HOW TO MAKE RENEWABLE ENERGY ECONOMICAL FOR THE PEOPLE OF PAKISTAN

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ABSTRACT

Energy is the key to economic success of any country. Pakistan is heavily dependent on imported fossil-fuels for generating electricity from thermal power plants and for mobility of its transportation system. On the other hand, Pakistan is blessed with plenty of renewable energy resources, such as hydro, solar, wind and biomass. The country has one of the best systems of canal-irrigation, electricity transmission-grid and natural-gas distribution in the world. In spite of this, Pakistan is facing acute power-shortage. More than 58,000 villages[†] are to-date without electricity. The gap between demand and supply in electricity is increasing by 10% every year and this gap in the demand and supply of natural gas is around 0.8Bcfd[#], which will widen in the years to come.

Using a combination of renewable energy sources within the existing infrastructure can be the best solution for eliminating this power short-fall in the country. Even in remote rural areas, where transmission-lines are not viable, decentralized power-generation using renewable energy technologies could prove to be the best sustainable solution. In this article, the use of Renewable Energy (RE) as a clean and sustainable source that provides a viable economic solution to the developing countries like Pakistan is highlighted.

1. INTRODUCTION

Much has been written and talked about the advantages of renewable energy in its various available forms, such as solar, wind, bio and hydro. The developed countries have set targets to escalate the implementation of these technologies; for example, in 2007 EU leaders agreed to source 20% of their energy needs from RE by 2020, while Germany is set to have 100% of its electricity power through RE by 2050 (EurActiv, 2007). Table-1 shows the individual targets of EU member States based on their respective Gross Domestic Product (GDP). India is investing heavily in renewable energy technologies (RETs), to become a regional market leader having 20% of the country's energy requirements met from RE by 2020 (Merinews, 2007). Pakistan, on the other hand, has set the target to have a 10% share of renewable energy in its national grid by 2015 (AEDB & GTZ, 2005), which seems difficult to achieve with the present pace of implementation. Due to acute power-shortage, Pakistan's economic development has been badly affected and it is losing US$ 3.34 billion per annum. The cumulative effect of the energy crises on the national economy is estimated at upward of 2% of the GDP during 2009-10 alone (GOP, 2010). According to the World Bank (Trading Economics, 2010), Pakistan's GDP is worth 167 billion dollars. Today, energy is the major issue that can destabilize any political structure. In order to avoid worsening law-and-order situation, due to longer periods of load-shedding and keeping the Kalabagh Dam on the back burner (due to political reasons) and the fact that any major dam would take seven to 10 years to complete, the policy-makers of Pakistan have to consider sustainable, short-term economical solutions in order to cater to the energy needs of the country. This goal can only be achieved if effective policies w.r.t energy conservation (EC) and RETs are adopted.

1.1 Approach

a. For any developing country, the upfront cost of any renewable energy technology (RET) is high. Therefore, the approach should be to focus on conserving energy before implementing any renewable energy project. It is a proven fact that energy-saving could be much more effective and cheaper than building conventional power-plants. Saving 1MW of electrical energy means that one would need to produce 1.3MW of electricity less to meet the demand. In short, energy conservation *is a pre-requisite* for implementing RETs.
b. Transformation of power-production to decentralized, clean & affordable renewable energy forms: Pakistan's major dams are located in the North, and most of the thermal power-plants are situated in the South, while major demand of electricity is in the centre, due to which there are considerable line losses. Therefore, Pakistan should *set up RE farms near areas of high demand*, which will also help to prevent the pilferage of electricity.

2. MAJOR ENERGY-CONSERVATION MEASURES

Major energy-conservation technologies must be used that are viable and can dramatically reduce the

† Energy Situation in Pakistan and Global Prospective, Presentation by Mr. Sabir Ali Bhatti, Consultant NESPAK, Lahore, May 2008.
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Table - 1: Renewable Energy Targets Set by EU Member States [EurActive, 2007]

Member State	Share of renewable energy in 2005	Share required by 2020
Austria	23.30%	34%
Belgium	2.20%	13%
Bulgaria	9.40%	16%
Cyprus	2.90%	13%
Czech Republic	6.10%	13%
Denmark	17%	30%
Estonia	18%	25%
Finland	28.50%	38%
France	10.30%	23%
Germany	5.80%	18%
Greece	6.90%	18%
Hungary	4.30%	13%
Ireland	3.10%	16%
Italy	5.20%	17%
Latvia	32.60%	40%
Lithuania	15%	23%
Luxembourg	0.90%	11%
Malta	0%	10%
The Netherlands	2.40%	14%
Poland	7.20%	15%
Portugal	20.50%	31%
Romania	17.80%	24%
Slovak Republic	6.70%	14%
Slovenia	16%	25%
Spain	8.70%	20%
Sweden	39.80%	49%
United Kingdom	1.30%	15%

gap between demand and supply of electricity and gas. These technologies include the following:

2.1 Durable Induction Lamps

The lighting load of street lights, flood and security lights, and that of production-halls can be significantly reduced if the existing mercury lamps, as well as sodium and metal halide lamps are replaced with the latest durable induction electrode-less lamps (Figure-1). This will bring a 50 to 70% savings in electricity, depending on the height of light pole and lighting requirements. The life of these lamps is 100,000 hours, while conventional lamps last about 20,000 hours. This means that labour and maintenance cost can also be saved. By replacing 5 million 250W conventional street lights (which in fact consume about 300W each, with choke losses) with durable induction lamps of 80W for 20-ft pole and further 5 million street lights with 120W for 30-ft pole, an average 2,000MW of grid power can be saved. The saved amount is equivalent to the construction-cost of one major water-reservoir and would eliminate half of the prevailing load-shedding in Pakistan.

Figure - 1: Energy Efficient Durable Induction Lamp in Round Shape

Figure - 2: SMD Tube Light

2.2 Replacing Conventional Tube Lights and Bulbs with their LED Equivalents

LED is the future domestic, industrial and commercial lighting-source, which can save more than 70% of electricity. The Surface-Mounted Diode-based (SMD) tube lights (Figure-2) are better and feasible for industrial sectors, such as spinning or weaving mills, where 2,000 to 3,000 tube lights are used 24 hrs/7 days. The pay-back period for such industrial sector is around one year. The cost analysis of good-quality LED tube light is given in Table-2.

Considering Pakistan's climatic conditions, one should be careful in selecting the right quality and source of LED lights, otherwise the financer will lose the investment, as these tube-rods may fail due to high temperature and grid fluctuations. M/S Sustainable Renewable Solutions (SRS Pvt. Ltd.) based in Lahore, Pakistan, introduced these lights few years ago and found the problems of fusing individual LED due to bad soldering, failure of their power-supply resulting from moisture or hot environment, reducing luxes with passage of time, and humming noise in its drivers.

Through continuous R&D and in cooperation with the foreign principal, the team at SRS has eliminated these problems and now the next generation of SMD tube lights has been introduced, which are being used in many factories of Pakistan. These tubelights are operating for quite some time now without any problem.

Table - 2: Cost-Benefit Analysis of 100 LED Tube Lights

	Existing 40W Tube lights	15-watt LED Tube light Option
Number of lights	100	100
Lux from 6ft	66	161
Actual Power consumed by each light (Watt)	73.92	15
Present Wholesale price of each light (Rs)	300	3,600
Total price of lights (Rs)	30,000	360,000
Working hours	24	24
Life of light (hrs)	8,000	50,000
Current electricity rate (Rs)	5.5	5.5
Annual Replacement cost (Rs)	38,054	0
Total power consumed (Watt)	7,392	1,500
Units consumed per month	5,322	1,080
Electric cost per month (Rs)	29,272	5,940
Annual electric cost @ present rate	351,268	71,280
Annual Saving with Replacement Cost	**Nil**	**Rs.279,988**
Saving during life time (Rs)	Nil	Rs.1,749,925
Payback period (yrs)	Nil	1.28 or 14 months

Note: Actual readings have been taken of power consumed by (i) 40W Philips Conventional Tube lights, with magnetic choke & starter installed at SRS display centre, and (ii) 342 LED 15W tube lights.

Figure - 3: Split Air Conditioners Fitted with Solar AC Kit at the Factory Office in Faisalabad

2.3 Installation of VFD or VSD on Heavy Motors

It is a proven fact that proper installation of variable frequency drives (VFD) on compressors, pumps and motors can conserve 20 to 40% of power. Usually, the pay-back time of VFD project is less than a year. These are the observations made by SRS & Cutes Corp. of Taiwan, through their Pakistani representatives who installed their variable speed drives (VSDs) in various textile mills.

2.4 Reducing Fan & Air Conditioners' Load by Solar Hybrid Kit

During summer season the duration of load-shedding increases, because of the increasing demand and heavy use of air conditioners and fans. SRS has developed a solar-thermal collector with electronic AC kit (Figure-3), which can bring 20 to 40% saving in air conditioners. These figures are based on studies conducted at SRS Laboratory. If 3.5 million air conditioners are fitted with Solar Hybrid AC Kit, and supposing an average of 30% of electric savings is achieved through this kit, then the resultant grid-power saving will be to the tune of 2,100 MW during hot season.

Similarly, Pakistan's fan industry should concentrate on manufacturing energy-efficient fans, rather than focusing on their cosmetics. Most of our ceiling fans consume more than 100W, while in the United States efficient fans made of plastic only consume 30W.

2.5 Saving Natural Gas by using Gas-Saving Kits

Since the cost of fossil-fuel based energy has gone up, considerably, measures need to be taken to conserve energy and shift focus on Renewable Energy Technologies (RETs).

- SRS has developed a mechanical electric gas-saving kit, which if installed on gas geysers can pre-heat the cold water and electronically shut down the gas on pre-set times. It is estimated that 33 to 60% of natural gas can be saved by using this kit. The cost of the kit is about Rs. 5,500, while its baffle cone can be purchased for nearly PkR.600/-
- A policy should be made for all the manufacturers of electrical and gas appliances to develop such energy-saving products. Also, there should be some monitoring system for implementation of such a policy.

Going parallel with implementation of energy conservation technologies and practices, one should look for sustainable economical solutions provided by renewable energy technologies. For developing countries like Pakistan, the focus should be on the use of the following technologies, systems and appliances:

3. SOLAR HEAT/POWER

Solar Energy can be further sub-divided into Solar Thermal and Solar Photovoltaic (PV) systems.

3.1 Solar Thermal System

The direct conversion of infra-red radiation of the solar spectrum into heat energy is called the 'Solar Thermal process'.

3.2 Solar Water Heater (SWH)

Solar water heater is the best example of viable solar thermal technology. The conventional gas geysers are 70% inefficient†, which viciously waste the natural gas resources. Pakistan is not left with enough gas-reserves to meet the country's energy demand. Solar water heaters can replace gas-geysers to prevent further wastage of country's natural resources. The habit of lavishly using hot water, coupled with other local conditions and problems in the product, such as leakage, hinders the widespread adoption of solar water heaters. Therefore, R&D is required for proper product-design of solar water heater, adaptable to local conditions, while gas burners can be used as a

† Energy Situation in Pakistan and Global Prospective, Presentation by Mr. Sabir Ali Bhatti, Consultant NESPAK, Lahore, May 2008.

backup. According to Alternative Energy Development Board (AEDB), 3,500 solar water heaters have been installed throughout Pakistan. There are 2 million consumers of Sui Northern Gas Pipelines Limited of Pakistan (Qamar-uz-Zaman Ch., et al., 2009), who have installed gas-geysers. If 5% of these are replaced with solar water heaters in the next three years, then there will be a positive impact on natural gas usage and on lowering the carbon foot-print.

3.3 Solar Process Heating

Hot water is used in many industries. The vacuum tube technology is the most efficient one provided the requirement for hot water is below 100°C. Tanneries, textile, pharmaceutical and food industries can save millions of rupees by installing large solar heating systems. If investment is an issue for adopting large solar systems, then at least partial load should be shifted to solar-thermal systems, which will resultantly help save natural gas and reduce GHG emissions. Pakistan's first large solar system, at Saddiq Leather Works on Sheikhupura Road (near Lahore), is delivering 40,000 litres of hot water daily. There is a need to study this system for annual output and cost benefits.

3.4 Solar-Thermal Power Plant

So far, no mega Solar-thermal power plant (STPP) has been installed in Pakistan. The National Electric Power Regulatory Authority (NEPRA) of Pakistan has determined the price of one unit of electricity to be US 18 cents for rental power plants, which makes the STPP a viable solution. It is recommended to install plants with capacity of 5MW to 50MW of combined-cycle STPP near Choulistan, Multan, Bhakkar as well as in South Punjab, where water is available and grid transmission lines are within 40 kilometres. It is recommended that a 5MW system be installed initially, because it is easy to manage and the initial problems, typical in such pilot-projects, can be indigenously rectified. This will build the technical capacity of the people and enable them to run large systems of 50 MW capacity.

STPPs can also be developed as a hybrid system, using natural gas or coal-fired turbines. The estimated cost of an American parabolic-trough technology is around US$ 3.45 million/MW. International financing can be arranged for such a project, provided the Government of Pakistan acts as a guarantor.

3.5 Solar PV System

The conversion of solar light into DC current is carried out by photovoltaic cells. A lot of research in this area has resulted in the development of some new efficient technologies. China has set up many large plants for the production of PV modules, due to which the cost of PV panels has been reduced from US$ 4/Wp to less than US$ 2/Wp in the last few years. The upfront cost of solar system is still higher for domestic users. With four hours back-up time, the cost of a solar PV system is around Rs.500/Wp. With some support from the Government and financial institutions, the Chinese PV technology can be introduced in the domestic market. If one million homes install 2 kW solar PV systems, then 2,000 MWp of grid power can be saved, which is half the electricity gap between demand and supply.

3.6 Thin-Film Cylindrical PV Modules

These modules are suitable for commercial or industrial units that have large roof-tops (Figure-4). It produces more power-per-unit-area and is easy to install. The roof is coated with white heat-resistant material, which can not only reduce the heating load of the building, but also reflect the solar radiation that can be absorbed by the thin-film cylindrical PV panels for generating DC current. This technology is successfully working at Masdar City, Abu Dubai, UAE, and in many parts of the Untied States and Europe. .

3.7 High-Concentration Photovoltaic (HCPV) Modules

For setting up large PV farms on expensive land, the high-concentration PV technology (HCPV) can be useful, as it requires 33% less land than conventional PV systems. In this module, light is concentrated through lens onto a single PV cell, due to which highest efficiency (29%) of PV module can be achieved (Figure-5).

For remote areas, where transmission and distribution of grid lines is not viable, small solar PV system is ideal to uplift the living standards of villagers.

There are still many villages without grid power in Pakistan. Many villages only have electricity poles but no electricity. These villages can be electrified with PV system by establishing a task force, consisting of NGOs, PV system suppliers, installers, donors and financial institutions.

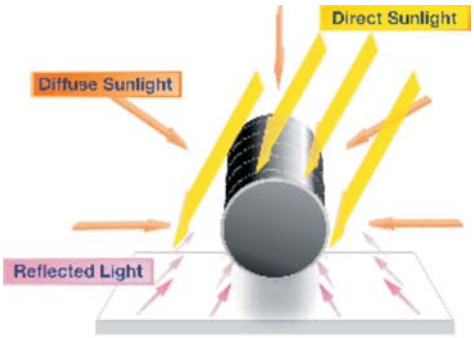

Figure - 4: Thin Film Cylindrical PV Module

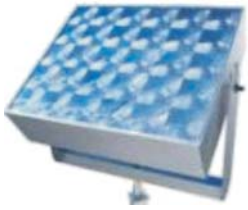

Figure - 5: High-Concentration PV Module

4. WIND POWER

Pakistan has an excellent wind corridor, starting from Keti Bandar that goes into Rajhistani Indian border. Such corridors are also present in Northern Areas and at Kalar Kahar, where 20 to 100kW wind turbines can be installed. Based on the wind data of Kalar Kahar, showing 293W/m^2 wind density at 50m, the site falls in marginal wind class-2 (Qamar-uz-Zaman Ch., et al., 2009). India is successfully running more than 900 wind turbines on the tail of this wind corridor and had installed a total of 11,807 MW of wind power capacity by March 2010 (INWEA, 2010), while Pakistan has installed only four 1.5 MW wind turbines. AEDB has issued more than 100 Letters of Intent (LOI) to different companies, for each of them to install 50 MW of wind farms. Out of these, only three have been issued Terms of Reference (TOR). There is a need to investigate the major hurdles, due to which investors are reluctant to initiate such projects in Pakistan.

It is to be kept in mind that generating power from wind is cheaper than solar energy. In contrast to solar energy, wind is also available during night. Small domestic wind turbine is a mature technology. For a city like Karachi, an ideal solution is a hybrid system of solar and wind energy. An affordable solution for city government is to install solar-wind hybrid street lights on the main roads. Citizens living in localities near the sea should be encouraged to install 1 to 3 kW wind turbines.

5. GENERATING ENERGY FROM WASTES

The organic waste can be converted into methane gas through biogas fermentation plant or syn-gas through gasification plant. PCRET has installed more than 4,000 biogas units of 5m^3, 7m^3 and 10m^3 capacities throughout Pakistan, mainly for cooking purposes (PCRET, 2010). According to PCRET, 19.125 million m^3 biogas can be produced daily by anaerobic fermentation of dung through installation of about 3.825 million family-size biogas plants, which could meet the cooking needs of about 50 million people (PCRET, 2010). Today, R&D is required to find ways for cheap and efficient digesters and the way to purify methane, in order to run large electric generators. Biogas as a power source is much cheaper than solar or wind power and, in the near future with proper policy and design, it can become a major source for pumping water, cooking food and supplying electricity in villages.

At present, the CNG stations in the country are subject to two to three days of load-shedding of natural gas. There is a need to develop large biogas plants for feeding gas to CNG stations on highways.

There is a need to develop a policy to set up a biogas plant along with treatment plant on every large drain, like the Hidyara Drain near Walton (Lahore), to get clean water for agriculture and useful gas for cooking or for running generators. This plant can be connected

to the natural gas distribution network.

6. HYDRO POWER

Large water-turbines are the cheapest means for producing electricity. Due to the country's internal politics and divergent views on water distribution, population displacement, royalty fee and other issues, main hydro-power projects could not take off. Such projects require five to seven years for completion. Another problem, which policy makers are unable to address, is the continued availability of water in rivers due to the climate change. It is recommended to give attention to mini and micro-hydro turbines, wherever the site permits supply of local power. These turbines require small head to operate. Some 538 mini/micro turbines have been installed by PCRET (PCRET, 2010). The Aga Khan Foundation and other NGOs are also active in installing these turbines in Northern Areas of Pakistan.

7. MAJOR CONSTRAINTS

Despite the readily available renewable energy resources and presence of good infrastructure, the present share of renewable energy is less than 1% in the total energy generation of Pakistan. Following are some of the constraints/hinderences to the adoption of renewable energy technologies in the country:

a. *Lack of Political Will:* Many countries of the world have formulated policies to use RETs for their national electricity generation and have set a target of 5-10 years to implement these policies. In Pakistan, such a will seems lacking and a serious effort is needed to actively achieve these targets.
b. *Cost:* The upfront cost of all renewable technologies is high, due to which their widespread adoption among the general public becomes a hurdle. With the increase in electricity, diesel and natural gas tariffs, and reduction in technology costs, many of the RE technologies are now commercially feasible. The availability of a large number of Chinese PV products in the Pakistani markets have resulted in the lowering of prices of PV panels to half in nearly three-year time. If this trend continues, then PV rate is expected to come down to 1 US $ / Wp, which is almost the same as of a coal power plant (Bundanoon, W. M., 2009).
c. *Absence of Subsidies:* In Europe, USA, Japan, and South Korea, and even in India, renewable energies are subsidized just like health and education sectors. Unfortunately, except for bio-gas, the Government of Pakistan gives no subsidy on the adoption of RETs. In accordance with the agreement with IMF, the government has to remove subsidy on electricity, due to which the tariff rates increase after every six months. However, there is no restriction to give subsidy to the clients adopting renewable energies, therefore the government should consider implementing a subsidized action-plan to promote renewable technologies.
d. *Lack of Professionals:* There are very few professionals of renewable energy technologies, who have good practical experience and know-how of the local conditions. The technical colleges and universities do not offer major courses in these technologies to educate people. It is recommended to develop criteria whereby only the companies that have trained employees and staff are authorized to design and install RE technologies. REAP (Renewable & Alternative Energy Association of Pakistan) should be given mandate by the Government to issue such certification programme.
e. *Social Issues:* Many of the renewable energy projects initiated by the Government of Pakistan or NGOs in the past failed because only the financial and technical aspects were accounted for, while social aspects had been ignored. In most parts of the country, the social system of feudalism that exists needs to be taken into account while planning any development activity in the area.
f. *Maintenance and After-Sales Service:* Another major factor, due to which renewable energy projects have failed in the past, is the lack of maintenance and poor after-sales service by the installers. It is, therefore, necessary to train the local people, so that they can maintain and repair minor faults and keep the systems operational. It is also recommended to install a system that is durable and requires minimum maintenance.
g. *Proven Technology under Local Conditions:* Pakistan has harsh climatic conditions. Also, the grid supply usually has spikes, dips and surges. The technologies that are successful in Europe and other countries fail in Pakistan, due to one or more of the reasons mentioned earlier. Thus, there is a need to customize and upgrade the renewable energy technologies according to the local conditions. Every solution-provider should offer the proven technologies, rather than experimenting at client's cost.
h *Investors' Risk:* Investors in large RE projects can face steep and unpredictable changes in the value of their assets due to rapid technological changes – changes that are much larger than the expected

physical life of their assets and, thus, can lower their assets' value before the end of their useful life. This issue can be addressed by basing the value of assets on the principle of accelerated depreciation and also by taking necessary measures to help encourage increased investment in RETs.

8. CONCLUSIONS

The strategy to make renewable energy available, at affordable and low cost, must take into account the following on fast-track basis:

i. Creating a think tank of renewable-energy experts and economists empowered to implement new policies. One of the important objectives of the think tank should be to examine the treatment of capital expenses in RE sector, with particular emphasis on the need to introduce accelerated depreciation and tax-breaks to help encourage new investments in alternative sources of power.
ii. Investing in R&D for developing low-cost and efficient renewable energy products.
iii. Creating public awareness and undertaking pilot-projects throughout the country, supervised by professionals.
iv. Attracting direct investment through subsidies, incentives and better feed-in tariff policy, which would result in early commercialization of emerging RETs.
v. Developing a highly skilled and capable human resource base, by educating and training engineers, architects, and technical personnel.
vi. The Government should adopt the "carrot and stick" approach, in order to give tax-breaks to users of RETs and to increase taxes on industries or power houses that pollute the environment.
vii A bill should be passed to define the different conditions/parameters for using varied RETs for 5 to 10 years so that financiers of RE projects are enable to recover their investments through depreciation deductions.

Several energy conservation measures & renewable energy technologies are discussed in this paper. *If only three technologies, namely Induction Durable lamps, solar hybrid air conditioning kit and solar PV systems, are focused upon, as described,* Pakistan can get a net benefit of 6,000MW, which provides for sufficient energy to not have load-shedding. The only thing needed to ensure this, is 'political will' and fair implementation of recommended policies by think tanks, comprising energy professionals.

Pakistan needs to move forward on the adoption of renewable energy technologies in order to meet its energy needs for effective socio-economic development.

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