ENERGY CRISIS AND ALTERNATIVE ENERGY SOURCES: OPTIONS FOR PAKISTAN

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Energy is the life line of Pakistan's development; it is a developing country that requires growing amounts of energy to keep the pace of development intact. Agriculture and industrial sectors are two important components of Pakistan's economy. China, India and other fast developing countries` quest for external energy resources is influencing the international energy system of supply and demand. China is projected to consume within twenty years what USA is consuming today. China is negotiating oil projects in different regions of the world. India considers energy security only second to its food security. The daily imports of India will rise more than three-fold within twelve years.The rise of Asia as a manufacturing power contributes to a precarious balance in the world's market for oil and natural gas. [1]

Middle East and Central Asian regions are rich in fossil fuels and Pakistan's contiguity with those regions is a precious asset. All major sources estimate that the world's proven oil reserves were between 1.1 and 1.2 trillion barrels. Nearly 65 percent are found in five countries in the Persian Gulf area: Saudi Arabia, Iraq, Kuwait, UAE, and Iran. [2] OPEC account for 69 percent of the world's proven oil reserves.[3] Unless alternative to crude oil quickly prove themselves, the market share of the Middle Eastern members of the OPEC will rise rapidly.[4] It is in the interest of both consumers and suppliers to diversify routes to avoid disruption caused by technological problems or political disputes.[5] Pipelines have become necessary evil for Central Asian Countries because existing export routes out of the Caspian basin are overtaxed, inadequate, inconvenient and unreliable and the open seas far away, large pipelines appear to be the only economic means of transferring Caspian crude oil.[6]

The energy crisis is international but in Pakistan it is severe mostly due to internal factors. Lack of long term planning, poor management, lopsided priorities, lip-service to conservation

measures, ad hocism, lack of accountability and international price hike are some of the major causes of the current energy crisis in the country. Though causes of insecurity in the region are global in nature yet measures should be adopted to improve the situation and transform Gwadar port into an energy transport hub and construct pipelines like TAP, IPI, and GUSA. Development of small hydro projects with an accelerated pace will help to overcome the immediate energy crisis. In recent years, the combination of rising oil consumption and flat oil production in Pakistan has led to rising oil imports from Middle East and the lack of refining capacity leaves Pakistan heavily dependent on petroleum product imports. Generating capacity needs to grow by 50 percent by 2010 in order to meet expected demand.[7] In 2005, 86 percent of primary energy production in the world came from burning fossil fuels.[8] By 2010 the gap between demand and supply of energy could reach up to 8,000 MW in Pakistan.[9] The power shortage is estimated to increase to about 5300 MW by 2010. The overall energy requirement of Pakistan is expected to be about 80 million tons of oil equivalents (MTOE) in 2010. The development of water resources would resolve the problem in the long run but in the short term, there was a limit to constructing costly thermal power projects given their high economic costs. A major shortfall is expected in natural gas supplies, as an official energy demand forecast indicates that the demand for natural gas, which makes up about 50 percent of Pakistan's energy consumption, would increase by 44 percent to 39 MTOE from 27 MTOE currently [10.]

The government had planned five major initiatives, including three gas import pipelines, the Gwadar port as energy hub and the LNG import to meet these energy requirements. But four of these measures, namely the three import pipeline projects, are uncertain at present, while concentration on energy facilities in Gwadar would chiefly depend on security situation, besides oil and gas import pipelines.[11] There is need to make the best use of existing power generation by taking conservation measures at individual, community and national level.[12] The programme of expansion of generating capacities that has been laid down under "Vision 2025" programme will help in this connection. It envisions increasing existing power generating capacity by 10000 mw by 2010 and

around 35000 mw by 2025 at an enormous cost of $35 billion to be shared by the government and private sector. The share of different sources of energy is stipulated to be as follows: hydro-electricity: 22563 mw, new gas fired plants: 4680 mw, coal fired plants: 4350 mw, nuclear plants: 1800 mw and finally 1500 mw from renewable energy resources.[13]

The difference between firm supply and peak demand is estimated at 5,529 MW by the year 2009-10 when firm electricity supply will stand at 15,055 MW against peak demand of 20,584 MW. The following projects will be great leap forward in this connection. The details of projects are Malakand-lll (81MW), Pehur (18MW) and combined cycle power plant at Faisalabad (450MW). Mangla Dam raising project would also add 150 MW capacity to the national grid. Besides this, Khan Khwar (72MW), Allai Khwar (121MW), Duber Khwar (130MW) and Kayal Khwar (130MW) are expected to be completed in 2008 along with Golan Gol (106MW) and Jinnah (96MW). Moreover, Matiltan (84MW), New Bong Escape (79MW) and Rajdhani (132MW) are expected by 2009 while Taunsa (120MW) is likely to be completed by 2010. WAPDA has also planned to install a high efficiency combined cycle power plant at Baloki (450MW), which is expected to be completed by 2010. A power plant 1 and 2 of 300 MW each at Thar Coal with the assistance of China are also planned for commissioning in 2009.[14]

Almost every regime has dealt with energy on an ad hoc basis. Long-term and sustainable planning of energy have been an alien concept. The fact that the IPPs were set up at the terms of the investors suggest that it was a move made in panic. Another example worth quoting here is that of the 969MW Neelam-Jehlum hydroelectric project. It was to be constructed in 2003 at a cost of $1.5 billion. It got abandoned until the present power crises intensified towards the end of 2007. The revised estimate is around $2.25 billion. In terms of project cost alone the delay has caused an extra $750 million. A positive step to coop with the current energy crisis is that energy offices should be run by qualified, committed and deserving people equipped with due mandate. Relevant ministries and departments should also be overhauled.[15]Government

has devised an energy management plan to save unnecessary use of power supply by closing commercial centers and markets at 9 pm.[16] To lower oil and energy prices in Pakistan some people suggest that by implementing 1 percent energy tax on all items that have GST will help.[17] The prevalent crisis is a consequence of imprudent energy policies over the last three decades.[18] There is a finite limit to future hydrocarbons supplies and it is time to look for new and innovative avenues to resolve our energy problems.[19] We are used to thinking of energy as something that can be found in reservoirs and coal seams, the resource of future lie elsewhere in the form of energy, but also in efficiency itself-in doing more with less.[20]

There is great scope for hydro power generation in Pakistan. Hydroelectric energy is a term usually reserved for large-scale hydroelectric dams. Micro Hydro systems are hydroelectric power installations that typically produce up to 100 kW of power.[21] Hydro-electricity accounts for 33 per cent.[22] In the fiscal year 1990-91 hydropower accounted for 45 per cent of all electricity produced in the country but it was reduced to 26 per cent with a 10-year period. The share of thermally generated electricity increased from 54 per cent to 71 per cent during the same period. Between the period of 1990 and 2003 the total consumption increased by 84 per cent, from 31twh to 57twh. Presently, an annual average increase of 7 per cent has been postulated.[23] In hydro power sector the potential which has been identified is about 46,000 MW out of which only 6,595 MW is utilized in the country.[24] It generates only 8000 mw of electricity against an installed capacity of 11327 mw.[25]

Most of the hydro power potential lies in the NWFP, Northern Areas (NA) and AJK. The potential available in canal system and in small rivers and streams if exactly calculated will give out much more higher figures. The country has over 2,000 MW of sites with studies to pre-feasibility and beyond for small and mini hydropower projects under 50 MW capacity, with many more sites yet to be identified. Small and Micro-hydropower projects are suitable for domestic investment and individual projects can come on line within 2-3 years. The total capacity in Pakistan is 19403 MW out of which the installed capacity of the hydropower stations in the country is about 6595 MW, in which 3767 MW is in NWFP, 1698

MW in Punjab, 1036 MW in AJK and 93 MW in the Northern Areas. This shows that only about 15 percent of the available hydropower potential has been harnessed. Micro, mini hydropower projects were developed for rural electrification by the provincial bodies, mainly in the North West Frontier Province through Sarhad Hydel Development Organization (SHYDO), Northern Areas Public Works Department (NAPWD) in administrative Northern Areas (NA) and NGOs like the Aga Khan Foundation with community participation. A similar approach was also adopted in Upper Dir district of NWFP by an European Union funded project together with IUCN. In addition, Pakistan Council of Renewable Energy Technologies (PCRET) also introduced the community based micro hydro stations (20-30 kW) in parts of NWFP in Swat, Dir, Chitral, Kohistan, Mansehra and Abbottabad districts. According to National Power Plan (NPP), the average annual growth is projected at an average of 7 per cent over the period of next 10 years, which means that country requires installing about 1200 to 1500 MW installed capacity each year in order to avoid load shedding and serious power shortages. This corresponds to a peak demand of nearly 30,000 MW in 2010 and 50,000 in 2018.[26]

The average cost of hydel energy generation in Pakistan was Rs0.50 per kilowatt hour in 2000-01. The annual per capita electricity consumption in Pakistan is around 320kwh, and this only caters for 60 per cent of the population. Forty per cent of Pakistanis still have no access to electricity. In Vision-2025 a short-term plan was developed and the commissioning date of eight hydel projects with a total generation capacity of 716MW was fixed on June 2006. These projects were proposed and designed as 'run-of-river' plants, which have no storage capacity, such as Ghazi Barotha hydropower project, in which no big reservoir is to be constructed. But unfortunately none of these projects could be completed.[27] The root-cause of the failure to provide the needed energy is lack of strategy for implementation. The strategy fails to take into account the ground realties and the project management capabilities of executing agencies.[28] Another reason is that the federal government has not taken small hydropower projects (SHPs) in its own hands. Such projects are very viable as they do not require building of large dams and do not pose problems of deforestation, submergence or

rehabilitation. Comparatively small capital investment and short gestation periods are required to complete these. In Pakistan all small hydropower projects up to 50MW are the responsibility of the provincial governments which cannot construct small hydropower projects due to financial constrains, among other reasons, Punjab has enough financial resources but it has made no real progress on small hydropower plants even though WAPDA has not only identified various locations having a potential of 350MW but also completed the necessary design works. In Azad Jammu and Kashmir, which is endowed with abundant hydel potential, the AJK Hydroelectric Board has only completed hydro projects having a capacity of 36MW against an identified potential of 5,329MW. This hydrogenation cannot even meet the electric demand of AJK itself, which is 250MW.[29] In Northern Areas the electricity demand is more than 100MW but total power generation from hydel power stations is a mere 46MW. To bridge the gap between demand and supply a diesel power plant with a total generation of 5MW has been commissioned by the government. Some experts have suggested power line from Tajikistan via Afghanistan to Northern Areas. Development of small hydro projects at an accelerated pace should be one of the tasks set by the policy to meet the present power crisis.[30]

Alternative Energy Development Board (AEDB) has initiated and successfully completed Pilot Project for the Development of Kaplan Turbines Technology in the local industry to harness the low head hydel potential in canals, streams and barrages to generate electric power.[31] Renewable energy is derived from natural processes that are replenished constantly. Included in the definition is electricity and heat generated from solar, wind, ocean, hydropower, biomass, geothermal resources, and biofuels and hydrogen derived from renewable resources.[32] The principle of supply and demand suggests that as hydrocarbon supplies diminish, prices will rise. Therefore higher prices will lead to increased alternative, renewable energy supplies as previously uneconomic sources become sufficiently economical to exploit.[33] Alternate energy technology can provide quick and sustainable solution for domestic sector in step with international practice replace 20-25 percent of fossil fuel based current energy generation with alternate

energy; cut fossil fuel imports. The 'plug and play' and main grid compatibility of these alternate energy options can alleviate misery of masses; therefore, it is time to shift country's domestic and agriculture sectors to alternate energy. It will help in the following ways: 1) The 'plug and play' and 'grid ready' alternate energy technology can bring immediate relief at grassroots and end three year waiting period. 2) The alternate energy solutions are cheaper because: (a) due to their proximity to consumers they reduce line losses, which in turn reduce energy cost. (b) it will allow energy generation at districts, tehsils and individual level. 3). Cheaper energy will promote small/medium industrial and manufacturing setups with multiple advantages including generation/sustenance of millions of jobs. 4) Cheaper sustainable alternate energy solutions will support and sustain country's agricultural sector offering critical advantages including higher production and increasing employment opportunities. 5) Reduce energy related disputes between federation and provinces.[34]

The shift to alternate energy can help Pakistan save 300 billion rupees being paid in annual subsidies to energy companies at the rate of 25 billion rupees per month.[35] The renewable market will boom when cost efficiency attains parity with other competing energy sources. Other than market forces, renewable industry often needs government sponsorship to help generate enough momentum in the market. Many countries and states have implemented incentives to encourage consumers to shift to renewable energy sources.[36] Critics suggest that some renewable energy applications may create pollution, be dangerous, take up large amounts of land, or be incapable of generating a large net amount of energy. Proponents advocate the use of "appropriate renewable", also known as soft energy technologies, as these have many advantages.[37] Thermal power is mostly produced by burning either natural gas or imported oil. Thermal power accounts for 64 per cent of the total installed capacity. Nuclear power plants account for 3 per cent. Nuclear energy is yet another source of energy and at present PAEC produces 472 mw. The country also needs to switch over to coal from the indigenous source of energy that is estimated to be the third largest in the world with a reserve of 33.0 trillion tons.[38] Coal currently provides about half of America`s energy needs.[39] There is

a reservoir of 135 billion tonns of coal in Tharparkar that can help produce more or less 20,000 MW of electricity. Some experts have also suggested that Pakistan should import electricity from Iran for Baluchistan as it would cost comparatively lesser than other measures.[40]

An important source of alternative energy is wind power. The wind is the fuel, which drives the turbine that generates electricity into a grid. Airflows can be used to run wind turbines. Modern wind turbines with rated output of 1.5–3 MW have become the most common for commercial use. Wind power projects can start generating electricity within two years.[41]In Pakistan 4200 MW can be generated by 1600 wind turbines with each generating of 3 MWs. The purchase of 1600 wind turbines should cost around 0.192 billion dollars (1600 x $1,20,000 per piece) which is not only fraction of 4.6 billion dollars being currently paid under subsidy head but will also cut expenditure on import of costly furnace oil and ease pressure on foreign reserves etc.[42] Pakistan has a considerable potential of wind energy in the coastal belt of Sindh, Balochistan and as well as in the desert areas of Punjab and Sindh. The coastal belt of Pakistan is blessed with a God gifted wind corridor that is 60 km wide (Gharo~Kati Bandar) and 180 km long (up to Hyderabad). This corridor has the exploitable potential of 50,000 MW of electricity generation through wind energy. In addition to that there have been some other wind sites in coastal area of Balochistan and Northern Areas. It is estimated that more than 5000 villages can be electrified through wind energy in Sindh, Balochistan and Northern areas. So far more than 18 villages have been electrified using micro wind turbines. Indigenous development of micro wind turbines has also commenced in Pakistan. World Wide Fund for Nature (WWF) erected three 500-watt windmills in Sindh. Each windmill cost about $1,000, including installation.[43]

Another form of renewable energy is solar energy. Solar energy in the context of renewable energy refers to energy that is collected from sunlight.[44] Solar energy has excellent potential in Pakistan that receives high levels of solar radiation throughout the year. Solar Energy is available at a rate of 1000 watts per square meter in Pakistan. This can be converted to DC electricity with the

help of Solar Photovoltaic cells, which may be used to pump water, operate fans, TV and telecommunications directly during daytime.[45] There are two types of Solar Thermal Technologies that are mature: (1) Solar Dish Stirling Engine Technology: A solar dish/engine system utilizes solar energy as the source energy to heat the working fluid of a Stirling engine which drives an electric generator. (2) Solar Parabolic Trough Technology: This system also utilizes solar energy as a heat source to generate steam which in turn runs a steam turbine which is used to generate electricity. Pakistan lies in an area of one of the highest solar insolation in the world. This vast potential can be exploited to produce electricity, which could be provided to off-grid communities in the northern hilly areas and the southern and western deserts. Applications other than electricity production such as solar water heaters and solar cookers also have vast applications.[46] It is said that solar energy is the one existing non-hydrocarbon technology that has any hope of filling the projected need for huge volumes of new carbon-free electricity-twenty eight terawatts-by 2050.[47]

Biogas is another source of renewable energy. Biogas can easily be produced from current waste streams, such as: paper production, sugar production, sewage, animal waste and so forth. These various waste streams have to be slurried together and allowed to naturally ferment, producing methane gas. Alternatively biogas can be produced via advanced waste processing systems such as mechanical biological treatment. [48] Biodiesel is a clean burning alternative fuel, produced from renewable resources. Biodiesel can be blended with petroleum diesel to create a Biodiesel blend or could be used directly. It can be used in compression-ignition (diesel) engines with little or no modifications. [49] Biofuel Plants use photosynthesis to grow and produce biomass or biomatter. Biomass can be used directly as fuel or to produce liquid bio-fuel. Liquid biofuel is usually either a bioalcohol such as ethanol fuels or a bio-oil such as biodiesel and straight vegetable oil. Solid biomass is mostly used directly as a combustible fuel, producing 10-20 MJ/kg of heat. Its forms and sources include wood fuel, the biogenic portion of municipal solid waste, or the unused portion of field crops. Biomass / Waste to energy systems are very versatile and can be used to many types of Biomass /waste into energy. Every city of

Pakistan produces thousands of tons of solid municipal waste as well as millions of gallons of waste water. It can be converted into energy and organic fertilizer. Biomass like rice husk, cotton stalks, jute waste, bagasse and other crop residues are also produced in thousands of tons in Pakistan that can be used for power generation purposes. AEDB is actively working for the Biogas, Landhi Cattle Colony; Karachi Pilot Project is to be funded by New Zealand Aid (NZAID). AEDB has also issued LoI to M/s Abbott Energy and Environment Consultant, Canada for 05 MW biomass / waste to power generation for Peshawar city.[50] Ethanol is a potential bio-fuel, which can be produced from molasses (a waste / by-product of sugar industry). Pakistan has large quantities of molasses, which become a renewable bio-mass for ethanol.[51]

A global seismic belt passes through Pakistan and the country has a long geological history of geotectonic events which indicates that Pakistan should not be lacking in commercially exploitable sources of geothermal energy. Potential geothermal energy sites are identified at Sehwan in Sindh and Koh-e-Sultan in Baluchistan. Geothermal power can be used for power production by pumping hot gethermal water from source rock to the surface and producing steam through heat exchangers to subsequently run steam turbine for electricity generation. The energy from hot geothermal water can also be utilized for conversion to power with the help of power tube thermal riser. This is one of the latest technologies for utilization of geomagmatic energy.[52] The wild wind and the radiance of the solar do not require an overseas army to defend the supply line or a foreign policy to manage it. Homegrown combustibles such as corn-based ethanol do not require an overseas army to defend the supply line or foreign policy to manage them. No of the alternative requires an army or a foreign policy. Windy places can capture wind, sunny places can capture solar, coastal realms and suitable terrain can capture forms of thermal.[53] It is also claimed that hydrogen is the end game, the final objective in the man`s quest to become energy independent.[54] For instance it is said that Honda`s FCX is the first of a new generation of twenty first century electric cars. FCX is driven by electrons, not by internal combustion. Those electrons are created by a hydrogen fuel cell.[55]Just as coal replaced wood and as oil replaced coal, the hydrogen fuel cell may at last

offer the economic proposition that could end the hundred-year monopoly of over transportation and revolutionize the economics and politics of energy.[56]

Hydrogen fuel cell is considered the power source of the future. Some experts suggest that it is time to replace fossil fuel and they think that hydrogen offers the best opportunity to do that.[57] Hydrogen fuel cell is a device. A fuel cell is a mini power plant that produces electricity without combustion. Chemical energy is converted directly into electrical energy and heat. When hydrogen fuel is a fuel source, heat and water are the only byproducts. Alternative Energy Development Board (AEDB) has taken an initiative in propagation and development of hydrogen fuel cell technology in Pakistan. Efforts are underway to introduce methanol-hydrogen fuel cell buses in major cosmopolitan cities of Pakistan. 01 kW Hydrogen fuel cell electric vehicle is being developed by a project sponsored under Public Sector Development Programme (PSDP) [58]. Some experts are of the opinion that the launch of a South Asian hydrogen and fuel cell technology platform through the South Asian Infrastructure Fund (SAIF) could lead to a long-term South Asian strategy for hydrogen and fuel cells to guide the transition to a hydrogen future in the next 20-30 years.[59]

We need to create the mixture of technologies, fuels, investments and policies working in concert. We need many fuels not just one. The technologies of the fuel of the future will not come cheaply, easily, or even soon. [60] It is vital for Pakistan to develop its own oil, gas, and hydel resources. Pakistan is blessed with abundant alternative/renewable energy resources all over the country It has bounteous solar energy, the coastal belt is suited for wind turbines and its coal reserves are third largest in the world. It is time to look for new and innovative avenues to resolve our energy problems. More energy can be produced from hydrocarbons, hydel, nuclear, and particularly renewable resources like, wind, solar photovoltaic cells, geothermal, hydrogen fuel cell, geo-magmatic, biodiesel, methane, ethanol etc. Development of alternative resources needs huge investment but it will be a risk worth taking for the safe energy future. The energy crisis in Pakistan is acute, self-inflicted but still addressable, what needed is vision and devotion.

End Notes

1 Oystein Noreng, *Crude Power Politics and the Oil Markets* (New York: I.B. Tauris, 2006) P. xxix

2 Leonardo Maugeri, *The Age of Oil, the Mythology, History, and Future of the World`s Most Controversial Resources*(London: Praeger, 2008) P212

3 Aloulou Fawzi, *The Future Importance of the Gulf in US Oil and Gas requirements, in Gulf Oil and Gas Ensuring Economic Security* (The Emirates Centre for Strategic Study and Research, 2007) P. 230

4 A.Y. Zalloum, *Oil Crusades America through Arab Eyes* (London: Pluto Press, 2007) P. 18

5 Rob Johnson, *Oil, Islam and Conflict Central Asia since 1945* (London: Reaktion Books, 2007) P 210

6 Michael P. Crossant and Bulent Aras, *Oil and Geopolitics in Caspian Sea Sea-Region* (London: Praeger, 1999) P75

7 Energy: General Overview, http://www.eia.doe.gov/emeu/cabs/Pakistan/Background.html

8 World Energy Overview, International Energy Annual 2005. http://www.eia.doe.gov/iea/overview.html , (Retrieved on 9/9/2008)

9 Dr Muhammad Asif, Pakistan: *Energy crisis in industrial sector*, 30th October, 2007, http://www.gasandoil.com/goc/news/nts74780.htm,(Retrieved on 19/7/2008)

10 *Pakistan's Energy Crisis to Worsen in Next Two Years*, Jan 9, 2008 Xinhua English Newswire, http://tdworld.com/news/pakistan-energy-crisis

11 Ibid

12 M. Sharif, *Pakistan's energy crisis: short and long-term solutions* The News, 3/4/2008 also http://www.opfblog.com/1499/pakistans-energy-crisis-short-and-long-term-solutions (Retrieved on 19/7/2008)

13 Ibid

14 Saqib Saleem, *Energy crisis in Pakistan and its solution* http://www.thefrontierpost.com/News.aspx?ncat=cn&nid=541&ad=05-05-2008 (Retrieved on 1/7/2008)

15 Dr M Asif, *Coping with the energy crisis,* April 17, 2008 http://www.thenews.com.pk/daily_detail.asp?id=107244 ,(Retrieved on 1/7/2008)

16 *Government striving to overcome energy crisis* http://www.app.com.pk/en_/index.php?option=com_content&task=view&id=38889&Itemid=2 (Retrieved on 24/5.08)

17 *How to lower oil and energy prices in Pakistan*? http://v4votes.com/2008/04/how-to-lower-oil-and-energy-prices-in-pakistan

18 Dr M Asif-II, *Coping with the energy crisis*, April 17, 2008 http://www.thenews.com.pk/daily_detail.asp?id=107244, (Retrieved on 1/7/2008)

19 Usman Aminuddin, *Opportunities in the Development, of the Oil and Gas sector in South Asian Region, Islamabad papers,* http://www.issi.org.pk/islamabad_paper/2004/oil_2004.htm, (Retrieved on 1/7/2008)

20 Lisa Margonelli, Oil on the Brain Adventures from the pump to the Pipeline (New York: NAN A. Talese 2007) P. 286

21 *Renewable energy*, Wikipedia encyclopedia http://www.wired.com/news/planet/0,2782,67121,00.html?tw=wn_tophead_2 http://www.stanford.edu/group/efmh/winds/global_winds.html http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=504&ArticleID=5562&l=en (Retrieved on 1/7/2008)

22 M. Sharif, *Pakistan's energy crisis: short and long-term solutions* The News, 3/4/2008 also, http://www.opfblog.com/1499/pakistans-energy-crisis-short-and-long-term-solutions (Retrieved on 10/7/2008)

23 Ibid

24 *Micro-Hydel* http://www.aedb.org/microhydel_basics.php

25 Op. Cit. Pakistan's Energy Crisis

26 Micro-Hydel http://www.aedb.org/microhydel_basics.php

27 Arshad H Abbasi, *Hydropower: way out of energy crisis* http://www.thenews.com.pk/daily_detail.asp?id=16101 (Retrieved on 24/5/08)

28 Ibid

29 Ibid

30 Ibid

31 *Micro-Hydel* http://www.aedb.org/microhydel_basics.php (Retrieved on 17/07/2008)

32 Biomass / *Waste to Energy Basics* http://www.aedb.org/biomass_basics.php

33 Fossil Fuel, http://www.solarnavigator.net/fossil_fuel.htm , (Retrieved on19/7/2008)

34 Rizwan Ghani, *Power crisis & alternate energy technology* http://pakobserver.net/200805/03/Articles04.asp, (Retrieved on 24/5/08)

35 Ibid

36. *Renewable energy*, Wikipedia encyclopedia http://www.wired.com/news/planet/0,2782,67121,00.html?tw=wn_tophead_2 http://www.stanford.edu/group/efmh/winds/global_winds.html http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=504&ArticleID=5562&l=en (Retrieved on 19/7/2008)

37 Ibid

38 Op. Cit. Pakistan's Energy Crisis

39 Edwin Black, *Internal Combustion How Corporations and Governments addicted the World to Oil and Derailed the Alternatives*(New York: St.

Martin`s Press, 2006) P. 278

40 Azhar Masood, *Construction of Dams to Overcome Energy Crisis* http://www.pak-times.com/2008/05/10/construction-of-dams-to-overcome-energy- crisis-prof-khurshid (Retrieved on 24/5/08)

41 Malik Ahmad Jalal, Wind power: a solution to energy crisis http://www.dawn.com/2007/01/29/ebr13.htm (Retrieved on 22/5/08)

42 Rizwan Ghani, *Power crisis & alternate energy technology* http://pakobserver.net/200805/03/Articles04.asp, (Retrieved on 20/5/08)

43 Mick Elmore, *Pakistan Searches for Solution to Power Shortages*, http://news.boloji.com/2008/04/19616.htm, (Retrieved on 23/5/08) Pakistan energy crisis and opportunities also http://towardsgreenerlife.blogspot.com/2008/04/pakistan-energy-crisis.html http://economictimes.indiatimes.com/PoliticsNation/Pakistan_searches_for_solution_to_power_shortages/articleshow/2929969.cms

44 Rodnney Janssen, Renewable Energy Working Party, The Netherlands, October 2002 http://www.iea.org/textbase/nppdf/free/2000/Renew_main2003.pdf (Retrieved on 26/07/2008

45 *Solar Photovoltaic*Alternative Energy Technologies http://www.aedb.org/solarpv-basics.php (Retrieved 11/7/2008)

46 *Solar Thermal* http://www.aedb.org/solarthermal-basics.php (Retrieved on 11/7/2008)

47 Paul Roberts, The End of Oil The Decline of the Petroleum Economy and the Rise of a New Energy Order, (London: Bloomsbury, 2004)

48 *Renewable energy*, Wikipedia encyclopedia http://www.wired.com/news/planet/0,2782,67121,00.html?tw=wn_tophead_2 http://www.stanford.edu/group/efmh/winds/global_winds.html http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=504&ArticleID=5562&l=en (Retrieved on 19/7/2008)

49 *Biodiesel* http://www.aedb.org/biodiesel_basics.php (Retrieved on 19/7/2008)

50 *Biomass / Waste to Energy Basics* http://www.aedb.org/biomass_basics.php (Retrieved on 15/7/2008)

51 *Ethanol* http://www.aedb.org/ethanol_basics.php (Retrieved on 1/7/2008)

52 *Geothermal Basics* http:www.aedb.org (Retrieved on 1/7/2008)

53 Edwin Black, *Internal Combustion How Corporations and Governments addicted the World to Oil and Derailed the Alternatives* (New York: St. Martin`s Press, 2006) PP. 274-5

54 Ibid PP. 310-311

55 Paul Roberts, *The End of Oil The Decline of the Petroleum Economy and the Rise of a New Energy Order* (London: Bloomsbury, 2004) P. 67