Pakistan

Renewable Energy Report

APCTT-UNESCAP

Asian and Pacific Centre for Transfer of Technology
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LIST OF ABBREVIATIONS

ADB	Asian Development Bank
AEDB	Alternative Energy Development Board
AJK	Azad Jammu Kashmir
CdS	Cadmium Sulphide
CdTe	Cadmium Telluride
DGNRER	Directorate General New and Renewable Energy Resources.
DNES	Department of Non-Conventional Energy Source
ENERCON	National Energy Conservation Center
EPA	Environmental Protection Agency
EU	European Union
FANA	Federal Administrated Northern Area
FATA	Federally Administered Tribal Area
FST	Fuel Stove Technology
GHG	Green House Gas
GIKI	Ghulam Ishaque Khan Institute of Science and Technology
GJ	Giga-Joules
GOP	Government of Pakistan
GTOE	Gigatonnes of Oil equivalent.
GTZ	German Cooperation Agency
HDIP	Hydrocarbon Development Institute of Pakistan
ICB	International Competitive Bidding
IEA	International Energy Authority
IPP	Independent Power Producer
IUCN	International Union for Conservation of Nature
KESC	Karachi Electric Supply Corporation
Kwh/m^2	Kilowatts hour per meter square.
LPG	Liquid Petroleum Gas
MHP	Microhydel Project
MNES	Ministry of Non-Conventional Energy Sources
MOE	Ministry of Environment
MOST	Ministry of Science and Technology
MTOE	Million Tonnes of Oil Equivalent
MW	Megawatts
MWh	Mega Watts hour
NAPWD	Northern Area Public Works Department
NCA	National Conservation Authority
NCS	National Conservation Strategy
NEPRA	National Electric Power Regulatory Authority
NGO	Non Government Organization
NIST	National Institute of Silicon Technology
NREA	New and Renewable Energy Agency
NREL	National Renewable Energy Laboratory
NUST	National University of Science and Technology
NWFP	North West Frontier Province
OGDC	Oil and Gas Development Company
PAEC	Pakistan Atomic Energy Commission
PCAT	Pakistan Council for Appropriate Technologies
PCRET	Pakistan Council of Renewable Energy Technologies

PCST	Pakistan Council for Science and Technology
PFR	Pre feasibility Report
PMD	Pakistan Meteorological Department
PPA	Pakistan Poultry Association
PPIB	Private Power and Infrastructure Board
PV	Photovoltaics
RES	Renewables Energy Sources
ROE	Return of Equity
ROW	Rest of World
SHYDO	Sarhad Hydro Development Organization
TCF	Trillion Cubic feet
TOE	Tonnes of Oil Equivalent
UNDP	United Nation Development Program
UNEP	United Nation Environmental Programme
UNIDO	United Nation Industrial Development Organization
UNOPS	United Nation Office for Project Services
WAPDA	Water and Power Development Authority
WEC	World Energy Council
WEHAB	Water, Energy, Health, Agriculture and Biodiversity
WHO	World Health Organization
WSSD	World Summit on Sustainable Development

EXECUTIVE SUMMARY

Pakistan is an oil importing country and its economy suffers the most by the oil prices inflict. Majority of its power generation is thermal with furnace oil, high-speed diesel and natural gas as fuel; coal is almost now existent. Because of fast growing economy and population the demand of energy is rapidly increasing. The electricity generation capacity in Pakistan is over 20,000 MW. This is not enough to meet our electricity demand. According to GOP estimates the generation capacity needs to grow by 50% by 2010 in order to meet the expected demand.

Pakistan is endowed with various renewable energy resources such as hydel, solar, wind, geothermal and bio-fuel. It can earn dividends if these resources are explored, exploited and developed properly. Hydropower source of energy is well known in Pakistan and there is ever growing experience in the sector to develop the hydropower potential indigenously in the country. Hydro-potential is estimated at about 50,000 MW, out of which about 6595 MW has been developed. Pakistan lies in an area of one of the highest solar insulation in the world. The average solar radiation is 5.5 KW/$m^{2\ and}$ there are more than 300 clear days. Wind energy is another important area where Pakistan can benefit by exploiting it in efficient manner. The wind potential is estimated upto 50,000 MW. Urban areas of Pakistan generate over 55000 tonnes of solid wastes daily. There are 56.9 million animals (Buffaloes, cows) in Pakistan, which can generate 21.35 million M^3 biogas and 36.0 million tonnes of bio-fertilizer per day. The creek systems of Indus Delta extends over an area of 170 Km. It is estimated that about 100 KW power can be produced from the source. There are more than 6000 surface indications of geo-thermal energy resources with an estimated potential of 800,000 KW.

In Pakistan most of the research, development, promotion and dissemination work in the field of renewable energy is carried out by Public Sector Organizations because of lack of such capabilities in the private sector. Pakistan Council of Renewable Energy Technologies (PCRET) and Alternate Energy Development Board (AEDB) are playing a major role in promoting the development of infrastructure for RE power generation in the country. However, small section of Pakistan Council of Scientific and Industrial Research (PCSIR), Agha Khan Rural Support Programme (AKRSP), National University of Science & Technology (NUST), GIK Institute of Engineering & Technology, COMSATS Institute of Information Technology and National Center for Physics and some departments of Universities are involved in the research and development of renewable energies in Pakistan.

Renewable Energy account for 180 MW of Pakistan's present power output, small to medium size hydropower plants offer the greatest renewable energy potential for Pakistan. The solar potential is estimated over 100,000 MW. Possibilities also exist in promoting greater use of wind, solar and biomass project. The GOP had approved the policy for development of Renewable Energy for power generation – 2006. According to this policy the wind and solar energy will be developed in the country to meet at least 5% of the total installed capacity through RE resources by 2030 (i.e. 9700 MW). Furthermore, 7,874 remote off-grid villages in province of Sindh and Balochistan will be electrified through Renewable Energy. Bio-diesel will be gradually blended with petroleum diesel to achieve a maximum share of 5% by volume of the total diesel consumption in the country by the year 2015 and 10% by 2025.

Development of the power generation potential of existing RE sources, solar, biomass, microhydel and windmills, offers substantial business opportunities for manufacturers and exporters. American companies already dominate the foreign-owned portion of the local RE power generation market with almost 25 per cent of market share, followed by European and Chinese companies, which have 10 per cent and 5 per cent of market share respectively. The remaining 60 per cent of current power is in the hands of domestic companies the main challenge faced in the execution of wind projects is the availability of equipment. Wind turbines are not available off the grid in the world market. This is due to the fact that United States has an extensive wind energy programme that offer tax rebate. All leading manufacturers of wind energy equipment have fully committed existing supplies to the American market.

The international donor agencies like Asian Development Bank (ADB), German Agency for Technical Corporation (GTZ), United Nations Development Programme (UNDP), European Union (EU-Asia) and World Bank have launched various projects for the promotion, utilization and development of renewable energy technologies within the country. The GOP should make strategies to encourage the stakeholders of Public and Private Sector by making a pragmatic National Policy for the development of alternate and renewable source of energy.

1. Introduction

The phenomenal pace of technological progress which has brought about a transformation in the world economy is dependent on a country's own degrees of self-reliance on the availability of conventional sources of energy. Energy provides an essential ingredient for almost all human activities: it provides services for cooking and space /water heating, lighting, health, food, production and storage, education, mineral extraction, industrial production and transportation. Modern energy services are a powerful engine of economic and social development, and no country has managed to develop much beyond a subsistence economy without ensuring at least a minimum access to energy services for a broad section of its population. Subsistence energy supply and ensuring the efficient use of energy is one of the major challenges of the 21st century. As the economies grow, the energy consumption grows but energy sources deplete with time.

Pakistan lacks in conventional energy resources exploration and spends more than 8.0 billion dollars on import of oil. It has relied almost exclusively upon fossil fuels and hydroelectricity as its primary energy supplies. Because of fast growing economy and population the demand of energy is rapidly increasing. Pakistan is in danger of facing huge deficits in the coming years and even at present the primary energy supplies are not able to meet the existing demand in proper way. The situation has become more difficult in the wake of meeting international obligations under Kyota protocol to reduce green House Gases emission and at the same time to meet the increasing demand for energy. We need to have a paradigm shift in the energy production from the traditional resources to the more sustainable and environment friendly renewable resources, while bringing an affordable strategic balance between cost effectiveness and environment friendly sources.

Figure 1: Map of Pakistan
Source: http://stjohnsdemocrats.files.wordpress.com/2008/12/pakistan_map.jpg

1.1 Geographic Profiles of Pakistan

Pakistan is situated between latitude 24 and 37 degree North and Longitude 62 and 75 degrees East. The country borders India in the east, Iran on the west, China in the north, Afghanistan in the northwest and the Arabian Sea in the south. A country map is shown in Fig. 1. The total area of Pakistan is 8,03,950 km^2, which includes Federally Administrated tribal and Northern Areas (FATA and FANA). The country is divided into four provinces namely, Northern West Frontier Province (NWFP), Punjab, Sindh and Balouchistan. The great mountain ranges of the Himalayas, the karakorams and the Hindu Kush form Pakistan northern highland of NWFP and Northern areas. Punjab province is a flat, mostly an alluvial plain, with five major rivers dominating the upper region eventually the Indus Rivers flowing south to the Arabian Sea. Sindh is bounded on the east by the Thar Desert and the Rann of Kutch and on the west by the Kirthar range, while the Balouchistan Plateau is predominantly an arid tableland encircled by dry mountains. Pakistan coastline is about 1046 km long extending from Indian border in the east to the Iranian border in the west.

1.2 CURRENT ENERGY SITUATION

A profile of Pakistan primary energy resources shows its dependence on conventional energy resources. Its share in energy supply mix is highly dependent on oil, liquid petroleum and natural gas. The primary commercial energy supplies during 2007-2008 were 62.9 million tones of oil equivalent (MTOE). The share of natural gas in primary energy supplies during 2007-2008 was 47.5% followed by oil 30.5%, hydro electricity 10.9%, coal 9.2%, nuclear electricity 1.2%, LPG 0.7%, and imported electricity 0.1%. Fig. 2 shows primary energy supplies by source.

Natural gas production during 2007-2008 was 3,973 million cubic feet per day and oil production 69,954 barrels per day. During 2007-2008, 27 exploratory and 53 developments wells were drilled mostly of gas/condensate, out of which 5 were by Oil & Gas Development Corporation Limited (OGDCL) and 6 by other companies. The energy consumption by section is shown in Fig. 3.

Cool production increased by 13% in 2007-2008 over the previous year due to multifold increased production from Barkhan Coal filed in Balochistan. The consumption of coal in power generation increased by 1.3% from 164,397 tonnes in 2006-07 to 162,200 tonnes in 2007-08 and the electricity generation during 2007-20was 95,860 Gwh (including 199 Gwh of electricity imported from Iran). The generation included 66.5% thermal, 30.0% Hydel, 3.2% nuclear and 0.2% imported. Presently, the electricity generation capacity in Pakistan is over 20,000 MW. This is not enough to meet our electricity demands and with an average increase of around 1000 MW per year in this demand, the problem will continue to grow. According to Government of Pakistan's estimates, the generating capacity needs to grow by 50% by 2010 in order to meet the expected demand.

The high dependence on oil import has a huge negative impact on economy and energy security of the country. The natural gas reserves are not in great position either with proven reserves of 28.62 trillion cubic feet (TCF). At this production level Pakistan's reserves would finish in 24 years. The measured coal reserves are in large quantity (3,303 million tones). However, currently coal is not playing a noticeable role in Pakistan's energy mix.

1.3 A short background of the development and utilization of renewable energy in the country.

The importance of renewable energy cannot be ignored; the biggest challenge facing renewable energy technologies is to excel in state of the art technologies where more renewable options can generate energy at cost, that are competitive with conventional sources. During the last twenty years, Pakistan has not shown quite significant developments in Renewable Technologies. Photovoltaic technology is being used in Pakistan for rural electrification, telephone exchanges, repeater stations, highway emergency telephone, centers, and refrigeration of vaccines. [3] Solar panels in different powers and sizes are available in the local market, which are imported from America, Europe, China and also being fabricated in the country. PCRET has designed and developed solar water-heaters, solar cookers, solar dehydrator and solar desalination plants. Solar dehydrators are being used in the northern areas for drying of fruits and vegetables. [4] Solar water heaters are also available in the market, which are imported from America, Australia, Europe, China and are also manufactured locally. PCRET is main agency involved in the installation of biogas plants in the country, which are locally manufactured in the country. Pakistan Council of

Renewable energy Technologies (PCRET) and Agha Khan Rural Support Programme (AKRSP) are also involved in the installation of micro hydel plants in the northern areas and NWFP. They have designed and developed micro hydel turbines, which are fabricated through local manufacturers. The wind turbines are imported from abroad, but the micro turbine fabrication facilities are established in the country.

Figure-2: Primary Energy Supplies By Source

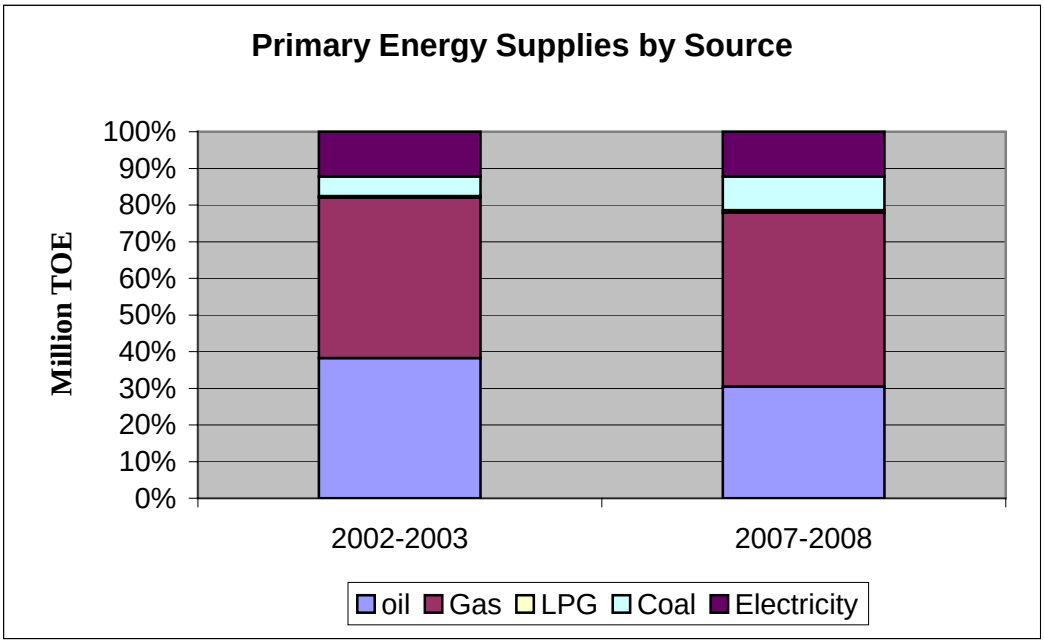
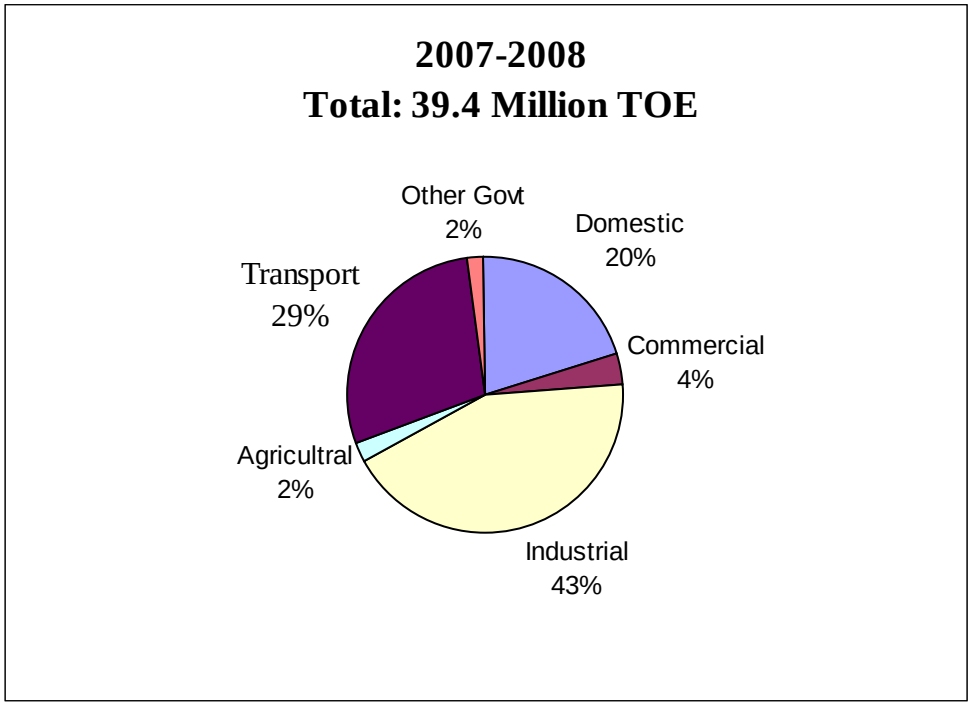


Figure 3: Energy Consumption By sector



1.4 Summary of Renewable Energy Resources In Country.

Pakistan is blessed with various renewable energy resources, such as water, solar, wind, geothermal and bio-fuel. It can benefit, if these resources are explored, exploited and developed properly.

1.4.1 Hydro Energy

A hydropower source of energy is well known in Pakistan and there is ever growing experience in the sector to develop the hydropower potential indigenously in the country. Hydro-potential is estimated at about 50,000 MW out of which about 6595 MW has been developed over the past 50 years. In addition, canal system with total of 58,450 km watercourses, farm channels and field ditchers running another 160,000 km in length has a huge hydropower potential at numerous sites/locations on each site, ranging from 1 MW to more than 10 MW hydel plants can be installed.

1.4.2 Solar Energy

Pakistan lies in an area of one of the highest solar insulation in the world. There are certain regions of south, Quetta valley and Central Punjab that receive maximum solar radiation, the nation wide average, however, has been recorded on daily basis as 5.5 KW/m^2. [6] This means that there is a vast potential for converting the untapped solar energy source for useful means. This potential can be exploited to produce electricity, which can be provided to off-grid communities in the northern hilly areas and the southern and western deserts. According to the Pakistan Energy Book 2004-05, solar energy falling on 0.25% Balochistan province would be adequate to meet the current requirement of the country with 20% efficient devices.

1.4.3 Wind Energy

Wind energy is another important area where Pakistan can benefit by exploiting it in efficient manner. This sector is getting worldwide attention with the development and availability of inexpensive technology that allows its easy conversion to useful energy. Recognizing the vast potential that wind energy offers i.e. upto 50,000 MW, a number of initiatives in Public and private sector have been taken. Pakistan has 1000 Km long coastline, which could be utilized for installation of wind farms. There are regions in the mountainous areas of Pakistan, which has the potential for wind energy generation. [3]

1.4.4 Biomass

Urban areas of Pakistan generate over 55000 tones of solid wastes daily. More than a total of 15 million layer-chicken and 528 broiler chicken birds were approximately produced in 2003 with a share of 22%, 68%, 3.5% and 6.5% of Sindh, Punjab, Balochistan and NWFP provinces respectively. According to unofficial estimates, hardly 5 to 10% poultry farms have membership of Pakistan Poultry Association (PPA). [7]. As per livestock Census 2006 there are 56.9 million animals (Buffaloes, cow, and bullocks) in Pakistan. [5]. On the average the daily dung dropping of medium size of animal is estimated 15 kg per day. This would yield 854 million kg dung/day. Assuming 50 % connectivity the availability of fresh dung comes out to be 427 million kg/day. Thus 21.35 million M^3 biogas can be produced through bio-methanation. In addition it will also produce 450 million ones of bio-fertilizer per day, which is essential requirement for sustaining of the fertility of agricultural land.

1.4.5 Tidal Energy

The creek system of Indus Delta extends over an area of 170 km. Tidal water flows in these creeks with high velocity during flood and ebb of tidal wave, which are very favorable condition for the extraction of energy from tidal currents. It is estimated that about 100 kW power can be produced from these altogether.

1.4.6 Geothermal Energy

Most of the high enpathalpy geothermal resources of the world are within seismic volcanic activity. A global seismic belt passes through Pakistan and the country has long geological history of geotectonic events. In Tibet, which occupies more or less the same geological position in Himalayan mountain ranges as Pakistan, more than 6000 surface indications of geothermal energy resources have been discovered with an estimated potential of 800,000 KW. [8]

2. Renewable Energy Market and Industries Scenario

Development of the power generation potential of existing RE sources, solar, biomass, microhydel, and windmills, offers substantial business opportunities for manufacturers and exporters. Due to in-country depletion of conventional energy resources and an expanding gap between power demand and supply, the development of RE sources in the country has gained momentum over the past 4-5 years. Renewable Energy policy 2006 emphasizes the development of renewable and clean energy in the country. The GOP has decided to encourage and invest in the development of the infrastructure necessary for power generation through RE sources. Alternate Energy Development Board (AEDB) is the executing agency on behalf of Government. The target of the Government of Pakistan power generation from RE sources contributes approximately 5 percent of the country's overall energy requirements by 2030. American companies already dominate the foreign-owned portion of the local RE power generation market with almost 25 per cent of market share, followed by European and Chinese companies, which have 10 percent and 5 percent of market share respectively. The remaining 60 percent of current RE power generation is in the hands of domestic companies. AEDB and the Pakistan Council of Renewable Energy Technologies PCRET are playing a major role in promoting the development of infrastructure for RE generation in Pakistan. [9]

2.1 Market Demand

Energy demand in Pakistan is accelerating rapidly and the power generation sector requires massive investments of private sector capital to meet this demand. With the economy experiencing high rates of growth; Pakistan's energy requirements have expanded at a rate of between 7 and 8 percent annually. Pakistan's current annual power generation of approximately 20,000 MW is insufficient to cover the growing gap between supply and demand. Daily load shedding of up to 700-MW occurs due to the current power supply shortage and poor transmission capabilities. Projections by various energy experts indicate that Pakistan would need to add at least 2,000-MW of power generation every year during the period 2007-2015 to meet the increasing demands generated by GDP growth target of 6 to 7 percent per annum. The GOP plans to meet the country's power generation requirements by allowing the private sector to develop 12 hydropower projects with a projected generation capacity ranging between 53-MW to 600-MW. In addition, existing independent power projects (IPPs) for private sector-owned investments in this sector – are being asked to expand their existing capacities. IPPs currently generate approximately 5900-MW of power

annually, mostly through conventional thermal methods. In November 2006, the Private Power and Infrastructure Board (PPIB), a department of the Ministry of Water and Power, announced seven new licenses that would be made available to private sector companies to develop hydropower generation at pre-selected sites.

Although conventional thermal power generated by coal, oil, and gas is expected to meet a large percentage of future demand, there is also enormous scope for more environmentally friendly options. The GOP has adopted a systematic development plan called 'Vision 2025' that targets a long-term capacity increase of around 35,000-MW by the year 2025. This planned expansion will cost approximately US$30 billion. Renewable energy accounts for only 180-MW of Pakistan's present power output. Small to medium-sized hydropower plants offer the greatest renewable energy potential for Pakistan; possibilities also exist in promoting greater use of wind, solar, and biomass power projects. The GOP's current infrastructure development program, officially called the Renewable Energy Development Sector Investment Program, is targeted to expand the country's power supply, especially in rural areas, such that it will permit approximately 600,000 new domestic connections for 4.8 million people. The investment program in RE development will consist mainly of small to medium-sized hydropower plants in the NWFP and Punjab province. This program will be implemented in the following three major areas.

Clean Energy Development:

The GOP is seeking foreign or domestic power firms to bid on contracts to expand its small hydropower generating capacity. The main projects to be completed under this phase of the program include construction of three grid-connected plants in NWFP ranging from 2.6 MW to 36 MW and five hydropower stations in Punjab ranging from 3.2 MW to 7.2 MW. The total capacity will be about 75 MW, which will generate about 400 GWh of annual energy output.

New Hydropower Projects		
Province	Name of Hydropower Plant	Capacity (MW)
NWFP	Dharal Khwar	36.6
	Ranolia Khwar	11.5
	Machai	2.6
Punjab	Chianwali	5.4
	Deg Outfall	5.0
	Pakpattan	3.2
	Okara	4.0
	Marala	7.2

Feasibility Studies and Other Due Diligence of New Sites:

The GOP is further seeking domestic or international firms to conduct various research activities into the feasibility of developing new potential hydroelectric generation projects. The first pre-feasibility report (PFR) will support preparation of eight additional feasibility studies involving new sites in NWFP (three) and Punjab (five). The feasibility studies include due diligence on technical, financial,

New Raw sites for Hydropower Projects		
Province	Name of Hydropower Plant	Expected Capacity (MW)
NWFP	Koto	18.0
	Jabori	8.0
	Karora	7.5
Punjab	BS Link RD 106	10.0
	BS Link Tail RD 316	10.0
	LBDC RD 258	6.0
	LBDC RD 461	3.5
	LCC RD 0	5.0

commercial, regulatory, operational, governance, legal, safeguards, procurement, and implementation matters. ADB will advise on the terms of reference for the experts conducting these studies. All studies will be required to comply with ADB operating rules and procedures.

Capacity Development:

This component will support work at the federal, provincial, and project levels to strengthen administrative oversight of the other two components of this project. The GOP is seeking domestic or international firms to assist federal and provincial government authorities in developing their technical skills relating to the management of development of the RE sector. Specific areas of support are to include better planning, policy work, training, financial management, fiduciary oversight, tariff setting, institutional strengthening, project management, safeguards, evaluation, monitoring, and reporting. Support will also include provision of information on international developments in the hydroelectric sector and technical backup expertise.

During fiscal year 2005-06, GOP has initiated several new projects in the renewable energy sector through its AEDB designed to promote, implement and execute alternative renewable energy technologies. Most of these projects are to be developed through private sector investment. The government has approved the following operating guidelines for the AEDB under the Energy Security Action:

- Wind and solar energy power generation should be developed such that at least 5 percent of total power generation capacity will be met through these resources (i.e. 9,700-MW) by 2030.
- A 100-MW wind power project should be installed at Keti Bandar and Gharo towns of Sindh province and its capacity should be increased to 700-MW by 2010.
- The GOP's Roshan Pakistan Program's goal of electrification of all villages in the country within the next three years should be carried out through RE power generation.
- Solar products like solar fans, solar cookers, solar geysers, etc. must be developed on a priority basis by the private sector.
- Laws and taxes should be designed to encourage household self-energy generation through such technologies as solar heating, solar geysers, etc.
- Solar water heating systems at the household level should be promoted in order to save energy. Solar water desalination plants should be installed in areas having brackish water.
- Efficient cooking stoves in villages should be promoted in order to conserve wood.

In December 2006, the Asian Development Bank (ADB) launched a development program of renewable energy in Pakistan through a multitranche financing facility (MFF) of US$510 million. This program is the first of its kind in Pakistan and also one of the first to be developed under the ADB's evolving clean energy and efficiency initiative. Contracts for the construction of the hydropower plants to be financed under this loan will be made available in accordance with ADB's Procurement Guidelines through international competitive bidding (ICB) procedures.

2.2 Market Entry

American products and services enjoy an excellent reputation in the local market based on their quality and durability. However, American companies face tough competition from European, Chinese, Japanese and Korean competitors, which generally have a larger presence in the country and are able to offer their products and services at competitive prices. Providing after-sales service is essential. Pakistani firms have shown a strong interest in collaborating with American firms to expand their access to the latest technology and expertise. The best way for American manufacturers and suppliers to penetrate the Pakistan market is to utilize the benefits of the network services and programs of U.S. Export Assistance Centers in association with the U.S. Commercial Service offices located in Islamabad, Karachi, and Lahore.

Using an Agent/Distributor: Many foreign firms in Pakistan appoint local agents to provide market intelligence and to facilitate distribution. These agents typically work on a fixed commission; other agents operate as consultants on a retainer ship basis, receiving their fee regardless of the volume of total sales. Many foreign principals appoint one or more agents/distributors to cover the entire country; at times foreign principals work through a regional office to cover this market. Several U.S. firms cover Pakistan through their Dubai, Singapore or London offices.

Probably the most common arrangement is the exclusive agency agreement, under which the supplier agrees neither to appoint another dealer/distributor, nor to negotiate sales through any other party. Under this arrangement, the agent receives commissions on all sales of the product regardless of the channels through which the order is placed. The agent often imports and stocks the spares most frequently required by the end-users. Agency agreements typically extend for a term of one to three years and generally require 30 to 90 days notice by either party for termination.

Joint-Ventures/Licensing: Joint ventures can be an attractive option in Pakistan, as there are many local entrepreneurs who have built a substantial base in their industrial enterprises and are seeking to combine their knowledge of local markets with foreign capital and technological know-how. The foreign joint venture partner limits its initial country exposure while enjoying the support of a local partner in a new market.

2.3 Market Issues

- The main challenge that the AEDB is facing in the execution of its projects is the availability of equipment. Wind turbines are not available off-the-shelf in the world market. This is due to the fact that the United States has an extensive wind energy program that offers tax rebates. All leading manufacturers of wind energy equipment have fully committed existing supplies to the American market. However through extensive marketing efforts, the AEDB states that it has convinced the four top OEMs – GE of USA, VESTAS of Denmark, Gamesa of Spain and Fuhrlander of Germany – to reserve the equipment needed to produce 50-MW in Pakistan.

- A similar supply problem exists with the components of solar energy systems. Due to current high demand, there is a shortage of solar power systems in the world market.

- Pakistan is a diverse and challenging market requiring adaptability and persistence. Careful planning and patience are the prerequisites for success in this emerging market.

3. Leading R & D institutions and national/international agencies in the country working in the area of renewable energy, particularly those working on capacity building and information dissemination and R & D and demonstration programmes.

3.1 Pakistan Council of Renewable Energy Technologies (PCRET)

PCRET is an R & D Organization working in the field of Renewable Energy Technologies. Its main thrust areas are Photovoltaic, Solar Thermal, Biogas, Microhydel & Wind which are discussed as under:-

Photovoltaic (PV)

PCRET has developed the know-how and processing technologies in the field of solar cells, modules and systems. Its research laboratories are equipped with facilities of growing silicon mono-crystalline ingots, slicing the ingots into wafers, fabrication of solar cells and devices and lamination of cells into PV modules. As a result, a number of products are being fabricated on a limited scale in the Council's laboratories. These include silicon wafers, Solar cells, PV modules, PV systems, such as solar lantern/Torch, Home light Systems, Street lights/Park Lights, solar Fountain and solar mobile charger etc. A number of such systems have been designed and installed for applications of lighting, fencing, water pumping and telecommunication. PCRET is up-grading its laboratory facilities under a PSDP project by constructing new laboratories, equipped with new state-of-the-art facilities which will enhance its solar module production capacity upto 80 KW annually extendable to over 1MW. In the next PSDP project the solar cell production capacity will further be enhanced to 500 KW annually to meet the growing demand of solar energy in the remote/rural area. The Council is also establishing renewable Testing Laboratories at par with international standards through Government PSDP projects. These Laboratories will test renewable energy based commercial products in line with ISO/IEC standards. During the last three years, 134 PV system of 26.5 KW capacity have been installed by PCRET electrifying 124 houses, schools and community centers. [10]

Solar Thermal

A number of solar thermal appliances including, solar water heaters, solar fruit and vegetable dryers, solar water distillation stills, solar room heating system, and solar cookers have been developed/fabricated by PCRET for domestic and commercial purposes. Recently PCRET has designed and developed a solar hybrid dryer for dehydration of apricot on commercial basis. Under PSDP project PCRET designed, developed and installed 10 solar dryers having 500 Kg capacities for drying of dates in Punjab. Research and Development work in the field of other solar thermal devices is in progress. [11]

Biogas Technologies

Biogas Technology is an environment friendly technology. It contributes towards eco system management and biodiversity conservation. It provides soot-free clean gas for meeting domestic fuel needs as well as enriched bio-fertilizer for improvement of fertility/productivity of agricultural lands. The dung from animal is the source of biogas. The raw material is available in Punjab, NWFP, Sindh and some parts of Balochistan. So far PCRET has installed 3500 biogas plants (with net generation capacity of 14395 M^3 / day) on cost sharing basis throughout Pakistan. [12]

Micro hydel Power

Pakistan is endowed with hydel potential of more than 50,000 MW, but only 16% have been tabbed till now and rest needs to be harnessed to reduce dependency on oil import. Northern hilly areas of Pakistan are rich in small hydro sources. PCRET is actively working on this technology with an objective to electrify remote hilly human settlements, which are beyond the reach of national grid, through installation of micro hydropower plants (5-50 KW) by harnessing the natural water falls. Until now nearly 5.5 MW electrical power generation capacity has been tabbed by PCRET through installation of 415 MHP plants electrifying 50,000 houses. Under other programmes 151 MHP plants are being built by PCRET with the help of NWFP government. The activity will not only provide electricity to houses, but also power small-scale industrial units. The Council has launched a project for the provision of electricity to earthquake-affected areas by installing 100 MHP plants. [13]

Pakistan also has a great canal network. These canals have thousand of sites of small falls to keep the flow of canal water. Such falls are good sources for small power generations. PCRET is developing the technology and has installed a demonstration of 7.5 MHP plant at Taxila. The Council has initiated another project to develop and install 200 KW MHP plants at canal fall for demonstration and commercial applications. [14]

Wind Energy Technology

Pakistan has a coastal belt of 600 kilometer long and 50 kilometer wide in the province of Sindh and Balochistan. There is also a wind belt in the Thar Desert of Sindh and the Cholistan desert in Punjab. In Sindh alone, it is estimated that 50,000 MW electricity can be generated through wind from Keti Bandar to Gharo in Thatta District. PCRET has installed 135 wind turbines ranging from 0.5 – 10 kW and has provided electricity to 1400 houses in the remote coastal area of Sindh and Balochistan by 2007. [11]

3.2 Alternative Energy Development Board (AEDB)

With the efforts of AEDB, aggressive lobbying for investment has been done with national and international investors to make them realize the potential of RE particularly wind energy. Working papers with national/international companies have been signed. So far 93 LOIs have been issued for 4650 MW wind power generation. National Renewable Energy Labs (NREL) USA under USAID assistance programme 2007 has carried out the wind resources study of Pakistan and developed a Maizo scale map showing the wind speed potential available at 50 meter altitude. The NREL wind resources map of Pakistan has given a great boost to the wind energy

development activities in the wind corridor region. The Board has installed about 30 windmills for pumping water in different parts of Sindh and Balohistan. So far more than 18 villages have been electrified using micro wind turbines. AEDB is negotiating with international companies to start micro wind turbines manufacturing and manufacturing of parts of large wind turbines. Accordingly 6 MW wind turbine has been installed in Jhimpir for power generation. The AEDB has electrified 4045 remote off-grid homes in 90 villages in all four provinces of Pakistan through RETs by December 2008. Another 400 remote off-grid facilities in Balochistan are in process of electrification under solar energy and rural energy programme.

AEDB has also initiated bio-fuel project in Pakistan. Pilot project for production of bio-diesel has been implemented. PSO is producing bio-diesel at a limited scale. PSO has also set up a Jatropha nursery and Jatropha model farm at its installation in Karachi. Several other Jatropha nurseries have also been set up by the private sectors. The Board has facilitated installation of 35 MW plant through biomass/waste of energy. M/S Al-Moiz Industries have set up a 27 MW biomass facility and has signed a PPA with PESCO for sale of 15 MW to the Grid. Similarly M/s Shakarganj Sugar Mills are providing 8 Mega Watts electricity to FESCO using spent spirit technology. Both these PPAs were signed in 2008. Various small hydel projects in the provinces of NWFP and Punjab have been initiated by AEDB with Asian Development Bank funding with accumulative capacity of 80 MW. These projects are being implemented through the provincial government and are expected to reach completion in 2011. [15]

3.3 Agha Khan Rural Support Programme (AKRSP)

Agha Khan Rural Support Programme (AKRSP) has since 1991 completed about 240 micro and mini hydel power schemes in six districts of northern areas. Up-till now a total of about 10 MW installed micro/mini hydel capacity has been implemented by AKRSP in the region. These projects have been executed and maintained by the local community based villages organization (Vos), while AKRSP has provided technical and financial support and trained plant operators from within the communities. The plants are operating successfully and are providing lighting, heating, cooking and other cottage industries in the area. AKRSP won the prestigious Ashden award (green Oscars) in 2004 and the Japanese award for most innovative development projects 2005 for its community based RE programme in the area. [16]

3.4 Other Sections/Departments of Universities/institutions in Pakistan working on RETs

3.4.1 EME College NUST

EME College of NUST (National University of Engineering and Technology), Islamabad is working on the research and developments of Renewable Energy Technologies. It has installed a solar water heater of 40-ton/day capacities at Lahore, solar water pumping system and solar house electrifications of 450 villages in FATA is being initiated from May 2009. Similarly, 50 units of solar/wind hybrid water pumping system and house electrifications in Kharan District of Balochistan province are under progress. Twelve solar cookers and two solar dryers having capacity of 50 kg each at Bagh Azad Kashmir have been installed. The current research emphases

are being made on Bio-diesel extraction, Energy Efficient Building Designs and Waste heat recovery in the foundries.

3.4.2 GIK Institute of Science and Technology, Topi, NWFP

Mechanical Department of the institute is entertaining student's projects on Solar PV, Hybrid solar systems, Biomass, MHP, and Solar tracking system. It is also collaborating with Pakistan Science Foundation on projects like Solar PV System and Solar Biogas digester.

3.4.3. COMSATS Institute of Information Technology (CIIT)

Physics Department of CIIT, Islamabad is working on Quantum dot solar cells, research is in the initial stage.

3.4.4. Bahauddin Zakriya University (BZU) Multan

Physics department of BZU has taken up the renewable energy as field of research and development although in the embryo stages.

3.4.5 Gomal University D. I. Khan
Physics Department of Gomal University has taken up the renewable energy as field of research and development still in the initial stages.

3.4.6 National Center for Physics (NCP) Quaid-e-Azam University Islamabad is working on Nano Catalysts for Bio-fuel Technology using non edible raw material such as Sukh Chain, Spent tea, Jatropha, solid butchery waste, solid domestic waste etc.

3.4.7. University of Engineering and Technology, Taxila

The Higher Education Commission's (HEC) Departmental Development Working Party (DDWP) has approved the establishment of a renewable energy research and development center. The center will facilitate research activities in the energy sector focusing on renewable energy and will offer MS and PhD post-graduate study programmes. The center will also train scientists and engineers in solar and hydropower energy fields. The center will provide the local industry counseling in design, component development, long term testing, certification, resource data and site assessment and technical assistance in establishing energy production units.

4. Institutional Infrastructure and incentive available for the promotion and utilization of Renewable Energy in the country

4.1. Institutional Infrastructure

In Pakistan most of the research, development, promotion and dissemination work in the field of renewable energy is carried out by Public Sector Organizations because of the lack of such capabilities in the private sector. The public bodies engaged in research in the field of Renewable Energy Technologies in the country are discussed below:

4.1.1 Pakistan Council of Renewable Energy Technologies (PCRET)

PCRET was established in 2001 by merging National Institute of Silicon Technology (NIST) and Pakistan Council of Appropriate Technology (PCAT). This was done to achieve a better coordination of activities and to avoid duplication of research. PCRET is committed to research, develop, promote and disseminate, impart training, provide energy services to the people in remote areas and create renewable energy culture in the country. This Council is actively working in the field of Photovoltaic, Solar thermal, Biogas, Wind and Micro-hydel technologies. PCRET has its headquarter in Islamabad and regional offices in the four provincial capitals. PCRET is extending its research and development to the general public in the form of quality products and services. Photovoltaic panels are being fabricated as per customer's requirements; solar cookers (both box and concentrator type), solar water stills, solar dryers and solar water heaters have been developed and disseminated. Expertise for designing of biogas plants as per client's needs, its installation and plant monitoring is available with PCRET offices in the country. PCRET has the technical know-how for surveying of potential sites for micro hydel power plants, designing of turbines and their installations and monitoring. It has established national and international liaison in the filed of R.E. and is providing advice and assistance to the government and relevant industries in the country. [11]

4.1.2 Alternate Energy Development Board

The government of Pakistan created Alternate Energy Development Board (AEDB) in May 2003 through act as central body on the subject of Renewable Energy. The main objective of the Board is to facilitate, promote and encourage development of renewable energy in Pakistan. The main functions of AEDB are to develop national strategy, Policies and plan for utilization of alternate and renewable energy resources to achieve the targets approved by the Federal Government in consultation with the Board. It acts as a forum for evaluating, monitoring and certification of alternate or renewable energy projects and products. It is interacting and coordinating with National and International agencies for promotion and development of alternate and renewable energies. AEDB has launched the Policy Development of Renewable Energy for power generation 2006 approved by the Economic Coordination Committee of the Federal Cabinet. The Board plans to indigenes on solar/wind related technologies in the next decade through national/international collaboration.

4.2 Incentives for promotion and utilization of Renewable Energy in the country.

Government is planning under Medium Term Development Framework (MTDF) to increase the share of renewable energies from zero availability to 9.20 MTOE by 2030. To achieve the objective, government has proposed an allocation of Rs. 3.0 Billion for the development of alternative energy (MTDF 2005 – 2010). Moreover it is the objective of the Science & Technology specially that of energy sector that the benefits of Research and Development specially indigenous R & D should be made available to the people in general and those of rural areas in particular.

4.2.1 General Incentives for RE Power Generators

The provisions stated below shall be made available to all qualifying renewable energy-based power projects falling in any of the following categories

- Independent power projects (IPPs) based on new plants (for sale of power to the grid only)
  a. Solicited
  b. Unsolicited
- Captive and grid spillover power projects (i.e., self-use and sale to utility)
- Captive power projects (i.e., for self or dedicated use)
- Isolated grid power projects (i.e., small, stand-alone)
  a. Solicited
  b. Unsolicited.

4.2.1.1 Guaranteed Market: Mandatory Purchase of Electricity

It shall be mandatory for the power distribution utilities to buy all the electricity offered to them by RE projects established in accordance with the provisions given in **Section 4.2.1.2**

4.2.1.2 Grid Connection, Off-take Voltage and Interface

Electricity shall be purchased from RE power producers at a voltage of 220 kV at the outgoing bus bar of the power station if the power station is located within 70 km of an existing 220 kV transmission line, or at 132 kV if it is within 50 km of an existing 132 kV transmission line, or at 11 kV if it is within 5 km of an existing 11 kV transmission line, or at 400 V if it is within 1 km of a 400 V distribution feeder. The minimum average power to be supplied in each case would be 1,250 kW/km, 250 kW/km, 100 kW/km, and 20 kW/km, respectively. The producer may also undertake to lay a new transmission line for connection with the main electricity grid. The power purchase tariff determination will be adjusted accordingly for each of these options.

*4.2.1.3.*Wheeling

RE power producers shall also be allowed to enter into direct (bilateral) sales contracts with end-use customers. Under this arrangement, they would be allowed to sell all or a part of the power generated by them to their direct customers, and the rest to the utility for general distribution. For direct sales, they shall be required to pay 'wheeling' charges for the use of the transmission and/or distribution grid network used to transport the power from the plant to the purchaser. In practical terms, the IPP shall inject electricity into the grid system at one point (subject to the provisions in **Section 4.2.1.2**) and would be entitled to receive the same amount at any other location (within the same distance from the grid as the distance of the plant from the system) upon payment of a corresponding wheeling charge, to be determined by NEPRA. This wheeling charge will reflect the cost of providing and maintaining the transmission interconnection, including the energy losses suffered *en route*, calculated on a utility-wide basis by NEPRA.

4.2.2 Specific Incentives for Grid-Connected RE IPPs

Specific incentives are provided under this policy to renewable energy based independent power producers (IPPs) selling all generated electricity (minus auxiliary consumption) to the grid. The underlying principle is that IPPs based on variable RE resources (such as wind and water flows) shall be made immune to factors which are beyond their control, and at the same time shall be rewarded if they perform better than reasonably expected.

4.2.2.1 RE Resource Variability Risk

In the case of grid-connected RE IPPs, the risk of variability in wind speeds (for wind power projects) and water flows (for small hydropower projects) shall be borne by the power purchaser. Benchmark' electricity production levels based on mean availability of wind or water flow for the month shall be determined for each project location on the basis of independently monitored data. The IPP shall be ensured revenues corresponding to this benchmark level, including potential loss of corresponding carbon credits, even if the resource availability temporarily falls below this benchmark, provided that the reduced electricity production is not due to fault of the IPP itself.

4.2.2.2 Production Incentives

For all power produced above than the benchmark level, a production bonus payment shall be made to the IPP.

4.2.2.3. Carbon Credits

All qualifying RE power projects (initially wind and small hydro IPPs) eligible for financing under the Clean Development Mechanism (CDM) shall be encouraged to register for Certified Emission Reduction (CER) credits with the CDM Executive Board, either collectively or individually. The Government shall also strive, in collaboration with international development agencies and to the extent possible, to facilitate project applications for such carbon credits in order to reduce the associated initial transaction costs for project sponsors. Importantly, as this policy creates significant incremental costs for the RE power purchaser (higher tariffs, resource availability risks, backup power provision, transmission and interconnection infrastructure, etc.), it is appropriate that any carbon credits thus obtained by RE IPPs be utilized to partly offset this burden so as to improve the economic competitiveness of RE-based grid power for both the rate payers and the producers.

Government of Pakistan 13 term of the project's Power Purchase Agreement (PPA), i.e., during and beyond the Kyoto Protocol's Initial Commitment Period (2008-2012), in the project's financial analysis on terms specified by the regulator (e.g., anticipated emissions offset and price per equivalent ones of CO2 abated), whether opting for up-front tariff or negotiated tariff. A mechanism and legalized institutional arrangement shall be specified by the AEDB and approved by NEPRA, comprising of potential primary beneficiaries (i.e., power producers and purchasers) jointly managing and selling the CERs thus obtained in the international carbon market at an optimum price. The annual carbon revenues realized subsequently shall be divided in the following manner: (a) an up-front, nominal deduction shall be made for the administrative costs of the joint CER management mechanism; (b) an amount not exceeding that required to bring the IPP's return on equity (ROE) to the level allowed

by NEPRA shall be payable to the power purchaser; and (c) the remaining revenues shall be divided in equal proportion between the IPP (as a 'green credit' for enhancing the financial returns accruing to the project's investors) and the power purchaser (as 'green tariff' support for lowering the per unit price of clean RE power, thereby increasing its attractiveness for purchasers and consumers). Projects shall be required to sign a separate agreement binding them to the terms of such a carbon crediting mechanism, but shall not be penalized for failure to qualify for or obtain sufficient annual CER revenues to fully compensate the power purchaser under Item (b) above, provided they have complied with the terms of the aforementioned carbon credit agreement, as certified by NEPRA. Under this arrangement, the carbon credit sharing mechanism will help further incentives and facilitate investments in RE projects, increase the share of renewable energy in utilities' power purchase portfolios, and reduce the cost of renewable energy-based power for the end user factors, which should help enhance the eligibility of such projects for CDM approval.

*4.2.2.*4 Security Package

The power purchaser shall enter into a specific Power Purchase Agreement (PPA) 2, based on a standard model agreement, with the RE power producer. The Government of Pakistan shall also enter into an Implementation Agreement (IA), which will guarantee the payment obligation of the public sector power purchaser on account of power sales extending over the term of the PPA. The PPAs will be much simpler than those for thermal or large hydro IPPs, and shall be based 2 in some cases; this may be termed as the Energy Purchase Agreement (EPA).

On the purchase of all power generated at a per-kWh rate—i.e., there will be no capacity charge, capacity testing, no risk, and no penalty conditions implied. The Government of Pakistan shall also undertake, as described in **Section 4.2.2.3 above**, to facilitate the acquisition of CDM Certified Emissions Reduction units (CERs) by qualifying projects, and the sharing of associated revenues under a separate agreement and based on payment-on-delivery terms, subject to verification of the same, between the RE IPP (as a 'green' credit) and the RE power purchaser (as 'green tariff' support).

4.3 Facilities for Captive and Grid Spillover Projects

For other categories of RE power generators, e.g., captive and grid spillover power projects, wishing to sell surplus power to the utility grid the, the following facilities shall be made available. These will be further refined and expanded for the next policy phase beginning in 2008 based on initial experience gained in the short term.

4.3.1. Net Purchase and Sales

An RE power project of capacity greater than 1 MW set up for self (captive) or dedicated use may supply surplus electricity to the power utility (grid spillover), while at other times drawing electricity from the utility to supplement its own production for local use, subject to the provisions in **Section 4.2.1.2**. In such cases, the net electricity a. supplied by the power producer to the utility in a month (i.e., units supplied by the producer minus units received by the producer, if greater than zero), shall be paid for by the utility at a tariff equal to the average energy cost per kWh for oil-based power generation (as determined by NEPRA for GENCOs/IPPs

over the applicable quarter of the year) less 10%, or b. supplied by the utility to the power producer in a month, (i.e., units received by the producer minus units supplied by the producer, if greater than zero), shall be paid for by the producer at the applicable retail tariff (e.g., industrial or commercial rates, depending upon the type of user connection). Such net purchase and sales or net billing arrangements will involve measurement of the electricity received and supplied to the utility by the power producer using two separate sets of unidirectional meters.

4.3.2 Net Metering

An RE power project of capacity up to 1 MW set up for self (captive) or dedicated use may also supply surplus electricity to the power utility while at other times drawing electricity from the utility to supplement its own production for local use subject to provision in **Section 4.2.1.2** In such cases, the net electricity a. supplied by the power producer to the utility in a month, i.e., units supplied by the producer minus units received by the producer, if greater than zero, or b. supplied by the utility to the power producer in a month, i.e., units received by the producer minus units supplied by the producer, if greater than zero, shall be paid for by the utility or the producer, respectively, at the applicable retail tariff (e.g., industrial, commercial, or residential rates). Such net metering arrangements may involve separate sets of unidirectional meters for recording the electricity received and supplied to the utility by the power producer, or special bi-directional meters capable of instantaneously recording net power transfers. This facility would be particularly suitable for incentivizing dispersed small-scale RE generation, such as rooftop PV panels, helping optimize their utilization and payback rates and obviating the need for expensive on-site storage batteries.

4.3.3 Banking

For net billing purposes, a rolling account of energy units will be maintained on the pattern of a bank account (i.e., debit or credit basis). Such banking accounts of net energy units shall be maintained on a monthly basis and final balances will be reconciled at the end of the year at the rates given in **Section 4.3.1**. Under this arrangement, a producer may generate and supply power to the grid at one location and receive an equivalent number of units for self use (say, at a factory) at a different or physically distant location on the grid at a different time without paying any wheeling charges, but subject to the distance limits for power input and off take as noted in **Section 4.2.1.2**. Any additional (net) units consumed by the producer (beyond those supplied to the utility at the plant location) in a given month shall be billed by the utility at the retail tariff applicable to the type of electricity connection obtaining at the consumer’s premises. Any excess (net) units supplied by the producer’s plant in a given month shall be credited to the producer on a rolling monthly basis (i.e., deducted from the next month’s consumption). Any accumulated energy unit credits accruing to the producer at the end of the year shall be paid for by the utility at a tariff equal to the average energy cost per kWh for oil-based power generation (as determined by NEPRA for GENCOs/IPPs over the preceding fiscal year) less 10%.

4.4 Financial and Fiscal Incentives

All renewable energy-based power projects will enjoy the following fiscal and financial incentives. These facilities shall be equally applicable to private, public-private, and public sector renewable energy power projects.

4.4.1 Fiscal Incentives

No customs duty or sale tax for machinery equipment and spares (including construction machinery, equipment, and specialized vehicles imported on temporary basis) meant for the initial installation or for balancing, modernization, maintenance, replacement, or expansion after commissioning of projects for power generation utilizing renewable energy resources (specifically, small hydro, wind, and solar), subject to fulfillment of conditions under the relevant SRO. Ii. Exemption from income tax, including turnover rate tax and withholding tax on imports. Iii. Repatriation of equity along with dividends freely allowed, subject to rules and regulations prescribed by the State Bank of Pakistan. Iv. Parties may raise local and foreign finance in accordance with regulations applicable to industry in general. GoP approval may be required in accordance with such regulations. V. Non-Muslims and non-residents shall be exempted from payment of Zakat on dividends paid by the company.

4.4.2 Financial Incentives

Permission for power generation companies to issue corporate registered bonds.
ii. Permission to issue shares at discounted prices to enable venture capitalists to be provided higher rates of return proportionate to the risk.
iii. Permission for foreign banks to underwrite the issue of shares and bonds by private power companies (IPPs) to the extent allowed under the laws of Pakistan.
iv. Non-residents allowed purchasing securities issued by Pakistani companies without the State Bank of Pakistan's permission, subject to prescribed rules and regulations.
v. Independent rating agencies available in Pakistan to facilitate investors in making informed decisions about the risk and profitability of the project company's bonds/TFCs.

5. Policy Instruments and Related Measures available in the Country for the Promotion, Utilization and Development of Renewable Energy Technologies (Rets.)

5.1 Policy Phasing

The Economic Coordination Committee of the cabinet had approved the policy for the Development of Renewable Energy for power generation – 2006. The policy laid down very liberal and attractive incentives for investment for investment aimed at putting Pakistan on the renewable energy map of the world. It would go a long way towards strengthening and improving power supply position of the country. The policy invites investment from the private sector for the following four categories:-

(i) Independent power projects (IPPs) for supply of power to the grid only;

(ii) Captive-cum grid spillover power projects for self use and sale to utility;
(iii) Captive power projects for self or dedicated use; and;
(iv) Isolated grid power projects for small and stand-alone use.

The policy comprises three phases: Short term, medium term and long term.

5.1.1 Short Term

(Projects achieving financial closure by June 30, 2008)

The focus during this phase would be on RE options amenable to immediate commercial development i.e. where commercially proven technologies and resources are readily available, such as small hydro, wind solar and biomass-based power generation.

5.1.2 Medium Term

(Projects achieving financial closure during period July 1, 2008 to June 30, 2012).

Based on past international and short term domestic RE policy experience, a more comprehensive 'medium term' policy framework will be prepared for the systematic implementation of RE technologies and scaling up of capacity deployment.

5,1.3 Long Term

(Projects achieving financial closure after June 30, 2012).

RE will be fully mainstreamed and integrated within the nation's energy planning process. RE energy producers will be gradually exposed to full competition from alternative sources – based on full-price, avoided cost accounting.

5.2 Targets

- Development of wind and Solar Energy to meet at least 5% of total installed capacity through RE resources by 2030 (i.e. 97000 MW).
- Electrification of 7,874 remote, off-grid villages in province of Sindh and Balochistan through Renewable Energy.

- Gradual introduction of Bio-diesel fuel blends with Petroleum diesel so as to achieve a maximum share of 5% by volume of the total diesel consumption in the country by the year 2015 and 10% by 2025.

5.3 Unique Features of Policy

- Wind Risk/Hydro Risk
- Guaranteed Electricity purchase
- Grid provision is the responsibility of the purchaser
- Attractive Tariff
- No import Duties on Equipment
- Zero Sales Tax
- Net Metering
- Banking of Electricity
- Wheeling Provisions

- Grid Spillover Concept introduced

5.4 Financial incentive to Investors

(i) There would be no custom duty or Sale Tax on equipment and spares meant for initial installation or for expansion of the projects.
(ii) Exemption had been allowed on income tax, including turnover rate tax and with holding tax on imports of machinery and equipments. [17,18]

6 Detail of Financial Institutions supporting Renewable Energy Projects (Including brief illustrative examples and status of the projects funded).

Many projects have been initiated by Donor Agencies themselves. Some major projects are:

Date	Project	Agency	Cost
Feb 2004	Commercialization of Wind Power Potential in Pakistan	UNDP	0.47 Mill US $
2004/2005	Pak German Tech Cooperation Programme	GTZ	3.50 Euro
2006/2007	Exploitation of Untapped Potential of Wind Energy	UNDP-GEF	3.10+0.72 GOP

Donors also fund AEDB in Numerous projects

Date	Project	Agency	Cost
Feb 2004	Renewable Energy Development	ADB	0.55 US $ Mn
2006	Renewable Energy Development Sector Programme	ADB	510.0
March 2007	Pakistan Renewable energy Policy Formulation and Capacity Development of AEDB		0.80

6.1 Asian Development Bank (ADB)

A Project Preparatory Technical Assistance (PPTA) was offered by ADB in November 2004 to analyse the renewable energy potential in each province and conduct feasibility studies of sample sub-projects for financing under an ADB commercial lending scheme. ADB was designated as the Executing Agency (EA), while the relevant departments in each province served as the Implementing Agencies (Ias).

Progress on Asian Development bank Renewable Energy Development Sector Investment Programme

No.	Name of Project	Location	Capacity & Cost in million	CoD	Status		
					LoI Date	Land Acquisition	Tariff*
A. Sarhad Hydel Development Organization (SHYDO) Government of NWFP							
1.	Daral Khawar	Swat	36 MW Rs.3075	31-12-2011	Not Applicable	In Process	US C 4.183
2.	Ranolia	Kohistan	12 MW Rs. 1077	31-12-2011	Not Applicable	In Process	US C 3.486
3.	Machai Canal	Mardan	2.6 MW Rs.318	31-12-2011	Not Applicable	In Process	US C 4.538

B. Punjab Power Management Unit (PPMU), Irrigation & Power Department Punjab.							
1.	Chianwali	District Gujranwala	5.4 MW Rs. 827	31-12-2011	Not Applicable	In Process	US C 4.541
2.	Deg Out-Fall	District Sheikhupura	5.0 MW Rs. 675	31-12-2011	Not Applicable	In Process	US C 4.183
3.	Pakpattan Canal	District Pakpattan	6.4 MW Rs. 462	31-12-2011	Not Applicable	In Process	US C 3.486
4.	Okara	District Okara	4.0 MW Rs. 693	31-12-2011	Not Applicable	In Process	US C 4.538
5.	Marala	District Silakot	6.5 MW Rs. 1.064	31-12-2011	Not Applicable	In Process	US C 4.183

In January, 2006, after conducting Technical, Financial & Economic analyses of 05 hydel sites in Punjab and 03 hydel sites in NWFP, the following high-head and low-head hydel sites were selected as suitable for loan financing:-

<u>NWFP</u>

(a) Ranolia : (11.5 MW)
(b) Daral Khawar : (35 MW)
(c) Machai : (3.5 MW)

<u>Punjab</u>

(a) UCC Main Lower near Gujranwala : (4.6 MW)
(b) Deg Fall Sheikhupura : (5.5 MW)
I Pakpattan Canal : (3.3 MW)
(d) LBDC Okara : (5 MW)

(e) UCCM Marala : (11.5 MW)

The cost of eight subprojects in NWFP and Punjab identified under the first set of subprojects were estimated as $ 145.0 million while $ 80.0 and $65.0 million for NWFP and Punjab provinces, respectively. The Government requested ADB to finance up to 80% of the total cost.

AEDB will be the Executing Agency (AE) for coordination and facilitation at the federal level, while the NWFP and Punjab governments will be the Executing Agencies at the provincial level. SHYDO will be the implementing agency in NWFP and the Punjab IPD will be the implementing agency (IA) in Punjab province.

- Based on the investment potential of RE in Pakistan, ADB agreed to provide $ 510.0 million under a Multi-tranche Finance Facility (MFF) for a period of 10 years (2007 – 2017) for Renewable Energy Development Sector Investment Program (REDSIP). The amount remaining after the approved projects would be available for any new Public or Public-Private RE projects that fit the ADB given selection criteria. The first tranche will be of $ 115 Million, which includes $ 10 million of ADF Loan.

- The loan became effective on 29 November 2007 after obtaining Government approval. Delay was due to revision of PC-I and subsequently in obtaining approvals from CDWP and ECNEC.

- The loans is financing three major areas:-

    - Construction of 3 hydropower projects in NWFP and 5 hydropower projects in Punjab.
    - Preparation of feasibility studies for 3 new sites in NWFP and 5 new sites in Punjab.
    - Capacity Development.

- The PC-Is for the 08 subprojects were approved by the CDWP on 19th October 2006. The Loan Negotiations took place in Islamabad on 30-31 October, 2006 and concluded with a signing ceremony between Government of Pakistan and ADB.

- Four hydropower projects from the Northern Areas amounting to about 54 MW are currently being considered for the Second Tranche loan. A public sector 50 MW Wind Farm is also being seen as a potential project under the REDSIP financing facility.

<u>TA FOR Renewable Energy Policy Formulation and Capacity Development of the AEDB</u>

- The goal of the TA is to facilitate the process of the development of Renewable Energy Policy of Pakistan. The purpose of the Policy is to expedite the process of developing indigenous, non-polluting, and renewable

sources of energy to help meet Pakistan's power shortage and improve the quality and reality of the powers system, including such issues in rural areas.

6.2 German Agency for Technical Cooperation (GTZ)

The GTZ on behalf of Federal Ministry of Economic cooperation and Development (BMZ) Federal Republic of Germany has been implementing the Renewable Energy Efficiency Programme since 2005, which aims to strengthen the capacity of public and private sector to promote the renewable energy efficiency in the country.

GTZ provided technical expertise and capacity building in:

- Rural Electrification
- Centre of excellence for Renewable Energy and Environment (CEREE) at the Balochistan University of IT and Management Sciences
- Wind Power Generation. International and domestic experts were made available to develop PPA and IA documents for Wind Energy Generation. Legal experts were also provided to carry out the legal vetting of documents.
- Clean Development Mechanism (CDM)
- National Renewable Energy Policy
- Micro-Mini Hydel Projects
- Establishing International Linkage
- Energy Efficiency
- Energy Conservation Fund (ECF)

6.3 UNDP/GEF Projects

- The first UNDP/GEF funded project relates to the "Sustainable Development of Utility Scale Wind power Production". This is a two-year project with a GEF funding of $ 3.1 million. The project aims to design and overall policy package to facilitate investment in wind energy, whereby providing a competitive enabling framework and corresponding incentive tailored for a market-on-grid wind energy production.
- The second UNDP project is $ 25,000 GEF funded PDF-A study relating to Productive use of Renewable energy through micro hydel projects has recently been signed. It is planned to start the project in Chitral area, which is based on micro-hydel systems in the range of 100-300 KW per unit. About 43 locations have been identified of which 5 have been short listed for this study. A medium size project will ensure after completion of PDF-A and once investment funds are arranged.

6.4 EU-Asia Invest Programme

- The EU Asia Invest program is a European Union funded initiative for the period of one year (May 2007 to July 2008) to boost private investment in the field of renewable energy technologies in Pakistan. The selected areas for intervention are solar, wind and small hydro.
- The main activities under the programme are:
    - Market information;
    - Capacity building seminars;
    - Companies match making in Pakistan;

- The partners of the programme are:
    - Alternative Energy Development Board (AEDB)
    - German Solar Industries Association (BSW)
    - Estonian Wind Power Association (EWPA)
    - European Small Hydropower Association (ESHA)
- The other associates are:
    - German Agency for technical Cooperation (GTZ-Pakistan)
    - German Wind Energy Association (BWE)
- A total of two capacities building seminars-cum-workshops were planned. The 1st one on wind Farm Development was held from 6th to 10th August, 2007 at Karachi and the other workshop on Off-grid PV Solar Systems was held in Islamabad.

6.5 World Bank Project

The World Bank had approved a study which is currently being undertaken by their consultants to develop an adequate policy and governance framework for off-grid rural electrification by assessing the effectiveness of socio-economic factors and governance structures in existing off-grid rural electrification projects and exploring and testing sustainable decentralized service-delivery models for future large-scale off-grid rural electrification in Pakistan.

7. Scope for Utilizing Renewable energy in the country

The primary supplies today are not enough to meet even the present demand. So, Pakistan, like other developing countries of the region, is facing a serious challenge of energy deficient. The development of renewable energy sources can play an important role in meeting this challenge. Present observation based on reviewing the geological set up, geographical position, climatological cycles and the agricultural/ and industrial/urbanization activities reveal that there are bright prospects for the exploitation of various renewable energy resources, which include mage and macro/micro hydel, biomass/biogas, wind and solar. Technologically, all these renewable energy resources are viable and consequently suit to efforts for poverty alleviation and cleaner environment in Pakistan. The country can be benefited by harnessing these options of energy generation as substitute energy in areas where sources exist. As Pakistan is an agricultural country and major part of population lives in rural areas, the electricity generated by renewable energy resources will also improve rural life, thereby reducing the urban migration that is taxing the ability of cities to cope with their own environmental problem. The scope for utilization of renewable energy resources is discussed as under:-

7.1 Micro hydro Power

Most of the hydropower potential lies in the North Western Frontier Province (NWFP), Northern Areas (N.A.) and Azad Jammu & Kashmir (AJK). There is also potential available in canal system and in small rivers and streams. Pakistan has hydel resource of about 50,000 MW but unfortunately we have exploited only 6595 MW. The vast irrigation system of Pakistan provides hundreds of sites for micro mini and small micro-hydro plants. Depending upon the head and flow of water suitable turbines can be utilized to generate electricity from

few KW to MW. Therefore, abundant potential is still need to be identified. The country has offered 2000 MW of sites with studies to pre-feasibility and beyond small and mini hydropower project less than 50 MW capacity, with many more sites yet to be identified. Small and mini hydropower projects are suitable for domestic investment and individual projects can come on line within 2 to 3 years to mitigate serious problems of load shedding being faced in the country.

Micro mini hydro power plants have been developed for rural electrification by provincial bodies mainly in the North Western Frontier Province through Sarhad Hydel development Organization (SHYDO), Northern Areas Public Works Department (NAPWD) in administrative Northern Areas (N.A) and NGOs like Agha Khan Foundation with community participation. A similar approach was also adapted in Upper Dir district of NWFP by an European Union funded project together with IUCN. In addition PCRET has introduced community based micro hydropower stations (5-50 KW) in parts of NWFP in Swat, Dir, Chitral, Kohistan, Mansehra and Abbottabad district. Until now 5.5 MW electrical power generation capacity has been tabbed by PCRET through installation of 415 MH P plants electrifying 56000 houses. The majority of the stations installed have basic designed civil structure, safety devise and electro mechanical efficiency. These plants are operational in off-grid areas. WAPDA's vision of 2025 indicates that a total of 2070 MW of new hydropower generation will be added to the system in next 16 years with new projects at the cost of US $ 32 million. Moreover, the PPIB is also sponsoring 22 hydropower projects with cumulative power generation of 5720 MW with an estimated cost of US $ 6.5 billion.

7.2 Wind Energy

Another renewable energy resource is wind energy. Despite many multi pronged efforts by the government and the private quarters, the country does not have a single grid connected wind farms on ground. According to a detailed study conducted by the National Renewable Energy Lab (NERL) in collaboration with USAID and Pakistan Metrological Department; the total exploitable potential is 132000 MW. The NREL has prepared solar and wind maps of Pakistan indicating the potential of power and the perspective locations of the projects. The Metrological Department after completing 6 year wind data acquisition project in the coastal area of Sindh and Balochistan has launched 2nd phase of the project which will collect imperative wind data in the northern areas. Additionally, the UNDP Pakistan is also planning to install some weather stations specifically for wind data acquisition in some potential areas like northern Punjab etc. These exercises will definitely pave way for wind power with full government support to the private sector. For wind power generation the actual land used is very small as compared to the total area. In fact only 2% to 3% area is used by installation of turbines, sub-station and internal wind farm roads. The rest of the area is available for any low height cultivation or cattle grazing. Co-incidentally almost all potential wind corridors in Pakistan are situated in barren areas; hence wind farming is the best utilization of that barren land. The potential wind corridors highlighted for the wind farming are southern Sindh (Keti Bandar, Gharo Hyderabad), northern Punjab (Kalar Kahar), Mardan area in NWFP, Nokundi, Kolpur, Makran and Chaghi area in Balochistan. By virtue of actual wind measurement and calculations, Pakistan Met. Department has defined the potential of only one corridor i.e. Keti Bandar, Gharo Hyderabad as 43000 MW. One can easily understand that if all these corridors added together can go up to the 132000 MW. Only one quarter of this value i.e. 33000 MW can be attained without a puff of fuel.

7.3 Solar Energy

There are two main techniques of power generation through solar radiation; one is Solar PV technology and other is concentrated solar power technology (CSP). The PV is the best suited for stand-alone power requirement of homes and offices. Although the world has experienced off-grid connected solar PV power plants, still it is a kind of domestic business. In contrary, the CSP technology is best suited for grid-connected power plants. However, example of small size captive power generation through sterling dish also exists in this technology. In addition, power generation from solar energy is also used for heating, cooling and cooking purpose. In Pakistan, except some isolated example there is no mass scale implementation of these simple technologies. Solar cooker in northern areas can greatly help saving forests. Solar water heater in cities can save valuable natural gas. There are some entrepreneurs and individuals making efforts in this field, but we have to integrate them for focus efforts and better results.

An area where solar PV can be used on mass scale is the lighting, indoor and out-door. Indoor lighting meant for offices and homes for which solar PV modules can be coupled with LED lights which require little electrical energy for the same luminosity and at the same time have very long life. Alternatively we can use energy saver. Out door lights mainly comprised streetlights. It is the time when city authorities should plan to implement a phase change out of traditional lights with solar PV and LED lights for streets and parks. We can start with alternate light poles if not all. Housing societies and the Townships of industrial units must also come forward to launch such projects. These projects will trigger local mass-production of solar PV modules and LED lights, which will result in low cost of such system.

7.4 Biogas

Biogas in Pakistan comprises fuel wood, agricultural waste and animal dung which is available in surplus in all parts of the country. Urban areas of Pakistan generate over 55000 tonnes of solid waste daily. As per livestock senses 2006, there are 56.9 million animals (buffaloes & cows) in Pakistan. Biogas is an environment friendly technology. It contributes towards eco system management and bio-diversity conservation. It provide soot-free gas for domestic fuel need as well as enrich bio-fertilizer for improvement of fertility /productivity of agricultural lands. The dung from animal is the source of biogas. The raw material is available in Punjab, NWP, Sindh and some parts of Balochistan. So far Pakistan Council of Renewable Energy Technologies (PCRET) has installed 3500 biogas plants with a net generation capacity of 14400 M^3 per day on cost sharing basis throughout Pakistan. It is estimated that about 21.35 million M^3 biogas can be generated using animal dung. This can meet energy needs of more than 38 million people or 6million households. Further 45 million tones/day of fertilizer can be produced as a bio-product. This is an important source of domestic energy and environment friendly way of disposal of the animal waste.

8. Indigenously developed Renewable energy Technologies

Pakistan is rich in different renewable energy resources which need to be exploited and developed. The status of indigenously developed renewable energy technologies is discussed as under:-

8.1 Solar Thermal

Solar Energy is abundant, freely available, widely distributed and can be converted into other forms of energy. The number of clear sunny days in the country varies from 250 in the northern region to above 300 days in most parts of the country. A number of solar thermal appliances including solar cookers, solar water heaters, solar fruit and vegetable dryers, solar desalination stills and solar space heating system have been indigenously developed and locally fabricated by PCRET, other sections of PCSIR, NUST, COMSATS, GIK and different departments of Engineering Universities etc. Many NGOs are popularizing these devices in the country.

PCRET

More than 500 solar cookers and 50 solar stills designed, locally fabricated and handed over to NGOs for dissemination and popularization.
Solar room heating systems designed, locally fabricated and installed at PCRET building.
10 solar dryers of 50 Kg capacities for drying of dates, designed, fabricated locally and installed at Muzaffargarh district Punjab.
Designed and developed solar hybrid system for dehydration of apricot on commercial scale.

Mechanical Engineering Department of EME College

Designed, developed and locally fabricated 40 tonnes per day capacity solar water heater and installed at an industrial unit, Lahore.
Designed, developed and fabricated 12 solar cookers for rural areas.
Designed and locally fabricated 2 solar dryers of 50 Kg capacities each, which are installed at Bagh (AJK).

8.2 Photovoltaic (PV)

Photovoltaic devices convert sunlight directly into electricity. The current use of photovoltaic in Pakistan is to protect gas pipes from corrosion, power transmission, PV relay station, telephone exchange, and rural electrification and to preserve vaccine/medicine in remote areas. PCRET in the public sector and Akhtar Solar in the private sector are fabricating solar cells/modules in the country.

- PCRET has well-established PV laboratories, which are producing 15 KW Solar Cells/modules annually. The production capacity will be extended to 80 KW by 2010.
- Akhtar Solar Ltd. is producing solar modules on limited scale; however, it has production capacity upto 2MW.
- 3000 solar lanterns have been designed, developed and fabricated by PCRET, which are being disseminated to rural areas for popularization.
- 134 system of 26.5 KW capacity have been installed by PCRET electrifying 124 houses, schools and community centers.

8.3 Micro Hydel

Most of the hydropower potential lies in NWFP, Northern Areas and AJK. However, potential available in canal system and in small rivers and streams is much higher. Depending upon the head and flow of water, suitable turbine can be fabricated locally to generate

electricity. Sarhad Hydropower Development Organization (SHYDO) & Northern Areas Public Works Department (NAWD). PCRET and NGOs like Agha Khan foundation are developing micro and mini hydropower plants for rural electrification with community participation. Pico and Micro Hydel Turbines upto 100 KW are being manufactured locally. Following workshops are currently fabricating micro and mini hydel pelton wheel and cross flow turbines.

- Hydrolink Engineering Services Tarnol, Islamabad
- Chitral Engineering works Taxila
- Mukhtar Engineering works Gujar Garhi, Mardan
- Chiragh & Co Gujar Garhi, Mardan
- Pak Renewable Pvt. Ltd, F-8, Islamabad
- Riswan Technologies Brandreth Road, Lahore

The existing workshops are at the primitive stage of technology development, where manufactured products have no testing and certification facilities. The technology level of local manufacturers is sub-standard for higher capacity turbine such as above 50 KW. Most of the manufacturers are either non-technical or technician level.

a. PCRET has installed 415 micro hydel plants of 5.5 MW capacity electrifying 56000 houses. The micro hydel turbines in the range of (5-50 KW) have been indigenously fabricated by the local manufacturers.
b. Agha Khan Rural Foundation are installing micro and mini hydel power plants for rural electrification with community participation. The Foundation has installed 240 hydel plants of 10 MW capacities. The turbines (30 to 70 KW) have been fabricated from the local market.

8.4 Biomass/ Biogas

Biogas is environment friendly technology and can be used for lighting, cooking, water heating and space heating. Dung from the animal is the source of biogas. 70% population in Pakistan lives in rural areas. So raw material is available in all the four provinces of Pakistan. Biogas plant is indigenously being fabricated in Pakistan. There are two types of biogas plants. The first type is built with built in fixed dome/gas holder (usually called Chinese or Nepalese design). The other type is built with moveable gasholder (usually called Indian design). PCRET has installed some fixed dome biogas plant in the beginning. It did not work well because of gas leak from the minute holes developed in the concrete dome. Thus the Chinese design could not succeed for want of proper technical skill required for the construction of leak proof biogas plants. Therefore, the Indian design of moveable dome with some modification was adopted and works successfully in Pakistan.

PCRET has standardized two sizes of biogas plants and provide these at 50% subsidized price, which are locally manufactured. The standard family size unit with 3 M^3 biogas output needs three cows/buffaloes and costs Rs. 35000/- (Rs. 17,000/- is contributed by the owner) [PCRET experience 2008]. The larger unit costs Rs. 45,000/- and provides 5 M^3 of biogas and needs 5 animals to provide input for the plant.

- 3500 family size biogas plants have been installed, which are meeting the domestic need of 3500 households in the rural area of the country;

- 3 community size biogas plants have been installed in rural areas of Islamabad, which are meeting domestic fuel need of 20 houses;
- A 1000 M^3 biogas plant is being designed for installation near Cattle Colony, Karachi. This plant will work under thermophilic conditions.

8.5 Wind Energy

Harnessing wind power to produce electricity on commercial scale has become the fastest growing energy technology. Economic, potential and technological forces are now emerging to make wind power available source of energy. Pakistan has tremendous wind potential. Most of the remote villages in the South can be electrified through wind turbines. It is estimated that more than 5000 villages can be electrified through wind energy in Sindh, Balochistan and Northern Areas.

- 600 houses have been electrified in the remote coastal areas of Sindh and Balochsitan through installation of small wind turbines (stand alone) systems.
- Coast Guard Check Posts at Lasbela have been electrified.
- Villages have been provided with battery charging facilities through a wind-powered battery-charging center.
- 500-Watts Wind Turbine has been manufactured locally. The second (improved) model is under field test.

A Local manufacturer M/s Marine Ltd., Karachi is making windmills for lifting 10000 – 22000 gallons/hour of water from a depth of 70 ft. The three types of windmills manufactured by Marine Ltd. are Jawana, Mujahid, Zoorawar with blade diameter of 20 ft, 10 ft, and 15 ft. respectively. The manufacturer has exported these windmills to Sheikh of Abu Dhabi for installation in the desert area for supply of drinking water for human and animals. [26] M/s Engineering concern Ltd (Pvt) and Agro Tool (Pvt) Ltd are manufacturing windmills for water lifting and generation of electricity. Following local companies are manufacturing windmills for power generation in the range of 0.5 – 15.0 KW.

- M/s Quetex International, Karachi : 0.5 – 20 KW
- M/s Grace Accumulators, Karachi : 1.00 – 5.00 KW
- M/s Energen Energy Generation : 0.5 – 1.00 KW
- M/s Euro Tech, Karachi : 0.5 – 2 KW
- Pak Wind Energy Private Ltd., Karachi : 1.0 – 15 KW

9. Selected case studies on dissemination/Demonstration/Promotion of RETs.

9.1 Case Study I:

Dissemination of Micro-hydel Technology in the Northern Areas

Water flowing through mountains, small rivers and streams is a tremendous potential source of hydropower generation, which can be successfully exploited to generate electricity and mechanical power by using mini/micro-hydropower plants. Up-till quite recently, PCRET has installed 476 MHP plants ranging from 5-50 KW capacity in the northern areas of Pakistan. This decentralized energy generation at source has electrified around 56000 households while shaft power is being used to generate electricity for small commercial applications primarily during daytime. The beneficiaries are running more than 80 cottage level industrial units. These MHP plants

are installed on community sharing basis. The local community/beneficiaries provide civil work including the power channel, fore-bay support for penstock pipes, powerhouse and waste way etc. They also provide wooden poles for distribution lines and the distribution wire. The Local Management Committee is responsible for keeping the MHP plants fully operational and evolves modules for the supply/sale of power generated to the local household and entrepreneurs of cottage level industries. PCRET trained one or two persons, identified by the community in the post installation operation and maintenance of the plant. The trained operators who are paid by the community maintain the plants. PCRET extends its support if there is any complaint. Impacts of the programme are as under:-

a) Financial Impact:

1.	Microhydel Plants installed	:	476 MHP Plants
2.	Installed capacity of MHP	:	7.0 MW
3.	Electricity Generation per year	:	9.0 million KWH
4.	Unit production cost	:	Rs. 5.0 per KWH

Total Financial Income per year: Rs. 45 million

(b) Economic Impact

1. Capacity building of local manufacture for generation of electricity
2. Generation of electricity at low price
3. Provision of electricity to areas where WAPDA Transmission does not exist
4. Promotion of small-scale industrial activities in rural areas
5. Economic development of rural areas

(c) Social Impact

1. Provision of Electricity
2. Education/Awareness
3. Improvement in the quality of life
4. Neat and clean atmosphere
5. Protection of Health
6. Creation of job opportunity

(d) Employment generated

- Electrician : 200
- Operators : 800

- Watchman : 400

9.2 Study II

Demonstration of Solar dryers in the date growing areas

Agriculture is the backbone of Pakistan economy, which produces large qualities of grains, fruits and vegetables. But due to the inadequate post harvest care, it is estimated that about 20-30 percent of produce is wasted. If solar dryers are used to remove excess moisture from the products before storage, their quality will not deteriorate during storage and insect infestation will be reduced. Similarly, large qualities of excess dates, now being wasted, could be solar dried in a controlled manner for use during off season. The drying in the open air produces low quality dates. PCRET designed and installed ten community size solar dryers of 500 kg capacity in the date growing remote areas of Punjab (District Jhang, Multan, Muzaffargarh and D.G. Khan), Sindh (Sukkur and Khairpur), Balochistan (Turbat, Panjgoor), NWFP, (Dera Ismail Khan) for demonstration purpose. The dryers were fabricated from the local market. The project was based on community participation and cost sharing, basis. The community nominated two suitable persons who remained associated from the beginning to the end of the project for the purpose of on job training. Twenty five tones of quality dates per year are produced from the project, generating Rs. 3.5 million revenue. The normal operation and maintenance, is the responsibility of the beneficiaries. However, PCRET technical assistance team is monitoring the performance of the community dryers, which are working satisfactorily. Impact of the programme are briefly discussed as under:-

COMPARISON OF NATURAL DRYING VS SOLAR DRYING

Natural Drying (Open Air Drying)	**Control Drying (Solar Dryer)**
25 tons of dried dates in year	25 tons of dried dates in year
Income from dried dates @ Rs.60/Kg	Income from dried dates
25000 x 60 = Rs. 1.50 million/year	@ Rs. 120/Kg
	25,000 x 120 = Rs. 3.0 million
Result: Low quality dates, (pollutant crawling insects).	**Result: Best quality dates** dust **of (Hygienic and free of Pollutant)**

Socio-economic Impact

- Socio-economic uplift of rural masses
- Development of agriculture based industry
- Production of high quality agricultural product
- Generation of local employment
- Saving of valuable fuel
- Operation, repair and maintenance training of solar dryers to local masses.

9.3 Study III

Promotion of Biogas Technology

The biogas is a cheap, clean, soot free and extremely convenient cooking fuel. It contains 50-70% methane, which is inflammable. Biogas is produced from the animal dung in a biogas plant through anaerobic digestion. Based on the effective heat produced, a 5 M^3 biogas plant would replace, in a month fuel equivalent of 64 Kg of LPG or 92.2 litre of kerosene or 750 Kwh electricity. For the housewives, biogas is easy to use and saves time in the kitchen. Biogas stove has an efficiency of about 55% vis-à-vis 10% efficiency of conventional fuel wood stove. Cooking on biogas is free from smoke and soot as well as substantially can reduce the health problem, which are otherwise quite common in most rural areas where biomass is the chief source of fuel. PCRET under a PSDP project has installed 3500 biogas plants each of 5 M^3 capacities in all the parts of Pakistan for promotion of biogas plants. They are producing 14395 M^3 gas/day, equivalent to 8924.9 liters of kerosene oil per day. It has saved an amount of Rs. 245.0 million/annum. These plants are installed on cost sharing basis. The cost of 5 M^3 biogas plant is around Rs. 45000/- out of which an amount of Rs. 17000/- is contributed by the government. The beneficiaries with the support of PCRET are maintaining these plants. Quantifiable benefits of the programme are discussed as under:-

(a) Financial Impact

Biogas plants installed	:	3500 biogas plants
Production of biogas	:	6.0 million M^3 gas/year
Wood equivalent	:	33.50 million kg/year
Kerosene oil equivalent	:	3.75 million lite/year
(worth @ Rs. 56 per litre)	:	Rs. 210.0 million/year
Production of bio-fertilizer (worth @ Rs. 2/- per Kg.)	:	Rs. 44.0 million/year
Total financial income per year	:	Rs. 254.0 million

(b) Economic Impact

- Saving of Rs. 254.0 million foreign exchange (saving from import of Kerosene oil and chemical fertilizer).
- Protection of Forest (33.50 million Kg of wood per annum)
- Protection of environment and bio-diversity.
- Enriched bio-fertilizer substituting import of chemical fertilizer.
- Increase in agricultural productivity.

(c) Social Impact

- Improvement in the quality of life
- Reduction in indoor pollution
- Neat & clean atmosphere
- Provided job opportunities

(d) Manpower Trained

• Masons	1000
• Welders	600
• NGOs workers	400
• Social workers	200
• Agricultural extension worker	70
• Progressive farmer	350

10. Barriers faced in transferring RETs

While the benefits of tapping the available renewable resource potential in the country as a low-cost, clean option have long been recognized in strategic planning, specific steps for promoting and developing these small-scale options have not been given due priority in the face of more pressing concerns with the overall national energy situation. Barriers to investment and adoption of renewable energy on a national scale can be classified broadly into several main categories, namely those that relate to policy, institutional, regulatory, fiscal, and technical information issues.

10.1 Policy barriers

Despite the development of a number of energy policies and plans, the priority accorded to the renewable energy sector in Pakistan remains low. While the acknowledgement of renewable resources as an alternative source of energy has prevailed in most of the policy and plan documents, little substantive action has been taken for their meaningful development, and almost no specific incentives have been offered to encourage the nurturing of a full-fledged industry based on thee technologies. While broad goals and potential projects for the development of renewable resources have been outlined under various government plans, there has been little accompanying support available for their realization. Within the various power policies that have attempted to restructure the power sector and promote private power investments over the years, so far no special efforts have been made to attract financing for renewable technologies.

10.2 Institutional barriers

Renewable energy research, development and implementation in Pakistan, have been hampered by a lack of institutional support and poor definition of mandates and responsibilities amongst those organizations that do exist for the purpose. Before the creation of AEDB, there was not a single agency with the overall responsibility for policy and planning adviser, and strategic management of the sector, and there were a number of disparate bodies set up with limited objectives and there was little

coordination amongst different players. As a result, the few initiatives taken, principally with respect to biomass, solar and wind energy applications have not been able to progress beyond the pilot or technology demonstration phase. Because of the absence of a systematic approach to renewable resource deployment, local community-level and distributed energy demand and supply options have not been properly assessed, aspects where renewable energy options can offer attractive applications, nor has the commercial exploitation of renewable power been properly evaluated, which would involve coordinating with agencies and utilities involved in such operations. The impact of such weak institutional arrangements has been to further marginalize renewable options, instead of finding ways of incorporating these into the mainstream energy planning and supply mechanisms.

10.3 Regulatory barriers

Regulatory barriers to private power generation are being gradually addressed in Pakistan through new institutional arrangements, although these would require further time and effort to become truly effective. However, incorporating improved regulations pertaining to commercial renewable energy projects would be necessary for protecting the interests of this new industry and to level the field vis-à-vis more entrenched competitive generation technologies.

10.4 Financial barriers

Financial and fiscal incentives, or lack thereof, can play an instrumental role in attracting or discouraging private investment in new technologies, such as wind and solar power. The Government of Pakistan must devise a fiscal regime specifically for commercial renewable-resource-based power generation, similar to the one it successfully implemented for thermal and later hydel, projects in the country [40].

10.5 Information and technology barriers.

A lack of general awareness, technological knowledge, and detailed information on the available renewable potential and energy markets in the country seriously impedes consideration of alternative energy options in the decision-making process, at both the national policy-making and investor-planning levels. Many mature technologies, and suitable areas of applications, especially in remote locations, have not been properly assessed for implementation in Pakistan because of ignorance of relevant technical and cost considerations or the absence of sound data on which to devise renewable energy solutions. Thus, the need for increasing the availability of technical information, education, and data collection on local conditions and resources has been identified as a way of facilitating an improved appraisal of renewable energy options. [27,28]

11. Strategies and future development of Renewable Energy

11.1 Strategies Policy Objective

The four key strategic objectives for developing Pakistan’s renewable energy resources include:

11.1.1 Energy Security

Mainstreaming of renewable energy and greater use of indigenous resources can help diversify Pakistan's energy mix and reduce the country's dependence on any single source, particularly imported fossil fuels, thereby mitigating against supply disruptions and price fluctuation risks. Additional costs and risks relating to fuel stocking, transportation, and temporary substitute arrangements are also irrelevant for RE systems, except for backup purposes.

11.1.2 Economic Benefits

When properly assessed for their externalities, renewable energy options can become economically competitive with conventional supplies on a least-cost basis. This is particularly true for the more difficult, remote, and underdeveloped areas, where RE can also have the greatest impact and the avoided costs of conventional energy supplies can be significant. RE can thus supplement the pool of national energy supply options in Pakistan, expediting economic empowerment, improving productivity, and enhancing income-generating opportunities—especially for currently marginalized segments of the population. Decentralized RE systems can also help reduce energy distribution losses and result in system-wide and national efficiency gains (e.g., as measured by 'energy intensity', or energy use per unit of GDP). A growing renewable energy industry can afford new prospects for employment and business opportunities amongst local manufacturers and service providers.

11.1.3. Social Equity

Pakistan's present low per-capita consumption of energy can be elevated through greater RE use. Issues relating to social equity such as equal rights and access for all citizens to modern energy supplies, improved human development indicators, poverty alleviation amongst deprived sections of society, and reduced burden on rural women for biomass fuel collection and use can also be addressed significantly through widespread renewable energy deployment. RE can thus facilitate social service delivery and help improve the well being of the country's poorest, which presently have little or no access to modern energy services.

11.1.4 Environmental Protection

Local environmental and health impacts of unsustainable and inefficient traditional biomass fuels and fossil fuel-powered electricity generation can be largely circumvented through clean, renewable energy alternatives. Similarly, displaced greenhouse gas emissions carry significant global climate change benefits, towards which Pakistan has pledged action under the UN Framework Convention on Climate Change.

11.2 Future Development of Renewables Energy strategies

Following strategies can help to develop the renewable energy sources in the country.

a) Mainstreaming of renewable energy and greater use of indigenous resources can help to diversify Pakistan's energy mix and to reduce the country's dependence on imported fossil fuels.
b) Introduce investment friendly incentives, and facilitate renewable energy market to attract private sector interest in RE projects, help nurture the nascent industry, and gradually lower RE costs and prices through competition.
c) Devise measures to support the private sector in mobilizing finance and enabling public sector investment in promotional, demonstrative, and trend setting RE projects.
d) Optimize impact of RE deployment in under developed area by
e) Integrating energy solutions with provision of other social infrastructure, e.g. educational and medical facilities, clean water supply, sanitation and telecommunication etc.
f) Help in broad instructional, technical and operational capacity building relevant to the renewable energy sector.
g) Facilitate the establishment of a domestic RET manufacturing base in the country that can help lower costs, improve service, create employment, and enhance technical skills.

12. Conclusion

Energy in its various forms like fuel and power, petroleum, feedstock and consumer item constitutes the nucleus of industrial and economic development. Energy and economical development are, therefore, so intricately intermeshed that to see the one operating without the other is manifestly inconceivable. The energy demand and cost is increasing globally but the reserves of convention energy sources like coal, oil and gas etc. are limited and are depleting at an alarming rate and are causing threat to environment due to emission of hazardous gases. It is likely that the environment damage cost due to production and use of conventional sources of energy will be added to their cost, which will make most of the renewable energy competitive. Therefore, we need to have a paradigm shift in the energy production from the traditional resources to the more sustainable and environment friendly resources, while keeping a strategic balance cost effectiveness and environment friendly sources. It is, therefore, imperative that the renewable sources may be developed and their contribution in the energy mix at national level may be increased gradually.

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NATIONAL ACTORS ON RENEWABLE ENERGY

PUBLIC SECTOR	
Pakistan Council of Renewable Energy Technologies, 25, H-9, Islamabad, Pakistan. Phone: +92-51-9258228, Fax: +92-51-925889, www.pcert.gvo.pk	Ghulam Ishaq Khan Institute of Science and Technology House No. 77, St. 45, F-10/4 Islamabad www.giki.edu.pk
ENERCON G-5/2, ENERCON Building Tel: 051-9206225 Fax: 051-9206004 www.enercon.gov.pk	Hydrocarbon Development Institute of Pakistan 230, Nazimuddin Road F-7/4, Islamabad www.hdip.gov.pk
NEAP-SP ENERCON Building G-5/2, Islamabad	Planning & Development Division Chughtai Plaza, Blue Area, Islamabad Tel: 051-9223770, Fax: 051-9201296 www.**planning**commission.gov.pk
Alternative Energy Development Board Islamabad, Pakistan www.aedb.org	Agriculture Technology ADBP Head Office Islamabad. Tel: 051-2840842 www.adbp.org
PCSIR Laboratories Complex 16, H-9, Islamabad www.pcsir.gov.pk	Department of Physics University of Karachi, Karachi www.uok.edu.pk
Council for Works and Housing Research (CWHR), F-40, SITE Hub River Road, Karachi www.cwhr.gov.pk	Institute of Natural Resources and Environmental Science (INRES) Islamabad www.inres.gov.pk
COMSATS G-5/2, Constitution Avenue, Islamabad www.**comsats.org**	Institute of Plant and Environmental Protection (IPEP) Islamabad, www.parc.gov.pk/n**ipep**.html
COMSTECH G-5/2, Constitution Avenue, Islamabad www.**comstech**.org	United Nations Office for Projects Services, 133 Ist Floor P Block Pak. Secretariat, Islamabad www.unops.org
Pakistan Institute of Engineering and Applied Sciences, P.O. Nilore,, Rawalpindi www.pieas.gov.pk	Institute of Environment Studies University of Karachi
Institute of Environment NUST, Rawalpindi, www.**nust**.edu.pk	

NGOs AND PRIVATE COMPANIES

1. Advanced CNG & Solar Technologies, 1st Floor No.70 Street No.21, Sector F-10/2, Islamabad, 44000, Telephone: 092-51-2298619, FAX: 092 51 2298619
2. AGECO Pvt Limited, Blue Area, Islamabad, Phone 2823336, 2277844
3. AL-Hassan Engineering & Construction Pvt. Ltd, Suite # 17, Hill Top Arcade,
4. Atna International, Address: 7th St. Sanat Road, Gujranwala, Pakistan 52300, Telephone: 0092-431-272636, FAX: 0092-431-276236
5. BCI Inc, Address: 150 Margalla Road, F - 6/3, Islamabad, Pakistan, Telephone: 92-51-2270467, FAX: 92-51-2270467
6. Consolidated Engineers, 108 E-1, Gulberg-III, LAHORE, 54600, Telephone: +92-42-576-4907, FAX: +92-42-5761247, Web Site: http://www.ecplaza.net/conseng
7. East West Infiniti (Pvt) Ltd, Address: Plot 146 Industrial Triangles, Kahuta Road, Islamabad, Telephone: +9251-111-222-102, FAX: +9251-449-1845: 444-6240
8. Engineers Associates, Address: 152/5 E Sara Lane Iqbal Park Defense, Lahore, Punjab Pakistan 54000, Telephone: 92-42-5725897.
9. Fine Metal Technology Engineering Associates, Office-12, Rehmat Center, I-8 Markaz, Islamabad, 44000, Telephone: ++(92-51) 5478016.
10. Gizri Boulevard, D.H.A., Phase IV, Karachi-75500, Telephone: +92-21-5833752, Attock Refinery Ltd, P.O. Morgah, Rawalpindi
11. Hagler Bailly, Center One 1, Street 15, Khayaban-e-Iqbal, F-7/2. Islamabad.
12. Hi-Tech Communication Services, #2-3-4, First Floor Communication House, Karachi, 74400, Telephone: +(92 21) 7730337, 7736880, FAX: +92 21 7771193.
13. Iqbal Engineering Company, E-362/26, opposite green complex
14. IST (Integrated Sustainable Technologies), Address: Industrial Plot No 33, Street No 10, Sector I-9/2, Islamabad, Pakistan, Telephone: 92 51 4438110
15. IUCN Pakistan Country Office, 1 Bath Island Road, Karachi, 75530, Pakistan, Telephone: ++92 (21) 586-1540 Voice, ++92 (21) 587-0287 Fax, main@lead.org.pk
16. Koh-i-noor, Address: 83a, Small Industrial, Estate #1, Gujranwala, Pakistan 52250, Telephone: 0092-431-259321, FAX: 0092-431-711596
17. LEAD House, F-7, Markaz, Islamabad, Pakistan, Telephone: 92-51-2651511, Fax: 92-51-2651512, Email: main@lead.org.pk
18. M/S Task Industries, Address: 119/Sector, 27- Korangi Industrial Area, Karachi, Sindh Pakistan 75500, Telephone: 0092215067373
19. MEFT (Pakistan) Private Limited, Address: House#65, Gomal Road, E-7, Islamabad, Federal Province, Pakistan 44000, Telephone: +92512822214, FAX: +92-51-2821261.
20. Mondial Traders (pvt) Ltd, Address: Carpet Chambers, 1st Floor, 10 Abbot Road, Lahore, 54000, Telephone: 92 42 631 6543, Web Site: http://www.mondial.biz
21. NEWAGE GROUP, A-1, 2nd Floor, Old American center Building, GPO Chowk, Rawalpindi Cantt., Punjab Pakistan 44000, Telephone: 92-303-6527523
22. Pak China Trade Impex, Address: 260-A Canal View, Housing Society, Lahore, Pakistan 5400, Telephone: 92-03008476761
23. Pakistan Council of Renewable Energy Technologies 25, H-9, Islamabad, Pakistan
24. Pakistan Institute of Engineering and Applied Sciences, P.O Nilore, Rawalpindi

25. Pakwinds, 209, Progressive Center, P.E.C.H.S-6, MAIN SHARAH-E-FAISAL, Karachi, Sindh Pakistan 75400, Telephone: +9221-4528736 / 4547090
26. Quanchi Amer Sidhu, Ferozepur Road Lahore., Pakistan 54000, Telephone: 92-42-5275654
27. RADAN Intl (Pvt) Ltd, Address: B-102 Block 2 G-Iqbal, Karachi, Pakistan 75300, Telephone: 92-021-4984870, FAX: 92-021- 4963284,
28. RAZIKI(PVT)LTD, Address: 904 Business Centre, Mumtaz Hassan Road,, Karachi, Pakistan, Telephone: 92-21-2419285, Web Site: http://www.raziki.com
29. Renewable Energy Consultants, 1116, Street 26, I-10/4, Islamabad, Phone: 4445326.
30. ROCKWELL GROUP, Address: 9-T, GULBRG-2, LAHORE, PUNJAB PAKISTAN 54000, Telephone: OO92-42-5756301, Web Site: http://rockwellcorp.com
31. Rural Development Foundation of Pakistan, RDF Center, Mauve Area G-9/1, Islamabad Pakistan, Phone: 92-51-858972, 260373
32. SAF International, Address: Panorama Centre, Raja Ghazanfar Ali Khan Road, Saddar Karachi, Karachi, Pakistan 007200, Telephone: 0092-21-5680763
33. Sarhad Rural Support Corp., No.129, St 8, Defence Officers Colony, Khyber Road, Peshawar, NWFP Pakistan 091-273731, 274540
34. Shirazi Trading Company, Nadir House, I.I, Chundrigar Road, Karachi 74000, Pakistan 74000, Telephone: 92-21-2424075, Web Site: http://www.atlasgrouppk.com
35. Society for Conservation and Protection of Environment, B-150, Block 13-D/2, Gulshan-e-Iqbal, Karachi Sindh Pakistan, Phone: 4965042/4976459
36. Solar East, 141 Own Heights, Block 13-D/3, Gulshqn-e-Iqbal., Karachi, 75300, Telephone: 92-21-4992339, FAX: 92-21-4992339
37. Solar-Energy-Technologies, Address: 151 Margalla Road, F-6/3, Islamabad, Pakistan, Telephone: ++92512270467, FAX: ++92512270467
38. Solargy Enterprises (Pvt) Ltd, Address: 86/1, 4th Commercial Street, Phase IV, D.H.A Karachi, Pakistan, Telephone: 9221-5845948, FAX: 9221-5845948
39. Star Tech, Address: 430-G Gulshen e Ravi Lahore, Lahore, Punjab Pakistan, Telephone: 92-333-4321496
40. SUNGI Development Foundation, H.No.17, Street # 67, G-6/4, Islamabad Pakistan, Phone: 273272, 276579,
41. Sustainable Development Policy Institute, No. 3, UN Boulevard, Diplomatic Enclave 1, G-5, Islamabad, Pakistan, Phone: 51 22 78 134, Fax 51 22 78 135, main@sdpi.org
42. Techno links Pvt Ltd, Address: 116 Bank Square Model Town, Lahore, Pakistan 54700, Telephone: ++92-42-5831174
43. Tecnasia International, Address: 64-A, Street 5, Chaklala, Rawalpindi, Pakistan 46000, Telephone: +92 51 5593507-5505553
44. Trillium Pakistan (Pvt) Limited, 10th Floor, AWT Plaza, 5-The Mall, Rawalpindi, Pakistan, Telephone: +92-51-5524181, +92-51-5567614, FAX: +92-51-5568044
45. TRIO GROUP OF COMPANIES, Address: #64, Khayaban-E-Surawardy, G-6/4, Islamabad, Pakistan 44000, Telephone: 92-51-823552, FAX: 92-51-272867
46. Vital Power Solutions, Address: 156/S, Block 2, Sir Syed Road, P.E.C.H.S., Karachi, Sindh Pakistan 75400, Telephone: 021-537 5471

Solar Powered System at Jalalabad Park
Azad Kashmir, Pakistan

Solar Powered Garden Lights
At Muzafarabad, Azad Kashmir Pakistan

400 Watts Solar Lighting System Installed
at School of Remote Area of Pakistan

A Mosque Lit by 200 Watts Solar Powered
System at the Kettibander Island of Pakistan

200 Watts Solar Powered System
at a Mosque in Thar Area

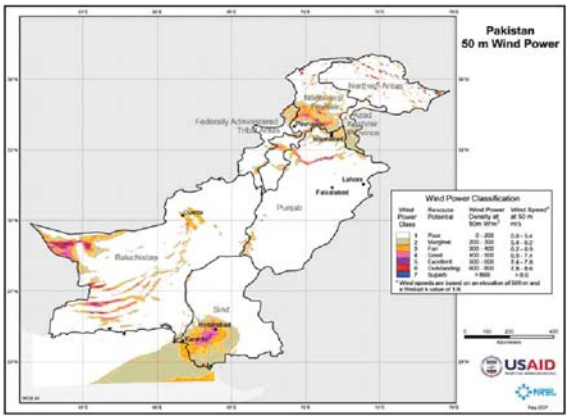
Biogas Plants Five Cubic Meters Capacity

Biogas for Lighting

Biogas for Cooking

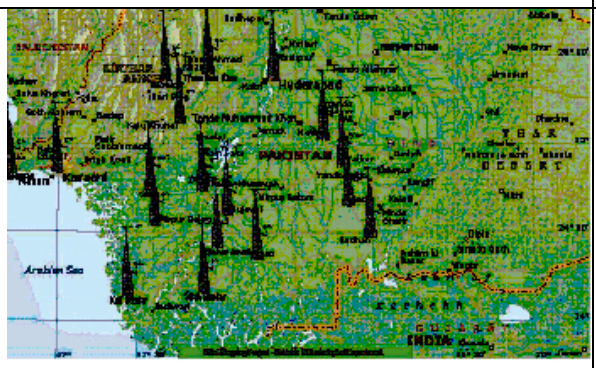
Micro Hydel Power Plants Installed
at Hilly Area of Pakistan

A Microhydel Plant installed
in Tribal Areas of Pakistan

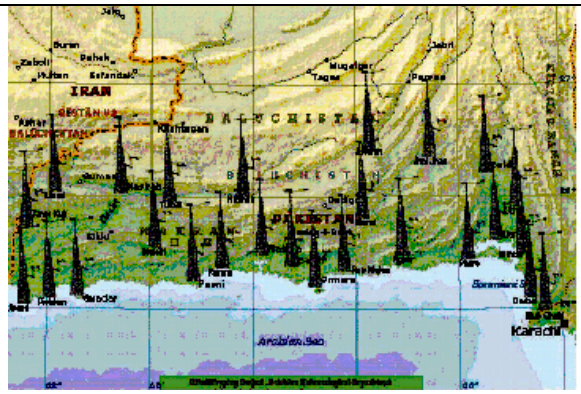


Pakistan Wind Power at 50 meter

Micro Wind Turbine Installed at Coastal area of Pakistan



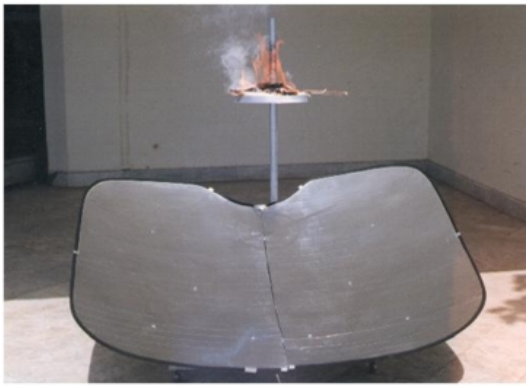
Wind Mast installed at Sindh Province



Wind Mast installed at Balouchistan Province

Solar Dryer for Drying of Fruits and Vegetable 500 Kg Capacity

Solar Water Heating System for Space Heating



Parabolic Type Solar Cooker

Solar Box Type Cooker

Desalination Solar Still at PCRET