Facilitate The Natural

Spencer D. Miles

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Dr. Devin Moeller
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Contents

Abstract:

It is *prima facie* axiomatic that the only processes and phenomena available for human purposes are those that occur naturally, as a consequence of the intrinsic physical properties of matter, and the finite mathematical principles that govern the interactions of the various expressions of energy.

From the curious tri-phasic availability of water on this planet, to the cleverly manipulated electronic properties of 'N' and 'P' type silicon, the entirety of technology may be defined as: "The considerate use of natural properties for the creation of a desired outcome."

The term "science" is a derivation of *scientia* - "knowledge" (also "sentience" and "conscience"), "engineering" is a derivation of *ingeniare* - "to contrive, devise" (also "engine", "genious", and "ingenuity") and "technology" from the greek τέχνη (tech-ne) - "art" (also "craft" and "craftsmanship"). It is stated that the scientist will discover and define the natural phenomenon (creating a catalogue of knowledge), the technologist will define and refine the applications of those discoveries (making a craft of the catalogue), and the engineer will direct this information into task-specific applications (applying a craft to a purpose).

It is a fundamentally philosophical endeavour ("the love of wisdom" - "wisdom" being "the application of knowledge, experience, and sound judgement") to begin from the central axiom that the most complete and appropriate "technological solution" to any given question is to simply "Facilitate the Natural".

This paper is a direct attempt to answer the contentious issue of "Energy" using a holistic approach, arising from the following axioms:

- Matter and Energy are neither created, nor destroyed, but only change forms with a necessary entropic loss from each conversion.
- "Efficiency" is defined as the percentage of energy (in Joules) directly used for the end-intended-purpose, after all losses are accounted.
- Intrinsic properties, and "spontaneous" phenomenon are superior and preferable to complex systems.
- Systemic Simplicity is innately more stable than Systemic Complexity.
- All forms of energy are ultimately expressions of the innate properties of the Atom.
- "Waste" is an unnecessary convention, but rather the reduction of complexity and conversion phases allows for a complete utilization of available energy.

The final application of this argument is the design of a comprehensive domestic energy harvest, conversion, and containment apparatus in a simplified and immediately manufacturable form; allowing for aggressive and seamless integration and economy of scale at the household level. This device is intended to be sold to the end-consumer and installed in the individual household, providing the following necessary services:

- Clean, Potable Water.
- Sewage Treatment and Reclamation.
- Ready-Energy Generation and Storage.
- Directly Available Heat energy.
- Beneficial Byproduction.

This paper will begin with a short exposition of the stated axioms before moving to a task specific application of the argument. After the narrative explanation of the application, certain design considerations, inclusive of economic arguments and obstacles, will be addressed prior to a presentation of the device. The paper will end with a short examination of the commercial and industrial scalability of the parameters.

The ultimate intention of this argument is to provide the necessary research and detail such that, granted license, anyone with suitable experience in manufacture may create, install, and operate the intended device.

Argument

Neither Created, Nor Destroyed

The fundamental axiom upon which the whole of natural science is built is the Conservation of Matter and Energy. All investigations into physical phenomena require an accounting of the mechanisms and pathways through which matter and energy flow. Stoichimoetric equations require and operate upon the preservation of mass. Even mathematics requires that the total quantity of an expression be preserved in its use in an equation. The very term 'equation' is the recognition that values cannot disappear.

Neglecting the nuclear processes of matter to energy conversion for the moment, the entirety of modern energy systems are encapsulated in three forms:

1. Chemical Energy
   The energy released through the conversion of atomic bonds.
2. Mechanical Energy
   The kinetic energy of inertia inherent in matter in motion.
3. Radiant Energy
   The oscillation of a media (including 'empty' space, and electromagnetics).

Figure 1 shows a balanced stoichiometric equation of the complete combustion reaction of Methane gas, arranged graphically as energy state of the reactants. It is shown that for one mole of Methane (CH_4) combusted in excess Oxygen (using 2 moles O_2) a first reaction reduces the energy state of the reactants by 802kJ to produce a gaseous mix of one mole Carbon Dioxide and two moles Water. The condensation of the resultant water-vapor further reduces the energy state of the product another 88kJ for a total energy-state reduction of 890kJ.

The reduction of the energy state of a chemical bond releases an equivalent amount of energy, usually in the form of radiant energy expressed as heat and light. Note that neither energy nor matter are "consumed" but rather converted. The embodied chemical energy of one mole of Methane (as a product of combustion) is -890kJ, thusly the chemical energy contained is 890kJ. Through combustion, the energy state of the Methane and Oxygen is reduced to the lower energy states of Carbon Dioxide and Water, and so the products are inherently more "stable" than the reactants. The process is reversible such that in the proper configuration, the addition of 890kJ energy to two moles Water and one mole Carbon Dioxide will produce one mole Methane and two moles Oxygen(2) - a process termed "heat of formation" illustrated in Figure 2.

The reduction of the energy state releases the embodied energy of the reactants, and the increase of energy state entraps energy in the bonds of the reactants. Thusly, an exothermic reaction is the reduction of enthalpy, while an endothermic reaction is the increase of enthalpy. At no point was matter or energy "consumed" but simply converted from the embodied energy of the chemicals Methane and Oxygen to the radiant energy of free heat and light.

Should the physical expansion of heat be entrapped, the chemical energy is converted to mechanical energy (with frictive losses) and should that mechanical energy be arranged to move a magnetic field passed a conductor, the chemical energy is conveyed into electrical energy (with inductive and resistive losses). The matter and energy are always present and neither created nor destroyed.

Returning briefly to nuclear processes, the decay of the nucleus is analogous to reduction in enthalpy in that the bonds of the sub-atomic particles are altered to release enormous quantities of radiant energy. Again, the overall quantity is conserved.

It is also worth noting at this point that at the quantum level - below the level of the atom, matter and energy become functionally indistinguishable. This is to say that all physical properties are the macro-expressions of the micro-interactions of energetic force-fields: ie. the 'physical contact' of a hammer and nail is in-fact the repulsion of the atomic field of the nail, by the atomic field of the hammer - no 'physical' contact actually takes place. From this perspective, it is apparent that what is thought of as "matter" is in actuality the presence of atomic force-fields; matter *is* energy.

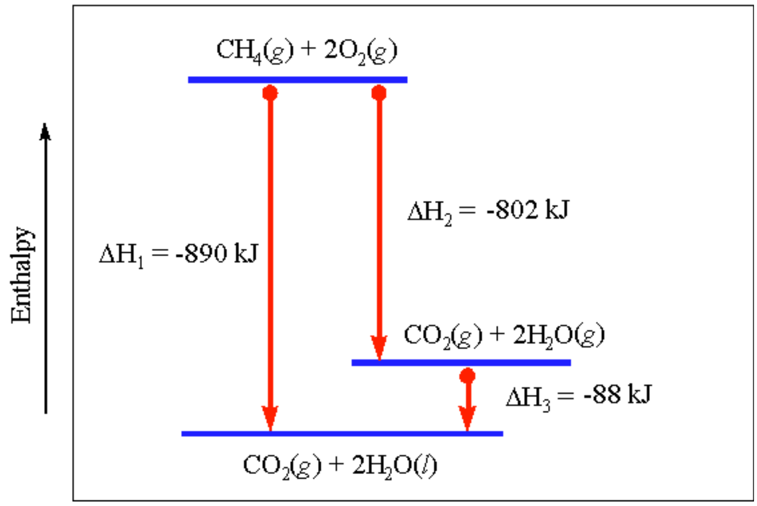

Figure 1: The Enthalpy of Complete Combustion and Condensation of Methane Gas
Energy Relations in Chemistry: Thermochemistry, Hess' Law; Avail: http://www.mikeblaber.org/oldwine/chm1045/notes/Energy/HessLaw/Energy04.htm.

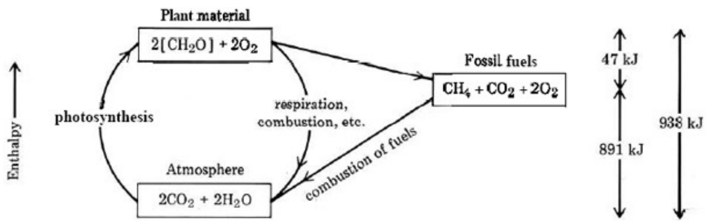

Figure 2: The Heat of Formation of Photosynthesis; *LibreTexts,* "Chemistry", 15.12 Photosynthesis, avail: https://chem.libretexts.org/Textbook_Maps/General_Chemistry_Textbook_Maps/Map %3A_ChemPRIME_(Moore_et_al.)/15Thermodynamics%3A_Atoms %2C_Molecules_and_Energy/15.12%3A_Photosynthesis

***NOTE:** The slightly different values for enthalpy from Figure 1 are the product of differing molarities of reactants.

Efficiency

For all practical purposes, 'Efficiency' is defined as "The percentage of available energy directly applied to the desired outcome". Other definitions do not take into account the Law of Conservation. Energy *cannot* be "lost" as it cannot be destroyed.

To make mention of "frictive losses" or "inductive losses" in the previous section is to account for the quantity of energy that is converted to expressions that are not used for the end-purpose. For example, a rotating shaft provides mechanical energy - but must 'loose' some of that energy in the form of oscillations in the bearing surfaces - heat - and most systems do not make use of this radiant energy in the intended output; in this example, the heat created by friction (the unintended interaction of atomic force-fields) is considered to be lost - not in existence, but rather as regarding the intended purpose.

Without regard to any system, the total energy output is exactly equivalent to the total energy input - not accounting for the intended purpose of the system.

$$ENERGY\ OUTPUT = ENERGY\ INPUT$$

Accounting for intended purpose, the efficiency of a given system is as follows:

$$ENERGY\ INPUT = USEABLE\ OUTPUT + UNUSED\ OUTPUT$$

The definition of the term "Energy" is "The ability to do work". The defined unit of this ability to do work is set as 1 Joule:

$$J = \frac{kg \times m^2}{s^2} = N \times m = Pa \times m^3 = W \times s = C \times V$$

For: J = Joule, kg = kilogram, m = meter, s = second, N = newton, Pa = Pascal, W = watt, C = coulomb, and V = volt.

And:

1 Kilowatt hour = 3.6 megajoules, and 1 cal_{th} = 4.184 joules; where one watt = 1 joule/second and one thermocalorie = heat required to raise 1g (1ml @ 1atm and 277.15°K) water by 1°K.

Accounting for Conservation:

$$Percent\ Efficiency = 100 \times \left(\frac{(Used\ Energy + Unused\ Energy)}{Energy\ Input}\right) = 100$$

Adjusted for utility:

$$E = 100 \times \left(\frac{J_{Used}}{J_{Avail}}\right)$$

It is readily apparent in the preceding equations that the only possible "loss" of energy is in the form of *unused* energy - energy available that is not applied to the intended purpose. This does not constitute a loss of energy, but rather *the absence of a use thereof*.

Intrinsic Properties

The innate characteristics of any given expression of matter constitute the basis upon which any anthropogenic system functions. One does not use a frictive material for a shaft bearing, in the same manner that one does not make use of a lubricated surface for breaking. The intrinsic properties of a material are directly employed in the use of that material. These characteristics being the intrinsic properties allows for the assemblage of systems that do not require great considerations for the desired traits.

An example of this function of matter would be to examine common construction techniques. The creation of a fire-resistant structure using flammable materials requires increasingly complex parameters to meet the original goal of fire-resistance. A super-structure consisting of Douglas-fir lumber must be coated with fire-resistant gypsum wall-board and encapsulated with fire-resistant foam and caulk. The construction of the same structure using native stone or concrete does not require such design parameters. Additionally, the use of Douglas-fir encapsulated with gypsum creates a mycophillic environment such that further design considerations must be employed to prevent the growth of harmful biotics. With lesser considerations, masonry construction is not nearly as susceptible to mold or mildew - and does not present a cellulose "feed-stock" for the toxic life-forms.

Spontaneous phenomena are they that occur without directed management; that is to say that a given configuration will act in a given manner without continued oversight. Convection is an intrinsic property of fluid matter in that the addition of radiant energy corresponds to a proportional reduction of sample density. Less-dense regions are subject to less gravitation and so will become displaced by more-dense regions, provided viscosity or other parameters allow for the motion. Adding the phenomenon of diffusion (motion from high concentration to low) to this phenomenon of buoyancy, the displacement of matter through convection induces a flow of replacing matter of greater density - provided no external factors prohibit such flow. These two phenomena acting in balance comprise the process known as a "thermo-siphon".

In examining certain ventilation practices, it is seen that the circulation of air (for this example - warm air) is forced through a fan from registers in a ceiling. The warm air is buoyant over the cooler air and so will remain near the top of a room unless acted upon by another fan. Under this configuration, the air tends to stratify and stagnate unless further energy is used against the natural gradient.

A spontaneous design would account for the buoyancy of the warmed air and so inject it at lower regions of the room, so that it rises of its own accord and both agitates the air above (preventing stratification) and draws additional cooler air into the upstream portion of the system (reducing the energy required to provide cooler air to the heating apparatus). In this configuration, energy is not required to provide motion against the natural gradient of convection, and so the system is inherently more stable and less energy demanding.

The intrinsic properties of matter and spontaneous phenomena that arise from them constitute a more stable and less demanding overall system.

Systemic Simplicity

A single moving part requires considerations for the reduction of friction, and creates inescapable wear. An active safety system, especially those that rely on moving parts, are only as effective as the weakest and most poorly designed portion of the system. The most obvious and undeniable example of this axiom is in the use of active cooling systems used in the Fukushima-Daiichi nuclear power plant. While functioning correctly, the safety systems functioned correctly. With the loss of electrical power for coolant pumping, a redundancy in the form of diesel-driven pumps activated as per design. The event that led to the loss of electrical power however also led to the inundation of the diesel engines. The reactor could not be controlled without active energy input.

Some reactor designs provide a "sodium plug" that melts of its own accord at a given temperature, and so passively stops the reaction without any oversight or energy input. Such a system is inherently more 'safe' due to the simplicity of a material melting at a given temperature, rather than the complexities of sensors, switches, internal-combustion, plumbing, and a fragile electrical grid exposed to unpredictable natural events like a tsunami.

Such simplicity actually moderates nuclear reactions in nature. In the case of Oklo, Gabon, the rise of ground water created a spontaneous neutron moderator such that the naturally occurring Uranium 235 was able to sustain a fission reaction. As the heat of the reaction accumulated, the water evaporated and so ceased acting as a neutron moderator and thereby stopped the reaction. The strata would cool and additional groundwater would flow into the region to begin the reaction again (https://www.scientificamerican.com/article/ancient-nuclear-reactor/).

It is apparent that simplicity in design is directly proportional to stability of process.

Innate Properties of the Atom

The essence of this particular axiom has already been demonstrated in the previous arguments. The actions within a nucleus dictate the properties of electromagnetism and chemical reactivity. More than this, the phenomenon of the photo-electric effect - and its derivative photovoltaics - is the direct product of the interaction between a photon, and an electron, owing to the intra-atomic forces involved with electron energy states.

This argument is presented separately as the essential foundation for the thesis of this paper. If Silicon atoms did not have semi-conducting properties, there would never exist a silicon semi-conductor. Even the so-called 'synthetic' compounds and elements are the simple product of the innate properties of matter - which is to say energy.

Energy (and its matter expression) is the fundamental natural, and thusly all actions, interactions, and reactions are natural phenomena.

The Non-Existence of "Waste"

The concept of "waste" is entirely anthropogenic. This axiom is self-evident and does not require exposition. Anything termed 'waste' is simply a quantity of matter or energy for which there is not a predetermined desire. The waste of one process constitutes the requisite of another, and so the ideal of 'waste-disposal' is indistinguishable from the concept of resource-irresponsibility. Waste does not exist.

The Apparatus

A device intended for domestic installation was considered. This device, as stated previously, is to provide:

- Clean, Potable Water.
- Sewage Treatment and Reclamation.
- Ready-Energy Generation and Storage.
- Directly Available Heat energy.
- Beneficial Byproduction.

These products/services are to be provided using forms of energy commonly available on site with the intent to reduce or eliminate added energy sources such as fuel or municipal electricity, and also must be formatted into the common domestic energy expressions: gas-fuel, 110VAC, potable water, domestic hot-potable water, and domestic heating/cooling.

Some domestic services such as ventilation and lighting are more efficiently generated using architecture or low-voltage electrical supplies as a means of avoiding conversion losses and unused heat generation as is the case with electrical fans and AC lighting. It is assumed that the domestic environment into which this apparatus is installed will take advantage of less energy-demanding architecture and engineering, thus reducing the overall requirements.

The energy inputs available at any given site, in varying quantities and qualities are: Solar thermal and luminescent energy, wind energy, and bio-gas production. The examination will begin with the bio-gas.

Biogas

Bio-gas is a byproduct of the anaerobic biological decomposition of biological waste. The term refers to the raw product from the process, prior to any benefaction or concentration, and on average is comprised as follows:

Methane (CH_4) 40-75%
Carbon dioxide (CO_2) 25-55%
Hydrogen sulfide (H_2S) 50-5000ppm
Ammonia (NH_3) 0-1%
Water (H_2O) 0-10%
Nitrogen (N_2) 0-5%
Oxygen (O_2) 0-2%
Hydrogen (H_2) 0-1%

Source: Renewable Energy Concepts: http://www.renewable-energy-concepts.com/biomass-bioenergy/biogas-basics/gas-composition.html

The target product is the Methane gas - a simple gaseous hydrocarbon fuel termed "Natural Gas" when derived from other sources - and must be separated from the other non-combustible or corrosive components, and concentrated into a denser format suitable for storage and combustion. The feed-stock for the production process is household biological waste including erated kitchen and yard waste but excluding urine, which is diverted from the source to other more suitable uses.

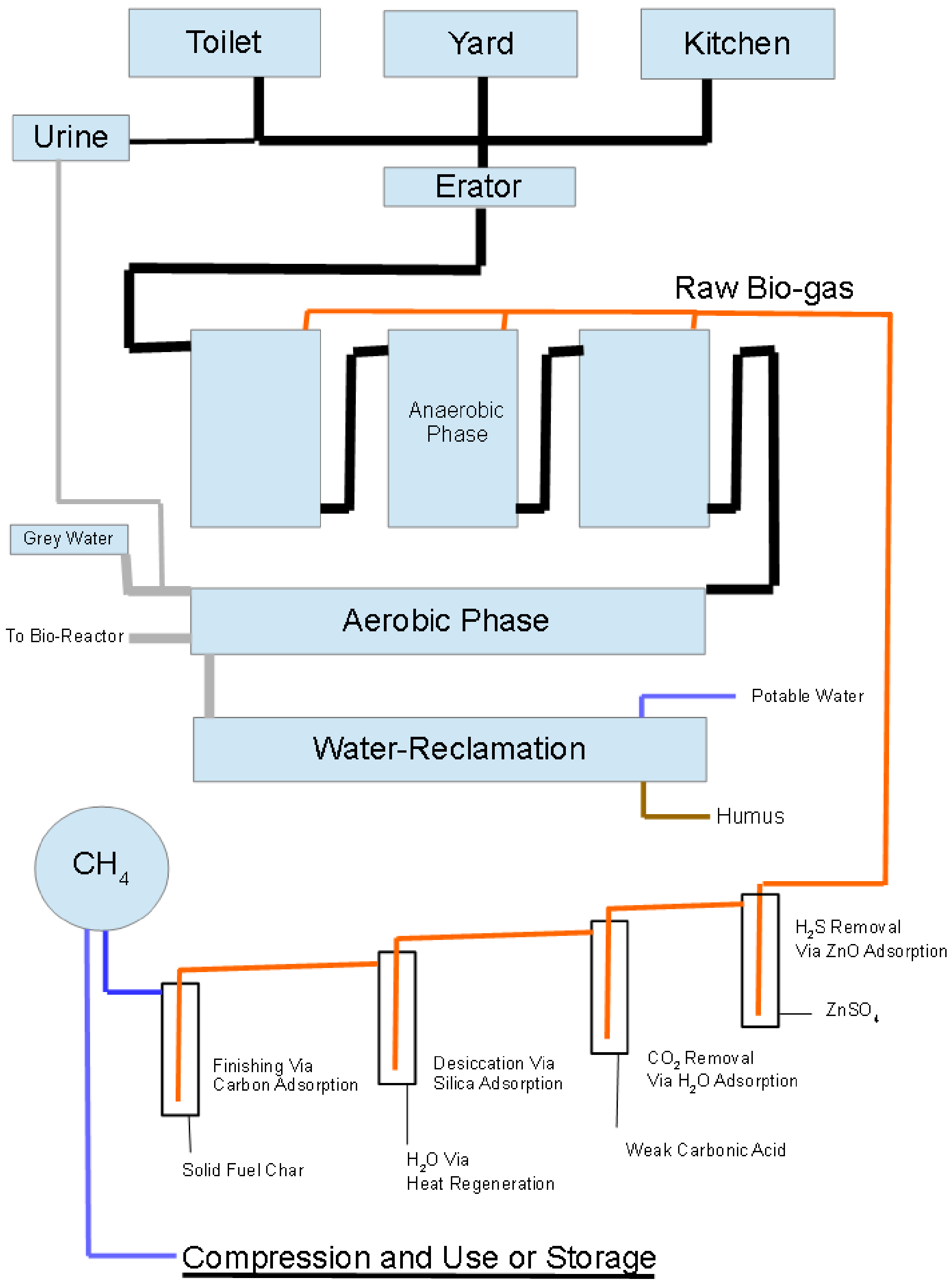

Figure 3: Methane Production and Benefaction System Diagram

The biological waste of the household is collected at the point of production. The toilet is run through a urine separation system and the urine is diverted into the grey-water bypass system. The kitchen and yard waste are collected through secondary hoppers in appropriate locations and combined with the solid sewage from the toilets before running through an electrically or mechanically powered erator-pump to create a slurry. The slurry is digested in a three-part cascade anaerobic digestor. Each chamber of the digestor is agitated at low-speed to prevent scum build up. The bio-gas is produced in this phase, and run through four filters for concentration and benefaction.

The slurry exits the anaerobic phase to enter the aerobic phase where it is combined with the grey-water bypass. Air is pumped into the chamber via a wind-driven, steam, or electrical aerator and methane production is stopped as the slurry is biologically converted to water, aqueous ammoniates, and humus. A portion of the water and aqueous ammoniates are pumped to the exhaust-scrubbing bio-reactor as a nutrient solution, while the bulk of the slurry runs to water reclamation. In water reclamation, the slurry is either used as a media in which to grow any number of crops, or dehydrated via solar-distillation into solid concentrate humus, with the water being collected for use as a potable supply.

The raw bio-gas first runs through solid Zinc Oxide to catalyze the Hydrogen Sulfide into benign Zinc-Sulfide (a phosphorescent compound of many uses). The bio-gas is then percolated through distilled water to catalyze the Carbon Dioxide to produce a weak solution of Carbonic Acid (useful as an electrolyte in a battery system, and diverted to the in-system battery storage array). The bio-gas is then desiccated through Silica beads (that are periodically regenerated by low-grade waste heat from other parts of the apparatus, the water vapor being collected as a source of potable water) and finally finished via Activated Carbon. The saturated activated carbon may be periodically used as a solid fuel in a boiler or other furnace - or used directly as a soil amendment as it is biologically beneficial.

The bio-gas is at this point nearly pure (>95%) Methane and may be used in any appliance configured for use with Natural Gas. The Methane is compressed and stored on-site for any variety of uses.

The system is sized such that the Anaerobic phase is equivalent to 30 days worth of waste production on site, with the Aerobic phase being equivalent, with a suitable margin for increased production (~10%). The benefaction system is a flow-through design and as such is of a lower capacity, each part being approximately 1% the volume of the Anaerobic Phase.

> One human produces 0.25 lbs of volatile waste per day that can be fully utilized in the reactor. [6-8] The mass branching ratio between methane and carbon dioxide is 0.35. With a conservative estimate, 50% of the waste will burn as methane, which has a specific heat (amount of energy released when the material is ignited) of 5.55×10^4 kJ/kg. [1] The usable energy one human produces in one day is

$$\frac{.25 \text{ lbs/day}}{2.205 \text{ lbs/kg}} \times 0.50 \times 0.35 \times 5.55 \times 10^4 \text{kJ/kg} = 1102.2 \text{ kJ/day}$$

> Source: Design of a Household Human Waste Bioreactor, Paul Andrew Cook, 2010
> http://large.stanford.edu/courses/2010/ph240/cook2/

The specific amount of energy available through the production of Methane gas in this manner is specific to the particular installation, and the given amount of yard/kitchen waste added to the system. Additionally, some households produce greater quantities of oils and fats in the sewage outflow, necessitating the installation of a grease-trap prior to the Anaerobic Phase of the system. These considerations are site-specific, as is capacity, and so cannot be addressed in this design.

Raw sewage and raw bio-gas are corrosive and hazardous substances requiring specific design considerations, notably the use of ABS and HDPE materials. Air infiltration must be prevented and so the Anaerobic Phase is kept completely flooded, also creating a slightly increased pressure to assist the flow of the gas from the system. Methane produced is stored in suitable vessels.

Heat Energy

The next subsystem in the Apparatus is the boiler. The purpose of the boiler is to create both the steam energy required for on-demand electricity production, and heated water for use in an hydronic heating system, in addition to other byproducts.

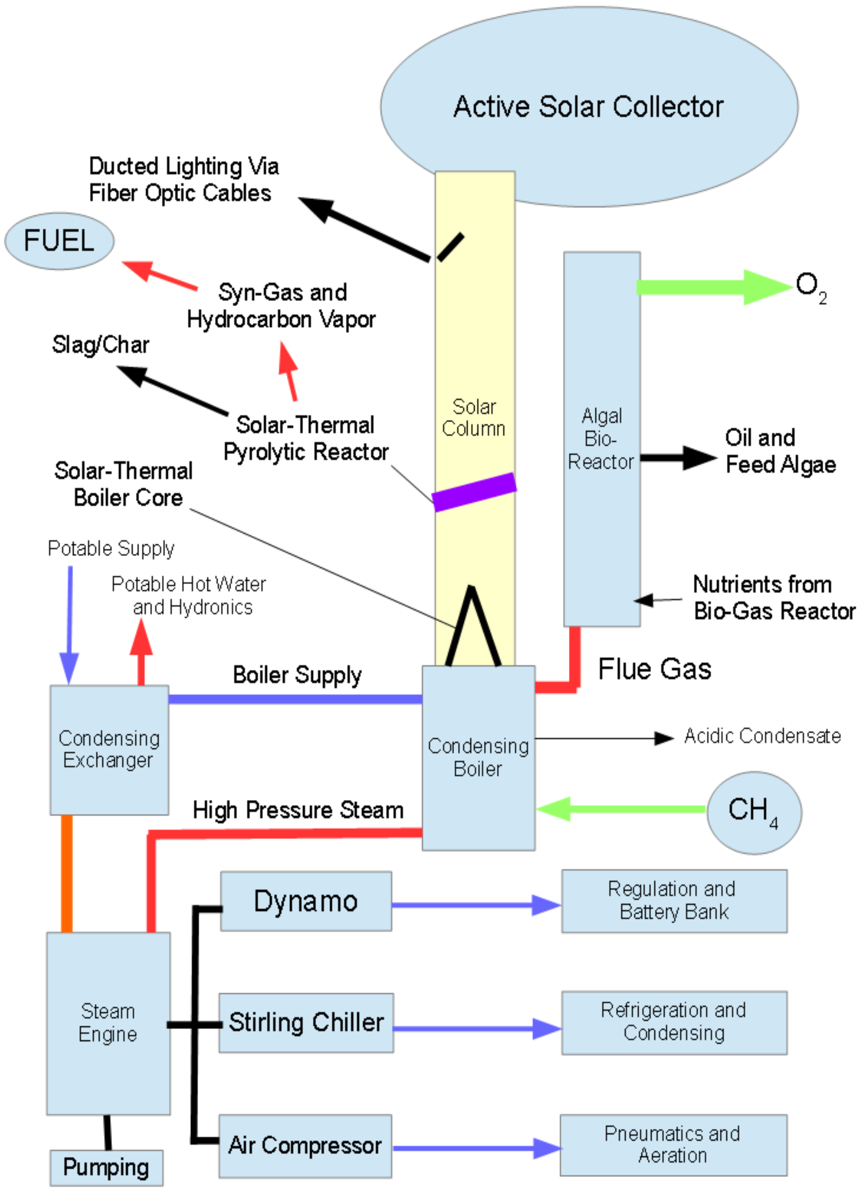

Figure 4: Heat/Steam System Diagram

The methane produced by digestion of sewage is used as the primary fuel in the condensing mono-tube boiler. The flue gas of the boiler is low-grade heated and may be directly injected into a solar-exposed algal bio-reactor for conversion to algae-based products and purified O_2. The algae may be used as a soil-amending fertilizer, an agricultural feed-stock, or as a precursor to the production of bio-diesel fuel-oil, or solar-thermal-catalyzed bio-crude oil. Condensing boilers produce weakly acidic condensate of negligible quantity that may be incorporated as an electrolyte in a battery system.

High-pressure saturated steam from the boiler is used in a radial steam-engine to produce rotational energy. The engine drives a dynamo to produce electricity, a Stirling-cycle chiller for direct expansion-based refrigeration, an air-compressor for pneumatic energy and aeration of other sub-systems, and various small pumps for circulating working fluids.

Generated electricity is sent to the battery subsystem. Chilled brine is used as a refrigerant for domestic food preservation, air-conditioning, and for condensers in other sub-systems. Pneumatic energy is used for sub-system actuators and boiler combustion-air, as well as aeration of the bio-gas system.

Hot-water outflow from the boiler is condensed in an exchanger to produce domestic hot water and hydronic heat, before returning to the boiler at a lower temperature. The working fluid of the boiler/steam engine sub-system is deionized water and is a closed system.

A large, elevated, double-reflecting parabolic dual-axis active tracking solar collector concentrates and directs sunlight into the solar column. The solar column is insulated from the weather by use of Aluminum-Oxy-Nitiride (ALON) ceramic windows for superior energy transparency. The column is an insulated, reflective duct adapted from "Sun-Tube" skylight systems.

A small reflector collects a percentage of the concentrated sunlight and directs it to low-grade optical fibers to be used as ducted-lighting for simple lighting applications. The fibers may be run in the same manner as low-voltage wires, with light fixtures consisting of a manually operated shutter ("light-switch") and a prism/diffuser to scatter the light. This configuration allows for natural sunlight to be ducted throughout a structure.

A rotary kiln consisting of a coaxial vacuum chamber serves as a solar-thermal Pyrolytic reactor. The outer tube of the reactor is ALON (for transparency) with the inner tube consisting of fused aluminum-oxide (sapphire) coated externally with Vertically Aligned carbon Nano-Tube Array (VANTA) for superior thermal collection and transmission. The space between the inner and outer tubes is evacuated, and the interior of the inner tube acts as a channel for shredded non-biological household waste to slowly pass as the reactor rotates. The extreme temperature within the inner tube, with oxygen deficiency, thermally decomposes the shredded waste into hydrocarbon vapors, syn-gas, and slag or char. The hydrocarbon vapors may be fractally distilled into fuels and paraffins, and the syn-gas may be used directly in the boiler. The slag or char is inert, and may be used in any number of applications - including as a resource-rich ore or (in the case of char) as a solid fuel.

The end of the solar column is the Solar-thermal boiler core, of similar construction to the Pyrolytic Reactor and integral to the central boiler, allowing for operation of the system without combustion as weather permits, and acting as supplemental heat at other times - while solar energy is available.

The capacity of the boiler is not tied to the Methane production, but is somewhat related in that the Methane serves as the primary fuel source. Secondary fuels for the boiler include Pyrolytic Syn-Gas, waste oil, and combustible solids not used in pyrolysis - including char produced by pyrolysis of biological materials and spent carbon from the bio-gas benefaction system. Many substances (plastics, foams, etc) should not be combusted as the production of certain flue gasses will harm the algal culture. Hydrocarbons and cellulose are the expected ancillary fuels.

The capacity of the heating and steam-generation system are directly related and should be sized according to the expected electrical demands of the household. As day-time lighting and refrigeration are supplied through alternative means, it is not necessary to account for the greater demands of electrical energy in the developed household: ie. there is reduced lighting demand during the daylight (in dark areas of the house), there is no refrigerator compressor to power, and no air-conditioning system. Domestic cooking is accomplished with Methane, and a larger optical conduit may be run from the solar column specifically for solar-cooking in the kitchen - it is not necessary to have an electrically powered stove or oven, and further, hydronics and water heating are byproducts of the process, and so there is no need for bulk electrical heating systems. Ventilation may be accomplished via passive architectural parameters, thusly reducing the need for electrical ventilation.

The Stirling refrigeration cycle is exceedingly efficient as it makes direct use of rotational energy to repeatedly expand a working gas, and the refrigerant brine is circulated via a mechanically driven pump integral to the steam-engine system. This method of refrigeration produces cryogenic-level cooling that allows for a dramatic thermal differential, thereby allowing for greater cooling capacity in a small physical format and providing for the possibility of increased Carnot-efficiency in thermal differential sub-systems such as the steam engine cycle. It is used in an on-demand basis, and should a cold-capacitance tank (heavily insulated ice box exchanger) be integrated into the system, all the necessary cooling may be created and stored during peak solar periods. This method completely avoids electrical conversion losses regarding all refrigeration.

The brine refrigerant may also be integral to atmospheric water harvest by means of a wet-desiccant system, as well as serving as a chilled electrolyte for saline-based batteries. In this configuration, cold-capacitance may be integrated into the saline-based batteries, increasing the adsorption efficiency of the desiccant, regulating the discharge heating of the batteries, and reducing physical complexity and maintenance by using one working fluid for no less than three sub-systems. Saline batteries are reported by Aquion Energy (https://www.solarquotes.com.au/blog/aquion-salt-water-battery/) to operate satisfactorily down to -5ºC - well within tolerance for a suitable cold-capacitance tank (~0ºC - ~+5ºC - the ideal temperature of a refrigerator) that is kept slightly warmer than the working refrigerant.

The pneumatic function of the system produces bulk air for combustion, and may be used for forced ventilation of the battery compartment, as well as serving to move air throughout an atmospheric water-harvest system - which in turn supplies chilled, anhydrous, pressurized combustion-air to the boiler allowing for maximum combustion efficiency via oxygen density and reduction of enthalpy of evaporation in humid combustion-air. Additionally, several servo mechanisms are necessary throughout the apparatus for the automation of the various processes, and the use of low-wattage electrical valves allows for pneumatic operation, reducing the energy requirements for the operation and automation of the apparatus as a whole - allowing for greater output-to-demand efficiency, as well as home-automation amenities such as automatic windows, doors, and vents.

The algal bio-reactor is intended for the benefaction of flue gasses and thusly all algae production is a beneficial byproduct. The algae has several uses from extended refinement, but is environmentally benign and beneficial in its native state. This byproduct may be consumed as a dietary supplement, used as animal feed, or even dumped as-is directly into soil and is wholly beneficial to the natural environment with certain simple considerations. The algae may also be dried and burned directly as a solid-oil-rich fuel.

Wind-Energy

The next sub-system of the apparatus is the collection of wind energy for use as both electrical generation and rotational energy for other sub-systems.

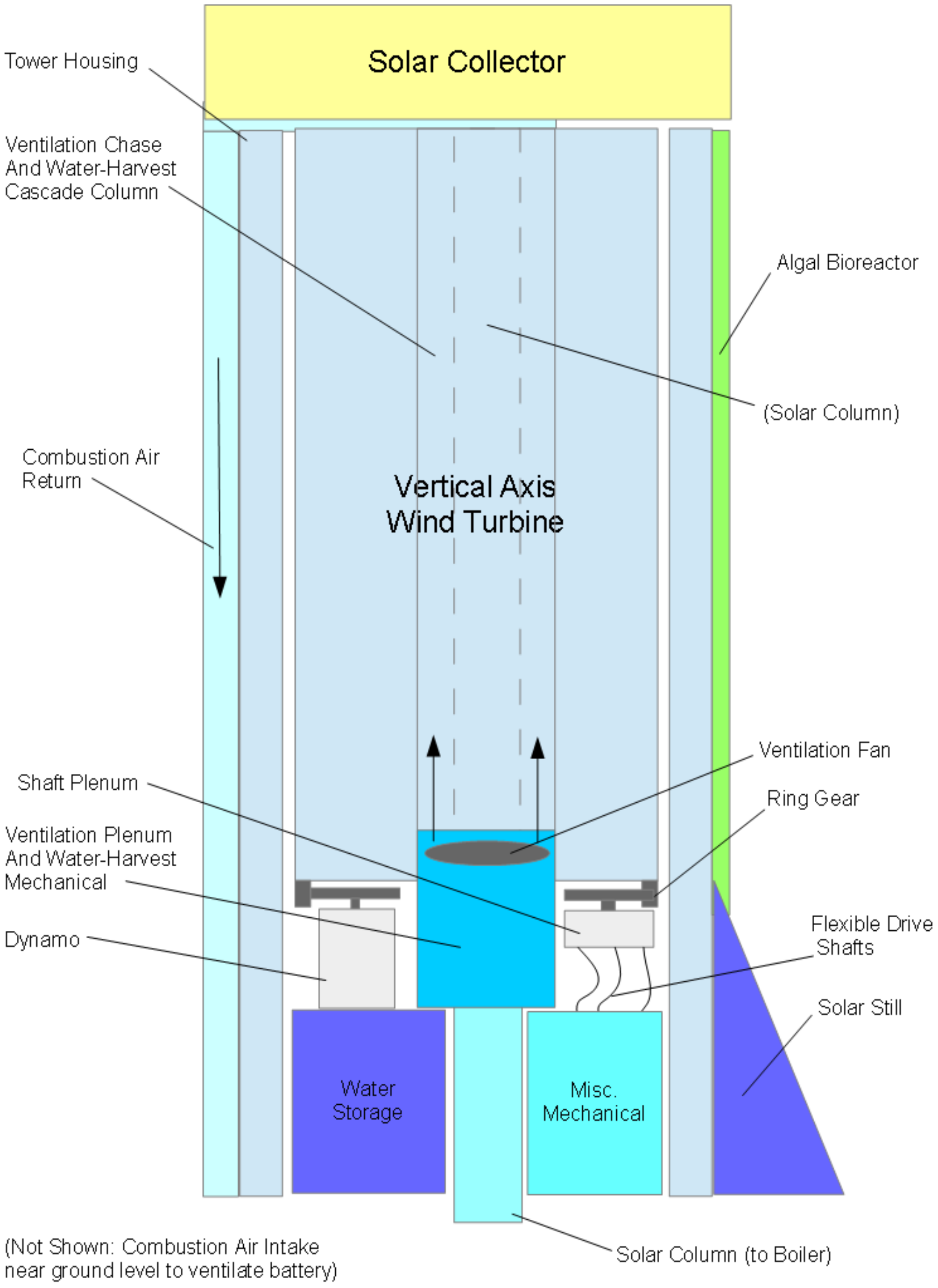

Figure 5: Wind Energy System Diagram

This sub-system is centered around a vertical axis wind turbine (VAWT) enclosed in a tower structure. This configuration is able to accept wind from any direction and, being enclosed in a tower, does not present the hazards or maintenance associated with axial turbines. Vertically arranged windows allow wind entrance and are closed via pneumatically actuated veins that, when extended, capture a larger surface area of wind. When closed, the VAWT is deactivated without regard to current wind conditions, and the veins allow for active throttling of the turbine by allowing for variation of wind captured.

At the base of the turbine, a ring-gear allows for power take-off for an array of dynamos and a rotational shaft plenum. Flexible shafts deliver rotational energy to other sub-systems and the dynamos produce electricity for storage in the battery system. Coaxial to the VAWT, the solar-column delivers solar-energy to the boiler sub-system. Surrounding the solar column, the combined water-harvest cascade column and ventilation chase allows for liquid desiccant to fall against a counter-flow of air (drawn from the exterior via the battery chamber) to adsorb latent humidity and cool the flow of air.

The desiccated, chilled air is then returned to the boiler via the air-compressor. This primary ventilation/combustion air feed is forced via a direct-drive fan attached to the VAWT, with ancillary electrical back-up fans installed elsewhere in the system. The exterior intakes for this air-flow may be incorporated into the boiler heat-exchanger to assist in warming the air prior to ventilating the battery, and cooling the boiler output. Any oxygenated di-hydrogen gas (HHO) produced by the action of a saline battery is removed from the battery chamber, de-humidified, and serves as an additional combustion source in the boiler. Additionally, the purified O_2 output from the algal bio-reactor may be incorporated into the ventilation air-flow so as to increase the O_2 content of the combustion air, as well as reclaim as a potable supply the humidity generated in the bio-reactor. Water produced via HHO combustion is negligible and is condensed in the condensing phase of the boiler without any additional design parameters.

A solar still is attached for passive distillation of non-potable water into a potable supply, being circulated via a pump driven with a flexible shaft from the shaft plenum. The saturated brine from the water-harvest cascade is fed as a secondary non-potable supply into the still where the captured potable water is extracted - it is kept separated from other non-potable supplies so as to preserve the electrolytic/refrigerant properties of the brine. Other sources of non-potable water include spent nutrient solution from the algal bio-reactor (including algae, and thereby dehydrating the algae for use) and outflow from the Bio-gas sub-system and grey-water. The in-flowing non-potable supplies are first run between the double-pane glass cover of the still to assist in the condensation of the potable evaporate on the inside of the glass due to the less-than-ambient temperature cooling effect of the in-flowing non-potable water. The still may be supplementally heated via waste heat from the boiler sub-system.

The dynamos may be of an axial-flux configuration and constructed as integral to a mag-lev bearing surface for the base of the VAWT. This configuration would decrease the design complexity of the dynamo - requiring no brushes or commutator, as well as decrease maintenance for bearing surfaces of the VAWT itself as such surfaces are nearly eliminated save only for the gearing-mesh for the shaft plenum (which may also be magnetic, thereby totally eliminating wear-surfaces in the VAWT).

The efficiency and utility of this sub-system increases proportionally to size, similar to the effective area of the solar collector mounted on the top of the tower. It should therefore be constructed as large as is acceptable under site-specific and architectural design constraints. This diagram may appear to be visually displeasing, but the tower may easily be designed and constructed in such a manner that it is very similar in appearance to a light-house, grain silo, belfry, or Victorian turret - all of which are used in aesthetic architectural designs. With suitable considerations, the tower may be quite appealing, and may not even appear to be any sort of mechanical apparatus.

The Battery

The primary electrical storage sub-system of the apparatus is a so-called "salt-water" battery. The electrolyte may be the refrigerant brine used in other sub-systems, ideally a saturated solution of $CaCl_2$ (due to its ancillary use as a wet desiccant) with a carbon anode and a manganese-oxide cathode. This configuration is reported to be essentially stable under normal conditions, and is reported by Wikipedia to give an energy density of ~100 watt-hour/kg with an NaCl electrolyte. The use of a calcium-salt solution electrolyte is not well documented, but is selected due to its superior hydroscopic properties and deep freezing point (-50ºC, as opposed to -21ºC for Sodium-salt solutions). The electrodes of the system are completely benign in the environment - MnO being a dietary mineral, and carbon a soil ammendment - and may be replaced and disposed of without difficulty.

Individual cells of the system are rectangular high-density polyethylene plastic with HDPE hangers for electrodes. The electrodes are quilted rayon pouches containing powdered materials for superior surface-area, and are arranged in alternating fashion from anode to cathode, with 316 stainless steel terminal buses. Cells are connected in series into nodes of target voltage, and several nodes are connected in parallel to increase current capacity.

Saline battery systems are large and heavy and so are placed in a purpose-built foundation for the super-structure of the apparatus, at the lowest point. Several dozen nodes are arranged to create a large storage capacity and, as this portion of the apparatus is entirely below ground level, temperature is moderated by earth-thermal capacitance. The battery chamber, being thermally stable and actively ventilated, contains all necessary regulation electronics for the electrical supply including charge control and inversion. The extreme upper end of the nodes are open to allow ventilation of any possible HHO gas generation, as well as to allow for circulation of the brine to other sub-systems. Electrodes may be extracted and replaced or maintained as necessary with minimal protection due to the minor difficulties in working with brine.

The design service of the battery is dependent upon the total energy-demand of the household, expecting at least 72 hours of no solar or wind energy input. As saline batteries may be entirely discharged without major degradation of their future performance, a relatively small margin of ~5% may be used in the design parameters; this makes the total energy capacitance 72 hrs of need + 5%.

Algal Bioreactor

Current systems of algal bioreactors make use of large diameter glass or plastic rigid tubing. It has been found in numerous tests that the density of the culture decreases with the amount of water having been penetrated by the incident sunlight. It is therefore ideal to use smaller diameter tubing, arranged in an ascending, winding manner, so as to maximize sunlight exposure of the culture. This arrangement allows for long lengths of less expensive plastic tubing, with some considerations for UV stabilization. As the reactor is exposed to environment, it is necessary to use double-wall tubing for thermal insulation against freezing.

An alternative configuration is analogous to a large triple-pane window. Simple long and thin flat panels are arranged in such a manner that the first two panes comprise an insulating layer from freezing, and the space between the middle pane and the rear comprises the reactor chamber - being about 3cm in thickness. The rear wall of the chamber need not be constructed of glass, but such would be most durable. The sides and rear of the reactor are insulated. This configuration does increase the reflection of sunlight as the angle of incidence changes throughout the day (this being the reasoning for the use of round tubing), but algae does require a certain moderation of sunlight. Through numerous accidental algal-cultures in home fish-tanks, it is conclusively demonstrated that the use of flat panels is in no way detrimental to algal growth. This configuration would be less expensive and easier to maintain than a tubing arrangement, and so is recommended.

The ambient heat of the flue gasses exiting the condensing boiler is well within tolerance, as is evidenced by the use of plastic exhaust lines in domestic condensing boilers. It does not present a difficulty. Further, the intrusion of the flue gasses aid in the agitation of the nutrient solution, increasing surface contact and therefore health and efficacy of the algae.

The nutrient solution is intended to be a dilute concentration of human urine. Human urine has an N:P:K value (average) of 11:1:2.5 (Source:http://www.goveganic.net/article217.html) and as a dilute liquid is ideal for the production of many usable crops, including algae. The urine is collected from the waste stream of the household and pumped into the bioreactor. Spent nutrient solution is dehydrated in the solar-still, and concentrated solution is returned to the aerobic phase of the bio-gas system.

The bioreactor is partially emptied and refilled on a regular, automated basis to maintain CO_2 benefaction. The outflow, as stated previously, is benign and quite useful - with the water being extracted as a potable supply.

Steam Engine

The steam engine is of a radial configuration, consisting of five, seven, or nine cylinders. This design is inherently balanced and dramatically reduces the number of parts, as well as increasing main bearing life by allowing the use of sealed roller bearings, as opposed to fluid layer babbot metal through its mono-planar design.

The piston rings are to be constructed of a suitable alumina ceramic, with the cylinder sleeves being a nano-diamond coated steel for increased wear resistance with a minimum of lubrication. The lubrication is carried within the de-ionized water used as the working fluid, possibly allowing for a permanently lubricated piston arrangement that does not require the compromises common to PTFE "oil-less" pistons.

The engine operates on a single axial valve face, having an intake and exhaust gallery of a suitable elliptical dimension such that two to three pistons are pressurized in sequence, with several others being open to lower pressure. The face of the valve is to be constructed of a suitable alumina ceramic, with the body of the valve being nano-diamond coated steel.

The dimensions of the thermally exposed wear parts must be designed such that the ideal fit is only encountered at operating temperature and pressure. While this would allow for a large amount of blow-by (requiring crankcase and valve-housing drainage and reclamation) it increases the wear life of the machine, and causes it to capture greater pressure under the higher operating temperatures.

The drive train of the steam engine assembly is a constant mesh herringbone gear system or direct shaft coupling depending on the driven accessory. Each accessory has a specific operation RPM and may be activated via a magnetic-to-mesh clutch if necessary. The steam engine is optimized to run at constant 3600 RPM for 60Hz AC generation.

Discussion

It is clear that a great deal of mechanical and electrical parameters must be met for the construction of the apparatus, and these considerations would comprise the greater part of the actual design. As the apparatus is site specific, this paper has given the design in an intentionally vague manner; the apparatus is directly scaled to expected demand.

The whole intention of this paper is to present the possibility of exploiting natural and spontaneous phenomena in a manner that would provide the essential necessities in a domestic environment. As such, this argument does not represent any attempt to address larger bulk energy needs, but rather to simply supply, on a case-by-case basis, the primary necessities of a developed residence. It may be specifically tailored to meet the needs of small to mid scale commercial applications by the inclusion or exclusion of specific sub-systems, but as such it is assumed that this application does not rely on any measure of municipal or centralized energy distribution networks.

In the case of installation where distribution networks are already in place, some considerations would allow this apparatus to be directly tied to these networks in a manner that would make "the grid" (electrical, gas, water, sewer) ancillary to the domestic requirements and, more than this, should a certain critical mass of these apparatus be installed in a limited geographic region, it becomes unnecessary to make use of centralized generation stations as each apparatus supplies a small surplus that is dumped to the "grid" to supplement those areas that are producing less than the current demand - each house in essence becomes a complete generation station in its own right, and only relies on the supplied surplus as becomes necessary during certain environmental conditions that reduce production.

While it is certain that many will take issue with the liberties used in the definitions in the argument section, it is shown (specifically in the definition of "efficiency") that the use of a different perspective allows for the supply of needs and whole-system approach in a manner that is not anticipated by the insistence on strict guidelines for what are, essentially, anthropogenic definitions. This argument is not intended to solve any conception regarding energy supply and demand, but rather to demonstrate that there are naturally occurring phenomena that, should they be facilitated and maximized, comprise the entirety of what is needed for a developed household - and further, that a complete approach, freed of arbitrary definitions, allows for the realization that "waste", "pollution", and "emissions" are nothing other than squandered resources - to be maximized and exploited to the extent possible, rather than vilified and legislated. It is entirely unnecessary to conflate engineering problems with political issues - and doing so preemptively retards the ability to solve these "problems" and in fact perpetuates them. The entirety of domestic energy may be supplied without any reference to large corporations or impotent bureaucracies - those are the true source of "entropy" in domestic energy systems.

One most obvious objection to this argument would be the imagined complexity of the system. As the apparatus may be employed in whole or in part, having been tailored to end-use, this argument does not obtain. The entire system as outlined herein, inclusive of the more "exotic" materials and solar-thermal pyrolysis reactor, is an order of magnitude less complex than entry-level hybrid vehicles that are mass-produced and purchased in quantities surpassing the hundreds of millions. The entirety of obstacles to solving these simple engineering issues are described as lack-of-will.

As of the time of this writing, the author is undertaking to construct such an apparatus and, with certain exceptions (lack of economy of scale, due to a one-off build) the whole system is to be constructed for $10,000.00 - less than a small car to provide all energy needs.