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Powering The People Beyond 2050

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Abstract

Accessible energy resources are declining due to increasing population, growing demands and depleting fossil fuel reserves. Worldwide utilities deregulation practices, privatisation, globalisation and political unrests are forcing individual nations to think of their energy outreach. Average energy consumption of 32% of us all is as high as 6795kWh/yr/person whilst just 1313kWh/yr/person for remaining 68% people. Oil and gas peaking fears from 2010 to 2017 and depletion by 2050 to 2060 are leading the individual countries to follow a blind race to explore and harness new energy sources i.e. the nuclear energy. Global energy consumption rate is about 474×10^{18}J out of which 82% is derived from fossil fuels and 18% from renewable energy resources. Annual global power consumption is about 15TW which is less than 1% of daily solar power supply. Sun shines earth with 89PW that we receive at rate 1321 to 1412W/m^2. In addition to continued natural solar power supply we will have coal and uranium reserves at least up to middle of next century. Technical analysis and engineering judgment shows there is not any immediate threat to human survival due to food and energy; however, it will not be available as much economic as oil. Apart from conventional measures like increasing machine efficiency, improving efficient energy use, promoting energy conservation, opting austerity and frugality, we also need to explore unconventional natural energy resources. This paper introduces two novel, unconventional energy resources consisting of earth batteries and atmospheric electricity. This work concludes to join the global grand energy transition (GET) effort by adopting 100% renewable energy policy 2050.

Keywords: Energy crisis, Renewable energy, Unconventional energy resources.

1. Introduction

Unrelenting reliance on fossil fuel energy approach has its physical limits due to increase in population and industrial expansions. Global community needs new energy resources to maintain the current growth trends. Many researchers have reported their views on alternative sources such as sustainable solar energy (Pearce, 2002), safe nuclear energy (Duffey, 2005), clean hydrogen economy (Marban and Valdés, 2006; Prosini and Gislon, 2006), ground source heat pumps and geothermal energy (Omer, 2006), bio-energy (Faaij, 2006), wind energy (Herbert et al., 2007), magneto-hydrodynamics and reverse electro-dialysis (Turek and Bandura, 2007). Suitable renewable energy policies need to be developed for effective use of available alternative sources (Bugaje, 2006). Well engineered strategies need to be initiated to integrate renewable energy sources in cost effective, efficient and coherent manner into existing systems (Henrik, 2007). Natural energy resources are scattered in nature in sky, air, sea and earth it is up to us to harness these treasures. Global power needs are just 16 to 17TW but existing fossil reservoirs consisting of uranium, fossils and sunlight are more than 45YW (45×10^{24}). They can run for a minimum period of 200 billion years if we can harness them. The sun produces enough energy in every minute on the surface of earth to meet full-year ongoing energy needs. Besides the above, there are many other renewable energy sources such as wind, geothermal, hydrogen and bio-energy that are not counted in above calculations. Energy statistics show that there is no immediate energy crisis or any chaotic human survival threat to global community in far ahead future. However, there is need for developing cheaper and cost effective techniques to convert existing energy sources into useful forms such as electricity. It is also of great concern to take care of nuisance effects of new

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renewable energy sources during the installation, operation and decommissioning at the end of their lives.

2. Global Energy Consumption

Natural energy sources may consist of burning fossils, uranium, sun, etc. We all hardly need less than 1% of any of available multiple energy reserves. All population on planet earth is about 6.6B (2B without electricity) but the agreed natural reserves are enough for several xonta billions people even yet waiting to come after several quadrillions of years in the future. According to “World Fact-book” (CPL, 2007) only Europe (2.8PWh/yr), USA (3.7PWh/yr)[1] and China (2.2PWh/yr) consume about 59% of the total electric energy (14.3PWh/yr) generated by all existing utilities of the global village and the rest of 196 countries consume about 1.80PWh/yr. India consumes 519TWh/yr whilst Pakistan only 72TWh/yr. India stands at 2nd position in population on global map and at 6th position in energy consumption whilst Pakistan stands at 7th position in population and 34th position in energy consumption. However, the kWh/yr consumption rates of India and Pakistan are 462kWh/yr and 431kWh/yr, respectively. Electricity consumption rates of the top ten countries are shown in Fig.1.

Details of units may be checked from internet (http://jimvb.home.mindspring.com/unitsystem.htm). According to US energy information administration data for year 2004 and key world energy statistics from the international energy agency for 2006, the power consumption of the whole world including transportation, industry, residential and commercial use is about 16 to 17TW. We spend lot more to produce such power due to 40 to 60% plant efficiencies. Total energy reserves consist of fossils such as coal (290ZJ), oil (57ZJ) and gas (30ZJ) whilst the rest come from fossils, nuclear (uranium) and solar energy as shown in Table 1.

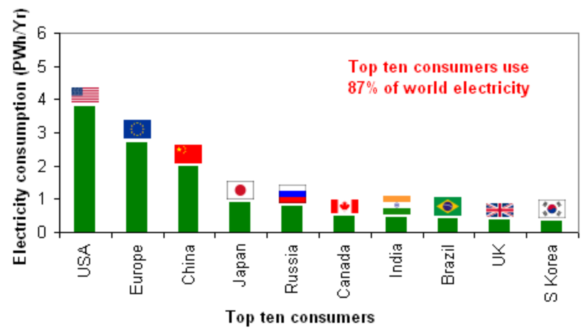

Fig.1. Top ten electricity consumers of the global village

Table 1. Natural energy resources available to humankind

Source	Sun	Fossils	Calathrates*	Uranium
Energy (J)#	3.8×10^{24}	36×10^{21}	1.5×10^{24}	2.5×10^{24}
Energy (KWh)	1×10^{18}	10×10^{15}	4.17×10^{17}	694×10^{15}

***Methane calathrates; Conversion rate 1kWh = 3.6×10^{6}J.**

Global population is increasing at a rate of 200,000 persons per day. Competition between depletion of resources and exponential rise of users is becoming intense with passage of time. China, India, USA and Indonesia constitute almost 50% of the world population but both China and India constitute 37% of the world population. Population plot of world top ten countries is shown in Fig.2 (Kevin, 1994; http://en.wikipedia.org/wiki/List_of_countries_by_population).

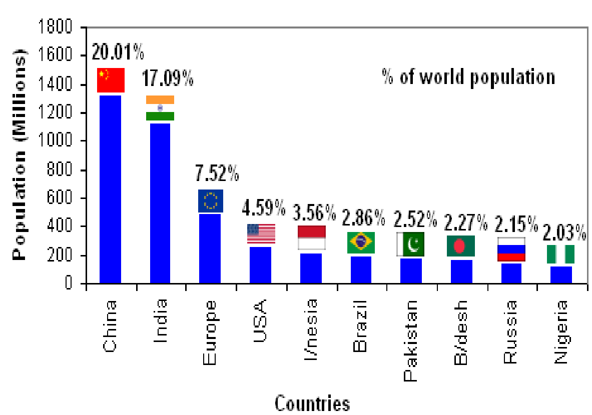

Fig. 2. Populations of top ten countries in the world

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[1] So far, the practical units in practice are only up to 10^{9}(Gigawatts), 10^{12}(Terrawatts), 10^{15}(Pittawatts), 10^{18}(Exawatts), 10^{21}(Zettawatts) and 10^{24}(Yottawatts) for powers and 10^{-9}(Nanosecond), 10^{-12}(Picosecond), 10^{-15}(Femtosecond), 10^{-18}(Attosecond), 10^{-21} (Zeptosecond) and 10^{-24}(Yoctosecond) for time in physics, however, SI units for further higher powers are 10^{27} (Xona), 10^{30} (Weka), 10^{33} (Vunda), 10^{36} (Uda), 10^{39} (Treda), 10^{42} (Sorta), 10^{45} (Rinta), 10^{48} (Quexa), 10^{51} (Pepta), 10^{54} (Ocha), 10^{57} (Nena), 10^{60} (Minga) and 10^{63} (Luma) watts and similarly the units for the time durations are10^{-27} (Xonto), 10^{-30} (Wekto), 10^{-33} (Vunkto), 10^{-36} (Unto), 10^{-39} (Trekto), 10^{-42} (Sotro), 10^{-45} (Rimto), 10^{-48} (Quekto), 10^{-51} (Pekro), 10^{-54} (Otro), 10^{-57} (Nekto), 10^{-60} (Mikto) and 10^{-63} (Lunto) seconds [Henrik, 2006; CIA, 2010].

Human body uses 2900Wh energy daily out of which 2030Wh is spend on BMR and rest 870Wh on physical activities. For $10x10^6$ kcal = 1 TOE, the 2500kcal/day equals to 0.09TOE/year. Poor nations consume food energy at an average rate of about 0.08 to 0.09TOE/person/yr whereas rich nations guzzle at rate of 0.13TOE/person/year. Most of us just live to eat rather than eating to live. Fats produce energy at an average rate of 9kcal/g (37.7kJ/g) whereas organic foods and proteins produce energy at an average rate of 4 kcal/g (70 kJ/g). It is difficult to quantify biomass as different regions use different food mixes. If everybody starts eating grains, then the world community needs 1.54 trillion kg foodstuff for one year. It comes out to be 228kg grain per person per year or 625g/person/yr. We have further redistributed the natural distribution to 295g for underdeveloped and 330g/person daily for peoples of developed countries. Global fossil fuels energy consumption rate is on average 1.7 TOE/person/yr. We all consume 10.75GTOE fossil fuels and 1.54 trillion kg food energies in one year. We do not believe, however, if socioeconomic method of reducing population to meet food and energy demands is up held, it is wise to follow nations which guzzle energy (6 to 8TOE/person/yr), which contrast to poor nations consuming energy at rate of just 0.5 to 0.7TOE/person/yr. Bumping off 12-13 persons here causes same effect as carnage of 1 person in oil gulping nations. UNO global food survey shows the people of 16, 25, 25, 21 and 5 countries live on rice, maize, wheat, cassava/yams/roots and millet/sorghums whereas people of 27 countries live on milk, meat and wheat. A normal person is supposed to consume 2500kcal/day whereas some people of rich nations consume at a rate of 3600kcal/person/day. People of Afghan and Ethiopia live on just 1600 to 1700 kcal/person/day. Pakistani people lack 270kcal/day whereas Indians hold a figure of 290kcal/day. UNO claims there were 1025 million hungry people in 2009, which have reduced to 925 millions in 2010. It is unreasonable to assume that hunger may decline, considering the rising energy shortages.

3. Big Wheel of Nature

Sun sends 174PW power towards earth out of which just 89PW (51%) power is absorbed on earth's surface and just 0.02% of it would be enough to meet the current energy needs of the whole global village (Jefferson et al., 2005). Energy cycle of solar power to earth surface is shown in Fig. 3.

Solar power density at earth's surface is 125 to 375W/m², equivalent to 3-9kWh/m²/day (http://www.nrel.gov/gis/solar.html). An average photovoltaic panel, with 15% efficiency, may deliver 15 to 60W/m² or 0.45 to 1.35kWh/m²/day electricity. Solar cell conversion efficiency of solar cells has steadily increased from 6% (1954) to 40% (2006) over a time period of 52 years. Thus, the size of solar power stations has exponentially increased from 500kW (1977) to more than 10,000kW (2006) as shown in Fig. 4.

Accessible solar power on earth surface is about 89PW which is about six millions time more than present 15 (2005) to 17TW (2010) power needs of the whole world. Energy supplied by sun in one minute is enough for global power need of one year. The solar PV power capacity is nine times lesser than solar thermal power capacity. Gradual increase in solar PV power is shown in Fig.5 (www.ren21.net).

Regarding solar hot water requirements by number of persons N, according to Firex catalogue (Firex, 1964), a fair estimation may be given by,

$$Q_d = N.q_h \qquad Q_h = Q_d.q_h$$

$$V_h = Q_d.v \qquad H = Q_d.r(t_h - t_c)$$

where Q_d is daily requirement (1/h), Q_h is maximum demand (1/h), V_h is hot water storage capacity (litres), H is heating capacity per hour (kW), t_h is hot water temperature, t_c is cold water temperature (°C) q_h is hot water required per person (75 to 150°C), a_h is maximum hourly demand (1/5 to 1/7), h is duration of peak load hours (1 to 4), v is storage capacity (1/5 to 2/5) and r is heating capacity (1/7 to 1/10).

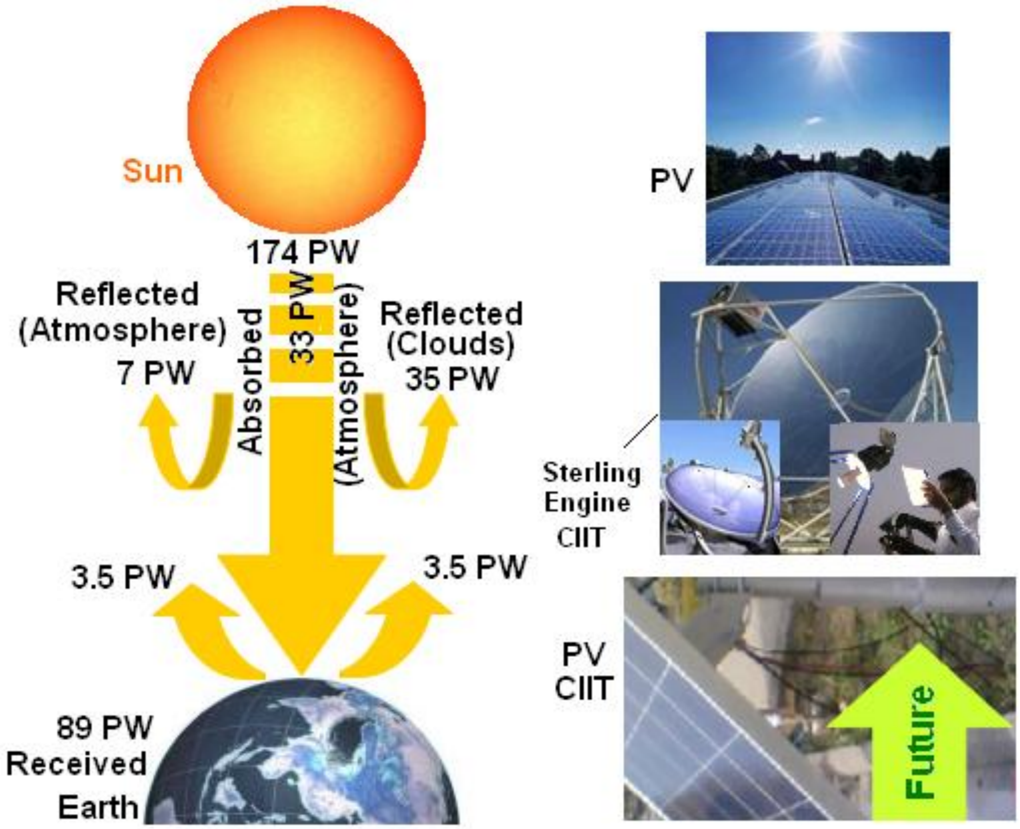


Fig. 3. Solar power cycle for earth and its conversion systems

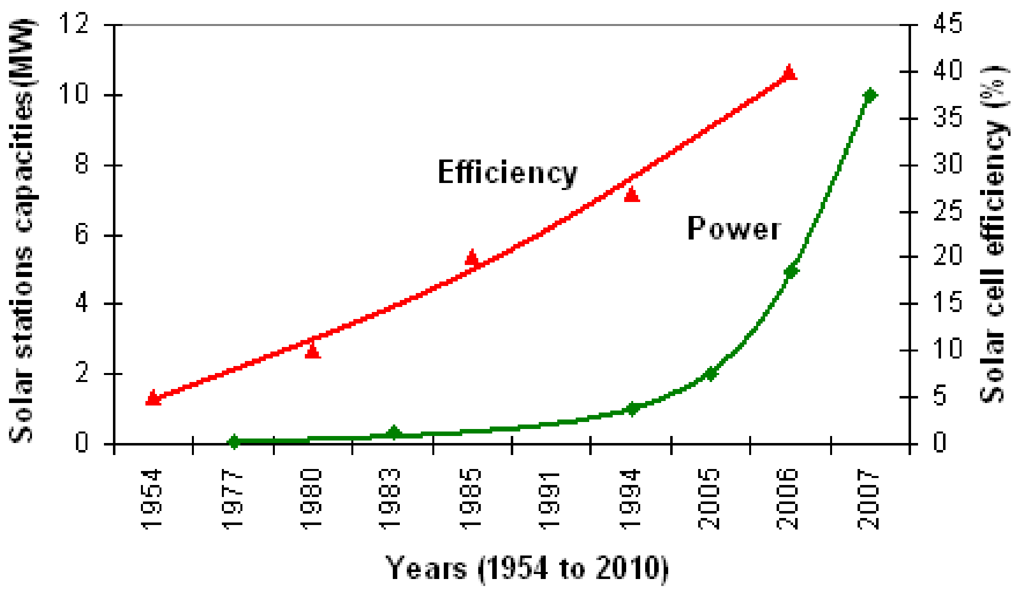


Fig. 4. Solar cell efficiency and grid capacity progress in 60 yrs

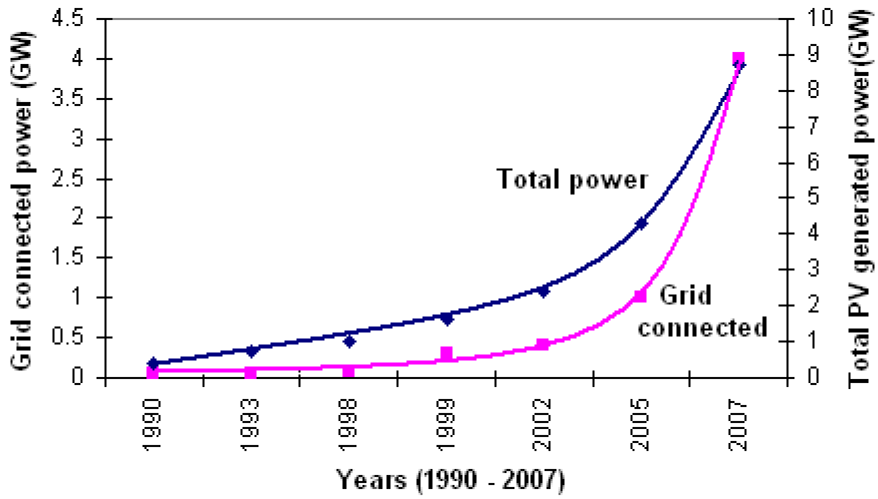


Fig. 5. History of solar PV power generation

Available solar energy in Pakistan is on average 5400 MJ/m^2 (1500 kWh/m^2) per year in Pakistan. Average temperature of a Firex make solar water heating potential for Islamabad-Pakistan, is shown in Fig. 6.

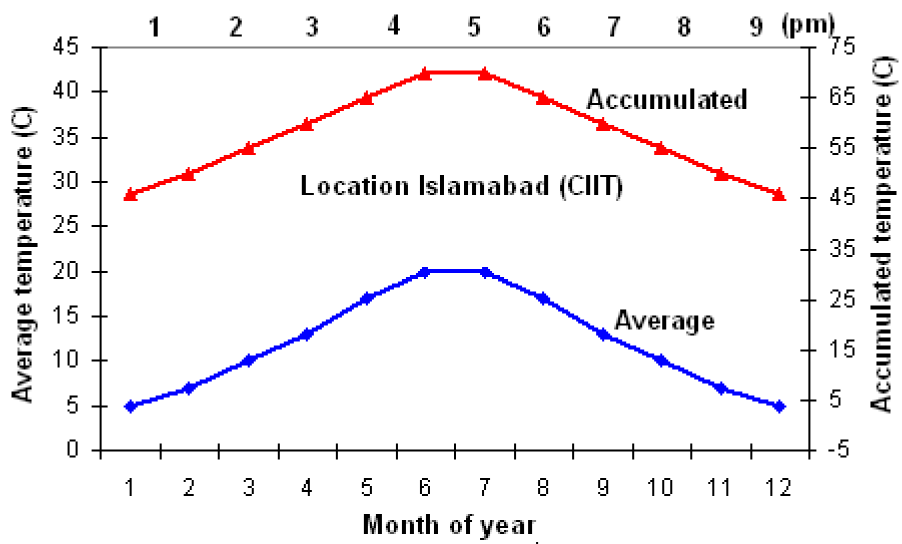


Fig. 6. Solar water heating potential in Islamabad, Pakistan

A typical panel solar collector (using flat pressed in tube type collector, 4psi, galvanised steel painted with acrylic coating, covered with transparent 5mm glass, back insulated to maintain temperature for 72hrs) may generate safe and clean energy equivalent to 200 litres of oil per year. Its payback time is estimated to be around 21 months. Afterwards, it goes on supplying pollution free energy for several years. It is cost effective compared to normal electricity usage and ideal solution when there is no electricity at all. Regarding small scale domestic use, it was found practical that a 120 W stand alone solar PV system consisting of solar module, charge controller and a battery can supply for 1 TV in 2hrs/day, 2 fans for 12 hrs/day and 4 energy savers for 6 hrs/day. Alternatively, a charged 30W solar system with inverter can supply three energy savers and a fan for over 15 hours during shutdown. Charge controllers of 6, 10, 20 and

40A are available along with 35, 75, 125 and 300W solar panels. Solar regulator cannot assure trip during power interruption without adequate electronic support and in phase injection in standalone mode to mitigate half cycle to a few hundred ms voltage sags during remote or local short circuit faults on distribution system. A typical solar panel may be used to power LED light fixtures to meet ongoing increase in demand of 1.5-2 GW/yr in Pakistan. A 100W solar LED fixture produces lumens comparable to a 400W bulb. Solar cell life time is 35 to 40yrs and payback time is less than five. Solar cells reproduce their cost over 30 times in their life. According to Clean Power Limited (CPL) report (CPL, 2007), the 100MW LED light fixtures payback time compared to thermal generation is about 1.8yrs and regarding power saving, it is 3.4yrs, as shown in Fig. 7.

As the money spent on electric compact fluorescent lamps saves us Rs.2,500/yr in electricity bills, similarly, the investment on solar energy is paid back in just few years as shown illustrated in Fig. 8.

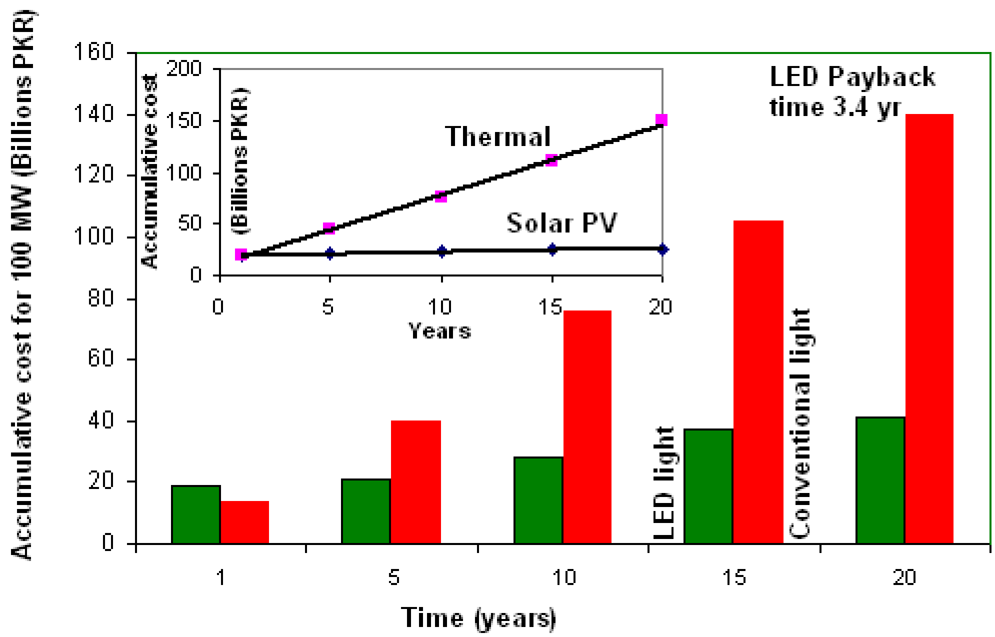


Fig. 7. Comparison of 100 MW light load thermal/solar costs

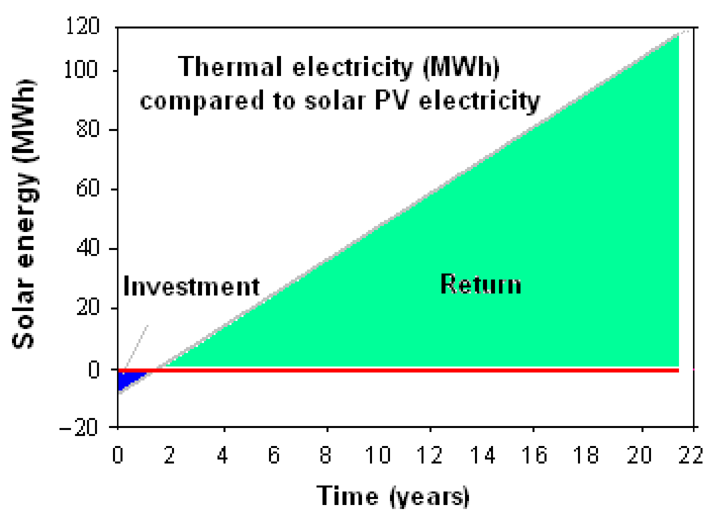


Fig. 8. Payback time of solar versus thermal generations

Edmund discovered photovoltaic effect in 1839. Philipp observed its wavelength dependent conversion in 1902 and Wilhelm made the first solar cell in 1913. New York Times forecasted the possibility of limitless solar energy in 1954. Solar powered satellites (1958) and Skylab (1972) were put in to the orbit. Attention was also focused on direct use of solar concentrators instead of photovoltaic. Solar cells may be configured as self supported 180 to 240 μm bulk materials later cut into wafers under top-down approach. Some organic dyes and polymers can be configured as thin-films deposited on support substrates. Under bottom up approach, nanoparticles (quantum dots) embedded in a support matrix can be configured as nanocrystal solar cells (Ginger and Greenham, 1999). Amongst solar cell, materials may include efficient but expensive single crystal monocrystalline silicon (c-Si), less expensive and less efficient poly or multicrystalline silicon (poly-Si or mc-Si) and reasonable efficiency and inexpensive multicrystalline ribbon silicon (mc-Si). CdTe and ormosil are more efficient materials for thin film solar cells. Copper Indium Gallium Arsenide (CIGA) multilayered flexible thin film solar cells may have 20 to 30% conversion efficiencies. GaAs multi-junction solar cell, e.g., triple junction GaAs, Ge, GaInP devices) has conversion efficiency of 30%. Organic and polymer solar cells (http://en.wikipedia.org/wiki/Polymer_solar_cell) (η=4-6%) are built from 100nm thin films of organic semiconductors such as polymers and small-molecule compounds like polyphenylene vinylene, copper phthalocyanine and carbon fullerenes. Silicon thin film solar cells a-Si (top) and nc-Si (bottom) may absorb visible and IR wavelengths to increase conversion efficiency and produce semi-transparent conducting solar windows. Concentrating PV (CPV) systems may employ lenses/mirrors to use larger area of light to benefit conversion efficiency of GaAs. Photo-electrochemical Cell (PEC) is solar cell consisting of semi-conducting photoanode and a metal cathode immersed in an electrolyte. It may produce electrical energy or hydrogen in a process similar to the electrolysis of water. Despite a lot of efforts, the silicon wafer-based solar cells are still dominant due to UV degradation effects with organic solar cells. Concept of PV distributed generation up to 15MW is now common and some utilities like Kanas Solar Electric Co are reported to plan complete switchover from conventional to solar power by 2018. Australia announced in October 2006 to build world largest CPV based 154MW solar plant by 2013.

4. Renewable Energy Resources

Large and small hydropower plants supply 850 and 85MW electricity. Biomass, solar and geothermal sources supply 250, 145 and 50 GW_{th} heating power. Winds, biomasses, photovoltaic cells, geo sources, the sun, thermal sources and oceans produce 121, 52, 13, 10, 0.5 and 0.3 GW_e power. Ethanol and bio-diesel production is currently 67 and 12 billion litres. All of above renewable energy resources constitute just 18% of total power and only 3% of total primary energy demand. Major renewable energy sources on earth include, but are not limited to, sun (88PW), winds (870TW), geothermal sources (32TW) and hydro energy sources (7.2TW). Global hydropower is just 40% of total power demand. Global power consumption requirements started declining from 837TW (2000) to 826TW (2002) but again started increasing at rate of 6.67TW/yr to date. To match the load, the generation started increasing from 115EW (2000) to 130EW (2005) at an average rate of some 3EW/yr. Total power producing infrastructure installed in 2005 using sun (96.4GW) [Solar PV (5.3GW), Solar PV grid (3.1GW), solar-thermal (88GW)], wind (80GW) and hydro (980 GW) sources was 1.16TW. Renewable energy increase rate is 0.008% whilst the global consumption rate increases at 0.8%. It means 0.792% additional load has to be met by other means such as nuclear and fossils. World leaders in promoting use of solar PV are Germany, Japan, USA, Spain and France whilst largest producers of solar-thermal power include China, Turkey, Germany, India and Australia. Middle East and whole of Islamic countries are paying least attention towards solar energy except Turkey and Pakistan. Average consumption rate has increased exponentially in last two years, so the alternative energy sources have to be met with. Worldwide electric power consumption in 2005 was met from hydroelectricity (816GW), biomass (264GW), wind (65GW), solar (100GW) and geothermal (109GW) energy. Present hydrocarbon fossil fuels reserves (http://www.eia.doe.gov/iea/res.html) may run for

129 yrs on coal alone, 45yrs on oil alone and 60yrs on natural gas alone. It is a relief that the sun will stay with us forever to drive our life cycle. Uranium reserves of 2.5YJ are equivalent to some 806ZWh. Available geothermal energy is around 13YJ but only 2YJ would be extractable by 2050. However, it would be enough for world's energy needs for several millennia (Smil, 2003). Renewable energy is the energy obtained from resources that are regenerative and cannot be depleted. Renewable energy sources contribute over 29% of human energy use today. The prime source of renewable energy is sunlight. Sun energy may be harnessed for industrial use either in the form of electricity using PV panels or heat using solar concentrators. China produces to use over 83% of worldwide solar hot water heating capacity (http://www.nrel.gov/gis/solar.html).

5. Earth Batteries

In view of global energy crisis to be caused by natural end of oil and gas within next 50 to 60 years time, it has become very important to look for alternative energy sources to hold back the human race from engaging in great energy wars. This work is a very honest effort to investigate the possibility of using earth batteries for remote village lighting, communication signaling and driving small scale electronic loads such as cell phones and LCD screens where there is no alternate source of electricity or in all villages and cities to simply conserve electricity. Assuming uniform electrode profile, the potentials of some common metals electrode pairs in soils are shown in Table 2.

Table 2. Potential of common metals.

Anode materials	Cathode materials			Battery
Material	**E°(V)**	**Materials**	**E°(V)**	**Volts**
Magnesium	**-1.75**	**Coke**	**+0.30**	**2.05**
Zinc	-1.10	Graphite	+0.30	1.40
Zinc	-1.10	**Copper**	**-0.20**	**0.90**
Aluminium	-0.80	Carbon	+0.30	1.10
Iron	-0.50	Coal	+0.30	0.80

To test the possibility of higher currents and voltages of a few large sizes, C, Mg and Al electrodes are under construction. Unlike air batteries used in vehicles, the earth batteries have very low Wh capacities. It has an average 0.63 mW power. It is too small to drive any motorised load except an electronic digital clock. Typical reduction potentials of various materials are useful for air batteries at STP are shown in Table 3.

Table 3. Standard reduction potentials of materials at 25°C

Anode materials	Cathode materials			Battery
Material	**E°(V)**	**Materials**	**E°(V)**	**Volts**
Li^+(aq)	**-3.045**	**F_2(g)**	**+2.870**	**5.915**
Na^+(aq)	-2.710	H_2O_2(aq)	+1.780	4.490
Mg^{2+}(aq)	-2.370	MnO_4^-(aq)	1.510	3.880
K^+(aq)	**-2.925**	**Au(aq)**	**+1.500**	**3.425**
Al^{3+}(aq)	-1.660	Cl_2(g)	1.360	3.020
Zn^{2+}(aq)	**-0.760**	**Cu^{2+}(aq)**	**0.340**	**1.100**

Per cell voltage ranges of earth batteries are much lower than air batteries. The best, Mg-C, earth battery has a maximum 2.05 volts whilst the best Li^+(aq)-F_2(g) air battery has 5.915 volts. However, air battery design needs to consider several other economic aspects for commercial use. A common Zn-Air battery can supply 312kWh in comparison with 22kWh NiCd battery. An experimental study was conducted to measure exact voltages and currents of an earth battery cells consisting of zinc and copper electrodes. The electrodes arrangement on earth's surface in open air environment consists of simple pricking of pointed electrodes on earth's surface. The electrode soil reaction voltage 0.92V may be used to drive small scale lighting and electronic loads. Outside bare earth, the currents and voltages were found higher at smaller distances and lower at relatively larger distances between cathode and anodes. The voltages and currents readings were found unstable on the digital multi-meter. Repetition of above experiment with interchange of electrodes from north to south resulted in relatively increased voltages and currents. Average magnitudes of voltages and currents were measured to be 0.91±0.15V and 0.7±0.25mA for multiple electrodes. Earth battery potential depends upon the electrode materials and their standard reduction potentials. If we choose higher positive and negative reduction materials the earth battery voltage can be enhanced. Theoretical voltage of

Zn-Cu earth battery is 0.92V but our measurements conducted with UNI-T professional digital VOAM # 1050444792 (Korea) were about 0.90±0.25V. To construct a high voltage battery, suitable electrodes must be chosen. The magnitude of the current magnitude depends on electrode surface areas. Variation of measured fluctuating voltages and currents are shown in Fig. 9.

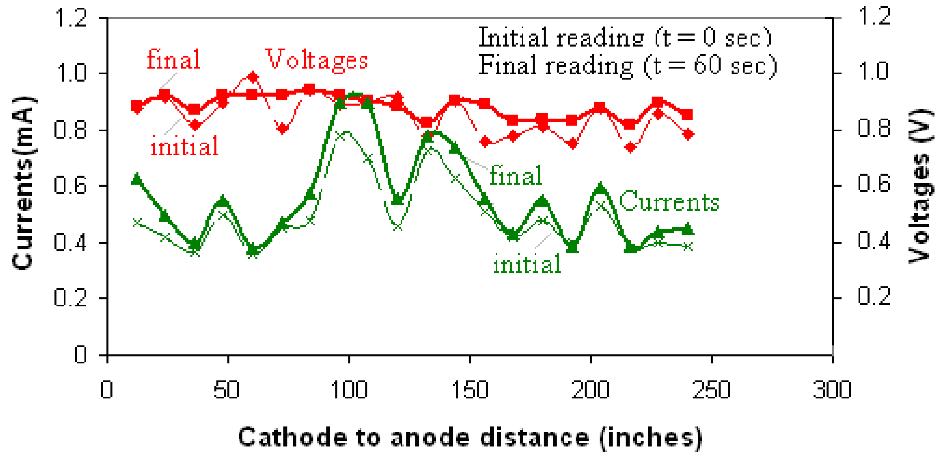


Fig. 9. Copper (south)-Zinc (north) earth battery voltages and currents in ground

When the same experiment was repeated inside the lab using insulated box mud cells, the voltage and current was found quite stable. It was supposed that the measurements made outside on bare earth might have extra telluric earth currents in addition to the normal earth battery currents. Maximum magnitude of the measured voltage was found to be 0.9 ±0.35 volts with currents in the 0.3±0.25mA range. Both the current and magnitudes continued to oscillate as if the some random potential source in addition to normal soil reaction voltage was found, modulating the constant DC earth battery voltage. Earth battery experimental arrangements using 4x4 inches square copper and zinc plates and copper electrodes and zinc containers are shown in Fig.10 and Fig.11, respectively.

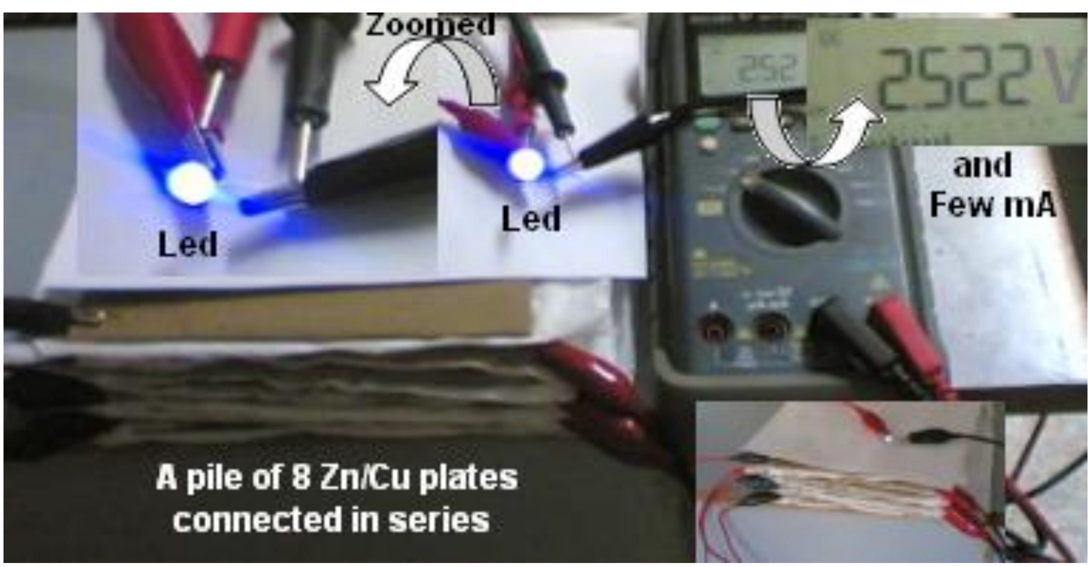


Fig. 10. Four inch square Zn/Cu plate electrodes 2.5V earth battery.

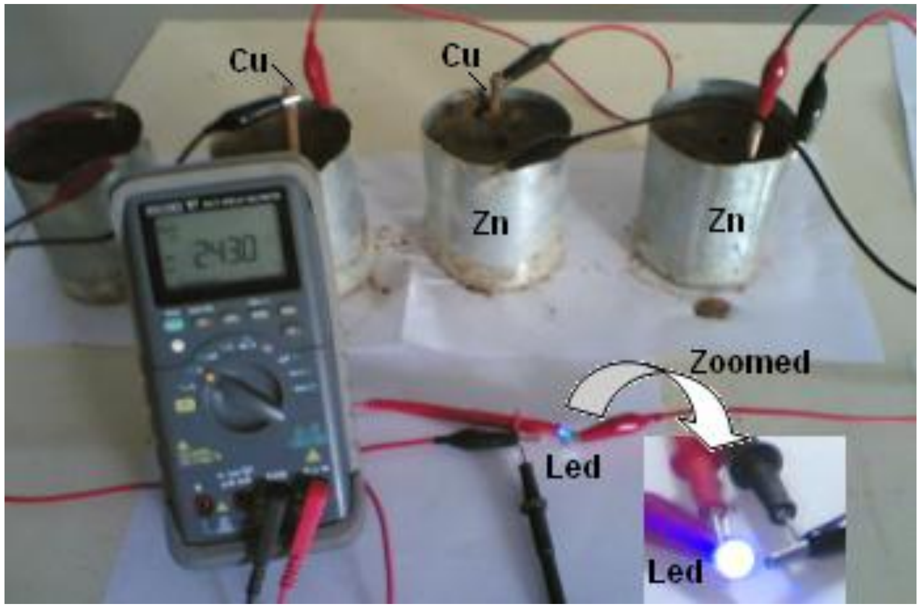
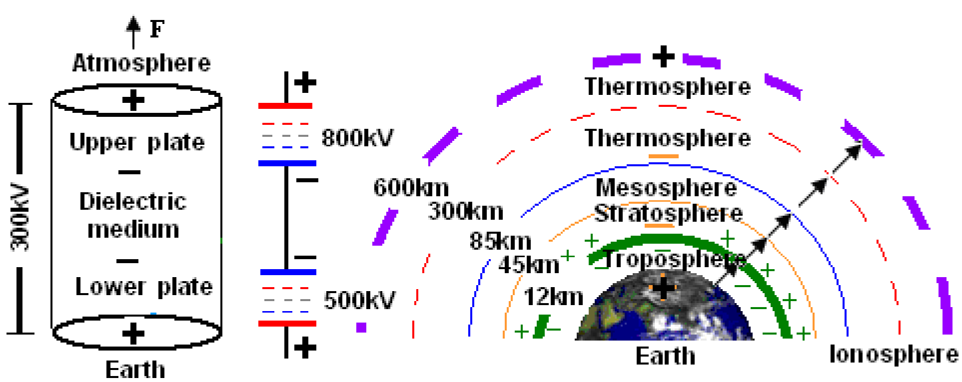


Fig. 11. Three inch diameter Zn cylinders and Cu electrodes 2.43V set up

Above earth batteries successfully lit LED for several days. When electrodes are dry, water needs to be sprinkled.. Calculations show large surface areas of earth batteries may supply enough current to power a large array of LEDs.

6. Atmospheric Electricity

Earth's atmosphere has a functioning dynamic global electric circuit consisting of conducting earth, conducting atmosphere, fair-weather downward currents and thunderstorms (Su et al., 2003). Global spherical capacitor plates have natural potential of 300kV. The capacitor continues to discharge downward from ionosphere to the earth at an average rate of $2x10^{-12}$ A/m^2 (@$2pAxA_{surface}$ = 1kA) (Pasko, 2003) in fair weather conditions and charges itself during thunderstorms from earth to atmosphere at a rate of 10 to 40kA. Average frequency of occurrence of thunderstorms on the globe is about 2000 Hz. This implies that an accumulative current in range of about 2 to 80MA continues to flow during storms. The discharge and charge rates are balanced by lightning processes (May, 2003). The ionosphere and earth together form a spherical capacitor that tends to exert upward force to pull plasma into upper space as shown in Fig. 12.



a. Biefeld effect b. Global spherical capacitor

Fig. 12. Spherical capacitor model of atmospheric electricity

Global Electric Circuit (GEC) contains electromotive force generators driven by the solar winds, atmospheric processes and earth's magnetic field. A scheme of global electric circuit based on reported data (Makarova et al., 1998; Makarova and Shirochkov, 1993) is shown in Fig.13.

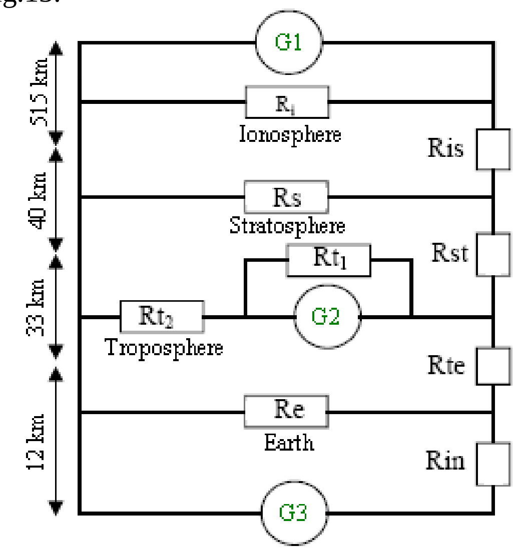


Fig.13 Equivalent global electric circuit (Makarova and Shirochkov, 1993; Rakov and Uman, 2003)

where G1 is an external current generator, G2 is troposphere voltage generator and G3 is the ground current generator. The passive elements of this circuit are the ionosphere resistance (Ri), stratosphere resistance (Rs), troposphere resistance (Rt; Rt_1 and Rt_2), earth resistance (Re), iono-stratosphere resistance (Ris), strato-troposphere resistance (Rst), troposphere-earth resistance (Rte) and earth's internal resistance Rin.

Total current in the circuit will be a sum of the currents in each conducting layer. Both generators could operate in the regimes of a current generator or a voltage generator. It will depend on a value of ratio of the load resistance and internal resistance of the generator. Whilst the exact atmospheric circuit is still debatable but average fair weather load resistance is about 100Ω. According to Markson (1978), the resistance between cloud top and ionosphere is about 10^5-10^6Ω and between cloud base and earth is 10^4-10^5Ω. Energy associated with global electric circuit is $2x10^{10}$J ($5x10^3$kWh) (Rycroft et al., 2000). Of course, the proposed scheme is a simplified version of a real GEC that is actually coupled with cosmos (Rycroft, 2006). This GEC does not include inductive and capacitive components and time variability of its parameters, which could give even a better answer. A research study (Singh et al., 2007) was critically examined the role of various generators of the currents flowing in the lower and upper atmosphere supplying currents to the global electric circuit. The earth's magnetosphere extends to several tens of thousands of miles into space. It is contracted on day side and tailed on night side. Strength of earth's magnetic field varies from 30 (equator) to 60μT (poles). Free energy thinkers believe the earth's magnetic field is a self-starting field of self-excited generators and can be used to produce electric power (Stong, 1974; Bryan and Hellemans, 2004). Energy content associated with GEC is illustrated in Fig.14.

According to earlier reports (Hale et al., 1981; Gonzalez et al., 1982), the middle atmosphere should be passive (Kelly, 1983), yet certain rocket measurements indicate the existence of large electric fields of unknown origin. Several studies have been conducted on various parameters, such as, atmospheric potentials, wave propagation, conductivity, resistance, telluric currents, Hall currents and electric field variations (Kasemir, 1979 and 1959; Rycroft et al., 2000). Where Rin, internal resistance of atmosphere generator, Ri, ionosphere resistance, Rfw, fair weather load and Rcg, clouds to ground resistance, as illustrated above. Nowadays, above circuit is modified as shown earlier in Fig. 14. More on global electric circuit is reported elsewhere (Sapkota and Varshneya, 1990; Singh et al., 2007). It appears as if there is little chance of operating atmospheric electric grid but it is very interesting to know earth's electrical environment to use atmosphere as a weather weapon for the locations suffering from floods and draughts. Further parametric details may be seen in classic published papers (Rycroft and Cho, 1998; NAP, 1986; Webb, 1971; Hill, 1971; Harison, 2004; Tinsely, 2000; Dolezalek, 1972; Plotkin, 1992). According to lightning energy calculation of Phillips Laboratory (Kozima, 1994), any single average lightning flash may produce 30 to 3000 kWh of energy. If the process could be repeated

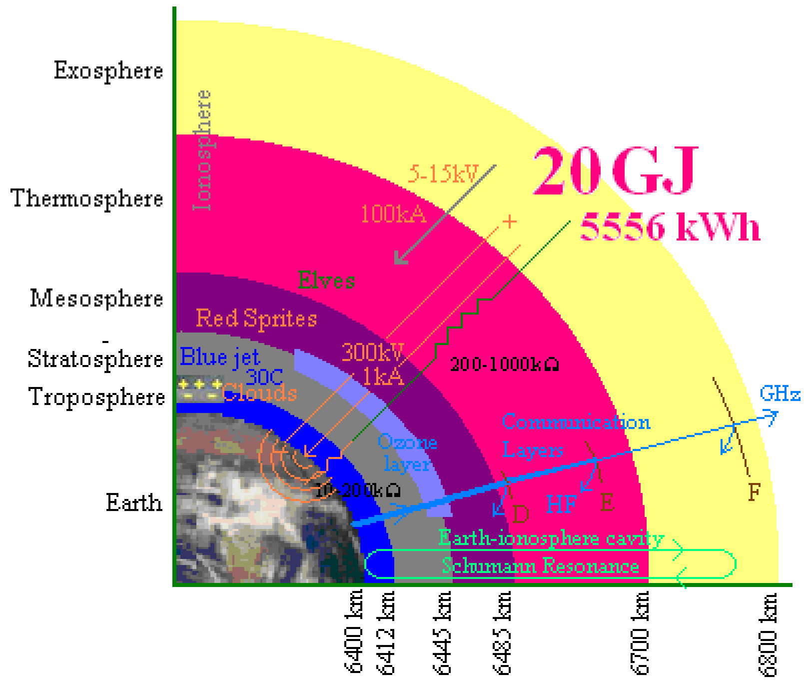


Fig. 14. Electrical environment of planet earth.

at high rep. rate (greater than atmosphere relaxation time constant ~ 100µs) then total energy received or stored in 24hrs could be as high as 1300×10^9kWh (instantaneous energy of GEC 5556kWh). This difference may be attributed to use of peak and measured RMS values in above project calculations. On the average, one lightning phenomenon may consist of 2 to 3 pulses. Therefore, 432×10^6 intervals were used instead of 8.64×10^9 intervals in laser triggered single 10µs pulse duration calculations. At rate of air breakdown, a voltage of approximately 15kV/mm, it takes 15×10^9V potential difference to cause lightning between 1km high cloud and earth as assumed in above calculations. Laser induced lightning is claimed to be huge source of energy in future.

Ultrashort pulse lasers can cause filamentation (Fontaine et al., 2000) in air to attract charges to earth through ionised channels. IR Nanosecond (Koopman and Wilkerson, 1971; Shindo et al., 1993) and UV Femtosecond (Xin et al., 1995; Méjean et al., 2006) lasers have successfully caused laser triggered lightning in outdoor and indoor lab environment but continued research is developing lasers with peak powers and pulse durations are expected to go beyond Yottawats and Yoctoseconds. As the time, space and mass become intertwined, therefore, according to Plank's Law, matter becomes converted into energy at power levels of Rintawatt and that black hole (zero volume with infinite gravity) convert mass into energy. A Rintawatt (10^{45}W) may be called a Bangawatt, after big bang theory and a Rimtosecond (10^{45}s) as Bangosecond. The numbers still continue but real laser pulses at above power and durations may satisfy threshold requirements of black hole processes and experiments in lab environment. Recent developments at CERN are a good sign in this direction. Origin of lightning phenomenon was explained elsewhere (Rakov and Uman, 2003) and glimpses on atmospheric electricity in published literature (May, 2003; http://www.windows.ucar.edu/; Tollefson, 2010; Tinsely, 2000; Dolezalek, 1972; Plotkin, 1992).

7. Grand Energy Transition

Current global energy demand is shared by oil (36%), coal (28%), gas (24%), nuclear (6%), hydro (6%) and renewable (1%) energy sources. Global community has been consuming 4000MTOE energy from 2000 to 2010 which is likely to increase to 1000MTOE by 2050. Global oil production has declined from 1,000,000 MTOE/day to 700,000 MTOE whereas energy consumption has increased from 500,000 to 700,000MTOE. Global oil production and export is on constant decline. Global oil production has declined from 40 in 2006 to 26 Mb/day in 2010 and is likely to further decline to 11 Mb/day by 2012. Gas production has increased from 2300 in 2000 to 2750MTOE in 2010 and is likely to peak at 3200 in 2020 to 2030 and decline to 1300MTOE by 2050. Coal production has increased from 2400 in 2000 to 3450MTOE in 2010 and is likely to peak at 3650 MTOE in 2020 to 2030 and decline to 2700 in 2050 and 1350MTOE by 2070. Global renewable energy supply was 15 in 1990, 20 in 2000 and 45MTOE in 2010 that is likely to increase to 200 in 2040 and 300MTOE by 2050. Global energy mix was 10.70GTOE in 2005 which is likely to increase to 11.80GTOE in 2015 and then decline to 10GTOE in 2035 and 6 GTOE in 2050. Global population of 6.75 billion in 2010 will continue to increase to peak at 7.5 billion in 2025 with subsequent decline to 5 by 2050 and 1.8 billion by 2100 (Chefurka, 2007). If no reliable alternative energy sources are found in time, then global energy consumption rate will decline to about 2GTOE by 2100 which is slightly higher compared to the direful dark stone ages (Thornhil, 2004).

Economic systems may collapse after oil and gas depletion but human race will continue to survive on renewable energy resources. We can save energy by increasing machine efficiency, efficient use of energy, energy conservation, frugality and austerity. Even if we are left with living option on organics and endosomatic energies, we can survive. Humans can conserve their body energy using warm clothes in whiteout. Humans have learnt harnessing animals, winds, waters, sun and chemicals. If nuclear fusion and artificial photosynthesis succeeds, we can produce hundreds of pitawatts power. Nervy view of imminent collapse of human civilization after few decades seems exaggerated and a drivel. The final verdict of a pessimist (David, 1995) is that there is nothing as a true renewable energy because of, ultimately, the sun's death is a billion years. Distant civilization's issue is not of immediate concern even until quite a few hundreds of centuries. Argument that trees will finish is unlikely as new trees continue to thrive on their decaying matter. Human civilization cannot collapse as long as the sun shines and humans do not start eating one another or some cosmic event wipes them out. Exosomatic use of energy for economic development depends on fuels availability. Global energy plans to harness renewable energy to replace fossil fuels in power generation by 2050 is an indication of innovation and change in lifestyles. This is a grand energy transition (GET) movement in human history since last eight to thirteen thousands years. Declining solid (wood and coal), peaking liquid (oil and CNG) and kicking off the gas (methane and hydrogen) fuels eons is illustrated in Fig. 15.

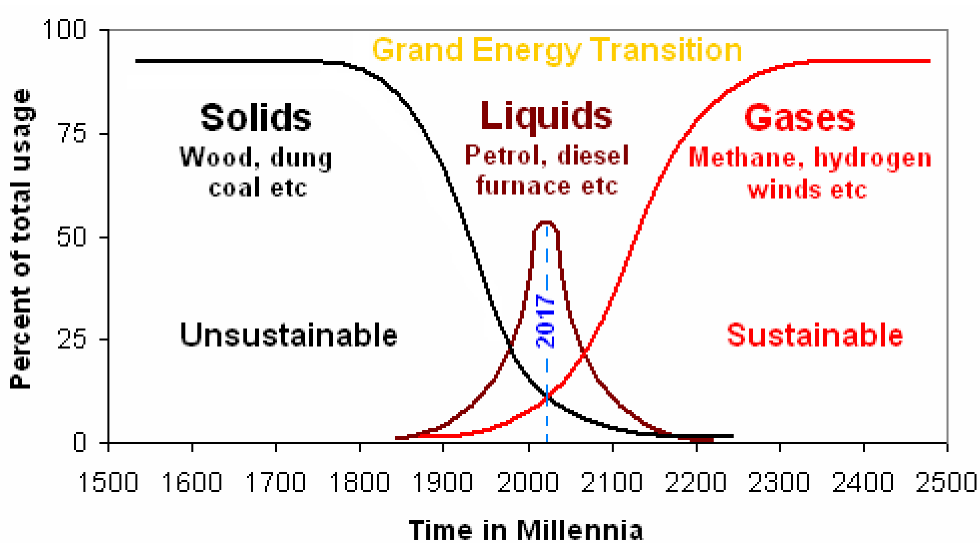


Fig. 15. Grand energy transition (GET) explanation (Robert, 2009).

World is producing crude oil, natural gas and coal at rates of 87.4 billionbarrels/day, 9.10 millionm^3/day and 17.52 million tonnes/day. We all are burning oil, gas and coal at an equivalent oil rate of 1000 barrels/s. Current 87.4 million barrels/day oil consumption is likely to decline to 39 million barrels/day by 2030. There is no chemical process which can clean ballooning CO_2 volumes from atmosphere. World hydrocarbons statistics is shown in Table 4.

Table 4. Global fossil fuels reserves statistics

Fuels	Total Reserves	Production*/Yr	End (Date)
Oil	1372 Billion barrels	31.90 Bb	2053
Gas	172,000 Billion meter^3	3295 Mm^3	2060
Coal	909,064 Million tonnes	6,395.6 MT	2155

***MT = Million tonnes, Mm^3 = Million meters cube, Bb = Billion barrels**

World community currently uses 75 to 80% fossil fuels and 20-25% renewable energy resources. Pakistan's primary energy supply of 58MTOE consists of natural gas (51%), oil (28%), hydro (13%), coal (7%) and nuclear (1%) sources. Energy supply of 26MTOE for power generation consists of natural gas (54%), oil (16%), hydro (28%) and nuclear (1%) sources. According to most authenticated information based on Pakistan Yearbook 2006, no renewable energy is being harnessed by power and energy utilities only AEDB is involved in some wind power project. Pakistan has a potential of 25,000MW solar, 30,000MW wind, 15,000MW wave and 41000MW hydropower out of which 10,000MW solar, 10,000MW wind, 5,000MW ocean and 25,000MW hydro power is economically viable. Pakistan has 85 billion tonne coal reserves which by underground coal gasification and Fischer-Tropsch coal to liquid (CTL) conversion process can fulfil all energy needs. A typical power plan for Pakistan may consist of increasing hydro, wind, nuclear, photovoltaic (PV), ocean wave and tidal power generation instead of 67% oil and gas as illustrated in Table 5.

Table 5. Pakistan's 100% renewable power plan 2050

Resource	2010	2020	2030	2040	2050	2060
Hydro (%)	28	33	37	40	45	Saturates
Wind (%)	0.5	1	2	3	4	Extensible
PV (%)	0.5	2	4	6	8	Extensible
Wave (%)	0	1	2	3	4	Extensible
Nuclear (%)	2	5	8	12	14	Extensible
Coal gas (%)	0	6	12	18	21	Extensible
Oil & Gas (%)	69	42	32	15	0	Depletes
Innovations (%)	0	1	2	3	4	Develops
Supply (MW)	13,000	18,000	23,000	28,000	33,000	38,000
Demand (MW)	15,000	19,000	23,000	27,000	31,000	35,000

Global community has five decades time period to increase currently 18% renewable energy power to 100%. Various countries follow different strategies depending upon their available renewable energy resources. A generalised transition plan may consist of first brainstorming to develop a local energy transition plan depending upon the available types of resources. Authorised task force must attend 100% renewable energy conferences to share their plan with energy experts. Task force may use the conference feedback to improve the plan and stay in touch to incorporate future developments. Initial energy transition plan may consist of using available, under development and future technologies over next four decades.

Demand and supply may increase in future at a rate of 400 and 500MW/yr due to widespread adoption of renewable energy technologies in private sector. WAPDA supply will be able to meet the power demand after 2020. Oil peaking by 2015 and gas peaking by 2020 will force oil and gas companies to go for alternative fuels. Fossil fuels crisis and climate change policies may not allow continued reliance on oil, gas and coal. Current fuel supply includes 29, 3 and 2 MTOE of natural gas, oil and coal. Difference in supply and demand is being met with imported oils. Pakistan has also signed a natural gas contract with Iran and NLG with Qatar. It is a midterm measure for few decades. Thereafter, the world communities would have money but there might be no shop to sell oil and gas. A possible alternative fuel plan for Pakistan is shown in Table 6.

Table 6. Pakistan's alternative energy plan 2050

Resource	2010	2020	2030	2040	2050	2060
Biofuel (%)	1	4	9	14	17	Saturates
Hydrogen (%)	0	2	4	5	6	Extensible
Nuclear (%)	0	6	11	16	19	Extensible
Heat pump (%)	0	1	2	3	4	Extensible
CTL/GTL (%)	5	5	15	30	44	Saturates
Petroleum (%)	30	30	17	8	0	Depletes
LPG/CNG (%)	64	51	38	24	10	Depletes
Innovations (%)	0	0	0	0	0	Develops
Supply (MTOE)	35	45	55	65	75	85
Demand (MTOE)	55	60	65	70	75	80

Technological innovations in renewable energy systems are too difficult to predict because of many complex reasons. However, if we continue to traverse in the correct direction, then sooner or later, it would be possible to reach the goal. There is a general feel that the fossil fuels will be followed by nuclear and biotechnologies which in parallel will be followed by renewable, hydrogen and laser fusion that will continue to exist for a long period until any new cheaper energy source becomes available, as illustrated by successive energy supply S-Curves shown in Fig.16.

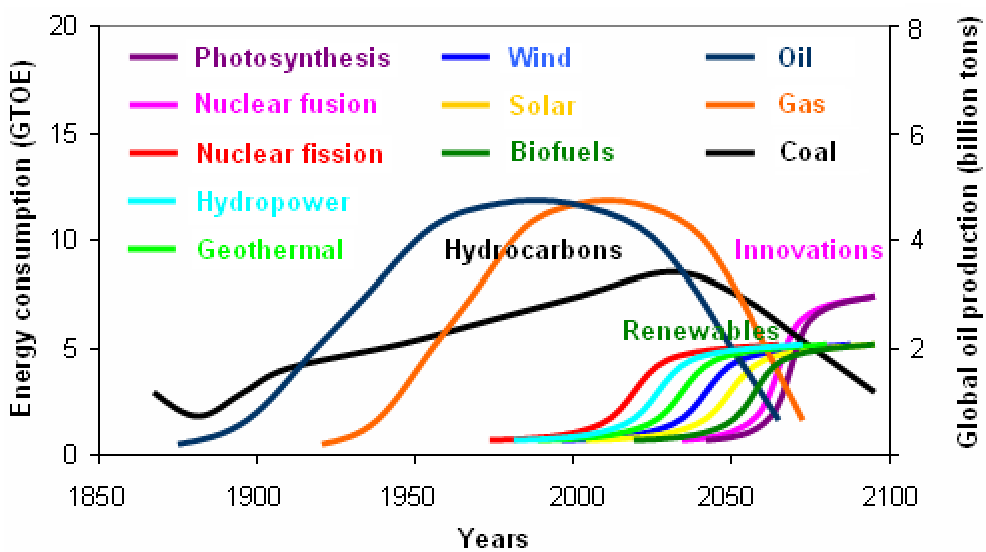


Fig. 16. Successive S-Curves for future energy supplies.

Oil, gas and coal crises are entangling water and food crises. One pound wheat and meat require 130 and 1,000gal of water during agriculture. Rich people consume annually 90 to 100 million tonnes of fish that poor cannot afford to eat. According to FAO World Bank Report of

2010, only 20% people of world occupy 76.6% of total global resources. Middle class (60%) use 21.9% of the resources and while the rest poor class (20%) have just 1.5% of total resources. Rich people enjoy over 51 times more than poor people. Global rich community annually spends $780 billion on arms for their security, $400 billions on narcotics and $50 billion on cigarettes which further add in CO_2 emissions. European Union and USA alone annually spend $17 billion on pets and $12 billion on perfumes. EU and USA annually spend $11 billion on ice creams and $8 billion on cosmetics. Average weekly food expenses of German, Japanese and Arab families are $500, $317 and $221, respectively, whereas those for average Bhutanese and Chadian families are $5 and $1.23 respectively. World community spends just a 1% of money on drugs, alcohols and cigarettes. If climate change is going to cause an inferno or blitzkrieg, that is a rich man's issue, not of poor communities. If we all are residents of the same planet with equal rights then let us stop bribe, scribe and uribe.

Humans spent 8,000 to 13,000 years without coal, oil, gas and electricity although fossil fuels were under their feet and electricity all around, even inside them. Islamic empire started study of nature following Roman Empire and laid down solid foundations of science, mathematics, geography, medicines and cosmology in seven centuries. Europeans started the industrial revolution in seventeenth century which prevails today. Europeans started coal mining in 1700s and invented steam engine in 1785. Oil discovery in 1859 led to invention of internal combustion engine in 1860s. Exploration of natural gas in last decades of 1800s led to development of gas engines in early 1900s. Ancient scientists invented the wheel but industrial revolution spun producing epic prosperity which earlier kings and emperors had not even dreamed. It is our moral duty to work hard to keep the wheel turning. If it stops, we all will be automatically in the Dark Age as an Arab said "Stone Age did not end for shortage of stones". It is energy (*money*) that makes the clergy (*mere*) go. A hungry poor man even loses the human thinking capability. To keep the lights on, let us think of the unthinkable to bring about a change. A grand energy phase change transition is already underway. To expedite the grand energy transition, let us recount our molecules, atoms, electrons and photons.

8. Depletion or Repletion Scenario

Nobody wants hearing bad news of depletion, especially when we are dependent on oil and gas for prosperity. We are all addicted to fossil fuels and need to get rid of it before it is too late. In light of the method of the economy,, it seems likely that we cannot get independence from oil chains. Everybody appreciates listening to abundance and repletion but that is mirage, not reality. Fossil fuels account for almost 86% of the global primary energy demand which is rising over time. Oil, gas, coal, renewable and alternative energy resources are 36, 27, 23 and 14% of overall energy mix. Solar, wind, geothermal, biomass and hydropower account for 8% and nuclear power just 6%. Situation is likely to worsen after oil, gas and coal production peak in 2015 at 30Gb/year, 2035 at 132Tcf/year and 2052 at 4.5GTOE/year (Maggio and Cacciola, 2012). A group of 6.8% scientists believe that oil production has already peaked in 2007 or earlier, 37.9% hold that it peaked between 2008 and 2012, 34.5% guess that it will peak between 2013 and 2012 whilst 20.7% claim that it will peak in 2023 or later (Pedro & Pedro, 2011). We are burning fossils fuels at rate of 1,000 barrels/s which produce 29Gt of CO_2 per year out of which hardly 6.8Gt is absorbed in natural processes and the remaining 10.2 Gt enters into the atmosphere (Gail, 2011). Widespread adoption of renewable energy programs in the last two decades have so far failed to compete the rising fossil fuels demands in the West, China and India. Economic systems are based on infinite energy resources which are in fact limited in nature. Fossil fuels depletion or repletion is a debatable issue but our consensus cannot change nature. Energy experts hold it is just a matter of earlier or later depletion but the fact remains that fossils fuels are on decline (Christopher et al., 2011). Environmentalists advise to minimise use of fossil fuels due to their adverse affects on nature, irrespective of repletion or depletion. We have to break our addiction to fossil fuels. There is still time to review our fossil-fuels-based economic policies before we really enter the post hydrocarbon era. Energy experts have started thinking of sustainable hydrocarbon fuels by recycling water and carbon dioxide with renewable energy resources (Bilanovic et al., 2009). Solar, wind, geothermal, wood, carbon dioxide and water are being examined to replace oil but there is no apparent success to date. Alternative energy sources are under extensive research due to looming energy crisis. High oil prices, environmental pollution, global warming, combustion enhancement, emission reductions and forced load managements in sultry summers are attracting scientists to harness explosive gases like acetylene, hydroxy and hydrogen.

9. Conclusions

Nature has scattered power and energy treasures in earth, oceans, airs and skies for people but it is up to our wisdom and efforts to explore and harness these resources. It is time to start extensive power and energy education and research programmes. Nature powers the planet most economically using photosynthesis technology. We are located on a rotating and revolving suicide mud ball in air, if prompt action is not taken. Keeping aside any social differences society has, it must be understood that this earth is ours. Water or oxygen molecules that we consume today might have passed through the stomach and lungs of our enemies in past. Energy supplied by sun in one minute to earth's surface is enough for power needs of 6.75 billion humans for one year, which already answers the question to energy integrals for whole days, years and the 200 billion year yet to come. To convert the available energy resources to our desired form, we have to engineer the technologies ourselves to tailor the resources according to our needs. It could be dangerous to destabilise atmospheric electromagnetic system and earth core in an attempt to try to explode atmospherics with RW lasers and earth with deeper drilling. It is more attractive to pay attention to organic molecules and solar energy driven artificial photosynthesis. Rocket triggered experiments have shown that laser triggered lightning to capture energy is less attractive than harnessing the air and water hurricanes and storms. Artificial photosynthesis has the potential to leapfrog impending and future energy crises. Pakistan must focus on underground coal gasification, hydro, solar, wind, calathrates and oceans. Key holds a key to overcome energy problem in Pakistan but photosynthesis and CO_2 and H_2O based economic fuel synthesis techniques would be the eventual solution for the global community. If the laser ignition fusion experiments do not succeed well by 2050, the global community will have no option except toil, austerity and frugality.

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