SOLAR ENERGY POWERED

ATMOSPHERIC MOLECULAR ENGINE

Sustainable Energy for America's Future

2010

THE DESIGNED SUSTAINABILITY GROUP

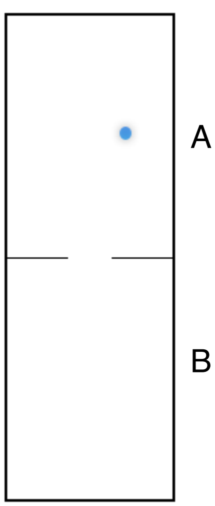
www.designedsustainability.org

Atmospheric Molecular Engine (AME)

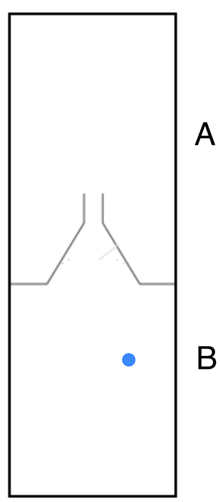
Background of Invention

Atmospheric Molecular Engine (AME) is an engine that derives its energy from atmospheric gas molecules. When the sun's electromagnetic waves hit the Earth, a portion of that energy is absorbed by atmospheric gas molecules . The phenomena we observe (wind, pressure, and temperature), are all due to the energy that has been transferred from the sun into the molecules of our atmosphere and the Earth's surface. Where traditional alternative energy has been largely focused on taking only a small portion of the electromagnetic wavelength (visible light) or by-products of thermal insolation (wind) and converting that into electricity, AME harnesses the solar energy already absorbed by our atmosphere, *without direct sunlight*. This is achieved through atmospheric pressure. AME's patent applied design creates a preferential direction for gas molecules to move, thereby generating a pressure difference to perform work.

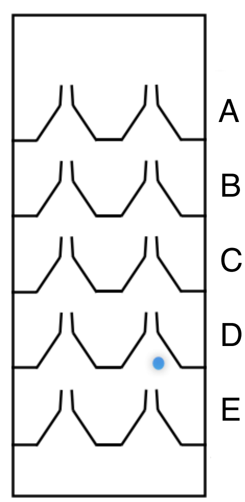
The fundamental logic is explained by the three examples below. In Container I, as the rule of uniform distribution ($P(X=x_k) = 1/k$) states, we know a ball (or molecule) moving in constant motion and with perfect elasticity will spend an equal amount of time on side A as side B. In Container II, if we use an asymmetrical partition, we deduce using statistical physics that the molecule will spend more time on side B than side A (a molecule on side A has a 180 degree entrance angle to transit to side B, where as the angled funnel walls on side B reduce this angle of entry). Furthermore, in Container III, if we increase the number of asymmetrical partitions, we can conclude that the particle will spend more time in section E than D than C and so on: the result is a preferential direction of transit. This is applicable to a large amount of molecules in that each subsequent partition will yield a larger number of molecules than the partition before, and where you have more molecules, you will have more collisions, which is more pressure being exerted on one side than the other, resulting in a force to perform work. The cumulative pressure difference simply depends on the number of partitions and asymmetrical holes per partition.



Container I



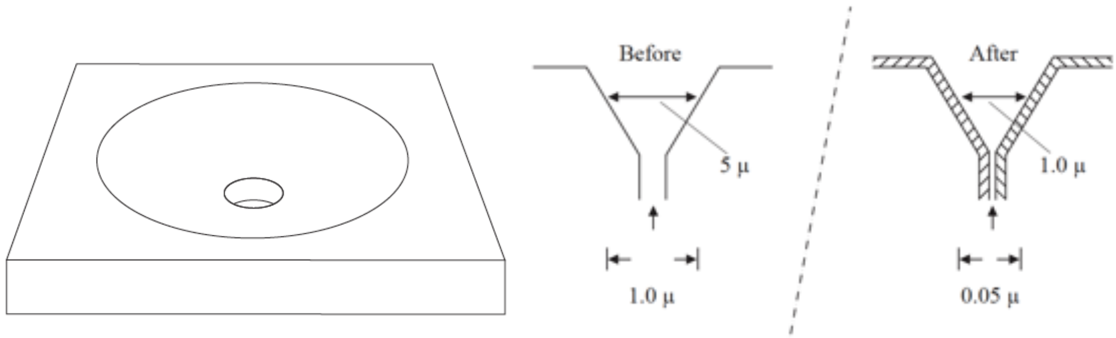
Container II



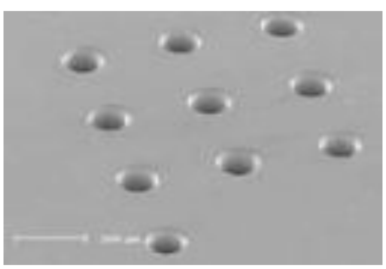
Container III

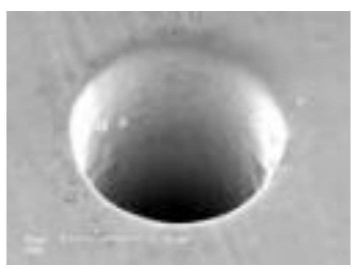
Manufacturing at Molecular Tolerances

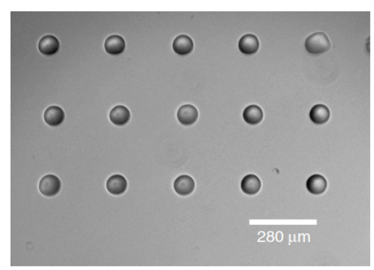
The principle of the patent applied (U.S. Patent Application No. 12/684,919) concept AME, is made feasible with the advent of nanotechnology and ever more advanced manufacturing capabilities in the industries of medicine, aerospace, semiconductors, and high density optical discs. Each of these fabrication processes is a two-step process: first being the creation of a through-hole, and the second, reducing the dimensions of the through-hole to meet required specifications.

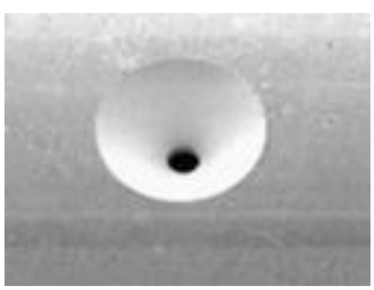


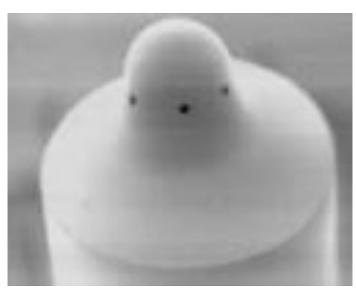
One method is using ultraviolet (high-repetition pulsed diode lasers) to drill cone-shaped pits into selected substrates, making cone shaped "through-holes". A diode-pumped solid-state laser (DPSSL) offers a combination of high peak power, high repetition rates and beam quality that make it suitable for drilling holes as small as 1 micrometer in diameter on stainless and carbon steels, titanium, ceramics, silicon and other hard materials up to 1 mm thick. The final step is ultra-thin film coating (conducting vapor deposition such as chemical vapor deposition, plasma enhanced chemical vapor deposition, sputtering deposition or electric discharge formation of nano layers) in a vacuum chamber to achieve uniformed deposition of another material on to the substrate, reducing each hole diameter to a desired dimension, such as 0.05 microns or less for the stem portion.









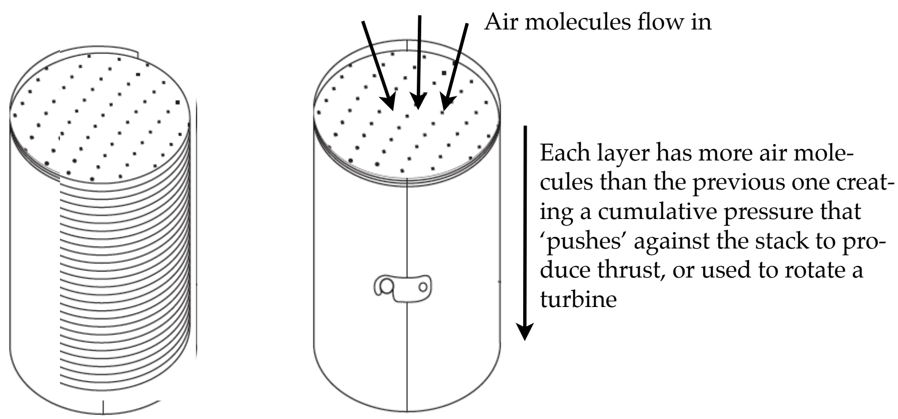


A second approach is using state-of-the-art ion beam machining to create a master stamper (identical to the production process of making high density optical disc masters) of densely packed needles. This injection molding of a polycarbonate substrate will form a partition consisting of cone-shaped pits. Again, micro-etching and thin-film coating processes will be applied to achieve the desired dimensions.

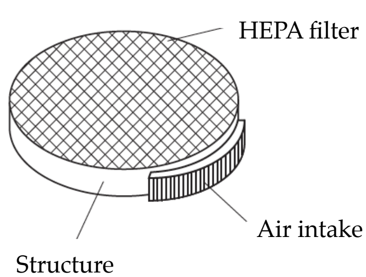
The third approach utilizes electroforming using a mandrel approximately six inches in diameter, full of cone-shaped needles around 5 microns thick and tapering down to a 30 degree angle. The tip of each mandrel needle is made with a non-conductive material to prevent metal deposition. Dipping the mandrel into a bath of electrolytic solution, a layer of metal such as nickel or nickel-cobalt will form over the needles, forming our partition up to 0.15 mm in thickness per hour (deposition rate). Companies such as Metrigraphics are already producing substrates that contain 56 million cone-shaped "through-holes" on a six inch area. The same thin-film coating process is then used to achieve desired dimensions.

The purpose of this shape and dimension is to give these "through-holes" the characteristic of having a greater cross-section for a gas molecule to transit in one direction than the other. Elementary geometry and probability states that if the above substrate were to equally divide an enclosed box, gas molecules traveling in the box will have a statistically higher probability of transiting from one end of the substrate than from the other.

By taking multiple substrates (or 'partitions'), stacking them on top of one another, and placing them in an open-ended system, we create a preferred direction of flow or transit, where with each subsequent partition, there will be a greater number of molecules and thus a higher pressure than the partition before.



At the head of each engine is a HEPA filter that is sandwiched by two air intake systems. The HEPA filter prevents dust particles to build up on the substrates and the dual air intake systems are to turn AME on or off and to allow replacement filters to be installed without exposing the substrates to dust.

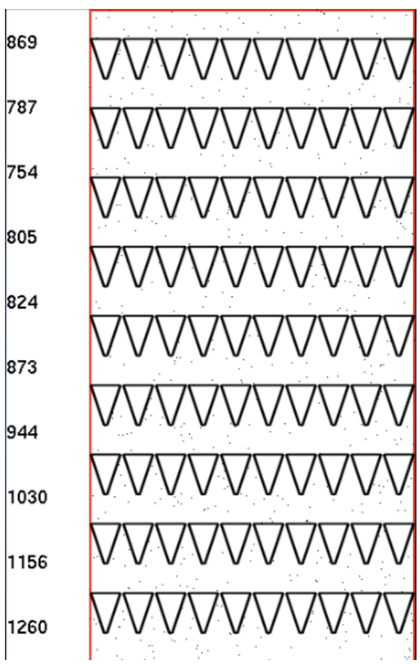


Computer Simulations

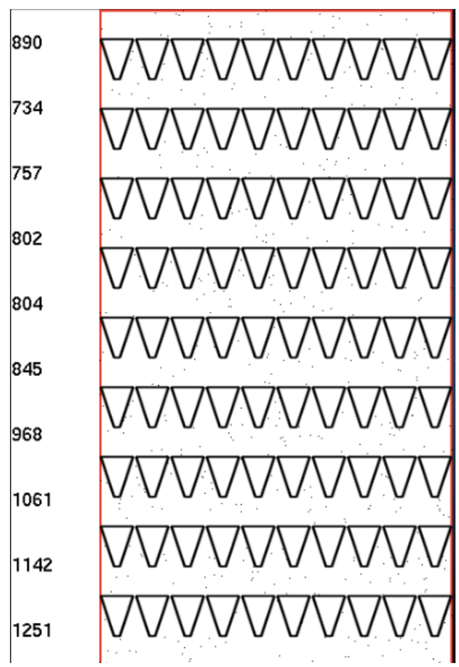
Two generations of computer simulation programs have been created for AME (see below), allowing us to manipulate variables like angle of cone walls, hole diameter, stem length, distance between holes, etc. In both generations, gas molecules would start evenly distributed throughout the engine, but at random points. The molecules would interact with perfect elasticity with the engine walls and with each other. We discovered an optimal configuration that yielded on average a 70% or greater pressure difference in an engine that contained only 10 substrates from head to the tail. To generate more pressure, we would simply need to add more substrates.

We didn't include van der Waal interactions because both Oxygen and Nitrogen molecules have negligible dipole moments. They rotate so fast that the interactions are very much like a ball hitting a ball. Also, the surfaces of our engine interior will be fabricated to be non-interactive, so the molecules will not encounter dipole interactions. Of course when we progress to simulating AME for CO_2 sequestration technologies, the inclusion of van der Waal interactions will be included because CO_2 has dipole interactions, like water molecules.

Simulation 150a



Simulation 163a



Simulation 150a specs:

Incline Angle - 29.5 degrees

Cone (top/tapered) - 20X diameter of an O_2 molecule

Cone (bottom/mouth) - 200X diameter of an O_2 molecule

Distance between Holes - 200X diameter of an O_2 molecule

Distance between Partitions - 10X the diameter of an O_2 molecule

Simulation 163a specs:

Incline Angle - 30 degrees

Cone (top/tapered) - 20X diameter of an O_2 molecule

Cone (bottom/mouth) - 150X diameter of an O_2 molecule

Distance between Holes - 150X diameter of an O_2 molecule

Distance between Partitions - 10X the diameter of an O_2 molecule

Critical Discussion Points - Thermodynamics

From an outsider's scientific view, AME seems to be able to perform work with a single heat source (in violation of 2nd law of thermodynamics), and it is microscopic scale vs. fluid dynamics, so molecular interaction should be considered. However, we are certain that if a pressure difference is resulted from the asymmetric through-hole, then the gas has increased entropy (higher disorder) through higher pressure or through higher temperature due to adiabatic compression. Our system will then discharge this higher pressure and temperature to the surrounding's cooler temperature sink. The second law of thermodynamics states that you can not dump heat into a source that is colder than the one you are taking heat from. It is imperative to know that AME does not dump heat into a source that is colder (head of the stack vs. end of the stack). In fact, by having higher pressure, the gas should be at higher temperature due to adiabatic compression. Therefore, we are actually dumping heat to a lower temperature reservoir than the gas experiences, so we are not violating the second law of thermodynamics here.

In regards to AME not working at a molecular level, that we are in essence playing "racquet ball" with a wall surface of vibrating balls (because at a molecular level nothing is smooth, and everything is vibrating); in actually, this is the beauty of AME, we do not care how the molecules incident the through-holes so long as they incident. Consequently, we do not care how the molecules collide with any walls or inter-molecular collisions prior to hitting the through-holes (this is because in Avogadro's number, every potential angle of incident will be realized). The same argument also addresses turbo-molecular pumps in that the blade of a pump at a microscopic level will also be in constant vibration, yet is still able to impart a directional travel vector to all molecules it encounters. We certainly know turbo-molecular pumps work until it reaches an equilibrium state (a low vacuum) where some gas molecules will be able to diffuse back into the evacuated space through the spinning blades or the random collision with ball surface bats the molecules back into the evacuated space.

When observing and validating the AME concept, you are definitely dealing with statistical mechanics rather than continuum mechanics, since the Knudsen number (mean free path divided by our hole diameters and/or length) will always be greater than 1. The question then becomes: How can this not work with solar energy continually providing velocity to gas molecules vs. a turbo-molecular pump, which uses the rotating blades to impart a directional vector to any molecules they encounters?

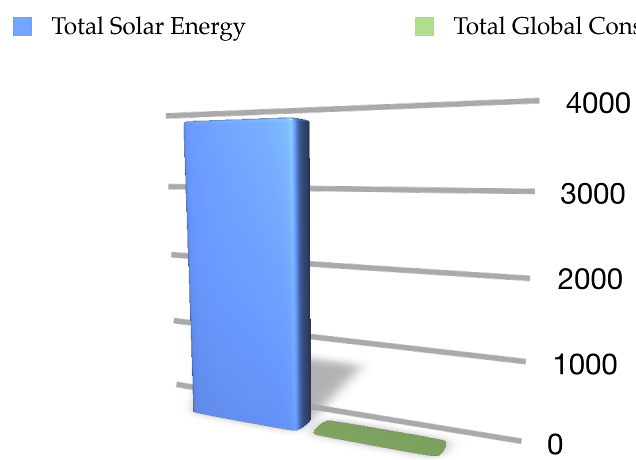
At higher pressure after a partition, we definitely have higher numbers of molecules colliding with the partition on one side vs. the other. If the transit cross section is sufficiently different, then this increase of molecules on one side may not off-set the creation of a pressure differential. This is precisely what our simulation has demonstrated, i.e. a pressure gradient exists after a time period. The adiabatic compression increases the temperature of the gas which means the molecules will be moving at higher speed, which should not off set the cross-section of molecules transiting a partition from two different directions. Again, the simulation results indicate there is a pressure gradient regardless of the speed we give to the molecules.

Most people did not believe that in an atmospheric situation by ionizing the air and accelerating its ions to create a flow was possible, since the mean free path will be so short that any ions will be neutralized immediately upon colliding with other air molecules (remember Avogadro's number). The Sharper Image air cleaner we have in our study proves this idea wrong. Not only can it create a powerful flow of air after ionizing a portion of it, but it also generates enough Ozone through chemical reactions for it to survive long enough that people can actually smell it.

With respect to rotating diatomic molecules like oxygen and nitrogen, their rotation make them into a perfect ball.

Solar Energy Facts

The obvious selection for a fuel source was the sun. Even though the sun ranks as a run-of-the-mill star, it releases a colossal amount of energy in terms of human capacity or need. Energy output per second is 3.86 X 10^{20} megawatts (MW), several billion times the electric capacity of total combined global utilities. The atmosphere receives a continuous 174 petawatts of incoming solar radiation. 6% of the insolation (10 petawatts) is reflected back to space, 16% is absorbed (28 petawatts), average atmospheric conditions (clouds, dust, pollutants) further reduce insolation traveling through the atmosphere by 20% (35 petawatts) due to reflection, and 3% via absorption (5 petawatts). Roughly, every second there are 96 petawatts of solar energy reaching the earth's surface, which translates to approximately 3,850 zetajoules (ZJ) annually. To put this into perspective, the entire world population consumed 0.471 ZJ in 2004.



Photovoltaics and Concentrating Solar Power Systems

Photovoltaic (PV) systems convert sunlight directly to electricity by means of PV cells made of semiconductor materials. Concentrating Solar Power (CSP) systems concentrate the sun's energy using reflective devices such as troughs or mirror panels to produce heat that is then used to generate electricity.

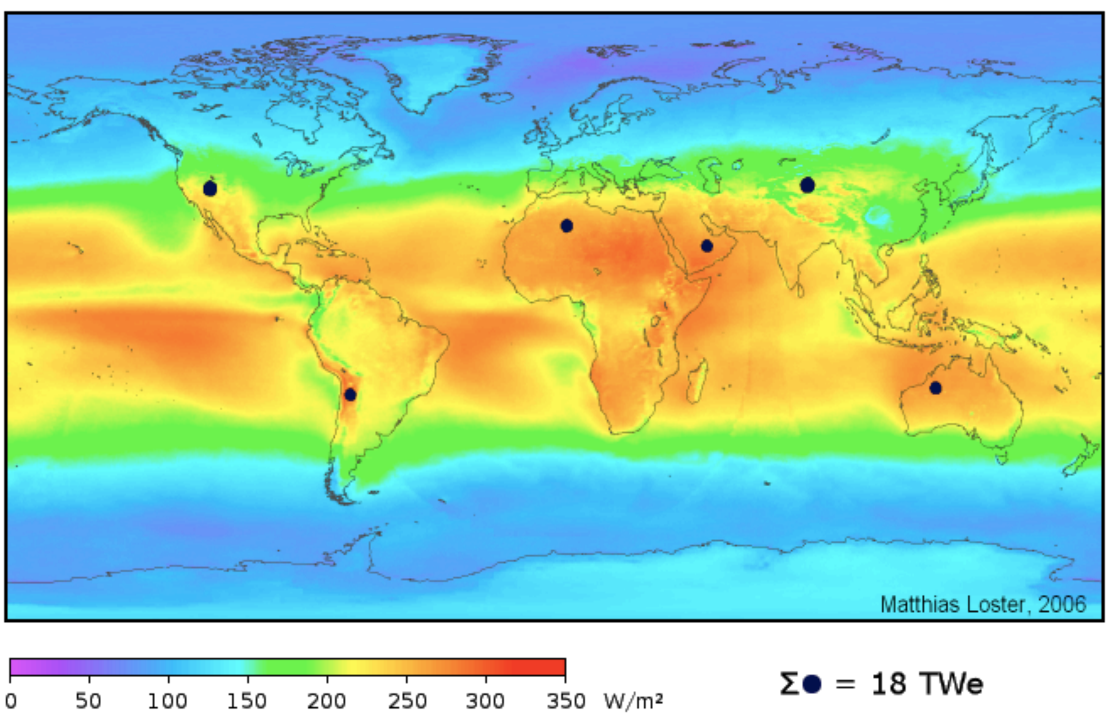
These are the two most common means employed to derive energy from the sun. However, both methods depend on sunlight to generate power and, therefore, can not produce energy or electricity half of the time.

Leaps and bounds have taken place in both PV and CSP technologies since 1981 where the cost per watt was around $10 to the $4-5 per watt cost in 2002, but the prices have stabilized and need to be much, *much* lower in order to become cost effective and commercially viable (considerably less than $1/watt). Currently, the average household is paying $0.15 per KWh, more than 5 times cheaper than the cost effectiveness of solar cells ($0.80 per KWh) in terms of cost/watt.

Fundamentally, it requires an immense amount of energy to develop solar cells and there have been many ambivalent views as to whether solar or photovoltaic cells have the ability to supply a significant amount of energy relative to global needs. Some scientists have even measured that with the advanced technology we have today, it still takes more energy to produce a PV cell than it will give out over its entire life (Silicon, baked at 1,600^{o}F for 17 hours, to make the cells). The table below shows the average cost in cents/kWh over 20 years for solar power panels.

Cost	Insolation								
	2400 kWh/kWp·y	2200 kWh/kWp·y	2000 kWh/kWp·y	1800 kWh/kWp·y	1600 kWh/kWp·y	1400 kWh/kWp·y	1200 kWh/kWp·y	1000 kWh/kWp·y	800 kWh/kWp·y
200 $/kWp	0.8	0.9	1.0	1.1	1.3	1.4	1.7	2.0	2.5
600 $/kWp	2.5	2.7	3.0	3.3	3.8	4.3	5.0	6.0	7.5
1000 $/kWp	4.2	4.5	5.0	5.6	6.3	7.1	8.3	10.0	12.5
1400 $/kWp	5.8	6.4	7.0	7.8	8.8	10.0	11.7	14.0	17.5
1800 $/kWp	7.5	8.2	9.0	10.0	11.3	12.9	15.0	18.0	22.5
2200 $/kWp	9.2	10.0	11.0	12.2	13.8	15.7	18.3	22.0	27.5
2600 $/kWp	10.8	11.8	13.0	14.4	16.3	18.6	21.7	26.0	32.5
3000 $/kWp	12.5	13.6	15.0	16.7	18.8	21.4	25.0	30.0	37.5
3400 $/kWp	14.2	15.5	17.0	18.9	21.3	24.3	28.3	34.0	42.5
3800 $/kWp	15.8	17.3	19.0	21.1	23.8	27.1	31.7	38.0	47.5
4200 $/kWp	17.5	19.1	21.0	23.3	26.3	30.0	35.0	42.0	52.5
4600 $/kWp	19.2	20.9	23.0	25.6	28.8	32.9	38.3	46.0	57.5
5000 $/kWp	20.8	22.7	25.0	27.8	31.3	35.7	41.7	50.0	62.5

Even with concentrators and new PV technology, they have major deficiencies; two most notably are that due to the atmosphere light reflection, angle of the Earth, etc., there is a limited area where placing these solar cells is viable. However, with the normal oscillation of the planet, that changes, and it would be impossible to move these massive collectors and PV arrays to suit the natural wobble of the earth. The figure below shows the average solar irradiance, watts per square meter.



The other major limitation is that even within the specific geographic location that is ideal for solar collectors, they still need to track the sun (collectors need to be pointed directly at the sun), and have about a 1 degree acceptance angle, meaning that once a collector is more than about a degree off, none of the rays will hit the focus. Even with cutting edge theory dealing with non-tracking solar collectors that can take off-axis beams through multi-angled surfaces, it requires multiple bounces of that light to hit the focus, and with each bounce, you lose 10% or more efficiency. With PV cells, the second major limitation is use of silicon crystals, which makes it very expensive. First of all, silicon crystals are currently assembled manually. Secondly, silicon purification is difficult and a lot of silicon is wasted. In addition, the operation of silicon cells requires a cooling system, because performance degrades at high temperatures. At the end of the day, solar cells with current technology can gather 4.5 hours of direct sunlight before they become useless, and some prototype units that are in development have the potential of 6.5 - 7 hours.

However, because the sun is moving across the sky, all solar cell efficiency goes down with a Gaussian curve, and will always be limited by the time during which the sun is directly visible. So even with more advanced technologies in the future, solar cells simply aren't available at night or even when it's very cloudy, and this brings into question the viability of solar and PV to replace fossil fuels as a primary power source.

Other Alternative Energy

Wind: Wind is the second most renewable resource after PV and CSP systems, roughly 3,600 Terawatts. However, a majority of it is in the troposphere and stratosphere, 5-8 miles high. The largest wind turbines have a hub height of around 300 feet and they can't really go much higher, and more height equals more wind and more power (as much as twice as much). There have been some great breakthroughs in wind technology today, but fixed wing turbines are limited in their potential due to the area of space any one arm can sweep through. Similar "kite" technologies have been developed where wings are attached to a tether and sweep freely through the air, controlled by gear motions at the base; however, they still are unable to reach the heights that are needed to produce energy on a large enough scale.

Ethanol: After extensive research and confirmation from the scientific community, producing ethanol on mass scale would require every country to have land on a scale with the Amazon in their back yard to supply quantities aiming only at the next 25 years of demand, and only for the automotive industry. On top of that, the availability of adequate food supplies could be threatened by biofuel production to the extent that land, water and other productive resources are diverted away from food production, and with a rapidly growing population, of which still billions are already malnourished, this can't be sustainable.

Hydrogen: When hydrogen is burned in air, the main product is water (however some nitrogen compounds may also be produced and may have to be controlled). Should greenhouse warming turn out to be an important problem, the key advantage of hydrogen is that carbon dioxide (CO_2) is not produced when hydrogen is produced. But after much dissecting of the technology and confirmation from scientists, We found that with hydrogen, you tend to use more clean electrons than you get inside any particular engine, be it automotive or stationary. Furthermore, what a lot of people do not know is that hydrogen is still dependent on fossil fuels. Since hydrogen is not available in significant quantities in nature in pure form, the main present way of getting hydrogen is steam methane reforming, and this will probably remain the most economical way as long as methane (natural gas) is available cheaply and in large quantities, and hydrogen is required only in small quantities. In either case, the law of conservation of energy tells us that all the energy to be obtained by producing the hydrogen must be supplied by the primary source, e.g. fossil fuels, nuclear, or solar. Of course, since these processes aren't 100% efficient, there is loss of energy. Therefore, the use of hydrogen as an intermediate is justified only when there is some reason not to use the primary source directly. For vehicles, the reason is that both nuclear and solar power plants are too large to carry around.

The Power Grid

There are definitely signs the national electric grid is seeing strain that may lead to reduced reliability. Historically, grid reliability has been addressed by providing generating capacity margin in excess of anticipated peak demand. The Electric Reliability Council of Texas has published information showing capacity could fall below prescribed target margins of 12.5% by 2009.

Elsewhere, the ability to bring additional generation capacity online has been hampered by environmental concerns. While coal has historically been the least expensive fuel for large-scale base power production, it also contributes the most to greenhouse gas emissions. Resource Media (2008) published a report showing more than two dozen coal-fired plant proposals upended in 2007—the result of strong public opposition and uncertainty over the cost of complying with future carbon caps and emissions policies.

Paul Joskow (2006) suggests that competitive wholesale electricity markets no longer provide financial incentive for the investment in peaking power plants that have high capital costs, low utilization rates, and uncertain demand requirements. Where free-market practices have led to capacity shortages, utilities and distribution companies have been forced to contract for additional capacity by mandate.

Operational Remarks

Atmospheric Molecular Engine was developed to address the global climate crisis in mass scale, and with the fundamental criteria of not requiring a primary fuel to operate, and to use only existing technology and proven manufacturing techniques to develop. AME approaches a mass scale strategy by addressing three critical points:

1. AME uses decentralized or dispersed power; therefore, there will not be a need to implement or integrate into a power grid because air is omnipresent.

2. AME uses (not consumes) air as a fuel; therefore, there is no need to optimize for efficiency because generally the cost of fuel dwarfs the cost of the engine over its lifetime, but since our fuel source is free, the only thing that matters is the upfront capital cost of the engine optimized for power per dollar.

3. AME's energy production is identical for automotive, household and consumer electronics, which makes the decision to switch to AME technology simple and effortless.

There are three crucial markets for AME: (1) electricity generation, allowing homes and businesses alike to produce their own electricity; (2) vehicle propulsion, replacing the gas tank and the traditional focus of miles per gallon; and (3) chemical batteries, since the very nature of AME technology revolves around the atmospheric pressure of gas molecules, even the smallest known chemical battery on the market today is enormous by comparison.

AME will also open up entirely new sub-segments in markets like refrigeration and air conditioning. The rapid expansion of atmospheric pressure generated by AME into a space will absorb heat from the space and achieve cooling (this is how current air conditioning systems operate) without the use of a refrigerant. This can also be applied to close-looped systems like refrigerators, central air conditioners, and industrial cooling systems. It can also be integrated into garments, hats, and other electronic systems producing localized cooling of head, torso, or heat sensitive ICs.

AME will also create entirely new market sectors, from aviation to military applications, cranes and elevator systems to architectural applications and prosthetics.

Closing Remarks

First to Market. The Designed Sustainability Group is the only organization researching and designing this technology. U.S. Patent Application No. 12/684,919.

Research. Our solution has been validated by Professor Chu of Clark University (mathematics dept.); Dick Chen, President of PSMC (Semiconductor ICs/Photomasking); Dr. Paul Renard from University of Toronto (Computational Fluid Dynamics).

Because AME is based on statistical physics combined with geometric shapes, and not based on extracting, refining, transporting or utilizing a primary fuel to operate, AME:

I. Has no moving parts (in the classical mechanical sense) to wear out.

II. Contains no fluids or gases that can leak out, as in some solar-thermal systems.

III. Consumes no fuel to operate.

IV. Has rapid response, achieving full output instantly. (average speed of molecules on the Earth surface is around 500 m/s)

V. Can operate in temperatures of -20C to 50C.

VI. Can operate day or night with similar efficiency.

VII. Has multiple applications ranging from energy generation to propulsion.

VIII. Produces no pollution while performing work (less the waste products involved in the manufacture).

IX. Requires very little maintenance.

X. Can be made from very common materials that will not strain natural resources.

XI. Is modular, which allows for a wide range of solar-electric applications, small to large.

XII. Has the highest conversion efficiency of any solar-thermal device available.

XIII. Has wide power-handling capabilities, from microwatts to megawatts.

XIV. Has a high power-to-weight ratio, making it suitable for applications ranging from wristwatches and cell-phones to rooftop installations.

XV. Is amenable to on-site installations i.e., decentralized or dispersed power.

XVI. Uses solar energy, which is abundant, clean, and cheap.

About Us

The Designed Sustainability Group researches, designs and brings to market products that actually make a difference through either providing a needed solution, or fixing an existing solution to make it more efficient, cheaper, or less wasteful. The Team consists of veterans in the areas of mathematics, physics, and trend analysis.

Management

Dr. Franklin D. Hwang is currently the Managing Director and Founding Partner of The Designed Sustainability Group, and is the co-inventor of the Atmospheric Molecular Engine. Dr. Hwang has an extensive background in Chemistry, Chemical Physics and Physics, starting at University of Tennessee where he researched chemical reactions via cross molecular beam techniques under Dr. Sheldon Datz in Oakridge National Lab (Sheldon is considered the father of molecular beam research). He was a lead scientist and project manager at Dupont working with mass spectrometer systems before moving to be the director of sales and marketing at Apollo Laser. He later went on to become general manager of the Jerrall-Ash division of Fisher Scientific, which handled the development of analytical equipment for elemental analysis. Dr. Hwang left Jerrall-Ash in 1983 to start TCI Corporation, which acted as a manufacture's rep for companies like Jerrall-Ash, Fischer Scientific, Instrument Lab, Apollo Laser, Spex Industries, etc. Later TCI began packaging products and technology developed by U.S. and Japanese companies for sale to Chinese state companies. This evolved into selling entire manufacturing solutions including the technology and factories. TCI then began its own product and technology development in CCD cameras and Liquid Crystal Display technology. After raising venture capital funding ($15M), TCI launched I-SeeYou Corp and began manufacturing videophones in 1999. He has a Bachelors of Science in Chemistry from Purdue University and Ph.D in Chemical Physics from University of Tennessee Knoxville/Oakridge National Laboratory.

Francis Hwang is currently a Partner and co-inventor of the Atmospheric Molecular Engine. His background has been geared towards engineering and more recently in business strategy/development. Francis Started his career at ESPN and Walt Disney as a Sr. Analyst in research and then Sr. Manager in Customer Experience where he was in charge of analyzing and packaging products across multiple entities of the Walt Disney Companies to streamline their offerings and reduce churn in subscriber-based businesses, as well as mitigating inefficiencies with internal resources. Francis later moved on to become Executive Director of marketing and strategy for YouCast Corp. (youcastcorp.com) where he helped craft the service offering for the agency dealing with consumer-facing web 2.0 products and music artists for brands looking for in depth measurable analytics in the social media landscape. Francis launched his first company My Red Rabbit (myredrabbit.com) three years ago where he first began to address social and environmental issues. At Red Rabbit, he wrote the business plan, procured funding and designed and implemented the marketing and sales strategy. Red Rabbit now services over 1,000 students in the New York City area with fresh, organic meals and snacks, that are pediatrician approved, everyday. He handed the business over to his long time friend and partner and remains a silent partner in that venture. His second concept which has been purchased privately, is called Bucket. His patent applied invention creates economies of scale through a ground breaking concept in coin currency capture and recirculation at the point of sale, using existing credit card technology to eliminate the massive inefficiencies retailers, banks and consumers alike experience when handling coin currency. Bucket will be launching in late 2010/ early 2011, and Francis will be minority partner in that venture.

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