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Infoenergy: Technology for Replacing Massive Degradation with Speedier (Cleaner) Energy

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ABSTRACT: This paper provides an information technology perspective of energy that can help explain and promote more environmentally friendly energy sources. Following the equation energy equals mass times velocity squared ($E = m * v^2$), a source 10 times more massive will produce 10 times more energy, but a source 10 times faster will produce 100 times more energy. Since chemical sources such as oil combustion are about ten times faster than mechanical sources such as waterfalls and winds, getting the same quantity of energy out of wind would require 10 times more mass (steel and concrete for wind towers), than getting it out of burning oil (CO2 and oil plants materials). A nuclear source is one million times faster than chemical, thus its mass requirement is negligible but technology (mainly information technology) is needed to safely drive its speed allowing us to substitute mass -i.e. future debris- with information.

Keywords: energy, environment, information technology, nuclear, quadratic contribution, energy technology, clean energy, matter minimization
JEL Classifications: H00; O10; O33; Q29; Q39; Q42; Q43; Q48

1. Introduction

Matter is shown as a superposition of equilibriums between the fundamental forces of nature (gravitational, electromagnetic, and nuclear). These equilibriums of forces are potential energy ready to cause spatiotemporal changes on its own or on other matter when, for any cause, the equilibrium is broken. The physical formalization of this relationship between matter and energy is shown by the family of equations of the form $E = m * f(s,t)$, where E represents the energy, m the mass, and f(s,t) is a function of space (s) and time (t).

Three levels of energy sources are defined according to the amount of mass from which a unit of energy derives: mechanical (water dams, winds, tides), chemical (fresh or fossil organic fuels) and nuclear (fission and fusion fuels). Some numeric references are considered: to produce the same amount of energy a water fall requires a water mass (falling from 100 meters high) from ten to one hundred times larger than the mass of chemical fuel (oil) required by a gasoline engine which in turn is one million (10^6) times larger than the amount of nuclear fuel required by a reactor to produce that same amount of energy.

A correspondence is presented between these levels and the common classifications of energy in the environmentalist literature (chemical, solar, nuclear, and alternative). At the same time it shows that the less massive energy sources, regardless of their classification, provide a higher margin for technology to prevent, after energy is extracted or produced, matter from becoming an environmentally detrimental waste (such as CO_2 and radioactive debris) or a degraded part of the environment (such as the eventually damaged parts of the basin of a water flow once it is dammed for massive hydroelectricity production).

Finally, it characterizes massive energy as Goliath while informed and smart energy as David meaning that in order to produce more clean energy and use less matter we need more technology or, essentially, more information. Information is presented as a likely function of space and time (i=f[s,t]) and we conclude that energy is a function of mass and information (E=m*f[i]), which in turn is a good stake for future development for physicists, engineers, environmentalists and sustainable energy entrepreneurs.

2. From Fundamental Forces to Useful Energy

Energy is needed by all living entities, including humans, as the food or fuel that sustains life. It is also needed to feed the machines that transport and transform matter –meaning the whole material environment- as well as regulate the temperature and illuminate it. The word energy originally meant a force that is assumed to be stored in some matter, such as our muscles. That is because we see it moving and we do not see any external cause. The external or profound cause is the previous formation and posterior rupture –whether controlled or not– of a chain of equilibriums of fundamental forces.

Place a small obstacle in the middle of a quiet river or a fluid highway and you will probably observe that the flow bifurcates and then the sub-flows reencounter while forming transitory blockages, maybe backflows, whirls, accretions, etc. These formations are temporal and dynamic equilibriums of partially opposite sub-flows. Physical waves, particles and even matter are sometimes interpreted as temporary equilibriums between the sub-flows or backflows that we call gravity, electromagnetism, and nuclear forces supposedly originated by an infinitesimal imperfection of an alleged primary and fundamental force of the universe (Mosterín et al., 1991; Weisskopf, 1980).

Matter is formed by superposed levels of fundamental equilibriums. The atomic nucleus is a balance between nuclear and electromagnetic forces. The molecule is a more complex electromagnetic array of two or more complementarily and partially unbalanced atoms. Macroscopic matter is an aggregation of molecules cohered, similar to the atoms inside a molecule, by complementary electromagnetic unbalances and helped by some topological complementarities. Finally, the large constructions made of macroscopic bricks of matter are usually static or dynamic equilibriums between molecular arrays, gravity, and aggregations of forces that we call mechanical forces. The equilibriums of forces can be broken by the incidence of an additional and relatively small force. Fracture a single column and the whole building can collapse. Knock down the wall of a dam and a flood will unleash. Drop a spark into a tank of fuel oil and a chemical chain reaction, a fire, will start. Throw particles at a nuclear rod and you better control the consequent nuclear chain reaction. With the help of control instruments (technology) such as gates, valves, triggers, levers, switches, sparkles, reactors and so on, the rupture of equilibriums can be provoked and regulated to profit from the liberated forces (Dyson, 1971; Wald, 1959).

3. Energy, Matter And Velocity

The equilibriums of forces make matter a source of energy. However, since the rupture of equilibrium only manifests itself through the changes it causes to its own container or to nearby matter, matter is also the object, the target of energy.

The changes that energy causes have been gradually identified and measured, particularly since the times of Newton. The basic dimensions for measuring it were (and still are) combinations of space and time such as velocity (distance/time), acceleration (distance/ $time^2$), and velocity squared ($distance^2$ / $time^2$). The first type of well identified and measured change was the mechanical change, the macroscopic movement. Later came the microscopic –molecular level change –mainly the temperature changes–. The third type was the subatomic level changes, the electromagnetic and nuclear interactions. Let us examine this in more detail.

In the seventeenth century energy was understood as the visible changes caused by a force to a block of matter. Experimental measures showed that in presence of constant friction, twice the effort can sustain the same speed for twice the weight, or it can square the velocity (v) of the original weight

–measured as mass (m)–. Thus, Newton formalized the concept of energy (E) as $E = m*v^2$ (Motz & Weaver, 2002).

In the nineteenth century Boltzmann helped to understand the temperature as the average speed of the microscopic (molecular, chemical level) particles moving at random and identified the non-random distributions with the notion of order which in the next century would be identified with information (Brillouin, 1962; Szilard, 1929; Tribus & McIrvine, 1971). The change of temperature was understood as another form of movement and the concept of heat was embraced by that of energy. For heat energy, velocity was substituted by a function of the temperature (T) thus $E = m\ f(T)$ (Uffink, 2004).

The twentieth century physicists interpreted light –and other radiations– as the movement of subatomic particles –such as photons–. This is a movement whose characteristic speed –the speed of light (c)– was found to be a physical limit beyond which any additional energy cannot add any speed. From there, Einstein concluded that what is eventually converted into energy is necessarily mass. This is expressed by the equation $E = m\ c^2$ (Goswami, 2000).

The three equations reflect the evolution of the concept of energy and each one refers to a different level of an energy/mass ratio, or energy concentration ratio. The more mass for the same energy, the less concentrated the energy is. The energy/mass ratio equals the squared velocity term of the equation $E = m\ v^2$. In fact, the velocity factor is a characteristic of the level of energy concentration. The mechanical level velocities are in the range of gravity (such as falling water and winds). The chemical level velocities are in the range of chemical explosions, one order of magnitude larger than the mechanical level. And the nuclear level velocities are in the range of the speed of light, six orders of magnitude larger than the chemical level. This means that to produce the same quantity of energy about 10 times more water is needed to fall from a 100 meters high dam than chemical fuel –such as oil- is burned in an engine. And about million (10^6) times more chemical fuel is needed than nuclear fuel[1].

Nonetheless, the evolution of the concept of energy does not chronologically correspond to the evolution of our use of energy. Much long before we used the mechanical level energy we mastered whether genetically or culturally a set of the chemical level energies: the biochemical reactions. The biologic component of these reactions slows down the chemical one, but, in compensation, it makes life possible. Biochemical processes such as digestion and respiration allow us to take plants and other animals as food, and use its energy to move our muscles. Obviously, we never needed concepts or equations to be able to do that. The necessary information was in our genes. But we also learned to use some biochemical energy: that of the muscles of other animals, such as horses, not as food but as work. We also learned to use the fire from biomass to warm the environment or cook the food. And we did it all long before we were able to exploit the hydraulic potential.

$E = m\ v^2$ means that the energy increases linearly with the mass and quadratically with the speed. In other words, 10 times more mass results in 10 times more energy, while 10 times more velocity results in 100 times more energy. Thus jumping from one level of speed to other (mechanical to chemical) and even from one sub-level to other (biochemical to fossil fuel) results in a much greater change than jumping from one mass level to other (10 times more water dams, for example). Of course, when we jump to the next level new problems arise. For example, the chemical level brings CO_2 emissions and its consequent greenhouse effects. And the nuclear level brings the threat of radioactivity leaks or, worse, accidental or belligerent explosions.

In the late XIX century horses were intensively used for transportation and industrial work in the city of New York. Their excretions and even their dead bodies exceeded all attempts of keeping the streets and other urban spaces clean, notwithstanding that for a period of time the recycling value of that waste –as fertilizers and for other uses– made them worth to carry outside the city. The accumulation of this biological waste became a public health issue that claimed for a drastic solution (Tarr & McShane, 1997). This meant abandoning the biochemical sub-level of chemical energy and jump to the chemical level. Horses were rapidly replaced by steam, thermoelectric and internal

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In rough numbers we assume that the velocity (v) of falling water is 30 meter/second (30 m/s), the speed of the molecules of a gas in internal combustion is 300 m/s and we have a unitary mass m. Since Energy (E) = $m*v^2$ we have that E (falling water) = 900 (in some energy unit) while E (chemical combustion) = 90.000 (in the same energy unit). Since the speed of light is about 300 million m/s, the comparative energy figure would be a 9 followed by 16 zeroes.

combustion engines. These engines generated less localized energetic waste, such as CO_2, which for many decades was imperceptible or tolerable for New Yorkers and other people. We have since developed systems for collecting, recycling, confining, and treating the chemical energy waste. Today some of these systems are very large and complex but they are not enough. We are once again generating more waste and environment degradation than we can handle (greenhouse effects, etc.). Just like the early XX century New York, the world drowns in energetic waste and suffers the environment degradation. And just like the dead carcasses of horses were part of the waste, today we are surrounded by the corpses of scrap machinery and all other debris from the chemical energy fueled industry. Temporarily we can solve this by upgrading and augmenting to a global scale the waste collecting, recycling, and treating systems. But sooner rather than later we need to devise a new energy option; a big jump towards a faster energy level (Bacher, 2002; Frye, 2008; Hanson, 2009).

4. Matter as a Source of Energy and as Energy Waste

About 10 liters (or kilograms) of a chemical fuel is needed to move a car that weights one ton at the speed of 100 km/h during one hour[2]. Here we have two masses, that of the fuel, which is the source of the energy, and that of the car, which is the destination or target of the energy. Naturally, everyone would like to reach the target for free or at least at minimal cost. We want to use less fuel to move faster or heavier cars. In other words, we want to maximize the target mass while minimizing the source mass. We want to minimize the source mass partly because we have limited amounts of source mass available and partly because the more mass we use, the more waste and environment degradation we get. Thus, we want to have the technology that maximizes the energy obtained from the minimal amount of mass for each type of energy source.

Primary Sources of Energy

The Sun is our main primary source of energy. Sometimes we use that energy immediately but more often than not we store it for later and more intensive use. Storing solar energy is critical because we do not always receive as much as needed (like during the nights or when it is concealed by clouds). The Sun is so distant that even in a clear day its energy arrives at Earth too dissipated for uses other than illumination, moderate warming, and photosynthesis. However, part is naturally stored in our planet in the form of clouds, lakes, biomass, and fossil fuels (Hubbert, 1971). Through photosynthesis plants absorb solar energy directly and slowly accumulate it in their tissue, which in turn accumulates further and much more slowly by fossilization. Solar light is also artificially concentrated through lenses or photovoltaic cells, which need an additional device such as an accumulator or a boiler with water in order to store it. Some of these systems require more time than others. For example, fossil fuels take geological eras to form, while the photovoltaic cell/accumulator pair, the wind, and the tides can take only hours. For this reason fossil fuels are considered non-renewable source of energy while photovoltaic, clouds, winds, tides, lakes and biomass are considered renewable sources.

Now, even though with respect to the Sun these are all secondary sources of energy, for all practical purposes only the stored energy can be considered a primary source.

The only forms of energy that do not originate in the Sun come from the nuclear energy contained in the terrestrial matter and the geothermal heat liberated mainly through geysers and magma. The terrestrial nuclear energy was already stored in the atoms of the matter that formed the planet (Murray, 1988). The geothermal heat is originated by geological friction between big terrestrial bulks of matter. However, geothermal energy (Kezar, 2007; Lund, 2004), also considered a renewable one, is only available in some relatively few geographic emplacements, such as the California geysers. And as for the nuclear energy, our current technology is only capable of extracting it for practical use from the more naturally fissionable elements, such as uranium (Duderstadt & Hamilton, 1976).

The Energy Chain

The primary source of energy is only the first link of a chain of energy sources. Some of the links are naturally occurring while others are highly artificial. For example the photosynthetic or vegetal tissue feeds the digestion of animals and its energy gets trapped in the animal tissue. Sometimes the energy of plant and animal matter –the biomass energy– feeds humans, burns openly to produce environmental heat, or burns inside the steam engine to generate movement. Other times it

[2] See for example http://www.calculatenow.biz/conversions/consumption.php

undergoes the process of fossilization and is converted into oil or natural gas. These fossil fuels are extracted by drills, transported, processed in refineries, and finally transformed into refined fuel.

Another example of an energy chain is that of hydroelectricity. The solar heat transforms the sea water into vapor. The vapor forms the clouds that originate rain. The rain feeds rivers and damns. The water falling from a dam or river moves a turbine. The turbine moves the rest of a machine or the electromagnets that transform the movement into electricity. This electricity is transported by electrical lines and used immediately or stored in batteries. To use the stored electricity we feed it back into electromagnets that transform it into movement or to an electrical resistance that converts it back to heat or light (Atkins, 2003). Yet another example is the photovoltaic cell located in the roof of houses that directly feed all the electric appliances contained in the houses (Swanson, 2009).

Each link of an energy chain and the chain as a whole has an input energy and an output energy. For example, the input energy of a dam is the solar heat and its output energy is that of the water fall. The dam is a link in the hydroelectric chain, whose output energy is electricity. The mass of an energy chain, from its first energy input to its last energy output, is the mass through which the energy is captured and stored as well as that of the necessary gear for processing it and even that of the affected environment.

The mass of the chain tends to be larger for slower sources. The mass of the total chain tends to be as large (or larger) than that of its slowest link. In other words, if one of the links of a chain is mechanical and the others are chemical, the mass of this chain per unit of energy delivered will tend to be larger than that of a pure chemical chain. This is because the slow links, following the $E = m v^2$ equation, are the ones that require more mass to capture, store, or transport the energy, and the next links usually need proportionally massive gear in order to process all that matter. For example, since wind is a low speed energy source, lots of wind has to be processed in order to obtain energy and this means many wind turbines, many accumulators, large grids, etc. Comparatively, the building of a current technology fission nuclear plant requires about ten times less concrete and steel that the 1,500 to 2,000 wind turbine needed to delivers the same amount of energy. And a natural gas plant requires something in the middle of the two (Peterson, Zhao, & Petroski, 2005).

Now, while wind and gas technologies are at the top of their levels of energy concentration in matter, current nuclear technology is far from reaching its maximum. Thus, we have to differentiate between the actual and the potential required mass for a type of energy.

When energy is extracted from an energy chain, part of the matter of that chain becomes waste or causes environmental degradation. When chemical fuel is burned its matter is converted to ashes and gases, among them the CO_2 which is charged with the greenhouse effect. We also run the risk of the engine exploding and causing nearby damage. When the basin of a water flow is intervened in order to extract hydroelectricity, its ecosystem is often severely damaged. And we also run the risk of the dam failing and causing downstream damage. When we produce and eventually dismantle or discard electric energy devices such as wind turbines and photovoltaic cells –which are environmentally very clean– along with the electric grids and accumulators they often require –which are not that clean– we also generate a significant quantity of environmentally harmful waste. When we build thermonuclear plants we generate radioactive debris and also run the risk of the plant failing causing extreme damage or of unauthorized personnel using the radioactive fuel or waste for belligerent purposes.

Finally, the logic says that the more massive the energy chain is, the more energy waste or environment degradation –actual or potential– it tends to generate. The total mass of an energy chain is positively related to the chances that the chain will produce more waste or environmental degradation. The higher the energy concentration (or density) with respect to the energy chain mass, the lower these chances are (John Tjostem, 2012).

5. Energy Chain Matter Minimization Margins

The world demand for energy grows with the population and with its buying power for transportation (fuel for automobiles, planes etc.), comfort (ambient temperature adjustment, light, power appliances, etc.), and goods and services (from roads, buildings, and cars to consumer electronics and food). It also grows with the need to repair the already damaged environment and to dispose or recycle the existing waste.

At the same time the energy offer is restrained by the rising costs of environmental restrictions, which arise from the growing social awareness that the energy wastes menace life in the planet (Hart, 2004). Consequently, one of our bigger challenges today is to increase the energy offer while diminishing the generation of environment threatening wastes and degradation (EIA, 2010). This requires identifying and investing in the energy chains with the highest matter minimization margin. The following paragraphs discuss the matter minimization margins for the more commonly known energy groups.

Chemical Energy Margins

When the solar energy hits the terrestrial matter part of it is altered and trapped in that matter. These alterations do not occur at the nuclear level but at the more superficial and less energetic levels: the chemical and mechanical levels. The main chemical alteration is the slow and complex process of photosynthesis (Rappaport, 1971). It forms a molecular level energy equilibrium supported by bonds of hydrogen and carbon atoms. It creates the carbohydrates of our food and biomass or, once fossilized, the hydrocarbons such as coal, natural gas and petroleum. These are the chemical secondary sources in which the solar radiation is stored on Earth. Thus, when we walk or drive a car, it is the solar energy which impels the movement, only that it does it indirectly.

In both, the slow process of photosynthesis and the much slower process of fossilization, solar energy tenses up a molecular bond between carbon and hydrogen atoms constituting the chemical equilibriums called carbohydrates and hydrocarbons (Lawlor, 1993; Wald, 1959). In order to liberate their energy in a controlled, profitable way, we gradually trigger the rupture of those equilibriums by putting them in contact with regulated quantities of oxygen, whether by respiration in our cells or by combustion in our ovens, engines, thermoelectric plants or other devices.

There are two sublevels of waste and environment degradation related to chemical energy: biologic and just chemical. The biologic type is associated with agriculture, alimentation, and muscular work. It is usually more localized and peremptory than the chemical one, but also far more massive. It was tolerated by rural, pre-industrial societies and the low intensity industrial urban ones. But once the cities reached a certain size, like the early twentieth century New York, they had to migrate to the next energy concentration level, the predominantly chemical one, that of the fossil fuels. And once again, with the intensive industrialization, the energy related waste and degradation is becoming intolerable for the post- industrial, global society, which is beginning to react with its post-industrial technologies (Loschel, 2004).

Hydroelectric Energy Margin

Solar energy is also stored in the forms of mechanical equilibriums. When evaporated by solar heat, water forms clouds whose lower layers are shadowed by the upper ones and condense, producing rain. Then water remains in high lakes and dams in an equilibrium between the gravitational attraction and the mechanical-static strength of its walls. By controlling the dam gates and letting the water fall propel mechanical or hydroelectric turbines, we profitably liberate the dammed energy. But the conversion of natural lakes or water flows to large hydroelectric dams often causes an ecological and physical degradation of their basin. This degradation is usually proportional to the size of the dam. In the cases of small or micro-dams the degradation can be insignificant and sometimes they can even improve their surroundings. But only the large dams can fulfill a significant part of the energy demand of modern cities. The environment degradation increases as the natural dams have already been exploited and the construction of new ones requires more severe and destructive basin interventions (Collier, 2004).

Moreover, hydroelectricity –as all others forms of electricity– is not easily and economically stored in mobile accumulators. Electrical accumulators are heavy pieces of particularly contaminating materials. Even the rechargeable accumulators deteriorate and need to be replaced with a frequency that questions the alleged cleanness of hydroelectricity with respect to chemical fuels.

Alternative Energies Margin

Solar energy generates differences of temperatures in the air and water that in turn cause the winds and, along with the planet movements, the tides. As in the case of the water falls, we can obtain electricity from these movements through the interposition of turbines. These are solar and earth movement related energies. We can also capture and use solar energy through photovoltaic cells. These and other forms of energy are called alternative with respect to the more established ones. They have not generated noticeable waste or environment degradation yet, but that does not mean that they will not if they were required to fulfill the energy demand that today is covered by chemical and hydroelectric energies. A similar consideration can be done in reference to the higher costs or subsidies needed by alternative energies, unless they can be dramatically reduced, which does not seem to be an easy goal (Jensen, 2004). The wind and tide energies, not to mention solar light, are minimally concentrated with respect to their energy chain mass, which means that large amounts of matter have to be handled one way or another to make them useful. They are only suitable for the production of electricity and, as in the case of hydroelectricity, can only be served from a grid or accumulated in highly toxic devices. The quantity of wind towers (Hau, 2006), tide turbines (Cruz, 2008; Hammons, 1993), photovoltaic cells (Swanson, 2009) and accumulators that would have to be produced, installed, connected, maintained and eventually dismantled to satisfy a considerable part of the world's energy demand would entail the generation of considerable waste. While they might initially seem a cleaner alternative to chemical fuels the total waste generated is not lower.

Nuclear Energy Margin

Most of the energy from the nuclear radiation from the center of the Sun is dispersed into space and what arrives to earth while still at the speed of light is very little. Thus, to make it useful it has to be accumulated. This accumulation requires storing it in matter. This accumulation can occur by natural photosynthesis (producing biomass), artificial photoelectric cells (feeding a grid or an electric accumulator), heating water and displacing it to higher ground (evaporation and rain), heating the air and making it move (winds), etc. Photosynthesis downgrades the originally nuclear level energy to a chemical level. Photoelectric cells, rain, and winds downgrade its original concentration in matter to a mechanical level. Thus, none of these are what we refer to as nuclear energy sources although their origin is nuclear.

Terrestrial nuclear energy is embedded in the matter that was expelled from the explosion of stars and formed the planets (H. A. Cole, 1988). It is stored in the form of equilibrium between the attractive force of the nucleus and the repulsive electrical force of the protons. As in the cases of all other energies, it can be liberated by destabilizing the equilibrium that contains it. In this case, the destabilization can be achieved by causing the fission or fusion of nucleuses (focusfusion.org, 2006). The fission process requires that the nucleus be a heavy one, such as uranium, so that the more external protons are almost out of the reach of the short range attractive force. In contrast, the fusion process requires elemental nucleuses, such as hydrogen, so that when forced to approach, their attractive forces can more easily reach each other, dislocate the repulsive force, and form a heavier nucleus. In both cases the original equilibrium is broken and some of its energy is radiated. Both fission and fusion reactions can be artificially started by throwing other particles to the nucleuses and making that a part of the radiated energy that destabilizes in turn other nucleuses, causing a chain reaction, a nuclear fire. This way we can obtain energy from the minimum matter, the nuclear particles. But the usefulness or destructiveness of this fire, like the more familiar chemical one, depends mainly on the precision of the starting and appeasement mechanisms as well as on the canalization of the liberated energy. We are still far from controlling the nuclear fire as we control the chemical one (Goodstein, 2005; Toth & Rogner, 2006).

We have learned so far how to start and moderately control the fission fire. Our civil fission reactors are very massive apparatuses, only suitable to heat fluids in enormous boilers for the production of thermoelectricity (Bodansky, 2004). They remind more an old fashioned steam factory than a high technology device. Some more compact fission reactors propel military submarines and a few commercial ships. Several countries have built and use fission reactors. In France these reactors have been stably and cleanly fulfilling the larger part of the electricity demand. In general when the fission reactors work properly, the electricity they produce is cleaner and cost-competitive with the fossil fuel option. But when they do not work properly, the consequences are much more harmful.

The current technology does not provide enough control as to make the nuclear energy acceptably safe. The fission radiation is meant to heat the fluid contained in the boiler for the production of thermoelectricity. But along with this process the radiation can alter the molecular bonds of the surrounding matter. In the case of living tissue, this can cause anomalies such as cancer. To prevent this, fission reactors are embedded inside heavy walls of lead and concrete. These walls get contaminated along with internal equipment, consumables etc. The whole reactor premises requires a rigorous maintenance program and, at the end of its life cycle, a complex, exhaustive, and very heedful dismantling. Nevertheless the risk of a radioactive leak is always there and whether because of unaffordable costs, unpredictable failures or other reason, if anything goes wrong, the consequences can be disastrous. The Three miles island (USA) incident triggered the first alarms. The disaster of the Chernobyl reactor during the dismantling of the USSR caused continental size contamination. The recent incident of Fukushima Daiichi (Japan), whose reactors were sapped by a seaquake, elevated the risk perception so high (Sovacool, 2011) that countries such as Germany and France suspended their development plans of nuclear energy. Furthermore, even if those civil incidents were well compensated by the benefits of the nuclear energy, the people remembrance of the USA atomic bombing on Hiroshima and Nagasaki and the cold war's MAD (mutual assured destruction) tensions are still present. The alleged Iran's nuclear menace updates it when necessary. It cannot be denied that as long as the use of nuclear energy proliferates, the risk of harmful accidents and belligerent uses increases. Thus it is not surprising that the world´s opinion on nuclear energy be adverse (Rockwell, 2009). Even the environmentalist opinion, which should ponder the development of nuclear energy as a path towards the replacement of the dirty chemical fuels, is very hostile. Notwithstanding, nuclear energy –in contrast with all other– has a large margin of improvement and technological development, as large as the difference between their levels of concentration in matter (Beckjord, 2003 ; John Tjostem, 2009; Tuker, 2008). Even economic analysis realizes that "… any ambitious carbon emissions reduction program that does not rely heavily on nuclear electricity cannot be justified economically and can only be justified on political or public safety grounds." (Leibowicz, Roumpani, & Larsen, 2013)

6. Summary of Energy-Matter Minimization Margins

The waste and environment degradation minimization margin of an energy source chain is plausibly related to its matter minimization margin. This margin is related to the level of energy concentration in matter, i.e. the level of the energetic equilibrium: mechanical, chemical and nuclear. The mechanical level is the most superficial one followed by the chemical one. The deepest equilibrium is the nuclear one. When this equilibrium is broken, matter does not only liberate its energy but matter itself is transformed to energy. It is the only form of energy liberation after which the quantity of matter is notoriously smaller than before. In the cases of mechanical and chemical equilibriums the matter is transformed, but its quantity does not change in any measurable amount.

The nuclear energy that can be extracted from a unit of matter is one trillion (10^{12}) times larger than the maximum chemical energy that could be extracted from the same quantity of matter and about ten to one hundred additional times the mechanical energy that could be extracted from the same quantity of water falling through hydroelectric turbines from 100 meters high. Thus, nuclear energy has by far the largest margin of matter minimization.

7. The Role of Information in Matter Minimization

Only some sets of positions of the parts of the source matter chain result in useful energy. The water that falls from a dam has to impact the sails of a turbine; if it goes elsewhere the energy will not be useful. The molecules of the gas heated by the burning fuel have to impact the piston of the engine; otherwise the heat will be lost to the environment. The organic metabolism of the carbohydrates has to form motor proteins and some other precise molecules; any other behavior would be pathologic for the organism. The nuclear particles have to hit only the exact pieces of the reactor they are meant to, or we will have a radioactivity leak.

Obviously the more options, the more difficult it is to put each part in a given place. The number of options is proportional to the space that the parts could occupy in an interval of time. The falling water can hardly go up or sideways; its space is limited by gravity and the height of the dam. Steam has more options, and thus it is more difficult to restrict its space within the same time interval. The chemical fuel delivers more useful energy when its combustion and conversion occurs in a chamber (internal combustion) than when it occurs in open air. The internal combustion engine delivers more useful energy than the external combustion one simply because the former leaves a much smaller number of options for the particles of the working fluid to go.

The speed of the nuclear energy particles is much higher than that of any other form of energy. This gives them the possibility of going to more places during the same amount of time. This is essentially the reason why nuclear energy is so difficult to control. The design of a nuclear reactor deals with far more possible wrong places within a unit of time than that of an internal combustion engine or a hydroelectric motor. Our approach to nuclear technology is comparable to the first human steps to control the chemical fire. We will have to replace the massive current fission reactors with more compact and safe, maybe fusion reactors, just like we replaced the furnaces with internal combustion engines. We need more experimentation, more knowledge; in one word, more information. We need to determine –and then develop– the right energy source matter chain option. If the number of desirable places was 1 and the number of all possible places for a particle to go was 2, then, in terms of information units, or bits, we would need 1 bit, since each bit expresses one choice between two possible ones. If the number of desirable places was 4, the number of bits would be 2, which is equal to the binary inverse logarithm of 4, that is, $-\log_2 (1/4)$, or $\log_2 (4/1)$. In general, if the number of desirable possibilities is n and the total number is N, the number of bits would be $\log_2 (N/n)$ (C. Cole, 1993; Shannon & Weaver, 1949; Tribus & McIrvine, 1971).

The maximum energy supply with the minimum waste and environment degradation or contamination hazards is just one possible output –or set of outputs– of the N possible set of outputs of an energy source. At the end, the design, development, construction and operation of such an energy source matter chain option –source of energy, machinery, processes etc. – will have to select the right choice $\log_2 (N)$ times, or obey $\log_2 (N)$ binary instructions. Since in the nuclear energy case the N is enormously larger than in any other case, the right nuclear device will have to resemble more an information technology product than a chemical fuel engine or a lead and concrete boiler. The stars such as our Sun are natural fusion reactors. They use stellar quantities of matter to accumulate the gravity power capable of breaking the equilibriums of the inner matter nucleuses so they fuse after liberating some of their repulsion energy. If we are to make a fusion reactor in our materially modest planet without menacing its life friendly characteristics (Cook, Marbach, Di Pace, Girard, & Taylor, 2001; McNamara, 2004), we will need to replace the matter with the only thing we can possibly have in such stellar proportions: technology, which is essentially information (Eveland, 1986; Rogers & Valente, 1991).

The information based nuclear industry will have to use virtual reality simulations instead of atoll annihilating nuclear tests; do data mining instead of uranium mining; use nano-processors not only to condense billions of songs in a minuscule IPod but to closely guide the nuclear particles to the right target.

Since the number of possibilities depends on the speed and is proportional to the information, and since the energy supply (E) with the minimum waste and environment degradation or contamination hazards is somehow proportional to the margin (m) of the source matter minimization, then we can replace the velocity term (v^2) of the equation $E = m\ v^2$, with the related information measure (i) so have $E = m\ i$, which we will call Infoenergy. The more information we have about energy, the less mass is needed.

Infoenergy is a conceptual synthesis of three crucial terms: energy, environment, and information. This synthesis was first introduced fifteen year ago (Salim & Ferran-Urdaneta, 1997) though with a partially different definition. This paper is not the right place to mathematically develop the new definition and even if it were, the authors are not sufficiently qualified for the task. The objective here is to propose this formula for future development and, more importantly, to contribute to the growing conscience that information technology is the option for replacing the massive, Goliath like energy industry. Hopefully, Infoenergy will help understand that using information technology to minimize the energy-source matter ratio is by far the most promising way to reduce the energy related waste and environment degradation. Infoenergy should help understand that the source chain matter minimization margins of alternative energy sources such as wind and solar light is too low to make them a realistic environment friendly option for solving the world's energy problem. Infoenergy should also help physicists, engineers, and economists include the information variable in their calculus and projections. Moreover, Infoenergy should stimulate eventual investors to approach nuclear energy in a new way, an informational rather than industrial one (hoping that Bill Gates will declare that his new energy business (Steiner-Dicks, 2010) is not divergent from his old information technology one). Infoenergy should make the David investors feel conceptually supported in their defiance of the big chemical fuel Goliath. Infoenergy is a call to energy decision makers to focus more on information than on matter.

8. Conclusion

We defined the energy source chain mass as the sum of the masses of the chain through which energy is extracted from its natural source and transported to its final consumption point. Then we established that 1) the energy associated waste and environment degradation is significantly and inversely related to the energy/mass –or squared speed- ratio of the energy source chain; 2) there are several source levels or types and their energy/mass ratios are different by several orders of magnitude; 3) the nuclear source has a much larger mass minimization margin than the chemical, solar, and alternative energy sources; 4) to get close to the nuclear matter minimization margin we require a technology enhancement that is logically proportional to the energy/mass ratio (E/m) of the energy source chain, that is to say, to the squared speed (v^2) of the classical energy equation $E = m\ v^2$; and 5) since the technology (experimentation, research, knowledge, etc) enhancement is essentially an information enhancement, the velocity dependent term can be replaced with an information dependent term, thus instead of $E = m\ v^2$ we have $E = m\ i$. And the larger the information with respect to the source chains mass, the more environmentally friendly the energy output. This can be called Infoenergy and is a synthesis of three currently crucial concepts: energy, environment, and information, one or two of which are often myopically ignored in the discourses that focus on the others.

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