochemical pathway of by plant life to convert CO_2 back into O_2). Therefore, air pollution (CO_X and NO_X) not only place greenhouse and poisonous gases in our air, the resulting NO_X gases reduce nature's ability to replenish our air. In conclusion, we must remove both carbon (C) and nitrogen (N) from combustion in order to provide clean energy.

Comparison of HyOx™ to Hydrocarbon ICE

Efficiency - In terms of efficiency, today's internal combustion engine (ICE) is 15%, power generating turbines 30% and jet engines 25% efficient. In other words, out of every: $1.00 of fuel placed in an automobile or truck, $0.85 is lost; $1.00 spent on your electric bill, $0.70 is lost; and $1.00 spent on jet fuel $0.75 is lost. Just as it costs money to heat your home, that hot engine block, cooling radiator and exhaust are all lost energy.

From the laws of thermodynamics:

Combustion Energy = Work + Enthalpy Losses + Entropy Losses + Friction and Combustion Losses

Within hydrocarbon ICE, for every $1.00 spent on fuel, most unfortunately:

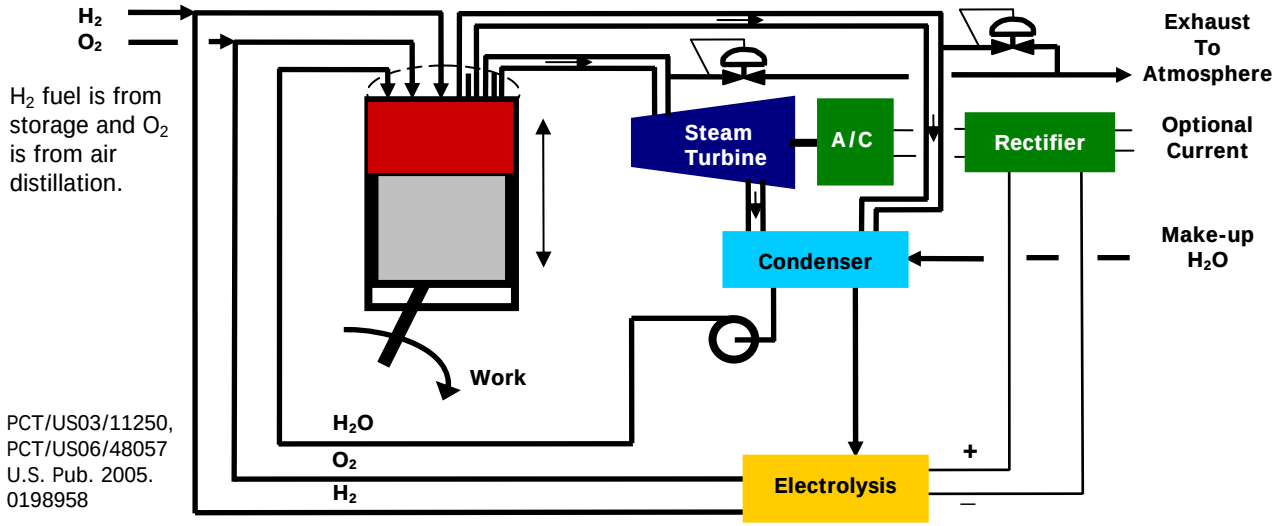
$1.00 = $0.15 + $0.35 (Cooling) + $0.35 (Exhaust) + $0.15

In thermodynamics, cooling losses are termed enthalpy (heat) losses and exhaust losses are termed enthalpy (heat) and entropy (pressure) losses. Therefore, the radiator has enthalpy losses; while, the exhaust has both enthalpy and entropy losses.

In stark contrast, HyOx™ increases efficiency to in excess of 50%:

$1.00 = $0.55 + $0.00 (Cooling) + $0.00 (Exhaust) + $0.10 + $0.35 (Recycle Losses)

Engine efficiency is increased at least 3 times (55% vs. 15%). HyOx™ performs this by directly following the laws of thermodynamics; HyOx™ directs all combustion energy to the piston or the exhaust. In short, there is no cooling loop (radiator), while combustion heat energy is trapped in the cylinder. Therefore, nearly all combustion energy which does not provide work leaves via the exhaust as hot water, steam, energy. This steam energy, which is near $0.70 of the $1.00 spend on fuel is then directed to a small steam turbine, similar to that used in the power industry, yet on the scale of a typical turbocharger. Condensate, water, from the steam turbine is then converted back into fuel and oxidizer (H_2 and O_2) by electrolysis of the H_2O condensate; the electrolysis is powered by the steam turbine. This energy recycle loop, which converts lost heat and pressure back into H_2 and O_2 is 40 to 80 % efficient, thereby reclaiming $0.30 to $0.60 of the $0.85 lost or $1.00 spent on fuel. This recycle loop, again, directly follows the laws of thermodynamics.



Further improvements may be made via a cooling cycle, wherein engine operation has an additional cycle (a cycle is one revolution of the crankshaft, e.g. one revolution from Top Dead Center (TDC) to TDC), i.e. between two combustion cycles. (This same improvement can be made in a turbine any time/location after combustion.) During this new cooling cycle, combustion heat energy previously absorbed into the combustion chamber is reclaimed as work. Water or low pressure steam is injected into the combustion chamber such that heat energy is turned into steam energy (pressure) during cooling. Computer models demonstrate this cooling cycle to be rather efficient work efficacious in displacement. One such model demonstrates:

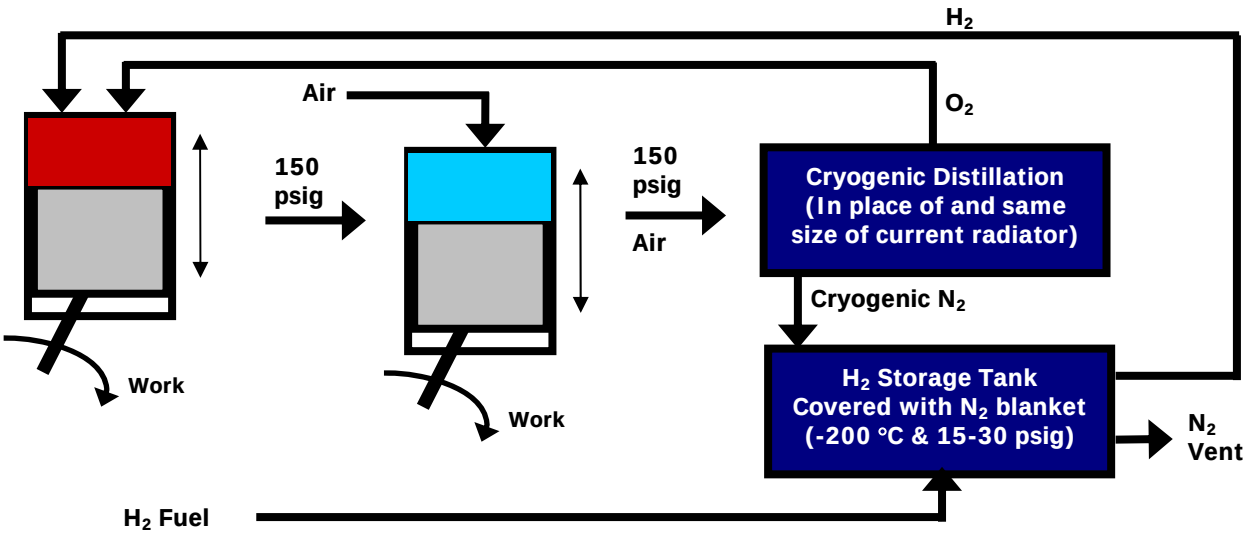
Moles of H_2O		0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
Initial Temp	K	773	773	773	773	773	773	773	773
Initial volume	L	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Final volume	L	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Initial pressure	atm	725.3	634.6	544.0	453.3	362.6	272.0	181.3	90.7
Work	**L-atm**	**81.2**	**71.1**	**60.9**	**50.8**	**40.6**	**30.5**	**20.3**	**10.2**
Heat	cal	10569.6	9248.4	7927.2	6606.0	5284.8	3963.6	2642.4	1321.2
	L-atm	435.0	380.6	326.2	271.9	217.5	163.1	108.7	54.4
Delta T	K	2113.9	1849.7	1585.4	1321.2	1057.0	792.7	528.5	264.2
Final pressure	atm	20.31	17.77	15.23	12.69	10.16	7.62	5.08	2.54
Final temp	K	278	278	278	278	278	278	278	278

Power – HyOx™ has the capability of producing 2 to 10 times the power of hydrocarbon ICE per displacement:

1. The HyOx™ oxidizer is O_2, not air. Air is 80% N_2, while N_2 produces NO_X. Further, NO_X formation takes power away from combustion as NO_X formation adsorbs energy. Therefore, HyOx™ operates with a 4 to 5 fold increase in available O_2 while limiting NO_X formation.
2. HyOx™ has the capability to add H_2 fuel and O_2 oxidizer to the combustion chamber under pressure. Therefore, HyOx™ has the capability to add H_2 and O_2 to the combustion chamber in amounts here-to-fore unavailable with hydrocarbon fuel and air combustion systems.
3. HyOx™, incorporating the Haase Cycle, a variant of the traditional Otto Cycle, furthers the power envelop, as described in the attached diagram.

HyOx™ Computer models demonstrate that the above advantages provide significant power improvement. One such computer model is attached as an exhibit.

O_2 and Cryogenic N_2 – As a safety measure, HyOx™ stores little to no O_2. HyOx™ makes its own O_2 as needed with cryogenic air distillation, which is the same process used for decades in the chemical industry. Further, this cryogenic distillation is "free" compared to hydrocarbon ICE. This is because HyOx™ requires no engine backpressure to atomize fuel; backpressure is negative energy, taking away power. H_2 is gaseous; therefore, HyOx™ has no need to atomize fuel. Hydrocarbon engines have about 150 psig of backpressure to atomize fuel; while, only 150 psig air is required for cryogenic air distillation. Therefore, HyOx™ obtains a significant power increase and eliminates NO_X formation by simply moving a negative energy, backpressure, of 150 psig from the combustion chamber to an air compressor.



(PCT/US03/11250, PCT/US06/48057 and U.S. Pub. 2005.0198958)

Another benefit of air distillation is cryogenic N_2, which is a good heat sink (absorbs heat). Cryogenic N_2 provides HyOx™ an ability to store H_2 at cryogenic temperatures, about -350 °F. At -120 °F and below, H_2 is easily chilled or liquefied, thereby increasing fuel storage density while storing H_2 at reasonable and safe pressures, e.g. 15 to 30 psig. This is a significant safety improvement over fuel cell applications at 1000's of psig.

The same thermodynamics which make HyOx™ a success in ICE, presents combustion solutions in power and jet propulsion applications. Attached is a diagram of a turbine power application along with a description of the minimal changes necessary within a jet engine to provide for HyOx™ jet propulsion.

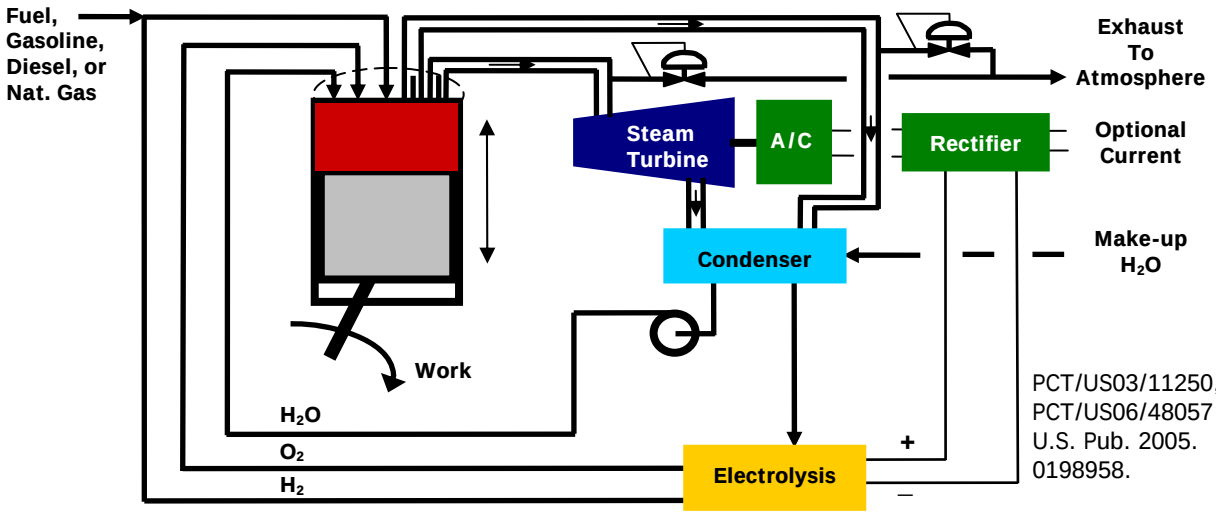
Comparison of HyOx™ to Fuel Cells and Electric Vehicles

First and foremost, literally billions of research $ have been invested in fuel cells worldwide. With these research $, fuel cells remain: 1) requiring platinum, wherein there is not enough platinum in the Earth's Crust for 1 year's automotive production, 2) expensive, wherein there is still no capability to manufacture a fuel cell vehicle at less than $100,000, 3) requiring overhaul, as fuel cells require a complete cleaning every 40,000 – 50,000 miles, 4) with fuel storage challenges, as H_2 is stored at 1,000's of psig, which is a safety issue, and 5) having power limitations, while the consumer has come to appreciate the power and feel of ICE.

In addition, literally decades and billions of research $ have been invested in batteries. Electric vehicles are energy storage limited, thereby distance and/or power limited.

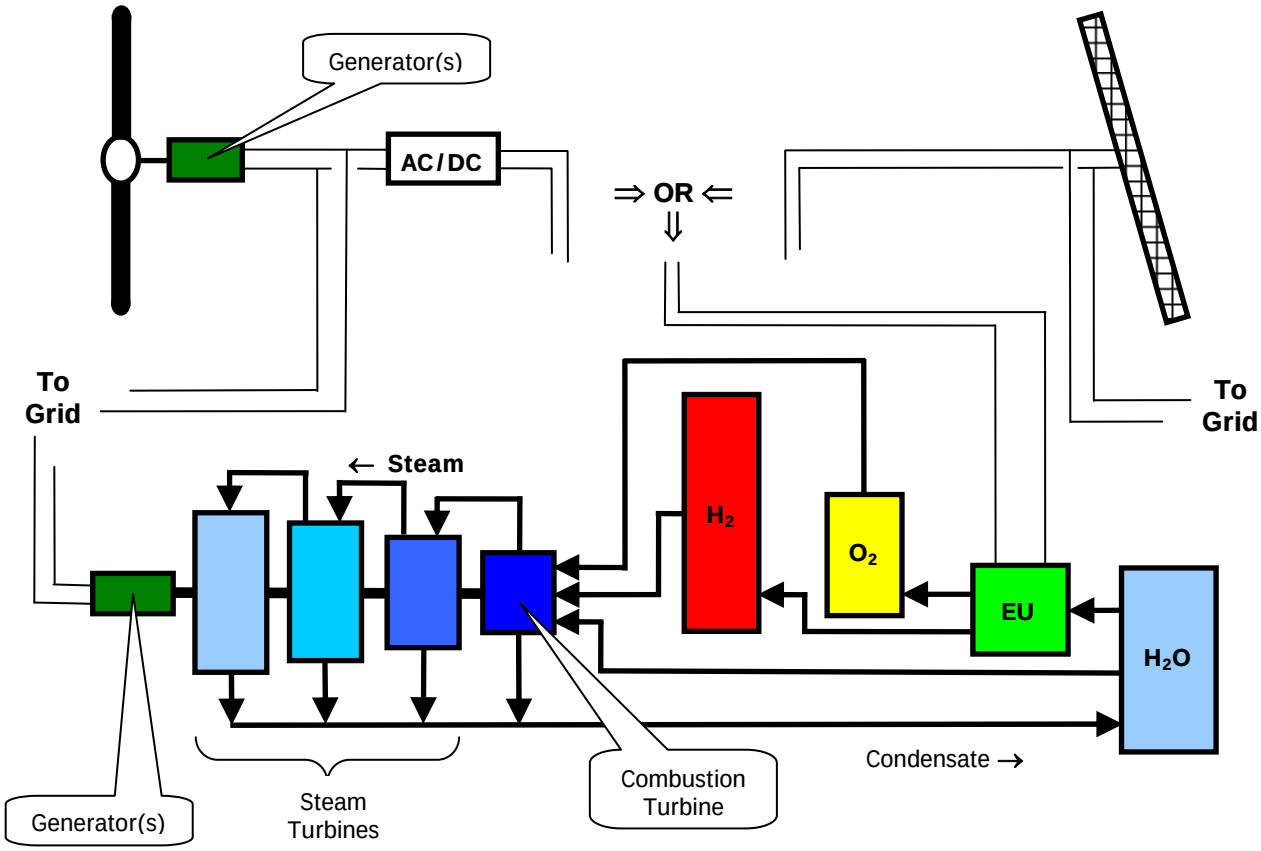
HyOx™ Interim

While the before mentioned HyOx™ presentation is the preferred means for HyOx™, at this time humanity has not developed an infrastructure for H_2 or electric vehicles. In any event, should a H_2 infrastructure be available today, there exist in excess of 600 million vehicles in the world today which operate with gasoline, diesel or propane. HyOx™ Interim is utilization of HyOx™ with hydrocarbon fuel. In combination, HyOx™ Interim increases fuel efficiency by near 100%; yes, a doubling of fuel efficiency, which means a reduction of 50% in fuel and a 50% reduction of CO_X and NO_X emissions.



HyOx™ Intellectual Property

HyOx™ provides an efficacious and economical means of energy storage in support of photovoltaic (PV) and/or wind power generation. This is because: 1) PV is only available during the day, while electrical power is also needed at night, 2) wind power is mostly available at night (gravitational pull of the Sun reduces wind during the day as compared to night), while electrical power is mostly needed during the day, 3) HyOx™ provides an efficient means of energy storage and electrical production (every kWhr sent to HyOx™ for storage translates into near 0.5 kWhr of electrical power when needed, and 4) Battery storage of electrical power is impractical. HyOx™ in combination with wind or PV is depicted below:

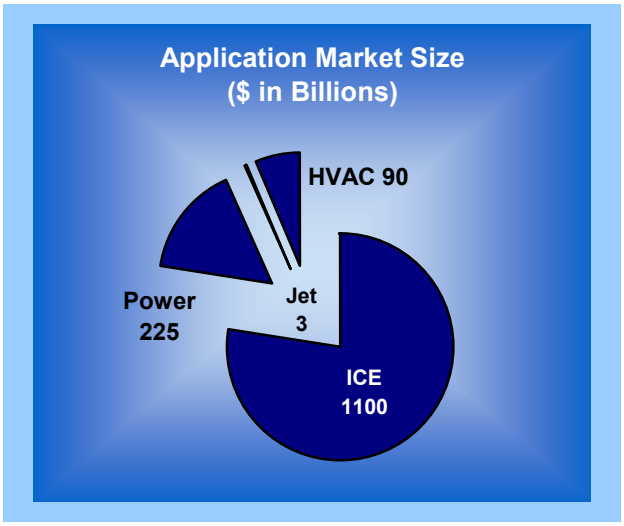


Market Analysis

Energy is a requirement in every home, office, business, manufacturing plant and mode of transport. However, our hydrocarbon based energy systems are harming the Earth's ecosystem, as well as all plant and animal life. The automotive, aerospace, power and HVAC industries have, in the past 10 years, been investing billions of $ in fuel cell technology with little success.

The combustion of fuel to produce mechanical, heat and/or electrical energy is the overall market of HyOx™; this is one of the largest, if not the largest, market of goods and services:

- Internal combustion engines are targeted for all transportation applications, including: automobiles, airplanes, trucks, buses, heavy equipment, etc. Gas turbine engines are targeted for all power (electrical) generation applications which utilize the combustion of fuel to generate electricity. The largest of these applications is on a megawatt (MW) scale, there is a significant market for smaller kilowatt (kW) applications,
- Jet engines are targeted for aerospace applications, and
- HVAC is targeted at all heating and cooling applications.



In transportation, within the U.S. nearly 15 million and worldwide nearly 50 million vehicles are produced annually. In operation today, there are nearly 300 million vehicles in the U.S. and nearly 600 million vehicles worldwide. Most importantly, there is about 1 vehicle per person in the U.S. (300 million people);

yet, there are only about 2 vehicles per 100 person in India and China (2.3 billion people); while, India and China are aggressively expanding their respective economies. Therefore, there does not exist enough hydrocarbon fuel for projected vehicle demand. For HyOx™, an estimated average wholesale price of $4,000 per engine per vehicle and 50 million annual vehicles translates into a $200 billion annual engine market; and, an average sales price of $20,000 per vehicle translates into a vehicle market of near $1 trillion. These figures do not include the replacement parts market. For HyOx™ Interim, an average installed cost of $1500 per vehicle in combination with 600 million worldwide vehicles results in a market of near $900 billion. Due to health challenges and global warming, this segment has a significant trend to commercialize a clean combustion technology. While this segment has historically been centralized among a few manufacturers in each region of the world or within each country, this segment has become much less centralized over the past 20 years with major firms now sourcing on a global basis.

Annually, the US generates near 4 Trillion kilowatt hours (T kWhr) of electricity; worldwide annual power generation is near 15 T kWhr. This power generates annual revenues of near $0.5 billion in the US and in excess of $1 Trillion world wide. Capital investment in power equipment is estimated to be near $3 per kWh for MWhr facilities and near $10 per kWhr for kWhr facilities; a 10% per year construction rate leads to a facility build value of $225 billion, annually. The Power Industry is recognized as the most air polluting industry; therefore, there is a significant trend in the Power Industry to commercialize improved environmental technologies. Manufacture of equipment in this industry is rather centralized; the major companies are GE, Westinghouse and Seamen's.

There are over 10,000 jet airplanes operating in the US and over 40,000 worldwide. Approximately 1,000 new jet airplanes are placed into service each year; wherein, the engine is the most valuable component having a wholesale price of $10,000 to over $10 million. This translates into an annual jet engine market of over $3 billion, excluding replacement parts. While the HyOx™ Jet Engine produces no CO_X and is more efficient that its hydrocarbon predecessors, the HyOx™ Jet Engine has the additional capability to operate as a Space Plane by utilizing air as an oxidant at low altitudes and O_2 as the oxidant at higher altitudes and in Space. The ability to launch a Space Plane instead of a rocket significantly reduces the oxidizer storage requirement while increasing the load capacity/fuel ratio. The Space Launch Business is currently a $10 billion dollar industry with the engine and engine servicing component valued at near 25% of the Industry. While environmental concerns are an important topic, air transportation is not a significant source of air pollution, being a distant third behind power generation and ground transportation. However, load bearing capacity and distance capability are key design criteria for all airplanes and Space Launch Vehicles. On a pound basis, H_2 has nearly 3 times the energy as compared to any hydrocarbon. Therefore, redesigning an airplane from hydrocarbon to H_2, be it of jet propulsion or internal combustion, will increase at least one of: the load carrying capability by a factor of near 3, the distance capability by a factor of near 3, and any combination therein. This industry is rather concentrated as well. The major companies would be GE, Boeing, Lockheed-Martin, Rolls Royce and Airbus.

Nearly every habitable structure has an HVAC system, including nearly all: homes, office buildings, commercial business, storage facilities and factories. As natural gas pipeline systems are changed to H_2, homes will require a HyOx™ HVAC unit. US sales of HVAC units are near $30 billion with world sales near $90 billion annually growing at a rate of 4.8%. This industry has become very environmentally conscious, having changed from Freon 11 and 12 to Freon 22 and 134a in the past decade. This industry is rather fragmented.

HyOx™ Intellectual Property

HyOx™ is patent pending worldwide in PCT/US03/11250, PCT/US03/41719, and PCT/US06/048057. While mostly patent pending, HyOx™ obtained the first award in Great Britain within GB 2407372 from PCT/US03/11250 and expects an allowance this year in the U.S., Germany, India, China and Australia. Divisional applications are pending in the US, as well as, various nations states for HyOx™ Interim.

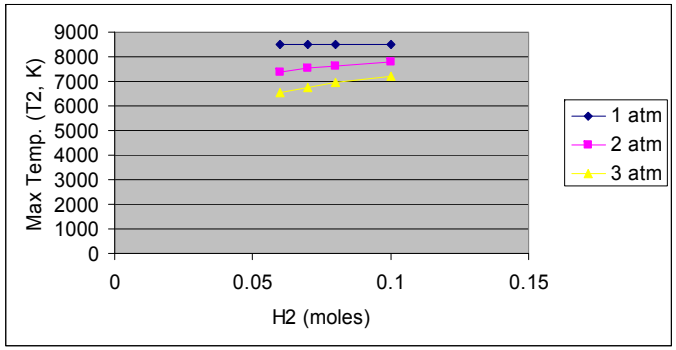
Executive Comment – While HyOx™ presents a significant opportunity for humanity, the ability to commercialize HyOx™ depends on our ability to drive change and our willingness to make a difference. Therefore, while investors in HyOx™ have the opportunity of significant returns, investment in HyOx™ requires a fortitude and patience which has, for some reason, left much of American Business.

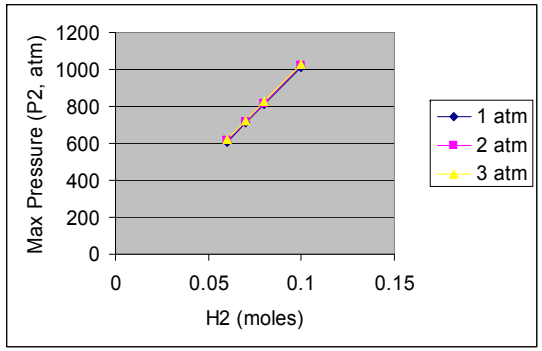
HyOx™ Computer Model – High Torque

(PCT/US03/11250, PCT/US06/48057 and U.S. Pub. 2005 0198958)

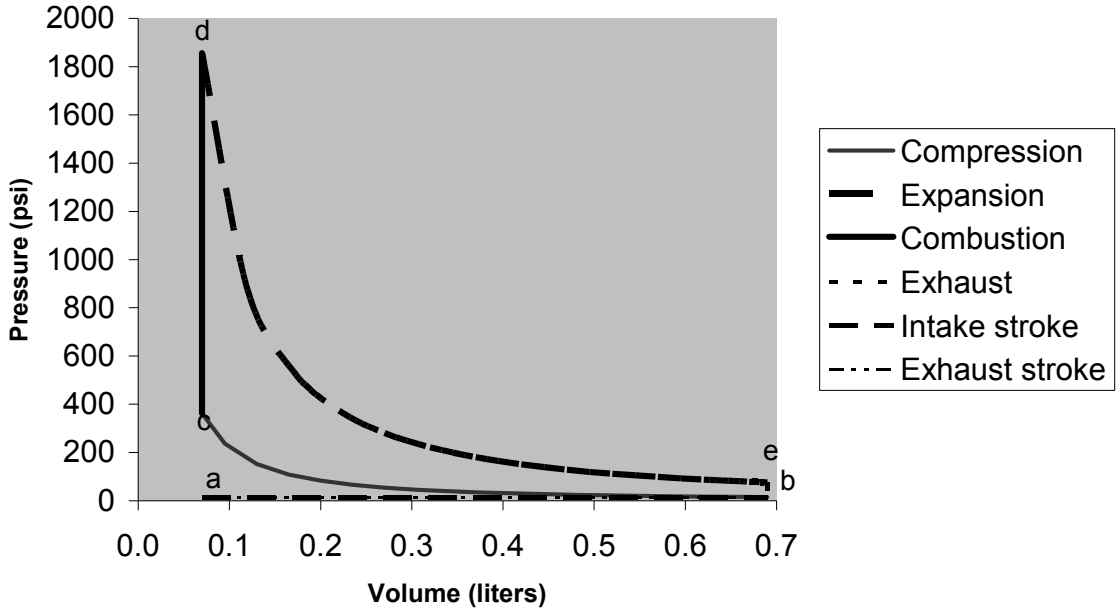
C.R. =	10	
D.S. =	0.069	Liter
Vo =	0.69	Liter
To =	300	K

				Compression				Combustion				Expansion		Output				
Ps	n (H2O)	n (H2)	Po	gamma	P1	T1	Q	delta T	T2	P2	P3	T3	W 0-->1	W 2-->3	net work	net work	HP
atm	moles	moles	atm		atm	K	kJ	K	K	atm	atm	K	l-atm	l-atm	l-atm	kJ	
1	0.0000	0.06	3.21	1.40	80.7	754	17.22	7757	8510	607.6	24.2	3388	-8.38	63.08	54.70	5.541	**1114**
1	0.0000	0.07	3.75	1.40	94.1	754	20.09	7757	8510	708.8	28.2	3388	-9.77	73.59	63.82	6.465	**1300**
1	0.0000	0.08	4.28	1.40	107.6	754	22.96	7757	8510	810.1	32.3	3388	-11.17	84.11	72.94	7.389	**1486**
1	0.0000	0.1	5.35	1.40	134.5	754	28.70	7757	8510	1012.6	40.3	3388	-13.96	105.14	91.17	9.236	**1857**
2	0.0100	0.06	3.57	1.39	88.0	740	17.22	6649	7388	615.4	24.5	2941	-9.31	63.89	54.58	5.529	**1112**
2	0.0100	0.07	4.11	1.39	101.5	742	20.09	6787	7529	716.7	28.5	2997	-10.71	74.41	63.70	6.453	**1298**
2	0.0100	0.08	4.64	1.39	114.9	743	22.96	6895	7638	817.9	32.6	3041	-12.10	84.92	72.82	7.377	**1483**
2	0.0100	0.1	5.71	1.40	141.8	745	28.70	7052	7797	1020.4	40.6	3104	-14.90	105.95	91.05	9.224	**1855**
3	0.0200	0.06	3.93	1.39	95.4	729	17.22	5818	6546	623.1	24.8	2606	-10.24	64.70	54.46	5.517	**1109**
3	0.0200	0.07	4.46	1.39	108.8	732	20.09	6033	6765	724.4	28.8	2693	-11.64	75.21	63.58	6.440	**1295**
3	0.0200	0.08	5.00	1.39	122.3	734	22.96	6205	6939	825.7	32.9	2763	-13.03	85.73	72.70	7.364	**1481**
3	0.0200	0.1	6.07	1.39	149.2	737	28.70	6464	7201	1028.2	40.9	2867	-15.83	106.76	90.93	9.211	**1852**



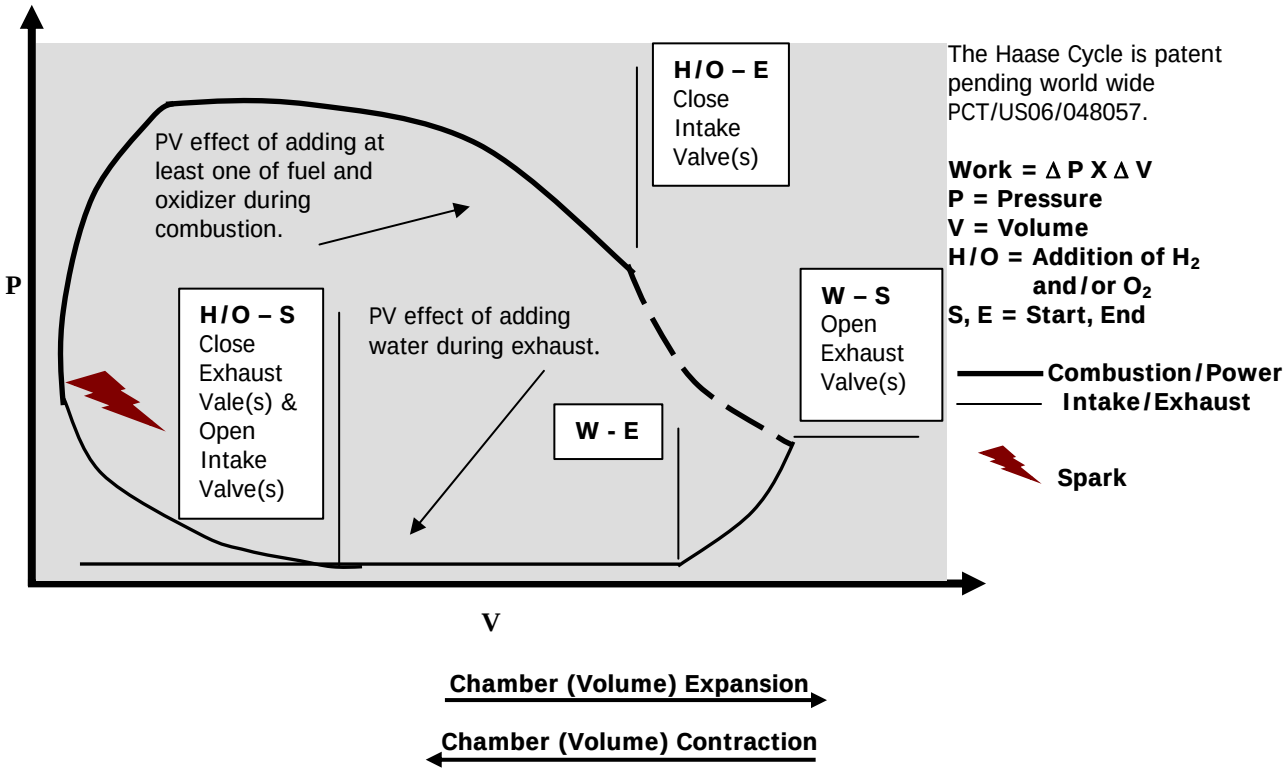


Otto Cycle



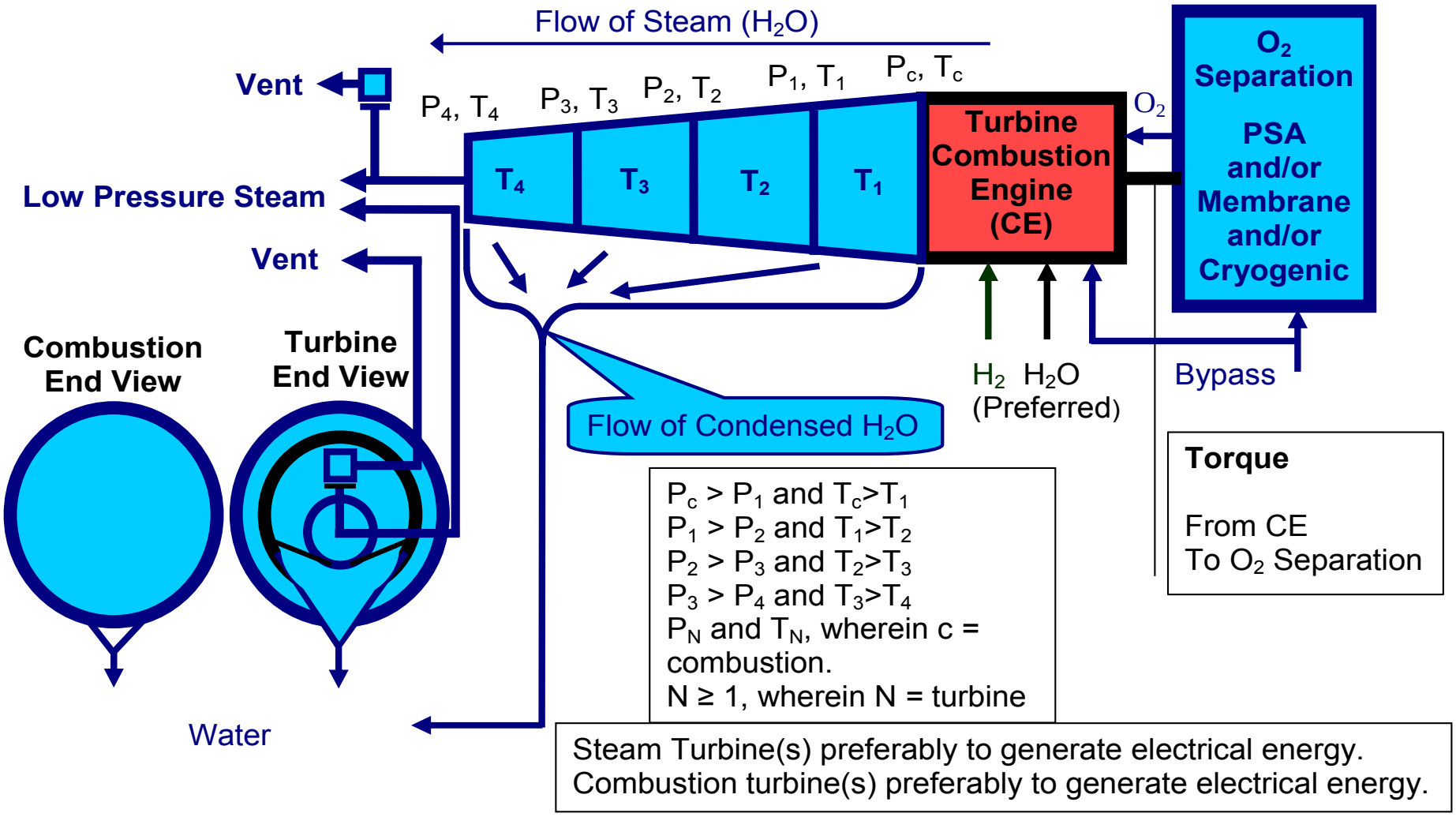
Haase Cycle

(PCT/US06/48057 and U.S. Pub. 2005.0198958)



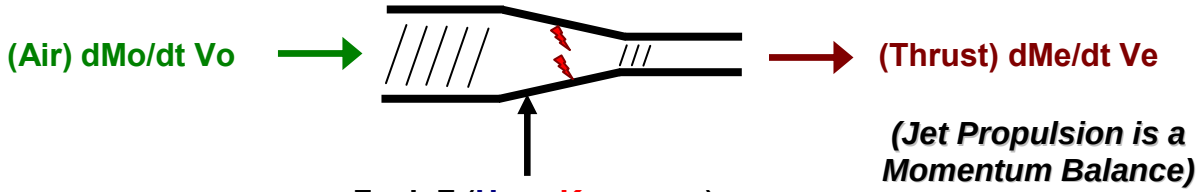
HyOx™ Steam Turbine Configuration Electrical Generation

(PCT/US03/11250, PCT/US06/48057 and U.S. Pub. 2005.0198958)



HyOx™ - Jet Propulsion

(U.S. Pat. Pub. 2005.0198958)



(Jet Propulsion is a Momentum Balance)

Ve >> Vo

Thrust = dMe/dt Ve – dMo/dt Vo, Let Me = Mo + M_F, M_F = mass of fuel.

$F = {}_{to}\int^{t1}\ {}_{Vo}\int^{Ve} Me - Mo = {}_{to}\int^{t1}\ {}_{Vo}\int^{Ve} Mo + M_F - Mo = {}_{to}\int^{t1}\ {}_{Vo}\int^{Ve} M_F$

$F_{WCT} = {}_{to}\int^{t1}\ {}_{Vo}\int^{Ve} \{M_{H2} + M_{O2} + M_{H2O} + M_{AIR}\}$, for Kerosene $F = {}_{to}\int^{t1}\ {}_{Vo}\int^{Ve} \{M_{FK} + M_{AIR}\}$

Is, $F_{WCT} \geq F_K$?; ∴ is, $\{M_{H2} + M_{O2} + M_{H2O}\} \geq \{ M_K \}$?
And, if air is used instead of O_2, then is $\{M_{H2} + M_{H2O} + M_{Air}\} \geq \{M_K + M_{AIR}\}$?

ΔH_{H2} = 51,571 BTU/lb., ΔH_K = 19,314 BTU/lb.,

$H_2 + ½\ O_2 \rightarrow H_2O$
lb.+ 8 lb. → 9 lb.

$C_{14}H_{30} + 43/2\ O_2 \rightarrow 14\ CO_2 + 15\ H_2O$
1 lb. + 3.47 lb. → 3.11 lb. + 1.36 lb.

Cp_K = 0.6 BTU °F/lb., $Cp_{H2O} \approx$ 0.46 BTU °F/lb., Cp_{H2} = 3.45 BTU °F/lb., Cp_{AIR} = 0.46 BTU °F/lb.,
$\Delta H_{V,H2O}$ = 974 BTU/lb., $\Delta H_{F,H2O}$ = 144 BTU/lb., Kerosene(K) a liquid, H_2 vaporizes @ STP

ΔH Combustion = Σ ΔH's

$\Delta H_K = Cp_K$ (lb. K)(1000) + Cp_{AIR} (3.47/0.18)(1000) + Cp_{AIR}(lb. AIR)(1000)
19,314 = (0.6)(1)(1000) + 0.46(3.47/0.18)(1000) + 0.46(lb. Air)(1000) .

∴ **For Kerosene, 1 lb. K/40.3 lb. air = 41.3 lb. thrust @ 1000°F.**

ΔH_{H2} = 3.45(1)(1000) + 0.46(8/0.18)(1000) + 0.46(lb. H_2O)(1000) + 974(lb. H_2O)
51,571 = 3450 + 20,444 + 1434(lb. H_2O), H_2O cooling = 19.3 lb., Air = 8/0.18 = 44.4 lb.

∴ **lb. H_2/44.4 lb. air/19.3 lb. H_2O = 64.7 lb. thrust. (Requires 10% air increase @ 1000°F).**

∴ **H_2 w/air cooling, 0.37 lb. H_2/39.22 lb. Air = 39.6 lb. Thrust**

∴ **Lb. thrust/lb. fuel: H_2/Air = 39.6; Kerosene/Air = 41.3; H_2/H_2O = 3.18**

∴ ***Previous H_2 issues now obvious; H_2 w/air simply requires more air.***

∴ **H_2/air Engines Require Increased Air Compression to Balance Thermodynamics, e.g. about 160% more air.**

∴ **Liquid O_2 and H_2O supplement combustion at high altitudes, and**

∴ **H_2O & H_2O/Air JtC Can Cool Exhaust Reducing Heat Trail.**