fusion **energy** solutions
of hawai‘i

Business Plan

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FUSION ENERGY SOLUTIONS OF HAWAII

Unlimited clean energy as long as humanity needs it: FUSION.

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I. EXECUTIVE SUMMARY

We live within a rapidly depleting hydrocarbon-based energy system that needs a clean, reliable, and sustainable primary energy source. Only fusion fits this specification and we have solved and patented the riddle to efficient fusion power. The whole world is the target market, encompassing electricity, petrochemicals, transportation, fresh water, and waste remediation. This project involves a proof of concept (POC) followed by construction of an operational 20MW commercial fusion power plant.

Turn-on of a successful fusion power plant engages all marketing target audiences. Our present technology positions us to beat all competition, for we can generate electricity with a fuel cost of only $0.0033/MWh. This 7-year, $570 million project leads to over $88 trillion of energy wealth for the 20 years following the project. A 10% return of energy value will bring about $8.8T to the company.

Our mission is to bring unlimited, clean energy to humanity. We are a Hawaii based, for-profit corporation of inventors, academics, and engineers possessing energy patents of great value. Our plan is to beat the ITER specification with a 2.4 kW fusion reactor, followed by a 20MW fusion power plant. POC, R&D, worldwide patents, and corporate operations cost $250M. The plant is $320M and will return up to $66M/year on completion. Civilization and humanity will then benefit from a habitable, sustainable planet with a relatively non-polluting energy source that never runs out.

II. THE PROBLEM AND THE SOLUTION

We live within a finite hydrocarbon-based energy system that is rapidly being depleted. We need a clean, reliable energy source of primary power. All energy sources presently used are secondary. They are not the original power source, but are just energy storage means. The primary source for all of these are fusion reactions that occurred in our sun or other stars.

Hydrocarbon fuels derive from energy captured by photosynthesis from sunlight. They release energy of stored sunlight from the past. Energy is stored in the bonding configuration of the molecules. Oxygen and hydrocarbons are molecules at a high energy state. Oxidation releases this stored energy to do work. Left are the same atoms arranged into molecules at a low energy state such as water and carbon dioxide. Plants using sunlight recycle these low energy molecules back to high energy molecules by photosynthesis. It is important to realize that this is a reversible reaction equation.

The problem is that over the last several hundred years man's energy use has increased to vastly exceed the ability of the photosynthetic pathway to keep up with the energy demand. Earth has a chemical battery consisting of billions of tons of living biomass stored in forests, farmlands, other ecosystems, and vast reserves of fossil fuels. The photosynthetic pathway can be likened to a trickle-charge system (Schramski et al., 2017).

The Schramski paper on thermodynamics [1] describes this depletion in terms of a quantity labeled omega (Ω). In year 1 AD, Ω approximated 70,000. By the year 2000 it was down to about 1040 and is in steep decline, approximating 0 in 2046. It is not necessary for Ω to reach 1 for the human population, economy, and biosphere to crash.

Humanity is now just becoming aware of these problems. Ongoing energy demand is met by continual drawdown of dwindling reserves. More efficient use of energy does not address the problem because this will not replace the energy when it's gone. Now there is interest in development of "alternative, non-hydrocarbon" allegedly sustainable energy sources; primarily being based upon wind, hydro, and solar.

They don't solve the problem. The equipment for harvesting this energy (solar panels, wind turbines) are manufactured using hydrocarbon (oil) energy sources. Solar panels, wind turbines , etc. have a finite life expectancy and must be repaired and replaced. We are running out of rare earths and metals needed for manufacture. Most importantly, these devices harvest energy from low energy density sources. Sunlight is plentiful but it's spread over vast areas. It's not practical for these sources to even approach becoming a replacement for oil and hydrocarbons.

The basic problem is we now need a primary energy source that has high power density, operates 24/7, 365 days a year, is easily transportable, is sustainable into the long-term future, is clean and reliable, and is safe. Only fusion fits this specification. Natural gas and methane hydrates may help in the transition period, but are not long-term answers. Fission is too dangerous and dirty. Fission fuels are in limited supply, sufficient for only about 200 years. Needed is a long-term permanent solution.

The long ongoing hydrocarbon energy usage has negatively impacted the environment by an over accumulation of low-energy molecules like carbon dioxide which is implicated in global warming.

Fusion remedies all of these issues. It emits no dangerous, long-lived radioactive wastes or carbon dioxide. Deuterium stores in the ocean will provide energy for as long as humanity needs it. Once carbon neutrality is reached free carbon dioxide can be synthesized into back to hydrocarbons to replenish Earth's chemical hydrocarbon battery, reversing the decline in **Ω**.

I learned in medical school that the most important issue in making a diagnosis is the history. I studied fusion research back to the 1940's, finding a logic flaw. The first fusion patent was granted to British Noble Laureate Sir George Paget Thompson in 1947, leading to construction of the Zeta Device in the 1950's. It was a variant of magnetic confinement, which has predominated fusion research since. Problematic are electrical resistance losses causing lack of power gain.

The Stellarator was invented by Princeton physicist and astronomer Lyman Spitzer in the 1950's. Lack of power gain continued due to resistance losses. Superconductivity was tried, but created other engineering problems.

Stellarators were followed by the Soviet Union's Tokomak by Oleg Lavrentiev, Igor Tamm, and Andrei Sakharov. Because of increased efficiency, it's become the favorite since the 1970's. The $35B ITER project (iter.org) is a Tokomak. A Tokomak finally broke even in 2001, putting out as much power as it took to operate. All this after $1.2T in fusion R&D.

The fusion process threshold is dependent upon particle collision velocity, period. No other variables are in the relationship. Early on, physicists made an erroneous assumption, coloring fusion research until today. With the assumption that fusion required duplication of the conditions occurring in the core of the Sun, ignition was postulated on increased temperatures and pressures. This was defined in the Lawson criterion, to which a variable of confinement time was added latter. But as stated above, fusion is only in proportion to particle collision velocity. Temperature, pressure, and confinement time are not in the fusion relationship. Therefore, I threw them out and focused only on particle collision velocity.

Scientists also assumed was that fusion occurs with random particle collisions. Randomness will work in the core of the Sun with its high gravitational field and resultant high ion flux, but not here on Earth. I came to realize that a vector (a directional component) must be added to particle velocity to make intentional collisions in low gravitational fields. Particles must be aimed towards each other. A particle accelerator is the only apparatus able to meet this specification.

Brookhaven National Laboratory (BNL) [2] was first to try this with a linear DC accelerator in 1989. Since they were researching the "cold fusion" phenomenon, they used heavy water ice crystals as a fuel. This choice clouded the results, discrediting the experiment. I believe if BNL had used deuterium gas as fuel, their experiment would have worked.

Dr. Leung of Lawrence Berkley National Laboratory (LBNL) [3] created a concentric DC accelerator which in essence is the BNL apparatus in a three dimensional array. These LBNL experiments proved the validity of this path with DC acceleration. It worked well as a bright-point neutron source, producing 1 e^{10} neutrons per second, about 0.01 watt. Since it was run on DC, the voltage and current were in phase, therefore power of about 120kW was consumed for the short duration pulses.

At about the same time as Dr. Leung's patent application, I filed patents on linear and concentric AC particle accelerators as fusion reactors. The LBNL reactor is time domain static, whereas the DeLuze reactor goes through a time cycle controlled by the electrical rotation of the AC potential. During the fusion portion of this cycle, the conditions in the LBNL reactor and the DeLuze reactor are identical.

Power is the ability to do work that equals force times a distance component: P = F x D. What drives fusion is solely the force component, the voltage or EMF. With DC, the particles move through the reactor's electric field in only one direction over a specific distance (D), expending power. DC acceleration was therefore unable to provide power gain. AC particle acceleration work was mostly done by Tesla in the 1890's. With AC, the particles move back and forth within a reactor's oscillating electric field, changing directions. The result is the net movement and the distance components are zero. In P = F x 0, P = 0. No power is expended or work done. Only force is used. With AC the path has gain. This is the secret to high gain fusion power.

Target Market

The Total Available Market is the whole world, that's everyone. Fusion is the only long-term answer to these problems. Over time fusion will become the primary energy source for Earth. This will take a considerable amount of time, but the market is huge.

World energy usage for the year 2010 was approximately 500 Quads. One Quad equals 1.0 X 10^{15} BTU. One standard barrel of oil equals 5.8 X $e10^{6}$ BTU. A Quad approximates the energy of 172 million barrels of oil. A 20 year projection is included where revenue to the company is plotted against the price of oil averaged for the time period. Revenue reached $1.7T with oil only averaging $20 per barrel. No usage increase was factored, though it is estimated world energy demand will be about 740 Quads in 20 years. It most likely would not be feasible to reach such market penetration without a massive worldwide "Manhattan"-like project brought on by an acute world wide energy crisis.

We address our Segmented Addressable Market as the electric power generation industry. In 2010 usage, that's also a huge 125 Quads per year. For the purpose of this business plan we will restrict Our Share of the Market to a proof of concept (POC) of the phase I and II reactors and a 20MW commercial power plant.

One of our competitors is the International Thermonuclear Experimental Reactor (ITER @ inter.org) in Cadarache, France. The goal of our POC is to beat ITER's specification: run a sustained fusion reaction with a 10-times power gain for one hour. ITER is not a power plant, but just a POC like ours. If they succeed, they plan a demonstration fusion power plant called DEMO. ITER started in 2007 with a $14B budget and was to be operational by about 2025.

As of a few years ago, they were up to a $36B budget and 10 years behind. The US contributes 9% to ITER's budget. The US Senate has debated pulling out of the project, most likely ending it. Our POC is to take only 2-3 years. If we beat the ITER specification, the entire world will be focused on our small company. Profound amounts of R&D funding will become available with the full attention of the electric generation industry. Subsequently to bringing on line a 20MW commercial power plant, the global electric generation industry will want to switch to fusion.

We have profound competitive advantages over our competition. Their approach is logic flawed, but they keep on trying to fix it with "Band-Aids." A big problem with confinement is generating magnetic fields of sufficient strength for the reactor to function. An electromagnetic field is in proportion to the current flowing through the electromagnet. In attempts get sufficient current, magnet windings are cooled by liquid helium to -263 °C, -459 °F, or 10 ºK.

To simplify, I will use ºK. What they are trying to do is contain a plasma that's over 10,000,000 ºK with electromagnets cooled to 10 ºK. To get power out of the Tokomak reactor to do work (generate electricity) they then plan to bring 500MW of power across the magnets at 10 ºK out to a radiation absorber approximating 922 ºK. While doing this, the magnets have to be maintained at 10 ºK. *A physicists dream, but an engineer's nightmare.* I believe it is impossible to successfully bring such amounts of power across such a temperature gradient. Sadly, it's not even necessary, for with our reactors, no such obstructive temperature gradient exists at all.

In an attempt to remedy this situation, the latest "Band-Aid" is what is called a bipolar confinement reactor. For example, the reactor being developed by the famous Lockheed Martin "Skunk Works." Cold temperatures are along a cylinder with the ends having plasma mirrors bouncing plasma between them. Plasma is confined by the magnetic field along the cylinder's length, but it's trapped from escape by the mirrors. Lockheed uses an interesting magnetic circuit and has ingenious looking plasma mirrors. They hope by making their reactor small that they may find some advantage.

Another competitor is the Laser Ignition Facility (LIF) at Lawrence Livermore Laboratory (LLL). The concept is valid, but execution is another engineering nightmare. They propose to drop fusion fuel pellets about the size of a pea into a chamber. The fuel is coated with an ablative material. On being hit with lasers, this ablative material rapidly blows off, ablatively compressing the fuel to a point where ignition occurs.

First attempts were problematic because the individual reactions were mini explosions, causing extreme turbulence in the chamber, and making it impossible to hit the next pellet with a laser beam. They need to ignite 10 pellets a second for this to work. The latest variant of this process has the pellet in a gold canister mounted on a robotic arm extending into the chamber. Along the canister is microelectronic circuitry so computers can accurately determine the exact location of the pellet (to what tolerance? a thousandth of an inch, or a millionth). A laser pulse goes through a complex system of laser amplifiers, is divided into maybe 100 individual beams, each beam guided by multiple adaptive mirrors to accurately focus the converging beams onto the fuel pellet. Watching a video of igniting just one pellet looked like a space shuttle launch, even with a mission controller. To function, these robotic arms must load 10 pellets a second, 60 seconds a minute, 1440 minutes a day, 365 days a year. Another engineering nightmare, totally unnecessary, and too overly complex to be a viable power source.

The sad thing is that all these issues stem from the mistaken assumptions made about 70 years ago. They will never get such complex systems to operate in an efficient and reliable manner to provide the primary energy source we need.

Tokomaks were the big gun in high energy physics for 50 years. Stellarators are now making a recent comeback. Stellarators hold the world record for being able to sustain a fusion reaction for 30 minutes. The best record for the more efficient Tokomak has been only 6 minutes. Recently Angela Merkel of Germany made the news when she pushed a button to turning on a fusion reactor at the Max Plank Institute in Germany. It was a Stellarator. It ran for a fraction of a second, producing about 6MW. Another Stellarator is being constructed in Japan.

The incredible strength of our approach is its elegant simplicity. Velocity impact fusion, as we have labeled it, has been shown to function reliably by Dr. Leung at LBNL. His reactor received the patent before ours. I spent six years debating with the patent office (USPTO) over the difference between AC and DC. The USPTO took the position that there was no difference between my reactor and that of LBNL. After six years, I won the argument.

Future products and services

As you look at our website (fusionenergysolutions.net) you see many advanced applications from cars, to desalinization plants, to rockets. But for this project we intend to just do the POC, build a power plant, obtain a research center, and start foundational work for future projects. We also plan to file foundational patents on the fusion technologies that will allow such advanced technologies to become a reality. Once we turn on a commercial power plant we will receive all the money needed to pursue research.

What differentiates our company is owning the intellectual property that means unlimited clean sustainable energy.   Importantly, this technology is elegantly simple.   It is capable of further improvement. Our phase II reactors will most likely run a reaction that has 110 times the power density of the D-D reaction. Future reactors we hope to patent will run a reaction with 2500 times the power density of the D-T reaction. This reaction can be made aneutronic. We have a patent and patent pending on technology to make the operation aneutronic. We designed and hope to patent on an energy absorber making it possible to put such reactors in cars, airplanes, and other small applications.

The potential from operational fusion is profound. We list three more markets, but there are others such as remediation of solid, liquid, gaseous, and radioactive wastes. The opportunity is the future energy market. All present energy used by humanity is secondary, limited, and originated with solar fusion.

1. Petrochemical Industry.
Our second customer would be the petrochemical industry. Our power source is a primary energy source, the actual source of the energy. Hydrocarbon products constitute secondary energy, the Sun being the primary source. Burning (oxidation) releases this stored energy. The wastes (CO_2 and H_2O) are molecules at low Gibbs free energy and accumulate in the atmosphere and oceans. Plants use solar (primary) energy to recycle some of these low energy molecules back to high-energy storage molecules (hydrocarbons and free oxygen).

With a primary energy source, petrochemical companies can take the accumulating low energy molecules and recycle them back into the high-energy molecules. They can then sell these compounds. The issue here is the lack of a primary energy source here on Earth. With a primary energy source operational on Earth, oil/petrochemical companies then become major players as part of an ultimate green industry. They will then be able to recycle “burnt hydrocarbons” (CO_2 and H_2O) back into fuels and other valuable petrochemicals. This requires an operational primary energy source on earth. We are presently just consuming stored sunlight of the past. Oil/petrochemical companies have the infrastructure in place to distribute these synthetically recycled, (and by design) cleaner burning fuels back to consumers.

2. Transportation Industry.
Our third customer will be the transportation industry: aquatic, land, air, and space. We have fusion driven engine technologies for all of these areas. A Boeing 747 equivalent going 250,000 miles on the hydrogen from a gallon of heavy water. A ship going around the world on the hydrogen from a gallon of heavy water. A space shuttle craft launched into orbit on the hydrogen from a gallon of heavy water. Spacecraft going to the moon and planets in hours to days, rather than weeks to years. Fusion engines permit constant 1-2 g acceleration/deceleration resulting in vastly reduced travel times, compared with fuel limited chemical propulsion engines. Unmanned craft can sustain higher g levels resulting in even shorter travel times. We have technology to make it possible to put these reactors in cars, trucks, and busses. A car going 35,000,000 miles or a city bus going 8,000,000 miles on the hydrogen from a gallon of heavy water.

3. Potable Water Industry.
Our fourth customer would be the fresh water industry. Nearly a billion people worldwide do not have access to fresh water. Half of the world's population suffers disease due to lack of sufficient fresh water. The USA's fresh water reserves are tapped to about their limit. Fusion driven desalinization plants we have designed can provide adequate fresh water in quantities needed with economically designed, constructed, and operated plants.

III. EXECUTION

Marketing and Sales

When we turn on an operational 20MW commercial fusion power plant, we will have reached our target market just by that accomplishment. Angela Merkel turning on a stellarator for just a fraction of a second was recently world news. An operational, functioning fusion plant producing 20MW of clean dependable power will be huge news. We propose to price the technology to be just a 10% return of the value of the electricity out the door. We will also be willing to set pricing for fixed periods, years in advance. Electric companies will be able to project costs for many years, making them more profitable.

Positioning

Our technology is unique. Using deuterium (D) deuterium fusion, with fuel bought just in small research amounts, we can generate a MWh of electricity for $0.25 in fuel. The Lawson criterion was mentioned previously. All other fusion research is done using deuterium tritium (T) as a fuel, because it is an easier reaction. It has a Lawson criterion of 1.0, whereas it's 1.4 for D-D fusion. Though it's 40% harder to accomplish, the LBNL reactor ran D-D fusion with no problems. Tritium is radioactive, a regulatory headache, and expensive. Other researchers run D-T in just an attempt to be able to turn on a sustained reaction.

With regards to oil and coal competition, our power plants could sell electricity below their fuel costs. For the 20 MW plant, the fuel cost is about $42K per year in small quantity pricing. D-D fusion will be operated to produce ^{3}He as a waste product, a rare gas presently worth $7.5M per pound. The exhaust gas is worth more than the electricity produced. Once successful, we can price the competition out of the market.

Strategic alliances

The most important strategic alliances will be first made with electric power companies, followed by oil companies. As the technology matures, alliances will be formed with transportation companies that make cars, ships, airplanes, and spacecraft.

IV. OPERATIONS

Introduction

Our 7-year, $570 million project leads to over $88 trillion of energy wealth for the 20 years following the project. The key innovation is a carbon free, pollution free, economical primary energy source for humanity: fusion. Contained, sustained fusion reactors represent tiny microscopic suns in chambers here on Earth. Controlled, relatively safe, sustainable, portable hot hydrogen fusion for as long as we need it.

We have incorporated to: raise funding, obtain energy system patents, do further research, bring fusion energy technology online, and address the challenges of truly sustainable, renewable energy.

Proof of concept

Proof of concept is the key to this whole project. Much depends on the successful completion of these experiments. The reactor will be a turn-key unit constructed by Atlas Technologies of Port Townsend, Washington, USA. A test site will most likely be built in Port Townsend, shielded to handle 2.45 MeV neutron flux.

The initial experiment will be a phase I reactor assembly approximately 0.6 x 0.6 meters and 0.9 meters high. The reactor is a borosilicate glass sphere of 12 liters volume and has a 20 mm interior target. It is surrounded by high voltage ceramics and an outer aluminum housing. Maximum design power is 2400 watts with a target temperature of about 870 °C. At 2400 watts, it will put out about 2.4 e^{15} neutrons per second of about 2.45 MeV energy.

The four goals of the experiments:

Reactor Turn on. This is defined as operation of fusion reactions within our prototype as demonstrated by two means. Neutron counting indicating significant neutron emission in about the 2.45 MeV range. Inlet fuel and outlet exhaust gas mass spectroscopy indicating significant increase in abundance of ^{3}He in the exhaust gases.

Sustained Reactor Operation for One Hour. This is defined as sustained fusion reactions with our prototype for a time period of one hour as determined by neutron counting and gas mass spectroscopy as defined above.

Sustained reactor operation for One Hour at 200% Power Level. This is defined as sustained fusion reactions with our prototype for a time period of one hour at twice the drive power level. The power input for this period will be calculated from integration of the data output from the power supply. Multi axis neutron counting and spectroscopy to verify the average number of fusion reactions per given time will be determined. Based on these counts, the average reactor power level will be determined. Inlet and outlet gas mass spectroscopy and gas species partial pressure determination will be used to determine the average number of fusion reactions per given time. These calculations will be used to verify fusion reactions occurring at two times the drive power level.

Sustained reactor operation for One Hour at 1000% Power Level. This is defined as sustained fusion reactions with our prototype for a time period of one hour at ten times the drive power level. At this point we will have just beat ITER's experimental demonstration goals. Calculations as above will verify that fusion reactions are occurring at ten times the drive power.

Following will be the same tests of a phase II reactor. Once these experiments succeed, larger reactors will be constructed and tested. We then will build and test a core of sufficient size to be incorporated into the 20MW power plant. After larger cores are successfully tested, design of the power plant can start.

20 MW power plant

Successful proof of concept opens multiple pathways of research and opportunity. Next, we plan a commercial demonstration plant of about 20 megawatts power output, and simultaneous marketing of future energy options to the electric power industry. This will be a $320 million project with about a 6-7-

year time budget. With successful demonstration; worldwide marketing, engineering, licensing, and construction can begin.

Our first customer will be the electric power generation industry. US electric power production in 2010 was about 38 quads yearly, about 25% of the world market. Based on 10% royalty and oil at $70/barrel the opportunity is about $46 billion yearly in the USA, and $182 billion yearly worldwide within about 10 years of operation of the prototype plant. This is based on the world energy usage of 500 quads in 2010, not factoring in estimated increased energy demand. World energy demand is projected to be 740 quads in 20 years.

Technology and patents

Fusion Reactors.

We have an issued patent on a spherical phase I reactor. A divisional application includes phase I reactors of differing shapes such a cylinders, Phase II reactors of similar shapes, a linear shaped reactor, fuel processing, and ancillary control systems. This is first generation technology.

Phase I reactors accelerate ions to a physical target and are power limited by the temperature of that target. Ions undergo fusion with rear-ended collisions at the target. Collision velocity approximates particle speed.

Phase II reactors accelerate ions to a virtual target and are power limited by the temperature of the reactor envelope, distant from the assembled reacting mass. This permits operation at higher power levels for a given reactor envelope size. Ions undergo fusion with head-on collisions with ions approaching from the opposing direction. Collision velocity approximates twice particle speed. It’s possible to have collision velocities that exceed the speed of light with sub-speed-of-light particle velocities. Such impact speed will allow operation of difficult fusion reactions where the Lawson criterion is very high. With such reactors we can run fusion reactions presently considered beyond the scope of present technology. It’s vital to get phase II reactors operational during the POC.

The current patent and its divisional application need to be updated with Continuation In Part (CIP) applications to bring them up to date with our current understanding of fusion technology. A CIP extends the patent life up to another 20 years. A CIP will bring the first-generation reactor line to its completion. We also have second generation reactors and a new set of separate patent applications must be filed for them. Japan, China, and India have a one-year foreign filing rule requiring filing the CIP within a year within those countries. We need funding for these legal processes to proceed.

The Lawson criterion (LC) does not directly apply to these reactors but is used as a tool indicating the relative difficulty of running different fusion reactions. We have described D-D fusion with LC = 1.4 and D-T fusion with LC = 1.0. We plan to run D-D fusion configured to produce purely ^{3}He waste, based on modifying reaction parameters to make the D-D fusion reaction to ^{3}He waste predominate. More importantly is D-^{3}He fusion which has a power density 110 times D-D fusion. Its LC = 16, making it 16 times more difficult.

Confinement reactors will not run this reaction, for they barely run D-T with a LC = 1.0. Operational phase II reactors will easily run D-^{3}He fusion making possible the following scenario: The first 2 pounds of D_2 gas, presently costing $12,000 will undergo D-D fusion producing 25,000MWh, a fuel cost of $0.48 per MWh. The pound of ^{3}He waste will be combined with a second pound of D_2 gas, also costing $6,000, to undergo D-^{3}He fusion producing another 5,500,000 MWh for a total of 5,525,000 MWh from $18,000 of fuel for a fuel cost of $0.0033 per MWh. At first we will just sell the ^{3}He gas for $7.5M per pound. With advanced technologies, including gas separation described next, ^{3}He gas becomes too valuable as a fusion fuel to just sell.

Second generation reactors will run the reaction ^{1}H + ^{11}B to ^{4}He which has a power density 2500 times D-T fusion. Its LC = 500. Advanced gas separation technologies, next described will make it possible to run this reaction in an aneutronic manner, making it safe for human-occupied vehicles that cannot house sufficient neutron-absorbing shielding, e.g., cars, trucks, airplanes, spacecraft.

Gas Separation.

Co-inventors Dr. Gary McMurtry and Dr. James DeLuze received a patent US 10,005,033 B2 on June 26, 2018. It discloses a field portable instrument to determine the ratio of ^{3}He to ^{4}He. The instrument incorporates a mass selective bandpass filter with a very high "Q" value. This determination can be predicative for volcanic eruptions and earthquakes. This was published twice in Nature's online journal Scientific Reports at: DOI: 10.1038/s41598-019-41360-5 and DOI: 10.1038/s41598-019-48268-0.

The above patent application was written and prosecuted by Dr. DeLuze. It was stated that this technology would apply to other gases such as CO_2. The patent examiner took the position that he would not allow the scope of the original application to extend beyond ^{3}He and ^{4}He, since other gases were not specifically named in the application. Enlargement of the scope required a separate application.

On June 26, 2018 I filed provisional application 62/763,728 using US 10,005,033 B2 as prior art. On this priority, Patent Cooperation Treaty (PCT) PCT/US2019/037324 was filed on June 14, 2019; and US utility application 16/442,253 was filed on June 16, 2019. These name 44 gases, including two isotopes of CO_2 with an AMU of 44 (99% of CO_2) with the remaining 1% with an AMU of 45. With such a filter, we can selectively pump CO_2 with an AMU of 44 without pumping gas at AMU 43 or AMU 45. During discussions with the patent examiner, who works on patent applications on filters for selective CO_2 removal, the patent examiner stated he never saw a filter with such sharp bandpass selectivity and very high adjacent channel rejection as described in our application. This new application covers a means of removing CO_2 from the atmosphere that eventually will be able to be commercialized to extract atmospheric CO_2 in gigaton quantities. It will allow the removal of the precursors of smog and even smog itself. It will provide means of separation of ^{3}He from exhaust gas and provide fuel processing permitting aneutronic fusion of ^{1}H + ^{11}B to ^{4}He.

Fusionsynthesis.

Fusion is the power source of Fusionsynthesis and sufficient deuterium is in the ocean for humanities power needs as long as we would need it. Fusion, the focus of this business plan, of itself is not enough to stop and reverse the decline of **Ω**. Our burning of hydrocarbon fuels has resulted in accumulation of carbon, oxygen, and hydrogen massed in low energy molecular states as water and carbon dioxide, causing the ecological problems we now face. These same elements combined with energy form the high energy molecules of hydrocarbons (methane) and free oxygen. Plants take fusion energy of the sun and recycle greenhouse gas (water and carbon dioxide) back to the high energy storage molecules hydrocarbons and free oxygen by photosynthesis. Plants and sunlight are incapable of meeting the energy demand of our present world population. We need to add the second pathway of Fusionsynthesis to run in tandem with photosynthesis, in-order to recharge Earth's chemical hydrocarbon energy battery and restore **Ω**.

Fusionsynthesis is a four step process starting with sustained fusion, which we have patented. Intellectual priority for the second step, CO2 capture, has been established by us in our June 26, 2018 provisional application: 62/763,728 and subsequent utility and PCT applications. As of 1/26/2021 PCT application PCT/US2019/037324 is filed in the US, China, Japan, India, the Russian Federation, and the European

Union. The third step of using electrical energy from fusion for the hydrolysis of water to hydrogen and free oxygen (to be discharged into the atmosphere) is in the public domain. FESH is presently prepared to file a basic patent on the final step: production of methane (natural gas) from hydrogen and carbon dioxide using energy produced by fusion.

The combination of fusion with Fusionsynthesis will provide an unlimited energy source and also the means of unlimited recycling of spent, low energy molecules back into the petrochemicals and raw materials needed for modern society.

This would put FESH in the position of owning all the patently available intellectual priority for Fusionsynthesis with our issued patent, divisional applications, and patents pending. Additional R & D needs to be done on steps two and four to increase efficiency and commercial adaptability. CIP applications will be filed as the technology develops and matures, but FESH would own this incredibly valuable intellectual property foundation. It will be the basis of future energy and materials recycling.

Milestones and metrics

Year 1. Recruit and hire business executive officers and staff. Purchase a Honolulu facility. Purchase, refurbish, and shield test site. Acquire prototypes, tools, instrumentation, and ancillary equipment. Design high power reactors, ^{3}He waste variant, variable frequency power supply, and water shield-tank. Test prototypes through the predetermined phases. Start variable frequency and full operational mapping. Test catalyst gases. Look for power plant site.

Year 2. Acquire high power reactors and power supplies. Make phase I vs II determination. Start environmental impact study (EIS). Continue experiments. Construct and test larger reactor cores.

Year 3. Continue EIS. Purchase water shield-tank. Purchase plant site. Do preliminary plant site preparation. Test high power reactors within limits of test site. Order or make purified water.

Year 4. Continue EIS. Install water shield-tank. Build test building at plant site. Install and start testing high power reactors. Install cooling water system. Fill shield-tank with purified water.

Year 5. Continue EIS. Test power output using cooling water system. Based on results, design final power plant turbogenerator system. Order parts for plant. Continue site work for final plant buildings.

Year 6. Complete EIS. Continue testing and mapping. Inspect for reactor wear. Start power plant construction.

Year 7. Finish power plant. Hook to electric grid. Run performance and reliability tests. Operate plant commercially.

Within each year, there will be milestones to reach. If milestones are not met, the situation will be re-evaluated and corrected. If the obstacle can't be overcome, the project will be terminated or renegotiated to commercialize other valuable intellectual property held by this company. This is not discussed in this business plan, for the focus is fusion and energy.

Key assumptions and risks

There are two. Neutrons are captured by the pure water shield tank, making deuterium fuel. Vacuum leaks will be handled Atlas Technologies.

Atlas Technologies built a lot of the LBNL reactor's components working with Dr. Leung. They are intimately familiar with that reactor, and how to manufacture it. On my first conversation with their VP and engineer, he became very interested in my project due to his knowledge of the LBNL reactor. He offered to do work in kind in exchange for stock in FESH. They are a specialty company dealing with ultra high vacuum issues and have been involved with most fusion projects, including ITER (iter.org.), the great hope of magnetic confinement. Atlas Technologies will be doing the final assembly and manufacture of our reactors, including voltage and vacuum testing. Vacuum leaks and voltage problems will be dealt with before the turn-key assemblies leave their plant.

V. TEAM AND COMPANY

Team

Up to this point in Fusion Energy Solutions of Hawaii's (FESH) existence, its team has consisted primarily of a group of inventors, academics, and engineers. We do have individuals in the management positions of the company, for it to function, but it is not an entrepreneurial business management team. Our team is sufficient to start a POC project, but as the scope becomes more of that of a business, we now need to find the right financial partners, recruit and hire a sharp business management team. Our academic and intellectual property team has developed intellectual property of great value. FESH is coordinated by the CEO wherein the other principals run portions best suited to their expertise. Members of our team have performed well in their respected fields, some with world renown in areas of science and engineering. Drs. McMurtry, and Wiltshire have collectively authored over 100 books, articles, and scientific papers in refereed publications. They teach, taught, and mentor post-doctoral fellows, graduates, undergraduates in geological oceanography, mineral resources, geochemistry, environmental sensor technology, ocean and mineral resources, marine technology, energy, and sustainable development.

Dr. James Robert DeLuze, President and Chief Executive Officer (CEO), will be one of the principal Investigator's (PI's) of this project. He received a BA from University of Hawaii (UH) in 1974, and a Doctor of Osteopathy (DO) from University of Health Sciences in Kansas City, Missouri in 1987. He did wastewater and alternative energy engineering 1972-79, founding Ecological Engineering Incorporated in Honolulu in the late 1970s. A patent issued to an employer on his intellectual property. Returned to school, becoming a physician. Practiced in areas of general practice, psychiatry, and osteopathic principals and practice in Hawaii and California. Admitted to Riverside County Board of Forensic Psychiatrists and practiced psychiatry in the Riverside County Jail System. Invented linear and concentric AC driven velocity impact fusion in December of 1998. Filed the patent and prosecuted it to issuance in 2012. Formed FESH in 2013.

Dr. Thaddeus Dobry, is Chief Engineering Officer (CENO) and retired Director of Academic Affairs of the University of Hawaii College of Engineering. He has intimate knowledge of graduates and faculty with unique ability to match the right engineer to a given project. Dr. Dobry received a BS in Electrical Engineering, Cornell University in 1975 and a PhD in Computer Science, University of California, Berkeley in 1987. He is past Interim Assistant Dean UH College of Engineering. He served as an Officer US Navy Nuclear Power Program and Submarine Service, completing the Navy nuclear engineering program.

Dr. Gary Michael McMurtry, Chief Science Officer (CSO) is a researcher with experience with high vacuum systems, plasma, and gas management. He received a B.S in Geological Sciences from University of California at Riverside in 1972, a M.S. in 1975, and a Ph.D. Geology & Geophysics in 1979 from the University of Hawaii (UH), Honolulu. Assistant, Associate Geochemist, Marine Geochemistry Division, Hawaii Institute of Geophysics, UH. UH Professor of Oceanography, 1988-Present. President, Pacific Environmental Technologies, LLC, an advanced environmental sensor research & development company, 1998-Present. 1983-1988, Science Program Director, NOAA National Undersea Research Program at the University of Hawaii, Hawaii Undersea Research Laboratory. 1980-1988, Assistant, Associate Geochemist, Marine Geochemistry Division, Hawaii Institute of Geophysics, University of Hawaii, Honolulu. A reviewer, program panelist for: US Consortium for Ocean Leadership, NASA Planetary Instrument Definition & Development Program, NASA Space Technology Research Opportunities-Early Stage Innovations Program, NSF Major Research Instrumentation and Ocean Technology Program, NOAA National Undersea Research Program, and international scientific journals. Reviewer of scientific and instrument development proposals to United Kingdom, French, and German governments. Over 100 articles published in refereed journals and books. More than 50 grants and contracts totaling over $18 million. Teaches and mentors post-doctoral fellows, graduate and undergraduate students in geological oceanography, mineral resources, geochemistry, and environmental sensor technology.

Jonathan S. Kono, consultant, is Owner and Principal Broker of Kono Properties Hawaii, a Hawaii Real Estate Company. He attended Hawaiian Mission Academy, La Sierra University and the University of Hawaii. He obtained his Hawaii Real Estate License through the University of Hawaii's Small Business College in 1979 and has been a licensed Real Estate Broker in Hawaii since 1981. Jon is a past V.P. and Manager of First Hawaiian Bank's Real Estate Department in their Trust and Investments Division and was affiliated with RE/MAX Honolulu for a number of years. Jon is a current Governing Board Member of Adventist Health Castle (Hospital) as well as a current member of the Executive Committee and Personnel Committee for the Hawaii Conference of Seventh-day Adventists. Jon is also Chairman of the Hawaiian Mission Academy Alumni Endowment Fund.

Dr. John C. Wiltshire, is Chief Technology Officer (CTO) and has extensive experience in many areas of energy production and equipment. Dr. Wiltshire graduated in 1976 with a B.Sc. in geology from Carleton University in Ottawa, Canada. He worked as an exploration geologist in the oil and mining industries for Noranda Mines, Chevron and Petro-Canada. Dr. Wiltshire earned a Ph.D. in Geological Oceanography from the University of Hawaii in 1983. He then became Ocean Resources Manager for the State of Hawaii in the Department of Business, Economic Development and Tourism. In this position, Dr. Wiltshire interfaced with the growing marine business and energy sector in Hawaii representing many of Hawaii's small marine companies in trade initiatives to China and Japan. In 1986, he joined the Hawaii Undersea Research Laboratory (HURL) as a senior researcher and served as its Director. HURL is NOAA's Undersea Research Center for Hawaii and the Western Pacific (NURC/H&WP). He is the Editor-in-Chief of the peer-reviewed journal Marine Georesources and Geotechnology. Dr. Wiltshire is Professor Emeritus and former Associate Chairman of the University of Hawaii's Department of Ocean and Resources Engineering. He has taught several courses at the University of Hawaii in the areas of energy and mineral resources. Wiltshire founded the environmental consulting company, TCI Hawaii, which handles a variety of projects in ocean observation and renewable energy sectors. One of six members of the central steering committee of U.S. Energy Policy Coalition, scientists and engineers commissioned by the Society of Mining, Metallurgy, and Exploration (SME) giving professional views on energy options to the U.S. government. He is a fellow of the Marine Technology Society (MTS) and was General Chairman of the 1500-person MTS 'Oceans' conference in 2011. He is on the Board of Directors of Pacific Congress on Marine Science and Technology (PACON), and on the program committee of the annual Offshore Technology Conference in Houston, the world’s largest offshore energy conference. Wiltshire has authored over 90 scientific papers on ocean resources, marine technology, energy and sustainable development.

Company overview

Mission statement.

Our corporation is established to raise funding, obtain patents, do research, bring fusion technology online; to bring hope to humanity by addressing challenges facing renewable energy and sustainability.

Company legal structure and ownership.

Fusion Energy Solutions Of Hawaii, Inc. is a Domestic Profit Corporation incorporated in the State of Hawaii, of the United States of America. It has 10,000,000 shares which are traded by private placement. One percent of stock is set aside for Academics. I hold approximately 89% of the stock. Equity shares will be made available by myself for investors funding this company.

History of company and technology.

I invented this hot fusion process in December, 1998. I had previously spent several years studying the broad history of technology. More than realized, things are often invented, lost, and re-invented latter. My prior experience included the engineering, invention, and design of sewage and water treatment equipment. My employer even patented some of my inventions. This experience with inventions and patents made it quite clear that there are ways to make some changes to an existing invention, and then patent it.

This experience made me very careful about filing the first patent. I re-engineered the design from multiple approaches, spending two years. This was very fruitful in that the Phase II reactor, which is basically an inversion of the Phase I concept, was the result. This Phase II reactor has much more promise than the original unit, but was very difficult to conceive. Some scientists without careful thought just dismiss it outright. But with careful evaluation, it is obvious that it has tremendous promise, and that my design assumptions are valid.

Another year was spent making the patent into more than just a reactor, but a complete power plant. The patent was filed, taking 10.5 years to issue. The last 6 years were spent with the U.S. Patent and Trademark Office (USPTO) debating AC compared with DC drive. The patent examiner had issued the patent to LBNL and claimed my invention was just a variant. This examiner had a Ph.D. in nuclear engineering. Patents have a “wrapper” which contains all correspondence between the inventor and the USPTO. The wrapper for the first fusion patent has over 1100 pages of correspondence, much going into deep technical discussion. Finally in 2012 the patent issued. It was the eighth US patent on a fusion reactor since 1972.

I also filed other patents and started research with Dr. McMurtry prior to the patent issuing. Once the patent issued, money did not automatically come. As you will see in the section on our team, we are mostly inventors, academics, and engineers. We did not have an entrepreneurial business management team or the money to hire one.

Fusion and our work are exotic. It is not easily understood, or its value appreciated by entrepreneurial investors who often look for a quick financial turnaround. The concept is a very difficult sell. This company focuses on research, patents, and developing new technology. US government funding was ruled out due to the “March in Rights” statue which would allow the US to just take the technology if we received even just one penny of R&D funding from them.

My approach was to get exposure through academia and by publishing peer reviewed articles. But my medical degree was not enough in such circles. This primarily medical background made things very difficult. But I continued with a first presentation of a poster and two papers at PACON 2012.

Work and research continued. We applied for the first MacArthur Foundation 100Million & Change grant. Application was for a POC and a 5-10Mw fusion plant. We did quite well in the review process.

So, the traction we developed is to have a very rare US patent on fusion technology that will work. The 7 years of research by Dr. McMurtry and Dr. DeLuze is paying off with the very important technologies we have just patented and have patent pending. This traction is nearly purely academic in the intellectual property arena and has great value. We now need to find the right financial partners, get a sharp business management team, and then change the world with fusion.

VI. FINACIAL PLAN

Introduction

Our 7-year, $570 million project leads to over $88 trillion of energy wealth for the 20 years following completion of the project. We will start with the proof of concept budgeted at $30M. This begins with construction and testing of a 2400-watt prototype research phase I reactor. This reactor and Lawrence Livermore National Lab's (LLNL) reactor, US 7,139,349 B2, are paradoxically nearly identical yet radically different. During the fusion duty cycle, the operation is exactly the same. The Livermore reactor is time domain "static", with one operational mode: accelerating ions inward to a target with a limited time, non-sustainable duration. Our reactors are time-domain “dynamic", cycling through an AC “driven" sequence, providing sustainable, repetitive power impulses producing continuous power.

Then Phase II reactors are to be tested. They are the phase I variants inverted, with the central target being virtual. The concentrically accelerated, radially, and axially centered ion beams collide at a central point. Head-on collisions of oppositely approaching ions provide collision velocities greater than a given individual ion's velocities, thus producing ion collision velocities sufficient to fuse light hydrogen, along with all heavy hydrogen isotopes. Phase II will also operate the reactions described earlier that had high values for the Lawson Criteria, such as the D-^{3}He fusion with 110 times the power density of D-D fusion, leading to a fuel cost of $0.0022 per MWh. Higher power levels can be run within a given reactor core size with Phase II reactors. We will push to get Phase II operational for the 20MW fusion plant.

Successful phase I and II prototype operation opens multiple pathways of research and opportunity. Larger cores with variable frequency power supplies will be tested to produce a core appropriate for the proposed power plant. Figures are in September 2018 US dollars.

Project Budget

Capital Cost Category	(September 1, 2018 $)
20MW Fusion Power Plant, Table 1-1	**320,000,000**
Proof of Concept	**40,000,000**
Ten World Wide Patents	**30,000,000**
Hawaii Lab	**80,000,000**
FESH Corporate Budget	**50,000,000**
Contingency Reserve	**40,000,000**

Sweat Equity to Dr. DeLuze	**10,000,000**
Total Project Cost	**570,000,000**

- **Proof of Concept:** Purchase of appropriate industrial facility, most likely in Port Townsend, Washington state. Remodeling and shielding of facility. Purchase of living quarters for visiting FESH staff. Purchase of vehicles, tools, supplies, heavy lift equipment. Contract work to Atlas Technologies for construction of prototypes through full-scale reactors, and mapping of their characteristics. Contract to other vendors for gas work, vacuum technology, and high voltage equipment. The high voltage equipment will range from simple single frequency through higher voltage variable frequency supplies for testing, performance mapping of prototypes, and functional reactor cores. One third of this budget is in contingency reserve.

- **Ten Worldwide Patents:** The long term value of this company will be held in worldwide patents on fusion, other advanced alternative energy, and sustainability technologies. A word-wide patent costs approximately $3M each. The U.S.A. has patent exchange treaties with about 145 nations. Fees to their patent offices and the required local representatives costs about $2M. The remaining $1M is for engineering and patent lawyers. FESH most likely will retain in-house legal and engineering staff.

- **Hawaii Lab:** Home office for FESH and site for ongoing research that is not associated with the University of Hawaii, and privately funded to avoid intellectual property conflicts. This will be located in Honolulu, Hawaii. It may involve more than one location. Much R & D needs to be done on advanced reactors, associated equipment, and technologies.

- **FESH Corporate Budget:** Operating budget for salaries, travel, taxes, insurance, and general corporate activities.

- **Contingency Reserve:** FESH is bringing advanced, beyond state-of-the art, technology on line. With such work there will always be unforeseen issues and costs.

- **Sweat Equity to Dr. DeLuze:** For this project to succeed, Dr. DeLuze must be in a physically and financially secure environment. Appropriate security for him is a necessity.

20 MW power plant

Pricing of this part of the project is based on a statistics and analysis study done by the U.S. Energy Information Administration entitled “Capital Cost Estimates for Utility Scale Electricity Generating Plants” of November 2016. A 2.2 GW advanced nuclear plant (fission) was described with a total project cost of $5,945 per kW. I adjusted these figures as follows. To downscale from 2.2 GW to 20 MW the cost was increased 100%. I used the cost estimate for a 20MW solar facility and increased the cost another 72% based on constructing the plant in Hawaii. The figure was then rounded to an even $16,000 per kW. Because of the small size of the plant, the fixed O&M expense was increased from $100.28/kW-year to $2000/kW-year. The variable O&M expense was changed from $2.30/MWh to $2.5/MWh since fuel is only $0.25/MWh. The yearly operating costs were then rounded to $4M year.

The director of Energy Procurement of Hawaiian Electric Company informed us: “For reference, Hawaiian Electric currently pays firm generator independent power producers between $100 and $180/MWh. This average cost takes into account various components of payment and is not strictly for energy. Please note that these power purchase agreements are quite old and do not necessarily reflect what we would pay in today’s market.”

I then estimated the returns from this plant based on a yearly output of 175,200 MWh at $100/MWh return. I rounded this to $17.5M/ year for electricity output. The plant will exhaust 3.5 pounds 3He/year @ $7.5M/ pound for $26.25 M/year for a total of $43.25M/year. Operation @ $4M/year results in a yearly profit of $39.25M, a good return on a $320M plant. Improvement in technology and upsizing will considerably increase this return.

Capital Cost Estimate

The base Cost Estimate for the Fusion Facility with a nominal capacity of 20 MW is $16,000/kW. Table 1-1 below summarizes the Cost Estimate categories for the Fusion Facility.

TABLE 1-1 – BASE PLANT SITE CAPITAL COST ESTIMATE FOR FUSION FACILITY
Technology: FUSION
Nominal Capacity (ISO): 20,000 kW

Capital Cost Category		(September 1, 2018 $)
Civil Structural Material and Installation		**44,265,000**
Mechanical Equipment Supply and Installation		**86,890,000**
Electrical / I&C Supply and Installation		**16,070,000**
Project Indirects (1)		**69,500,000**
EPC Cost before Contingency and Fee		**216,725,000**
Fee and Contingency		**32,875,000**
Total Project EPC		**249,600,000**
FESH Costs		**70,400,000**
Total Project Cost		**320,000,000**
Total Project EPC	**/ kW**	**12,480**
FESH Costs 22%	**/ kW**	**3,520**
Total Project Cost	**/ kW**	**16,000**

- **Civil and structural costs:** allowance for site preparation, drainage, the installation of underground utilities, structural steel supply, and construction of buildings on the site.
- **Mechanical equipment supply and installation:** major equipment, including but not limited to, reactor, pressurizer, steam generator, steam turbine generators, condensers, pumps, and other auxiliary equipment.
- **Electrical and instrumentation and control:** electrical transformers, switchgear, motor control centers, switchyards, distributed control systems, and other electrical commodities

- **Project indirect costs**: engineering, distributable labor and materials, craft labor overtime and incentives, scaffolding costs, construction management start up and commissioning, and fees for contingency.(2)
- **FESH costs:** development costs, preliminary feasibility and engineering studies, environmental studies and permitting, legal fees, insurance costs, property taxes during construction, and the electrical interconnection costs, including a tie−in to a nearby electrical transmission system within one mile.

(1) Includes engineering, distributable costs, scaffolding, construction management, and start-up.
(2) Fees for contingency include contractor overhead costs, fees, profit, and construction.

Sales forecast

Projected is a 7-year project involving $570M project leading to $88 trillion of energy in next 20 years after project completion. This calculation is based on a 20-year time period, wherein the average penetration into the world energy market is 50%. World energy usage is set at 500 Quads per year, based on the world energy use of 500 Quads for 2010. To be conservative, no usage increases were factored in though world usage is projected to be 740 quads in 20 years. A Quad approximates the energy of 172 million barrels of oil. Fusion Energy Solutions is to collect 10% of the value of the energy produced as royalty on this 50% of world energy usage. The revenues to the company are then tabulated on the average price of energy based on the average price of a standard barrel of oil over this 20-year time period. One Quad equals 1.0 $e10^{15}$ BTU. One standard barrel of oil equals 5.8 $e10^{6}$ BTU. Operating expenses of the company are not deducted from these figures. FESH has ten million shares.

REVENUE PROJECTION

Cost of oil $/barrel	20 year revenue $ Trillion	20 year revenue per share $
10	0.862	86,200.00
20	1.724	172,400.00
30	2.586	258,600.00
40	3.448	344,800.00
50	4.310	431,000.00
60	5.170	517,000.00
70	6.034	603,400.00
80	6.896	689,600.00
90	7.758	775,800.00
100	8.862	886,200.00

Our first customer will be the electric generation industry. Our second customer would be the fresh water industry. Our third customer will be the transportation industry: aquatic, land, air, and space. Our fourth customer would be the automobile industry. Our fifth customer would be the petrochemical industry. We stop at five, but there are others such as remediation of solid, liquid, gaseous, and radioactive waste. The economic model that we are using to approach the supply/demand is simple. Fusion Energy Solutions of

Hawaii has a working fusion velocity impact reactor that can create unlimited amounts of clean energy. Through research and proven concept we have found that the amount energy that can be created with our reactor has the highest potential power gain on the market. Our reactors can also be made small enough to fit in a vehicle, producing 30-40 kW. They can be made in a house sized 10 kW unit. No other fusion technology can be downsized to such small units. Of course, they also can be upsized to gigawatt class sized units. We are unique with having the technology to produce fusion reactors over such a large power range. They are elegantly simple and do not have the thermal barrier problems of other approaches.

VII. APPENDIX

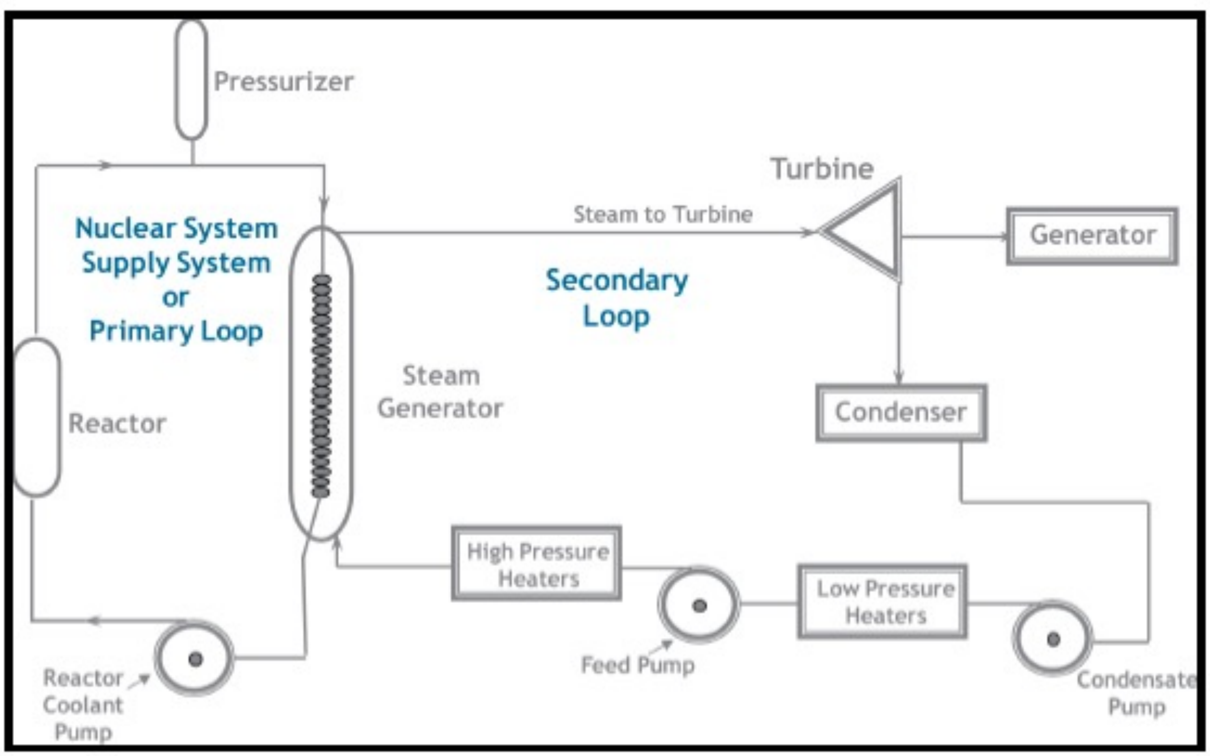
References cited in plan

[1] Schramski, J.R.; Gattie, D.K.; Brown, J.H. Human domination of the biosphere: Rapid discharge of the earth-space battery foretells the future of humankind. *PNAS* www.pnas.org/gi/doi/10.1073/pnas.1508353112 (June 8, 2015).

[2] Beuhler, R.J.; Friedlander, G.; and Friedman, L. Cluster-impact fusion. *Physical Review Letters*, 18 September, 1989, **Volume 63**, Number 12, (18 September, 1989), pp 1292-1295.

[3] Leung, K. N. Spherical Neutron Generator. Issue date Nov 21, 2006, U.S. Patent; US 7,139,349 B2.

Fusion Power Plant Design Configuration



How We Will Do a $40M Fusion Proof of Concept When ITER is Spending $35B

We are seeking $40M in funding to test a proof of concept of our U.S. patented[1] fusion reactor. Our competition is the $35B ITER project in France, the culmination of over 60 years and $1.2T in fusion R&D. Explanation of how we hope to exceed the ITER specification is the topic of this paper.

The Trinity fission explosion of 1945 was 12 years latter followed by the first commercial fission power plant built bye PG%E in 1957. Hope and expectations were high in the 1950's, but the first fusion explosion Ivy Mike in 1952 has not yet been followed by a fusion power plant 66 years later.

I'm a physician by training and learned "If you listen to the patient long enough, they will tell you what is wrong with them." An accurate diagnosis is central to medicine and its key is an accurate history. The history is a doctors most informative and accurate tool. Prior to being a physician, I was a field engineer. These jobs taught: "Keep it simple, stupid"; "The greater the complexity, the higher probability of failure"; and "Don't forget your roots."

Years studying the history of technology including fusion, reading every U.S. fusion patent, or at least its abstract lead to my discovery. I learned by studying the approaches of others going to the 1940's where quantum mechanics theory spawned the idea that the Lorentz force possibly could duplicate conditions in the core of the Sun. Random ion collisions occur with sufficient frequency to sustain fusion where positive ions approach with sufficient velocity, provided by force, overcoming the Coulomb barrier so ions touch. The strong nuclear force takes over and fusion occurs and is solely dependent upon particle collision velocity, period.

Three forces are relevant: (1) Gravitational force proportional to an object's mass drives fusion in the Sun and stars; (2) Magnetic force proportional to current is proposed for confinement reactors; and (3) Electric field force proportional to Electromotive Force (EMF), called voltage, is proposed for velocity impact fusion. As atoms fuse, the nuclear binding energy per nucleon decreases releasing excess energy. Large stores of ocean heavy hydrogen promises to power humanity with clean energy for as long as we need it. Success with fusion justifies the $1.2T spent on R&D, for our future survival depends on it.

Going to fusion's "roots," it was appropriate to consider modeling the Sun. Ignition was postulated on increased temperatures and pressures, but they are not factors of the fusion process. I threw them out. Also assumed was random collisions. Randomness will work in the core of the Sun with its high gravitational field and its resultant high ion flux, but that won't work here on Earth. I came to realize that a vector (a directional component) must be added to particle velocity to make intentional collisions in low gravitational fields. Particles must be aimed towards each other. A particle accelerator is the only apparatus able to meet this specification.

The first fusion patent was granted to British Noble Laureate Sir George Paget Thompson in 1947. This culminated with the ZETA Device in 1956, the first large scale fusion machine. It failed by not being capable of generating sufficient magnetic fields electrically. Magnetic force is proportional to the magnitude of current flow. This consumed more power than produced by fusion due to electrical friction losses (resistance) in the magnet's windings. This beginning started a pathway to nowhere, for assumptions and presuppositions were established that color fusion R&D till today. As development proceeded and failed, R&D got into a pattern of a "lets just add one more fix and we will be there" syndrome. The "roots" were forgotten and prior assumptions and presuppositions were not reevaluated. Sixty years and $1.2T latter we are "almost there" with no real end in sight.

Next was Lyman Spitzer, founder of Princeton Plasma Physics Laboratory, and his Stellarator. It failed for the same reason as ZETA. In the 1965 a Stellarator was made with a super-conducting electromagnet. Cooling the electromagnet wires to the boiling point of helium (-268.9 °C) was close to the observed -269°C where electrical resistance (friction) would become zero. It was not able to work effectively. To date the Stellarator holds the world record for sustaining fusion for 30 minutes.

Then came the Tokomak from the USSR with the first super-conducting Tokomak operating in Moscow in 1979. Tokomaks are more efficient than Stellarators, becoming the preferred approach for over 30 years. To date they have only been able to sustain fusion for as long as 6 minuets. Stellarators are now making a comeback with Angela Merkel making world news recently turning one on at the Max Plank Institute in Germany. It operated a fraction of a second at about 6 MW. One is being built in Japan.

Bandaid after bandaid has been applied to magnetic confinement until a Tokomak finally "broke even" just after 2000, operating at about 102%. No fusion reactor has ever reached a 2 times (200%) power gain. ITER's design goal is to get to 10 times gain (1000%) for just one hour. Then that's success. Then a power plant is hoped to be built. But a power plant needs to be reliable 24/7, 365 days a year.

The great "ITER hope" started in 2007 as a 17 year Tokomak project budgeted at \$14B. By about 2014 it was 10 years behind and cost was up to \$35B. Some say it will exceed \$50B if it ever turns on. It's funded by a seven member entity, with the U.S. contributing 9%. In 2014, the U.S. Senate wanted to pull out of the project,[2,3] killing ITER, and amounting to a treaty violation. The Senate wanted to do it anyway.

The biggest bandaid is superconductivity in which a metal conductor looses electrical resistance below -269°C. This is less than 5°C above absolute zero which is -273.15°C (-452.1°F). They approach this temperature by boiling liquid helium at -268.9°C. So they still have a slight amount of electrical resistance (friction) left. That means the current flow generates heat.

This problem is being worked on by CERN[4] of Switzerland. They are developing high temperature superconductive electromagnets, hoping to achieve superconductivity with the boiling point of nitrogen -195.8°C (-320.4°F) and then with the boiling point of tetrafluromethane CF_4 -127.8°C (-198°F). This takes very exotic materials and construction, yet it's still over 200°F below zero. This very cold structure (think of a block of ice on one of the moons of an outer planet or Pluto) and that this block of ice surrounds a fusion reaction proposed to be over ten million °C. Start thinking about "keep it simple, stupid." It gets worse. That extreme cold must be maintained for that contained hot star to exist. As soon as the cold rises a few degrees, the star ceases to exist.

Can it get worse? Yes, and by many orders of magnitude. There is the problem with quenching.[4] The magnetic field produced by the electromagnets and their temperature must be closely monitored or they quench, meaning loose superconductivity. The inertia of huge amounts of current flowing suddenly sees electrical resistance (friction) making voltage which is now dropped across this resistance making power generating heat. This abrupt generation of heat can melt, sometimes explosively, the windings destroying the magnet and closely related structures. This occurs within a fraction of a second.

It's further worse. We have this ten million degree star in a block of ice at -200°F. The purpose of the star is to boil water to steam at about 650°C (1202°F) by the star in this block of ice. It is now necessary to bring megawatt levels of energy across this -200°F block of ice to a structure outside of it at 1202°F to produce steam to run the turbogenerators. While doing this, the -200°F block of ice containing the ten million degree star must be maintained at -200°F or the whole process just stops. These severe engineering contradictions require complex new technologies to be developed. No Tokomak has ever sustained fusion for more than 6 minutes or has even reached anywhere near a 2 times power gain. Enormous amounts of energy must be expended attempting to maintain this cold region.

Call in the calvary! The bipolar reactor to the rescue. The latest bandaid is a reactor where the cold is limited to being along the length of a tubular reactor. The ends are not cold so energy can escape out. These end caps comprise a plasma mirrors. The magnetic force along the tube constricts the plasma to a thin, tubular centrally confined plasma which tries to go out through the ends. In theory, the plasma mirrors in the end caps cause the plasma to bounce back into confined plasma tube. A well publicized variant of this reactor is now being made and publicized by the famous Lockheed Skunk Works. A nice try, but overly complex and as we will see an attempt to solve an unnecessary problem.

What has happened here is a long process of starting with a process that looked good in theory based on a certain set of assumptions. As the process failed, a new bandaid was applied in the hope of salvaging the project. These steps have gone on over 60 years to where the people now involved are disconnected from the original assumptions. They are on a set track. They have not questioned the original assumptions for validity. This is how we have wasted over $1.2 and 60 years going down the wrong pathway. And now it's said we are 20-40 years to fusion power as the reality sinks in.

I prosecuted my patent application personally meaning I had to defend my application against the entire fusion patent record. The patent examiner had a Ph.D. in Nuclear Engineering. The prosecution took 10 1/2 years. The patent wrapper, papers sent back and forth between myself and the patent office, is over 1100 pages, often of very deep technical arguments. I won and I learned a lot. I don't have a Ph.D. in physics, but have an education few Ph.D.'s have.

We don't live in the core of the Sun. It's not feasible to duplicate those conditions here on earth. Sadly, it's not even necessary. High energy physics has become fixated on magnetic force. Gravitational force is out of the question, for it requires a mass several times the mass of the planet Jupiter to drive fusion with gravity, and then you have a small star. But there is one more force available: electric field force. This force was proposed for fusion by three entities.

Brookhaven National Laboratory (BNL) in 1989 constructed a linear Direct Current (DC) accelerator claiming deuterium-deuterium fusion with ions accelerated to 200 to 325 keV impinging on TiD loaded targets. They published a paper in 1989 in Physical Review Letters.[5] The authors proposed "a possible new path to fusion power." Unfortunately they were studying "cold fusion" and used heavy water ice crystals as fuel. The study was discredited. Accelerating deuterium ions instead of heavy water ice ions most likely would have brought improved results. The BNL paper paper was seminal in that it pointed out the correct path. BNL was so close nearly 30 years ago.

Next was Lawrence Berkley National Laboratory (LBNL) which in 2001[6] disclosed a concentric DC accelerator and proved vectored particle acceleration using deuterium gas. The LBNL reactor works quite well as a bright neutron source. It produces 1.0 X 10^{10} neutrons per second with 120 kV of DC at 1 ampere of current per square cm. of target area, 120 kW. The LBNL reactor appears to function as multiple copies of the BNL device, without an outlet aperture, in a concentric design. By operating on DC, current continuously flows through the power supply as electrons flow from the ground plane through the power supply to the target and then back to the ground plane as a current of positive charge carriers. This current flow of positive ions to the target completes the circuit, resulting in high power consumption. This current flow does not contribute to its function as a fusion reactor, but is a totally parasitic function of the DC potential across a resistive plasma.

My spherical reactor differs from the LBNL reactor in several aspects. Operating on AC, it presents a nearly pure capacitive load, not a resistance. A central spherical target is contained within an insulated borosilicate glass envelope containing the fusion reactive gas. The envelope is enclosed by a alumina ceramic insulating layer enclosed by an outer aluminum housing which is the ground plane. AC potential is applied between the central target and the ground plane. The materials separating the target and ground plane are permeable to electric fields, but comprise sufficient electrical insulation to keep the circuit open. An oscillating electric field between the ground plane and target is produced within my reactor by the applied AC electric potential.

All that has moved through the system power supply were oscillating EMF impulses with no net current flows. No power is dissipated with AC across a capacitance. With a sine wave EMF applied, the current is 90 degrees out of phase and a cosine wave. Multiplication of these two provide a sine wave power function at twice the drive frequency approximately centered on the x axis. The resulting power function averages zero.

The overall result is there has been nearly no movement of charges through the system, therefore the force applied by the power supply is multiplied by charge movements approximating zero. No net work or power consumption has been performed.

BNL was so close nearly 30 years ago. Later LBNL experiments proved the validity of this path with DC acceleration. Power is the ability to do work that equals force times a distance component: P = F x D. What drives fusion is solely the force component, the voltage or EMF. With DC, the particles move through the reactor's electric field in only one direction over a specific distance (D), expending power. DC acceleration was therefore unable to provide power gain. AC particle acceleration work was mostly done by Tesla in the 1890's. With AC acceleration, the charge carriers have a net motion approaching zero. They constantly change direction as driven by the voltage polarity changes provided by the electrical rotation of the applied potential. They move in an oscillating motion between the target and the inner layer of the reactor, constantly moving inward and outward. Their average motion over a rotational voltage cycle approaches zero. The circuit is open in that a limiting resistance provided by an insulated space has an exceedingly high resistance of 6 e^{15} Ω. As a result only 2.4 e^{-6} W of electrical power is dissipated which is dwarfed by the 2400 W nuclear output power, thus a billion times gain. For all practical purposes few electrons and no positive ions would ever be able to pass through the 6 cm thick alumina ceramic material. Current does not complete a circuit in either clockwise or counterclockwise motion. There is no net charge movement, no significant electrical work is done, or power expended. Such a block of current (the distance component) while allowance of passage of the force component is possible only with AC acceleration. This provides high power gain, theoretically approaching a billion times. Only force is used. This is the secret to high gain fusion power.

This reactor has no requirements for superconductivity for an electric field is solely in proportion to voltage, the electromotive force (EMF). It operates is by direct application of the force component. In electricity, current is a distance component, the number of charge carries passing a point in a given time. In the oscillatory motion of the charged particles in my reactor, the net distance is zero. P = F x D. With D approximating zero, drive power approximates zero.

With no superconductivity there are no cold temperatures. Maximum power of the reactor is dictated by target temperature, set at 1600°F by limiting the power to 60 watts per square cm. of target area for longevity. In advanced reactors, the target can be internally cooled by a fluid, allowing higher power levels for a given reactor size. There are no cold temperature gradients through which released energy must pass, temperature drops are smooth, and cooling allows for the reactor to operate at higher power levels. The engineering contradictions of confinement do not exist with the velocity impact fusion. The design is elegantly simple, keeping with: "Keep it simple, stupid." Simplicity provides for high reliability, keeping with the inverse of the motto: "The greater the complexity, the higher probability of failure." Its simple design provides for making smaller sized reactors, thus we can do proof of concept with a 2400 watt reactor rather than a 500MW reactor. With complex requirements of maintaining superconductivity, it's not financially feasible to design a confinement reactor of only 2400 watts. Turn on of an efficient, reliable, and stable operation of a 2400 watt fusion reactor will make history. The first fission criticality was at the University of Chicago in December 1942. Fermi operated Chicago Pile One (CP1), costing $2M in 1942 dollars, at a peak power of 1/4 watt. This was historic and started the Manhattan Project. We plan to operate a 2400 watt fusion reactor, at 10,000 X the power level of CP1, on a $40M budget. It will become equally historic as CP1.

References:

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A Four-panel project slide summarizing the reactor

AC Velocity Impact Fusion Reactor Prototype

Dr. James DeLuze, Fusion Energy Solutions of Hawaii (FESH)

Technology Summary

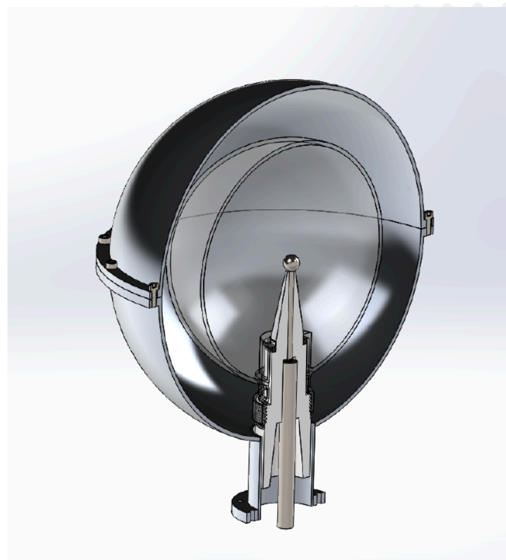
- *Concentric AC Particle Acceleration.*
- *Real or Virtual (higher-power) Targets.*
- *Operational using DC at Lawrence Berkley Lab.*
- *Logical adaptation of proven DC to AC.*

Technology Impact

Carbon-free clean energy using Ocean deuterium will supply our needs indefinitely. This will enhance US economic security by technological lead with a zero emissions energy source bringing energy independence and improved efficiency in all economic sectors.

Proposed Targets

Metric	State of the Art (ITER)[2]	Proposed (ACVIF)
Power Gain	Goal up to 10 X	10 X to 1,000 X
Power Range	? to 500 MW to ?	1kW to 1GW
Optimal Fuel	D-T Fusion	D-D Fusion
Driving Force	Magnetic Field	Electric Field
POC[1] Cost	$35B+[3]	≤$100M[4]



Cross-section of proposed prototype concentric AC velocity impact fusion reactor (ACVIF) with real target. To simplify, gas connections, insulation, and shields not shown.

High gain, simple, inexpensive, fast to develop structure.

1. Proof of concept.
2. International Thermonuclear Experimental Reactor, iter.org
3. POC budget estimate only.
4. ACVIF POC & grid ready demonstration electric plant est. budget.

Fusionsynthesis

We face the most serious threat in history. The focus on climate disruption, sea-level rise, and other environmental issues is a distraction. They are symptoms of a much more serious problem: Energy Depletion.

Dr. DeLuze is an inventor and sincerely believes his company Fusion Energy Solutions of Hawaii, Inc. (FESH) has workable solutions. Further elaboration on the problem will help to understand the solution.

Like a car, the Earth has an energy storage battery, and it's nearly dead as of 2021. A 2015 PNAS study estimates this battery may become fully discharged in approximately 2046, see link below.

A battery is a chemical means of storing electric energy in the configuration of molecules. Only the molecular configuration of the atoms changes, not the atoms themselves. In a charged state a car battery is composed of lead and sulfuric acid. In a discharged state a car battery is composed of lead sulfate and water. Charging a car battery returns the composition back to lead and sulfuric acid.

Earth has a hydrocarbon oxygen battery. In a charged state this battery is composed of free oxygen and hydrocarbons. In a discharged state this battery is composed of water and carbon dioxide. Charging Earth's battery reverts these accumulations of carbon dioxide and water back into free oxygen and hydrocarbons.

We have more people and advanced technology energy demand than plant life and sunlight can accommodate. This high energy demand exceeds the ability of photosynthesis to replenish energy taken from the battery. As a result, the state of charge of Earth's battery has been in decline for over a 1000 years and it's now about 99.2% dead. Most don't realize that water is also a greenhouse gas, for it safely collects in the ocean. Carbon dioxide of itself is not bad, it is just a component part of an accumulating discharged battery. Charging Earth's battery reverts these accumulations of carbon dioxide and water back into free oxygen and hydrocarbons. That this battery is nearly dead is our environmental problem, not the carbon dioxide! Earth's battery just needs to be recharged.

Proposed solutions include wind and solar power, but this will not solve our energy depletion dilemma. The energy density of wind and solar is just too low and they both require fossil fuel for construction. A 6 MW offshore wind turbine needs about 32 years to break even on the CO_2 emitted by just the manufacture of the 100 tons of concrete comprising its tower. The issues are complex, and the environmental cost of manufacturing this "green" equipment is just not considered.

With the magnitude of present energy consumption, for solar and wind to be sustainable, some estimate that over 95% of the world's population would need to be eliminated. However, this assumes the carrying capacity of the system is still the original 500M sustainable population such estimates assumed. But we have been in severe overshoot 100's of years, and the present carrying capacity is most likely much smaller than the original 500M sustainable population estimate.

We propose an alternative. Creation of a nonpolluting primary energy source using fusion energy. Over one trillion dollars has been spent on the research, going down what we consider wrong pathways. After 15 years of work, we received US patent 8,090,071 B2 on a new approach to fusion. This path was first taken by Brookhaven and then Lawrence Berkley National Labs and shown operational at Berkley. Berkley just did not have net power gain, but our AC variant promises this highly elusive power gain. This becomes the primary energy source, like the engine in a car.

Also needed is a charger, like the generator in a car. After 8 years of research, a patent on a very selective filter to pull CO_2 from the atmosphere has been filed, PCT/US2019/037324. We believe we also have the remaining answers (subject to future patents) for the rest of the solution wherein fusion energy will recycle carbon dioxide and water back into free oxygen and hydrocarbons. Once reaching carbon neutrality, oil companies using existing technologies will be able to synthesize the excess hydrocarbon methane (natural gas) into synthetic heavy oil for safe sequestration in the ground. Storage of concentrated CO_2 is dangerous, for it is a deadly poison. We call this process Fusionsynthesis, and it will run parallel to photosynthesis and recharge the Earth's biomass energy battery. There is sufficient deuterium in the ocean to support ten billion people for over four trillion years using Fusionsynthesis.

This research is critical, for no matter which study you use, we have no more than about 25 to 100 years of useable energy left. Then its total, not partial extinction, as proposed by the schoolgirl Greta. Watch our ten-minute video on how our new reactor works compared with the current state of the art. Included is a description of the Earth's energy photosynthetic pathway that now must be supplemented by Fusionsynthesis for continuing survival. Merely obtaining fusion is not sufficient, the energy needs to be accessible in useable biomass. Visit our website at: www.fusionenergysolutions.net

The following two articles are presented as an example to point out the brutal truth about energy depletion and are not for the faint-hearted. Read both of them. They illustrate the point made above: Merely obtaining fusion is not sufficient to solve energy depletion. We also need a charger converting energy to biomass. The biosphere battery needs to be recharged…This means Fusionsynthesis. This is the recharging plug! Andrew Nikiforuk in The Tyee wrote The Earths Battery Is Running Low: https://thetyee.ca/Opinion/2015/08/10/Earth-Battery-Running-Low/

Stating: "We've drained our planet's stored energy, scientists say, with no rechargeable plug in site." In his review on an article presented in the Proceedings of the National Academy of Sciences: https://doi.org/10.1073/pnas.1508353112

Nikiforuk States: "Although the battery metaphor made headlines in leading newspapers in China, India and Russia, the paper didn't garner "much immediate attention in North America… That's a shame because the paper gives ordinary people an elegant metaphor to understand the globe's stagnating economic and political systems…Eventually, without sufficient living biomass to run the biosphere, it simply doesn't matter how much oil, solar, nuclear, etc. energy you have, as there is no biosphere left for humans to use it. Biomass is not an interchangeable energy. There is no replacement and we are depleting it rapidly."

The state of battery charge reported above is approximated by the Ω value in Fig. 5. The slope from 1980 to 2000 is a $-\Delta$ 22.3 Ω/year. Ω approximates 0 in 2046. There is uncertainty with these figures, but most studies have similar findings.

We face the most serious threat in history. FESH is globally most likely the only firm attempting to provide a complete solution. Over the last 2000 years humanities rate of energy use has exponentially exceeded the rate that it is replenished by photosynthesis. The components of the 99% discharged battery have accumulated in our atmosphere and oceans resulting in the symptoms of climate disruption, sea-level rise, and other environmental issues. At the present rate of energy consumption, the Earth's energy battery becomes dead as shortly as in 25 years. Humanity then goes extinct. Only high rate recharging by Fusionsynthesis, or its equivalent, will be able to stop the discharge and then start a gradual recharge of the Earth energy battery. Recharge will normalize the carbon balance, eliminating the symptoms of climate disruption, sea-level rise, and other associated environmental issues.

FESH is a small startup with critical intellectual property. We need your financial help and support. This is going to take everyone's help and will become the largest worldwide project in history in-order to succeed. Our biggest hurdles are adequate funding and time.