Islamic Republic of Pakistan
Alternative Energy Development Board

Data Collection Survey on Renewable Energy Development in Pakistan

Final Report

January 2013

Japan International Cooperation Agency (JICA)

Nippon Koei Co., Ltd.

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Islamic Republic of Pakistan
Alternative Energy Development Board

Data Collection Survey
on
Renewable Energy Development
in
Pakistan

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Location Map

Source: Prepared by JICA Study Team based on the map downloaded at http://www.freemap.jp/

SUMMARY

1. Background

Pakistan is facing the acute electricity shortage. The gap between the estimated peak demand and the recorded peak supply of electricity in 2010 was around 5,000 MW. The gap between demand and supply in 2012 is estimated at more than 7,000 MW with the forecasted peak demand in 2012. This shortage of electricity supply affects harmfully daily life of the people and economic activities in Pakistan.

The Government of Pakistan (GOP) addresses the resolution of electricity shortage as urgent issue. As the countermeasure of the resolution, the GOP placed the policy to make the electricity sources of Pakistan be diversified by developing indigenous resources: coal, large hydro power, and renewable energy (RE).

2. Objectives and Scope of the Study

This survey aims to comprehensively collect data and information regarding the development of RE in Pakistan, and explore the possibility of cooperation by Japan for disseminating renewable energy. This will contribute to the realization of diversifying power generation sources under the policy of the GOP.

Target Renewable Energies

- Solar Power Generation
- Wind Power Generation
- Small Hydro Power Generation

In case of promoting Japan's grant aid project for solar power generation, the target power supply system is a grid-connected system, and the off-grid solar power generation system is out of scope of the survey.

Target Area of the Survey

- Islamabad Capital Territory
- Punjab Province
- Sindh Province

Target Facilities and Places for Field Survey

- Solar Power Generation: Hospitals, airports and universities in Islamabad, Lahore, and Karachi
- Small Hydro Power Generation: Potential sites in the northern part of Punjab province
- Wind Power Generation: Gharo-Keti Bandar Wind Corridor in Sindh province

3. Study Team

The Study team consists of international experts enumerated below.

International Experts

1	Mr FUKUCHI Tomoyasu	Team Leader / Renewable Energy Development Planning	NK
2	Mr OGAWA Ryosuke	Deputy Team Leader / Market, Economic and Financial Analysis	NK
3	Mr Deepak Bahadur BISTA	PV (Photovoltaic) Power Generation Planning	NK
4	Mr HIRATA Kiyoshi	Small Hydro Power Generation Planning	NK
5	Mr SHINOKI Seiichi	Wind Power Generation Planning	JWA
6	Mr TANAKA Shinji	Environment and Structure Planning	NK

NK: Nippon Koei, Co., Ltd.
JWA: Japan Weather Association

4. National Policy on Renewable Energy Development

The GOP had constituted the Alternative Energy Development Board in 2003 as the apex body for the development of RE in the country. The Ministry of Water and Power (MoWP) has prepared the first-ever Renewable Energy Policy of Pakistan (RE Policy) in 2006 that was approved by the cabinet having legal binding, which envisages mainstreaming of RE in the development plans of the country.

The RE Policy has set out the road map as well as certain legislations for the development of renewable energy technologies (RETs) in the country.

5. Provincial Institutional Support for Renewable Energy Promotion

The Policy for Power Generation Projects Year 2002 allows the provinces of Pakistan and AJK to develop power generation projects up to a maximum capacity of 50 MW in public or private sectors using RE sources.

The Government of Punjab established Punjab Power Development Board (PPDB) in 1995 for the implementation of power generation using RE sources. The Government of Sindh established Alternative Energy Wing to implement the RETs in the province.

6. Confirmation of Policy Change: Objectives and Strategy

Currently, the latest government policy for RE is the RE Policy 2006. The formulation process of the medium term policy, for the period of July 2008 to June 30, 2012, began in 2007/08, however, the medium term policy has not yet been issued. The situation means that there has been no change in the objectives and strategy of the policy for development of RE from the RE Policy 2006.

7. Current Performance of Road Map

The quantitative indicator for the target of Road Map in the RE Policy is set only for wind power generation. The current situation of wind power development as appraisal is that its performance is seven years behind the target.

The reasons for slow progress in wind energy development is that AEDB was very optimistic in setting up the RE targets. They set targets at a time when no groundwork has been done. No wind mapping has been done for the wind corridor.

8. Potential of Renewable Energy

Solar Power:

Generally, the entire Pakistan has a high potential for solar energy. The annual average horizontal solar radiation per day in these areas is more than 5.48 kWh/m^2. For comparison, the highest solar radiation measured in Japan is in Naha of Okinawa Prefecture, in which the annual average solar radiation is around 4.5 kWh/m^2.

Wind Power:

The high potential of wind power is found in the coastal areas of southern Sindh province, the southwestern area of Baluchistan province, the narrow west-to-east belt in the northern part of Punjab province, and the southern area of Khyber Pakhtunkhwa province (formerly North-West Frontier province until April 2010).

Hydro Power:

There are four major rivers (Ravi, Chenab, Jehlum, and Indus) in Pakistan that have large potential for hydro power generation. The hydro power potential of Pakistan is estimated at around 60,000 MW in which around 57,000 MW is above 50 MW and around 2,300 MW is below 50 MW.

9. Existing Project and Future Prospects of Solar Power Generation

The existing projects installed through the national budget are all off-grid systems and the same through the collaborations of international organization/donor agencies are also off-grid systems except for the system installed by Japan's grant aid.

As Pakistan receives high solar radiation in most parts of the country and has enough available space for installation of solar power generation system, there is high potential for solar power generation.

10. Solar Electricity Generation System Installed by Japan's Grant Aid

Under Japan's grant aid program, two systems were installed in Islamabad, namely, one system at the Planning Commission (PC) and the other system at the Pakistan Engineering Council (PEC). The capacity of the system is 178 kW each and the both systems were completed in March 2012. Since then, they are operating as the first grid-connected solar power generation systems in Pakistan.

The purposes of this grant aid project are to promote clean energy introduction by demonstrating grid-connected solar generation, build technical experience on solar system and its grid connection, and contribute to the mitigation of greenhouse gas emission.

11. Existing Project and Future Prospects of Wind Power Generation

In Jhimpir site of Sindh province, two investors, namely, FFC Energy (Ltd) and Zorlu Enerji, almost finished their construction of wind farms. They are supposed to achieve commercial operations date (COD) within 2012: combined installed capacity of 106 MW.

By July 19, 2012, AEDB has issued the Letter of Intent (LOI) to 37 wind farm project developers with generating capacities in the range of 2.4 to 350 MW each. It is seemed that the wind power in the country will have a bright future.

12. Existing Project and Future Prospects of Small Hydro Power Generation

A number of sites for small (below 50 MW) hydro power potential were identified in Punjab, Khyber Pakhtunkhwa (KPK), Azad Jammu & Kashmir (AJK) and the northern mountain region of the country. At present, the number of the existing small hydro power plant in Punjab province is six and the total capacity of them is 64 MW.

There are a lot of potential sites for small hydro power generation in Punjab province using irrigation canals. The number of potential sites is approximately 780 sites.

13. Possibility of Applying Japanese Technology

Solar Power Generation:

The trend is that whenever quality power is required, reliable technical support is required from manufacturers/suppliers, even if the cost is a little higher. In Pakistan, based on the point of view of the long years of experience in manufacturing and installation and quality of support, it is highly possible for financially strong firms to select Japanese products.

Wind Power Generation:

Once Japanese products are introduced as total systems, the operation, maintenance and service systems will also be introduced at the same time. This is similar to the case of the bullet train or the “Shinkansen”. Therefore both countries will benefit if Japanese technology will be introduced in the field of wind power generation in Pakistan.

Hydro Power Generation:

The package type bulb turbines of Japanese manufactures have competitive prices. If it is possible to conduct local production by using Japanese design under Japanese guidance in Pakistan, further reduction of costs would be expected. Bulk production of the same design and size of turbines and generators would reduce the cost of systems. Japanese small hydro power turbines utilize technologies for less maintenance. These technologies could be applied in Pakistan.

14. Field Survey of the Pakistan Institute of Medical Sciences (PIMS)

The Pakistan Institute of Medical of Sciences (PIMS) is part of the public sector and lies within the Islamabad Capital Territory. It provides medical facilities to the public; not only for patients from the capital city but also for patients from the surrounding areas of the capital city.

The field survey was conducted to explore the possibility of installation of solar power generation system at PIMS by Japanese grant aid. According to the field survey result, it is possible to install the solar power generation system at PIMS and its approximate cost is estimated in Japanese Yen as shown below.

- 1.0 MW System: 554,070,000.-
- 1.5 MW System: 831,072,000.-
- 2.0 MW System: 1,085,172,000.-

15. Field Survey of Other Potential Sites for Solar Power Generation and Potential Project

The field survey was conducted for solar power generation at four airports, seven hospitals, and six universities.

As the potential projects for Japanese grant aid, the projects are selected in the two categories: large scale more than 20 MW and medium sale of 5 MW to 20 MW. According to the above categories, the potential projects of solar power generation are selected shown as below.

✓ Large Scale Solar Power Generation Project at:

- New Islamabad International Airport
- Karachi International Airport

✓ Medium Scale Solar Power Generation Project at:

- Lahore International Airport
- Punjab University
- National University of Sciences and Technology (NUST)
- Qaid-e-Azam University

16. Field Survey for Wind Power Generation and Potential Project

The Study team for wind power generation carried out their field survey of Karachi and Gharo-Keti Bandar Wind Corridor, Sindh province.

Assuming a Yen Loan project, implementing organization must be a public sector. The most possible candidate for the implementing organization in the wind corridor area will be the local government of Sindh. The Government of Sindh showed an interest and emphasized that there is no obstacle for them to implement such project. Hybrid power plant project including PV and wind power generation system is an idea proposed by Sindh government, which will be an option for Yen Loan project.

17. Field Survey for Hydro Power Generation and Potential Project

The field survey of small hydropower potential sites in the northern part of Punjab province was conducted at total 20 sites.

The seven sites were evaluated as the potential project for Japanese grant aid among the sites visited. These sites were considered based on the available head, stable discharge and site conditions from the information of the field survey and existing F/S.

18. Recommendation for Japan's Official Assistance

Recommendations of Japanese assistance for RE development in Pakistan are as follows based on the result of the survey:

(1) Solar Power Generation Project at Pakistan Institute of Medical Sciences (PIMS):

The project is recommendable for Japanese grant aid. The solar power generation will be a grid-connected system and the PV module of the system will be installed at the premises of PIMS. The project contributes much to the management of PIMS financially by reducing the payment of electricity tariff. The project also helps in disseminating RE in Pakistan in the form of solar power generation.

(2) Small Hydro Power Generation Project in Punjab Province:

Based on the result of the field survey for small hydro power generation, the potential projects are selected. Each of these projects is recommendable for Japanese grant aid and packaging all the projects is also recommendable for Yen loan. Besides the development of hydro power, it is recommended to install the PV module over the canal, being a hybrid of hydro and solar power generation.

(3) Technical Assistance to the Provincial Government:

Technical assistance to the provincial governments for the development of RE is recommendable. The provinces in Pakistan are allowed to develop power generation projects up to a maximum capacity of 50 MW through public or private sectors using RE sources. There have been needs to develop institutional and human capacities in the provinces.

(4) Wind Power Generation Project in Sindh Province:

Large-scale wind power generation project in Sindh province is recommendable for Yen loan project. In the southern part of Sindh province, there is the wind power potential and land is properly arranged for the developers. The private sector has already commenced the wind farm project, thus, the risk of the project implementation is relatively low.

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Abbreviation and Glossary

General

AEF	Alternative Energy Fund
AMR	Automated Meter Reading
ARE	Alternative/Renewable Energy
ARET	Alternative and Renewable Energy Technologies
B/C ratio	Benefit - Cost ratio
BOD	Board of Directors
BOI	Board of Investment
BOO	Build, Own, and Operate
BOOT	Build, Own, Operate, and Transfer
BPC	Bulk Purchase Consumer
CDM	Clean Development Mechanism
CEO	Chief Executive Officer
CER	Certified Emissions Reduction
CPP (1)	Capacity Purchase Price
CPP (2)	Capital Power Plant
CPPs	Captive Power Producer
CPPA	Central Power Purchase Agency
CSC	Customer Services Centre
DISCO	Distribution Company
DOP	Development of Power
EDCF	Korea Eximbank, Economic Development Cooperation Fund
EIA	Environment Impact Assessment
ELR	Electricity Loss Reduction
EPP	Energy Purchase Price
FAS	Fuel Adjustment Surcharge
FRP	Financial Recovery Plan
FS	Feasibility Study
FY	Fiscal Year
GDP	Gross Domestic Product
GENCO	Generation Company
GOP	Government of Pakistan
IA	Implementation Agreement
IEE	Initial Environment Examination
IMF	International Monetary Fund
IPP	Independent Power Producer
IRR	Internal Rate of Return
KIBOR	Karachi Inter Bank Offered Rate
LIBOR	London Inter Bank Offered Rate
LOI (1)	Letter of Intent
LOI (2)	Letter of Interest

LOS	Letter of Support
NADRA	National Database Registration Authority
NEQS	National Environmental Quality Standards
NGO	Non-governmental Organization
POE	Panel of Experts
PPA	Power Purchase Agreement
PPP	Power Purchase Price
RCC	Regional Control Centre
RE	Renewable Energy
REL	Rural Electrification
RORB	Return on Rate Base
SPP	Small Power Producer
WUL	Water Use License

Name of Organizations

ADB	Asian Development Bank
AEDB	Alternative Energy Development Board
BOI	Board of Investment
CPPA	Central Power Purchase Agency
FBR	Federal Board of Revenue
HEC	Higher Education Commission
JICA	Japan International Cooperation Agency
KESC	Karachi Electric Supply Company
MoWP	Ministry of Water and Power
NEPRA	National Electric Power Regulatory Authority
NPCC	National Power Control Centre
NTDC	National Transmission and Distribution Company
NUST	National University of Sciences and Technology
PC	Planning Commission
PCRET	Pakistan Council of Renewable Energy Technologies
PEC	Pakistan Engineering Council
PEPCO	Pakistan Electric Power Company
PEPA	Pakistan Environmental Protection Agency
PMD	Pakistan Meteorological Department
PPDB	Punjab Power Development Board
PPHC	Pakistan Power Holding Company Ltd.
PPIB	Private Power & Infrastructure Board
Punjab-EPA	Punjab Environmental Protection Agency
SBI	Sindh Board of Investment
SEPA	Sindh Environmental Protection Agency
WAPDA	Water and Power Development Authority

Name of Distribution Companies

FESCO	Faisalabad Electric Supply Company
GEPCO	Gujranwala Electric Power Company
HESCO	Hyderabad Electric Supply Company
IESCO	Islamabad Electric Supply Company
LESCO	Lahore Electric Supply Company
MEPCO	Multan Electric Power Company
PESCO	Peshawar Electric Supply Company
QESC	Quetta Electric Supply Company
SEPCO	Sukkur Electric Power Company
TESCO	Tribal Areas Electricity Supply Company

Electrical Terminology / Unit

Solar Power
Wind Power
Hydro Power

V	(Volt)	Unit of voltage
kV	(kilovolt)	1,000 volts
W	(Watt)	Unit of active power
kW	(kilowatt)	1,000 watts
MW	(Megawatt)	1,000 kW
Wh	(watt-hour)	Unit of Energy
kWh	(kilowatt-hour)	1,000 Wh
MWh	(Megawatt-hour)	1,000 kWh
GWh	(Gigawatt-hour)	1,000 MWh
VA	(Volt-ampere)	Unit of apparent power
kVA	(kilovolt-ampere)	1,000 VA
MVA	(Megavolt-ampere)	1,000 kVA
Var	(volt-ampere reactive)	Unit of reactive power

Place Names

(Administrative Area Name)
Islamabad Capital Territory
Punjab Province
Sindh Province
Balochistan Province
Gilgit-Baltistan
KPK - Khyber Pakhtunkhwa
FATA - Federally Administered Tribal Authority
AJK - Azad Jammu & Kashmir
(Wind Corridor)
Gharo-Keti Bandar
Jhimpir

Fiscal Year

Pakistani Fiscal Year: July 1 to June 30

Currency and Currency Equivalents

Rs.	Unless otherwise defined, it means Pakistan Rupees.
JP¥	Japanese Yen (JP¥1.0 = Rs.1.2155)
US$	United State Dollar (US$1.0 = Rs.94.54)
	Source: National Bank of Pakistan (Selling Rate), as of September 26, 2012

Glossary

(a) Alternative Energy:- means energy that is non-conventional and normally derived from nontraditional sources

(b) Bi-directional meter:- means a metering device or devices that measure the total electricity that has flowed in a circuit from one reading date to the next in each of two opposite directions, and that store in separate data registers the data regarding the flow of electricity in each direction.

(c) Bio-fuel:- Liquid fuels and blending components produced from biomass feedstocks, used primarily for transportation including biodiesel and ethanol.

(d) Biogas:- refers to a medium Btu gas containing methane and carbon dioxide, resulting from the action of microorganisms on organic materials.

(e) Biomass energy system:- refers to technology which uses biomass resources to produce heat, steam, mechanical power or electricity.

(f) Biomass resources:- refers to organic non-fossil material of biological origin constituting a renewable energy source.

(g) BOO:- mean Build-Own-Operate, project operates similarly to a BOOT project, except that the private sector owns the facility in perpetuity.

(h) BOOT:- means Build-Own-Operate-Transfer, involves a private developer financing, building, owning and operating a facility for a defined period of time, after which the facility is transferred to the Government.

(i) Captive Power Generation:- means generation that is solely dedicated to the generator‘s self use.

(j) Carbon Credits:- are a mechanism for monetizing the value of carbon emission reductions and are actualized through various facilities such as the Clean Development Mechanism.

(k) Consumer:- means a person or his successor-in-interest who purchases or receives electric power for consumption and not for delivery or re-sale to others, including a person who owns or occupies a premise where electric power is supplied.

(l) CaPP:- means Captive Power Plant, is a plant which produces electricity for its own use or for a group for their own use.

(m) DISCO:- means Distribution Company, an entity engaged in the distribution of electric power as licensed by NERPA.

(n) Distribution:- means the ownership, operation, management or control of distribution facilities for the movement or delivery or sale to consumers of electric power but shall not include the ownership, operation, management and control of distribution facilities located on private property and used solely to move or deliver electric power to the person owning, operating, managing and controlling those facilities or to tenants thereof.

(o) Distribution of Electricity:- refers to the conveyance of electricity by a Distribution Utility through its distribution facilities.

(p) Distribution Facilities :- means electrical facilities operating at distribution voltage and used for the movement or delivery of electric power;

(q) Distribution Voltage:- means any voltage below minimum transmission voltage.

(r) Distribution Utility (DU):- refers to any electric cooperative, private corporation, or government-owned utility which has an exclusive franchise to operate a distribution system.

(s) Generation:- means the ownership, operation, management or control of the generation facilities for delivery or sale of the electric power and not solely for consumption by the person owning, operating, managing and controlling those facilities.

(t) Generation Company:- refers to any person or entity authorized by NEPRA to operate facilities used in the generation of electricity.

(u) Generation Facility:- refers to a facility established for the production of electricity and/or thermal energy such as, but not limited to, steam, hot or cold water.

(v) Geothermal energy:- Hot water or steam extracted from geothermal reservoirs in the earth's crust. Water or steam extracted from geothermal reservoirs can be used for geothermal heat pumps, water heating, or electricity generation.

(w) Geothermal Energy Systems:- refers to technology that converts geothermal energy into useful power.

(x) Geothermal Resources:- refers to: (i) all products of geothermal processes, embracing indigenous steam, hot water, and hot brines; (ii) steam and other gases, hot water, and hot brines resulting from water, gas, or other fluids artificially introduced into geothermal formations; (iii) heat or associated energy found in geothermal formations; and (iv) any by-product derived from them.

(y) Grid:- refers to the high voltage backbone system of interconnected transmission lines, substations, and related facilities.

(z) Grid spillover:- means a generator established to supply one's own needs as well as selling to the utility grid.

(aa) Hybrid Systems:- refers to any power or energy generation facility which makes use of two or more types of technologies utilizing both conventional and/or renewable fuel sources, such as, but not limited to, integrated solar/wind systems, biomass/fossil fuel systems, hydro/fossil fuel systems, integrated solar/biomass systems, integrated wind/fossil fuel systems.

(bb) Hydel:- refers to hydroelectric power plants Small hydro' is used to collectively refer to hydel capacity of less than 50 MW, consisting of micro' hydro (units of less than 150 kW installed capacity), mini hydro (150 kW to 5 MW), and small hydro (between 5 MW to 50 MW).

(cc) Hydroelectric Power Systems: or Hydro power Systems:- refers to a technology that converts kinetic/potential energy of water to electric power.

(dd) Hydroelectric Power Resources:- or Hydro power Resources¬ refers to water resources found technically feasible for development of hydro power projects which include rivers, lakes waterfalls, irrigation canals, springs, ponds, and other water bodies.

(ee) Net billing:- means the change in the net flow of electricity between the customer and the grid.

(ff) Net-Metering:- refers to a system in which a distribution grid user has a two-way connection to the grid and is the net flow of electricity to the grid.

(gg) Non-power applications:- refers to renewable energy systems or facilities that produce mechanical energy, combustible products or forms of useful thermal energy.

(hh) Ocean Energy:- refers to energy from waves, tides, thermal gradients or any other energy derived from the ocean.

(ii) Ocean Energy Resources:- refers to supply of ocean energy available within a given area.

(jj) Ocean Energy Systems:- refers to technology which converts ocean or tidal current, ocean thermal gradient or wave energy into electrical or mechanical energy.

(kk) Off-Grid Systems:- refers to electrical systems not connected to the National or Regional Grids of Pakistan.

(ll) On-Grid System:- refers to electrical systems connected to the National or Regional grids of Pakistan.

(mm) Renewable Energy:- is energy generated from natural resources which are renewable naturally replenished.

(nn) Renewable Energy Developers: or ―RE Developers:- refers to individual/s or a group of individuals or entities formed in accordance with existing Pakistan Laws engaged in the exploration, development and utilization of ARE resources and actual operation of ARE systems/facilities.

(oo) Renewable Energy Resources:- are energy resources that are naturally replenishing but flow-limited. They are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time.

(pp) Renewable Energy Systems:- refers to technology which convert ARE resources into useful energy forms, like electrical, mechanical, etc.

(qq) Rural Electrification:- refers to the delivery of basic electricity services, consisting of power generation, sub-transmission, and/or extension of associated power delivery system that would bring about important social and economic benefits to the countryside.

(rr) Rural Energy:- refers to provision of alternative and renewable energy to rural areas usually through nontraditional means and often focused at income generation activities.

(ss) Rural Energy Service:- is the provision of end-user energy services from any and all ARE.

(tt) Solar Energy:- refers to the energy derived from solar radiation that can be converted into useful thermal or electrical energy.

(uu) Solar Energy Systems:- refers to technology which converts solar energy into thermal or electrical energy.

(vv) Tariff:- means the rates, charges, terms and conditions for generation of electric power, transmission, inter-connection, distribution and sales of electric power to consumers under a licensee.

(ww) Tidal energy:- is the kinetic energy in tides that can be converted into useful forms of energy.

(xx) Transmission:- means the ownership, operation, management or control of transmission facilities.

(yy) Transmission System:- refers to the grid composed of 66kV and above lines and supporting infrastructure.

(zz) Upfront Tariff: refers to the pre-determined tariff by NEPRA at which the distribution company will purchase electricity. Power producers can opt to use this upfront tariff instead of filing a separate petition for determination of tariff.

(aaa)Wave energy:- is the transport of energy by ocean surface waves, and the capture of that energy to do useful work.

(bbb) Wind Energy:- refers to the energy that can be derived from wind that is converted into useful electrical or mechanical energy.

(ccc)Wind Resources:- refers to the availability of wind in a given area over a given period of time.

(ddd) Wind Energy Systems:- refers to the technology that converts wind energy into useful electrical or mechanical energy.

(eee)Wind Risk:- is defined as the risk of variability of wind speed, and therefore effective energy output of the wind IPP.

CHAPTER 1 INTRODUCTION

1.1 Background

Pakistan is facing acute shortage in electricity. The gap between the estimated peak demand and recorded peak supply of electricity in 2010 was around 5,000 MW. This gap was the depressed peak demand due to scheduled load shedding. The duration of the scheduled load shedding is becoming longer. The gap between demand and supply in 2012 was estimated at more than 7000 MW with the forecasted peak demand in 2012. This shortage in electricity supply adversely affects daily living and economic activities in Pakistan.

The Government of Pakistan (GOP) addresses the resolution of electricity shortage as an urgent issue. As a countermeasure of the resolution, the GOP placed a policy aims to diversify energy sources used to produce electricity in Pakistan by developing indigenous resources, e.g., coal, large hydro power, and renewable energy.

The shares of energy sources in electricity generation in 2011 were 62.5% thermal, 33.6% hydro, and 3.9% nuclear and imported electricity. For thermal power (62.5%), the share of coal is 0.1% while the rest comes from oil and gas. Before 2000, oil prices reached a low point. In line with the policy of the GOP to generate electricity at the least cost option, the share of oil and gas in electricity generation by thermal power plants had been increased. However, with the rise of oil prices after 2005 including price fluctuation steered by the Lehman Crisis, the oil and gas thermal power stations are facing difficulties for sustainable operation.

Under the above circumstances, the development of renewable energy has become an effective area of interest for Japanese assistance.

1.2 Objectives and Scope of the Study

This survey aims to comprehensively collect data and information regarding the development of renewable energy (RE) in Pakistan, and explore the possibility of cooperation by Japan for disseminating renewable energy. This will contribute to the realization of diversifying power generation sources under the policy of the GOP.

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- Small Hydro Power Generation

In case of promoting Japan’s grant aid project for solar power generation, the target power supply system is a grid-connected system, as the off-grid solar power generation system is out of scope of the survey.

Target Area of the Survey

- Islamabad Capital Territory
- Punjab Province

- Sindh Province

Target Facilities and Places for Field Survey

- Solar Power Generation: Hospitals, airports and universities in Islamabad, Lahore, and Karachi
- Small Hydro Power Generation: Potential sites in the northern part of Punjab province
- Wind Power Generation: Gharo-Keti Bandar Wind Corridor in Sindh province

1.3 Study Team

The Study team consists of international and local experts and staff as enumerated below.

International Experts

1	Mr FUKUCHI Tomoyasu	Team Leader / Renewable Energy Development Planning	NK
2	Mr OGAWA Ryosuke	Deputy Team Leader / Market, Economic and Financial Analysis	NK
3	Mr Deepak Bahadur BISTA	PV (Photovoltaic) Power Generation Planning	NK
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6	Mr TANAKA Shinji	Environment and Structure Planning	NK

NK: Nippon Koei, Co., Ltd.
JWA: Japan Weather Association

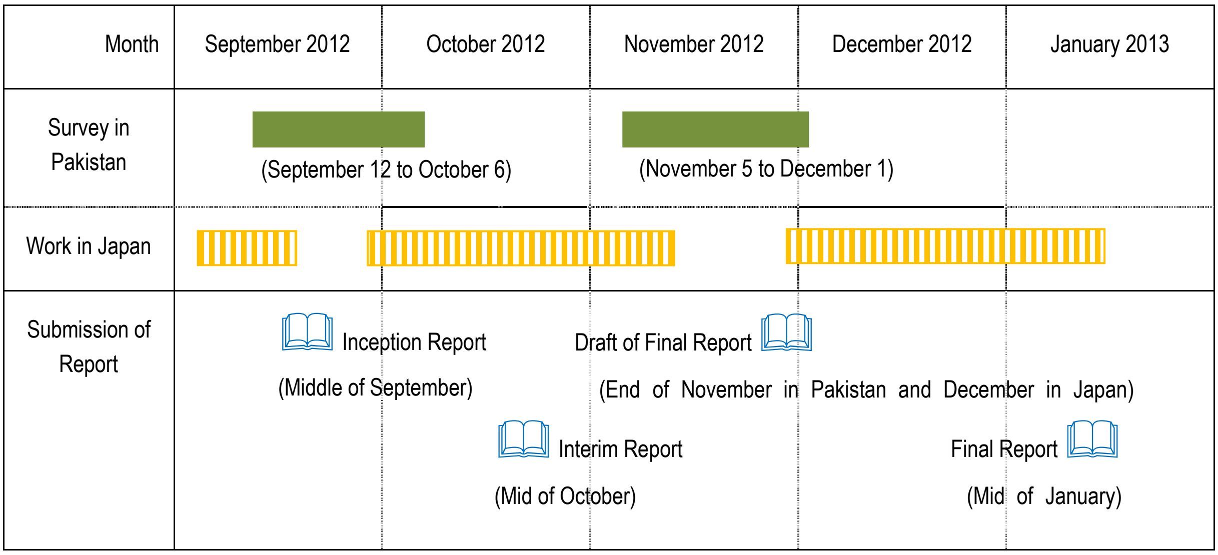
National Experts/Staff

1	Engr Allah Bux	Renewable Energy Promotion (Institution)-1	NEC
2	Mr Babar Mahmood	Renewable Energy Promotion (Institution)-2	NEC
3	Syed Ahmed Ali Shah	Environment	NEC
4	Syed Ammar Raza	Solar Power Generation	NEC
5	Engr Jahanzaib Amjad	Hydro Power Generation	NEC
6	Mr Ahsan Jawed	Wind Power Generation and Electricity Development Plan	NEC
7	Syed Tauqeer Hussain	Economic and Financial Analysis, and Market Survey	NEC
8	Mr Tahir Nazir	Secretary	NEC

NEC: National Engineering Corporation

1.4 Record of Major Activities

The overall schedule of the study is shown below.



Survey in Pakistan

- First Site Survey:
  Arrived in Islamabad on September 12, 2012
  Left Islamabad on October 5, 2012 (arrived in Tokyo on October 6, 2012)
- Second Site Survey:
  Arrived in Islamabad on November 5, 2012
  Left Islamabad on November 30, 2012 (arrived in Tokyo on December 1, 2012)

Major Activities

- September 17, October 5, and November 21, 2012: Meeting with JICA
- September 18, 2012: Courtesy call to AEDB and PCRET
- September 25 and October 3, 2012: Meeting with PEC
- September 27, 2012: Site visit and meeting with PIMS
- September 27, 2012: Meeting with PPDB
- September 28, 2012: Site visit and meeting with NUST
- November 9 to 17, 2012: Site visits in Lahore and Punjab province (Small Hydro)
- November 11 to 15, 2012: Site visits in Karachi and Sindh province (Solar and Wind)
- November 16 to 17, 2012: Site visits in Islamabad and Area nearby (Solar)
- November 18 to 20, 2012: Site visits in Lahore (Solar and Market)
- November 28, 2012: Meeting with AEDB

Report Submissions

- Inception Report:
  Submitted in the middle of September to the beginning of October 2012 (depending on schedule of visit to related agencies and institutions)
- Interim Report:
  Submitted in the middle of October 2012

- Draft of Final Report:
  Submitted in the end of November 2012 (submitted in Pakistan) and submitted in the middle of December 2012 (submitted in Japan)
- Final Report:
  Submitted in the middle of January 2012 (officially submitted in Japan)

CHAPTER 2 REVIEW OF THE RENEWABLE ENERGY DEVELOPMENT PLAN

2.1 National Policy of Renewable Energy Development

2.1.1 Renewable Energy Development in the National Development Plan

The GOP made a five-year development plan known as the Medium Term Development Framework (MTDF)[1]. This framework provides priorities of the GOP for development in the next 5 years. The MTDF stated that from 2005 to 2010, the long term National Energy Security Plan, which covers up to year 2030, has been approved by the GOP.

The energy sector development is aimed at the following:

- Enhancement in the utilization of hydro power, and exploration and production activities of oil, gas, and coal resources, and to increase the share of coal and alternative energy in the overall energy mix;
- Optimum utilization of the country's resource base to reduce dependence on imported oil through an institutionalized strategy;
- Creation of a conducive environment for the participation of private sector; and
- Development of the local energy scenario in the context of regional perspective.

Over the long term, the share of coal, renewable and nuclear components in the energy mix will continue to increase with substantial reduction in the share of oil.

2.1.2 National Policy on Renewable Energy Development

The GOP had constituted the Alternative Energy Development Board in 2003 as the apex body for the development of Alternative/Renewable Energy (ARE) in the country. The Ministry of Water and Power (MoWP) has prepared the first-ever Renewable Energy Policy of Pakistan (hereinafter referred to as the "RE Policy") in 2006 that was approved by the cabinet having legal binding, which envisages mainstreaming of renewable energy in the development plans of the country.

The RE Policy has set out the road map as well as certain legislations for the development of renewable energy technologies (RETs) in the country. The RE policy is summarized as shown below.

(1) Goals of the RE Policy

The specific goals of the RE Policy are summarized below.

i. Increase the deployment of RETs in Pakistan to provide a higher targeted proportion of the national energy supply: a minimum of 9,700 MW by 2030, and universal access to

[1] The MTDF 2005-10 is the first of the five-year operational strategies on the road to 2030 (Vision 2030). After the launch of the MTDF 2005-10, the Planning Commission has been tasked to work out the details of how Pakistan sees itself in 2030 and the strategies, policies and the resources to get there.

electricity in all regions of the country.

ii. Provide additional power supplies to help meet the increasing national demand.

iii. Introduce investment-friendly incentives, and facilitate renewable energy markets to attract private sector interest in RE projects.

iv. Devise measures to support the private sector in mobilizing finance and enabling the public sector investment in promotional, demonstrative, and trend-setting RE projects.

v. Optimize impacts of RE deployment in underdeveloped areas by integrating energy solutions with provision of other social infrastructure.

vi. Help in broad institutional, technical, and operational capacity building relevant to the RE sector.

vii. Facilitate the establishment of a domestic RET manufacturing base in the country.

(2) Scope of the RE Policy

The RETs included in the RE Policy are as follows:

- Small hydro of 50 MW or less capacity;
- Solar photovoltaic (PV) and thermal energy for power generation; and
- Wind power generation.

Other RETs such as biomass, bio-fuel, geothermal, and etc., are not dealt within the RE Policy.

(3) Road Map of the RE Policy

The RE Policy[2] comprises three phases: short, medium, and long terms.

<u>Short Term Policy: the period up to June 30, 2008</u>

The short term policy lays down incentives to (i) attract investment to Pakistan on the renewable energy sector, (ii) remove existing barriers for project implementation, and (iii) materialize reasonable-sized pioneering projects through successful commercial operation.

<u>Medium Term Policy: the period from July 1, 2008 up to June 30, 2012</u>

The medium term policy framework was prepared for the systematic implementation of RETs and scaling up of capacity deployment.

The framework greatly emphasizes on the competition within RET application category (e.g., grid-connected wind farms) as well the programmatic development of dispersed RE power generation market (e.g., solar home systems).

<u>Long Term Policy: the period after June 30, 2012</u>

In the RE Policy, only the image of expectation of RE within the period has been stated. The

[2] http://www.aedb.org/Policy/REpolicy.pdf

image is that RE will be fully mainstreamed and integrated within the nation's energy planning process, and RE energy producers will be gradually exposed to full competition with conventional energy sources.

(4) Revised RE Policy

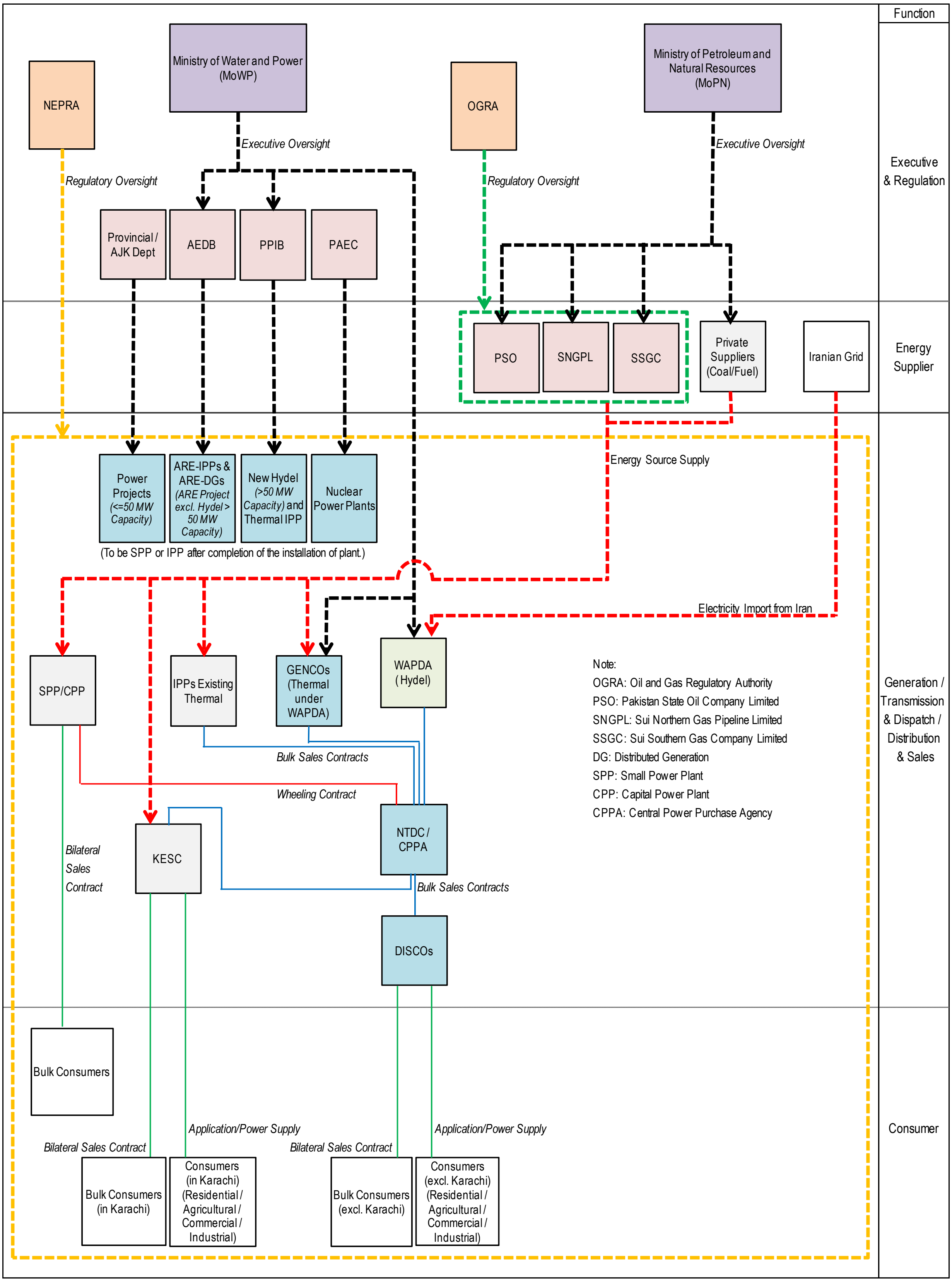
The revised RE policy was supposed to be enacted in 2009, and its draft was prepared and submitted for cabinet approval, which is yet to be approved by the cabinet. Hence, the RE Policy of 2006 is still enforced.

The RE Policy of 2006 includes the institution to offer lucrative incentives and covered risks to the project sponsors, with its main purpose to attract investments in this sector. The details of the institutional part of this policy are discussed in **Sub-chapter 2.2.2** and **Sub-chapter 2.2.3**.

2.2 Institutional Arrangement for Renewable Energy Development

2.2.1 Institutional Framework

The organizational chart of the Pakistan power sector highlighting the inter-relation of various agencies is given in **Figure 2.2.1-1**.



Source: Prepared by JICA Study Team based on RE Policy 2006, AEDB

Figure 2.2.1-1 Organizational Chart of Pakistan's Power Sector

The MoWP acts as the executive arm of the GOP in executing the federal government policies and strategy in the power sector. It also coordinates with relevant provincial governments and their agencies in achieving national policy objectives.

The National Electric Power Regulatory Authority (NEPRA) was set up under the Regulation of Generation, Transmission and Distribution of Electric Power Act in 1997 (known as the "NEPRA Act"). NEPRA is the apex regulatory body mandated to act as an independent regulator to secure reliable and sustainable electric power supply in Pakistan.

The National Transmission and Dispatch Company (NTDC) is the sole transmission system operator licensed by the NEPRA and is responsible for the maintenance, planning, design, and expansion of the national transmission network. NTDC was incorporated on November 6, 1998 and commenced commercial operation on December 24, 1998. It was organized to take over all the properties, rights and assets, obligations and liabilities for 220 kV and 500 kV grid stations, and transmission lines and network owned by the Pakistan Water and Power Development Authority (WAPDA). NTDC operates and maintains 12x500 kV and 29x220 kV grid stations, 5,077 km of 500 kV transmission lines, and 7,359 km of 220 kV transmission line in Pakistan. NTDC is a government-owned corporation.

NTDC was granted the Transmission License No. TL/01//2002 on December 31, 2002 by the NEPRA to engage in the exclusive transmission business for a term of 30 years, pursuant to Section 17 of the Regulation of Generation, Transmission and Distribution of Electric Power Act, 1997.

NTDC transmits the electricity purchased from the government-owned thermal generation companies (GENCOs), WAPDA, which generates electricity by hydro power, and independent power producers (IPPs) through the Pakistan Power Holding Company, Ltd.(PPHC)[3] and Central Power Procurement Agency (CPPA)[4]; or under any other legislative regime specified by the GOP time to time. NTDC is also responsoble for the safe and reliable operation of the national grid by their owned National Power Control Centre (NPCC) which issues power dispatching and load shedding control order.

The Karachi Electric Supply Company (KESC)[5] and the eight distribution companies provide distribution services under license from the NEPRA.

ARE-based independent power producers (ARE-IPPs) are the generation companies established for the dedicated sale of electricity under guaranteed agreements with NTDC, CPPA and DISCOs. Likewise, the Distributed Generators (DGs) of ARE produce electricity for captive use and the surplus electricity can be sold to bulk consumers and utilities under the bilateral contract.

Bulk consumers are any user that receives electricity either through 11 kV or 400 V lines. These include both the private and public sector institutions and industries. The bulk consumers are charged at a flat rate per unit of electricity they consume.

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[3] The government established the PPHC and transferred all outstanding circular debt of Rs.216 billion to this company to clear the balance sheets of DISCOs and GENCOs

[4] CPPA is created to deal with the functions of transaction of sale and purchase of electricity between power generation companies and distribution companies in accordance with NEPRA rules. Pakistan Electric Power Company (PEPCO) was dissolved and replaced by CPPA. Unlike PEPCO, CPPA has no administrative or financial interference or authority to interfere in affairs of DISCOs. DISCOs are given more autonomy and now they are overlooked by CPPA only for the agreements of power purchase. CPPA is part of NTDC with their office in WAPDA House, Lahore and was established in 2012 after dissolution of PEPCO.

[5] KESC is a power generation, distribution, and transmission company owned by a private sector, which supplies electricity to the consumers within Karachi City only. All the other DISCOs are the government owned companies.

The Alternative Energy Development Board (AEDB) was established in 2003 as a “one window” facilitator for the development of ARE in the country. On the other hand, the Private Power and Infrastructure Board (PPIB), was established as a “one window” facilitator for the generation projects of conventional private power sector, including hydro projects of above 50 MW per capacity.

The provincial governments of Balochistan, Khyber Pakhtunkhwa, Punjab, and Sindh support the development and implementation of ARE projects within their territories. Similarly, the Northern Areas comprising the Gilgit-Baltistan (GB) province and the State of Azad Jammu and Kashmir (AJK) support the development of ARE projects through provincial departments.

Additionally, the Board of AEDB also ensures provincial representation for smooth ARE project implementation. AEDB has their field offices in provinces that keep liaison with the provincial authorities and deal with issues as mandated by the provincial government.

2.2.2 Law and Act

There is no renewable energy law or act in Pakistan except the act that provides for the establishment of the Alternative Energy Development Board (Act No. XIV of 2010). The act is called AEDB Act and is shown in **Appendix A-1-1**. However, the RE Policy includes functions of law and act, regulations, and rules which have legal binding force. Besides that, the RE Policy includes the detailed guidelines for determination of tariff for grid-connected IPPs. This mixture of policy, regulations, and guidelines in one document for the purpose of having a policy seems to be causing some confusion over the policy document.

The contents of regulation and rules in the RE Policy are shown below:

(i) Scope of the RE Policy

(ii) Categories of Power Generation Project for Private Sector

(iii) General Incentives for RE Power Generators of All Categories

(iv) Specific Incentives for Grid-connected RE IPPs

(v) Facilities for Captive and Grid Spillover Projects

(vi) Facilities for Off-grid and Dispersed RE Power Generation

(vii) Procedure for Setting Up IPPs for Sale of All Power to Grid

The details of the above are shown in **Appendix A-3-1**.

2.2.3 Subsidy System and Risk Coverage

There is no subsidy and no feed-in tariff (FIT) system for the RE-based projects in Pakistan.

However, the RE Policy includes the guideline to determine the selling tariff of electricity generated by RE to the grid.

The guideline is designed so as to attract private investment by the pre-determined calculation methodology of tariff for the private sector to obtain the profit from the projects. The resultant tariff calculated according to the guideline is usually higher than the tariff of conventional generation. The concept of this guideline is to mobilize private resources through higher tariff, which is same as the concept for subsidy; however, the approval of the tariff depends on evaluation result and decision by NEPRA.

Besides, there is the upfront tariff which is only for wind power generation at present. The upfront tariff is the pre-determined tariff decided by NEPRA at which the distribution companies purchase electricity. The idea of the upfront tariff is almost same as FIT. However, there is no budget source for the subsidy of the tariff. Thus, the announced upfront tariff seems to be unattractive for the project investors. The further information of upfront tariff is shown in **Appendix A-3-2**.

As incentive for investors, the RE Policy sets forth the risk coverage for wind and small hydro generation. Wind risk is defined as the risk of variable wind speed, and, therefore, of the effective energy output of the wind Independent Power Producer (IPP). This risk is to be absorbed by the power purchaser. In the same way, hydrological risk is defined as the risk of variable water flows, and, therefore, of the effective energy output of the hydro IPP. This risk is to be also absorbed by the power purchaser.

2.2.4 Preferential Taxation System

(1) Customs Duty:

The regulations of the GOP, through the Federal Board of Revenue (FBR) Statutory Regulatory Order (SRO) No. 575(1)/2006 dated June 5, 2006, provide for 0% duty on imports of machinery, equipment and spares for commissioning and expansion of projects for power generation utilizing RE resources. The source rules regarding customs duty are driven under the RE Policy.

(2) Special Excise Duty:

Special excise duty is also 0% for imported machinery, equipment, and spares for commissioning and expansion of projects for power generation utilizing RE resources.

(3) Sales Tax:

No sales tax is levied on import and local supply of imported plant, equipment, machinery, etc. regarding RE based upon the SRO and the recent notification SRO 369(1)/2011 dated May 7, 2011 issued by the FBR, GOP.

(4) Income Tax:

No income tax or withholding tax (WHT) is required at the import stage in view of the SRO 947(1)/2008 dated September 5, 2008 and SRO 263(1)/2011 dated March 19, 2011. In Pakistan, a certain amount of WHT is charged at the time of transaction with the assumption that there are some associated incomes with that transaction. This WHT is later adjusted at the end of the year towards income tax paid.

2.2.5 Concessionary Loan

The AEDB, through State Bank of Pakistan (SBP), had arranged for concessionary loans for power plants that will use alternative and renewable sources of energy. SBP had notified this through its Circular No. 19 dated December 1, 2009.

For the loans of power plants for RE that will be repaid in five years, those will be charged with the an interest rate of 12.40% (9.9% interest plus spread of 2.5% per year), and those that will be repaid in ten years will be charged at 12.50% (9.5% plus a spread of 3% per year). These were interest rates when banks were offering loans at 15.50% (KIBOR 12.5%+3%) per year.

Now, the SBP, through its monetary policy announcement on October 5, 2012, had reduced the interest rate (KIBOR) to 10% effective from October 8, 2012. Thus, the effective rates from banks for general financing as of October 8, 2012 is 10% of KIBOR rate plus a spread of 2.5-3%, i.e., 12.5% to 13% per year.

The above situation means that there is no difference between concessionary and ordinary loans at present in terms of interest rate.

2.2.6 Preferential Treatment for Foreign Investment related to Renewable Energy

The Policy for Power Generation Projects Year 2002[6] is specifically focused on encouraging foreign direct investment, and protecting and safeguarding the interest of investors. Some of the salient features for foreign investors are as shown below.

(1) Allowing 100% foreign ownership with a minimum 20% equity contribution requirements.

(2) Sponsors can divest equity after six years of project commissioning.

(3) Conversion of Pakistani rupee and remittance of foreign exchange for project-related payments ensured by the GOP. According to tariff policy, the project sponsors are entitled for adjustments in dollar-rupee parity. This ensures that the total foreign component of the tariff will be paid to the project sponsors at the current exchange rate, thus, protecting them against any losses due to decrease in value of Pakistani rupee.

(4) Performance obligations of power purchaser and provinces/AJK guaranteed by the GOP. Besides, the AEDB also had secured a line of credit from ADB to give additional guarantee of up to US$50 million for renewable energy project. In order to overcome the fear of project sponsors for the inability of the GOP to pay for its obligation, ADB had issued a revolving line of credit for US$500 million. This line of credit provides for US$50 million per project additional guarantee besides sovereign guarantee by the GOP. This guarantee by ADB assures the investors that in case the GOP is unable to pay for its obligation towards that RE project, ADB will pay them up to US$50 million.

[6] Private Power and Infrastructure Board

(5) Continuity of payments in case of political force majeure. This force majeure could arise due to change in government policy as a result of any change in political setup in the country. The projects that are already initiated under the policy will be guaranteed to be paid by GOP for its obligation as per agreement for the term of the project.

(6) Adjustments in tariff for changes in benchmark interest rates (LIBOR/KIBOR).

(7) Foreign component of fixed and variable O&M cost are to be indexed with US Consumer Price Index (CPI). In the tariff component, the costs that are eligible for indexation are either indexed at the US CPI or Pakistan Wholesale Price Index (Pak WPI). The local cost component of tariff is indexed at Pak WPI while the foreign cost component of tariff is indexed at US CPI. So foreign cost component like insurance expense is indexed quarterly on the basis of any change in the US CPI.

(8) IPPs are not exposed to impact of exchange rate variation for US dollar, euro, pound sterling and Japanese yen up to the commercial operation date (COD). At COD, the capital cost of IPP is to be fixed in US dollars based on any of the four currencies of EPC contract accepted by the NEPRA at the time of tariff determination.

(9) Foreign debt may be obtained by IPP in US dollar, pound sterling, euro and yen; periodic adjustments in the debt service component of tariff are made to cover the exchange rate variation for these currencies. In case of foreign loan, IPPs are allowed for indexation of both principal and interest component to be adjusted on the basis of any change in conversion of the corresponding foreign currency. The variation is allowed at the prevailing TT & OD selling rate of relevant foreign currency.

(10) Performance guarantees to PPIB/GOP and letters of credit in favor of power purchaser are accepted in euro, pound sterling and yen in addition to US dollar.

(11) ROE is adjusted for variations in US dollar/Pakistani rupee rates.

To attract local and foreign investment in the power sector especially on RE resources, the GOP has announced certain incentives for the power project investors/sponsors. These incentives are briefly described as follows[7]:

- There is no restriction on sending out the profits and proceeds from the sale of electricity from these power plants out of the country;
- The government provides land on lease at subsidized rates to setup these power plants. For instance, for wind projects in Sindh, the lease is only EUR 7 per acre per year; and
- To protect investors/sponsors of these power plants, the GOP enters into power purchase agreement for the term of project life of up to 30 years. During this term life of project, if for any reason the government stops buying electricity from the power plant, they will still pay them for the capacity purchase price (CPP) that includes fixed O&M, debt servicing cost, insurance cost, and return on equity (ROE).

[7] http://www.aedb.org/

2.2.7 Provincial Institutional Support for Renewable Energy Promotion

The Policy for Power Generation Projects Year 2002 allows the provinces of Pakistan and AJK to develop power generation projects up to a maximum capacity of 50 MW in public or private sectors using RE sources.

The following departments of the Punjab and Sindh provincial governments work for power development:

(1) Punjab Power Development Board (PPDB):

The Government of Punjab established the PPDB in 1995 for the implementation of power generation using RE sources through a one-window operation. To utilize the potential of RE sources, the Government of Punjab drafted the "Punjab Power Generation Policy"[8].

(2) Environment & Alternative Energy (E&AE) Department, Government of Sindh:

The Government of Sindh established Alternative Energy Wing under the E&AE Department in 2002 to implement the RETs in the province. The department is headed by the provincial secretary[9].

2.3 Environmental Institution for Renewable Energy

2.3.1 Outline

The environmental legislation covers all kinds of development projects including RE projects. There is no dedicated environmental legislation for RE projects.

(1) Legal and Regulatory Framework

The environmental institutions in Pakistan are shown below.

- Pakistan Environmental Protection Agency (Pak-EPA)
- Balochistan Environmental Protection Agency (BEPA)
- Sindh Environmental Protection Agency (SEPA)
- Punjab Environmental Protection Agency (Punjab-EPA)
- Khyber Pakhtunkhwa (KPK) Environmental Protection Agency (KPK-EPA)
- Gilgit-Baltistan Environmental Protection Agency (GB-EPA)
- Azad Jamu & Kashmir Environmental Protection Agency (AJK-EPA)

The environmental legislations of Pakistan are shown below.

- Pakistan Environmental Protection Act (PEPA), 1997
- Pakistan Environmental Protection Agency Review of IEE and EIA Regulations, 2000
- National Environmental Quality Standards (NEQS)
- National Environmental Policy, 2005

8 "Punjab Power Development Policy (Year 2006, Revised in 2009)", Government of Punjab
9 Website of Government of Sindh: http://www.sindh.gov.pk/dpt/Environment/

- The Punjab Environmental Protection (Amendment-XXXV of 2012) Act, 2012
- Sindh Wildlife Protection Ordinance, 1972 and Amendments 2001
- The Punjab Wildlife (Protection, Preservation, Conservation, and Management) Act, 1974
- The Forest Act, 1927
- Antiquities Act, 1975
- Canal and Drainage Act, 1873

(2) Initial Environmental Examination (IEE)/ Environmental Impact Assessment (EIA)

The IEE and EIA are based on PEPA of 1997. According to the Pakistan Environmental Protection Agency Regulations 2000, the power projects, regardless of public or private sector, must obtain approval of IEE or EIA from the concerned EPA. The Pak-EPA is responsible for any project that is planned within the federal territory. The provincial EPAs are responsible for the projects planned in their own respective provinces.

In the energy sector, the scale of the project will form the basis for deciding which of IEE or EIA has to be applied for the project. Projects which require IEE and EIA are listed in **Table 2.3.1-1**.

Table 2.3.1-1 List of Projects Requiring IEE/EIA in Energy Sector

SCHEDULE I: List of Projects requiring an IEE in Energy Sector
Hydroelectric power generation less than 50 MW
Thermal power generation less than 200 MW
Transmission lines less than 11 kV, and large distribution projects
Oil and gas transmission systems
Oil and gas extraction projects including exploration, production, gathering systems, separation and storage
Waste-to-energy generation projects
SCHEDULE II: List of Projects requiring an EIA in Energy Sector
Hydroelectric or other power generation over 50 MW
Thermal power generation over 200 MW
Transmission lines (11 kV and above) and grid stations
Nuclear power plans
Petroleum refineries

Source: Pakistan Environmental Protection Agency Regulations 2000

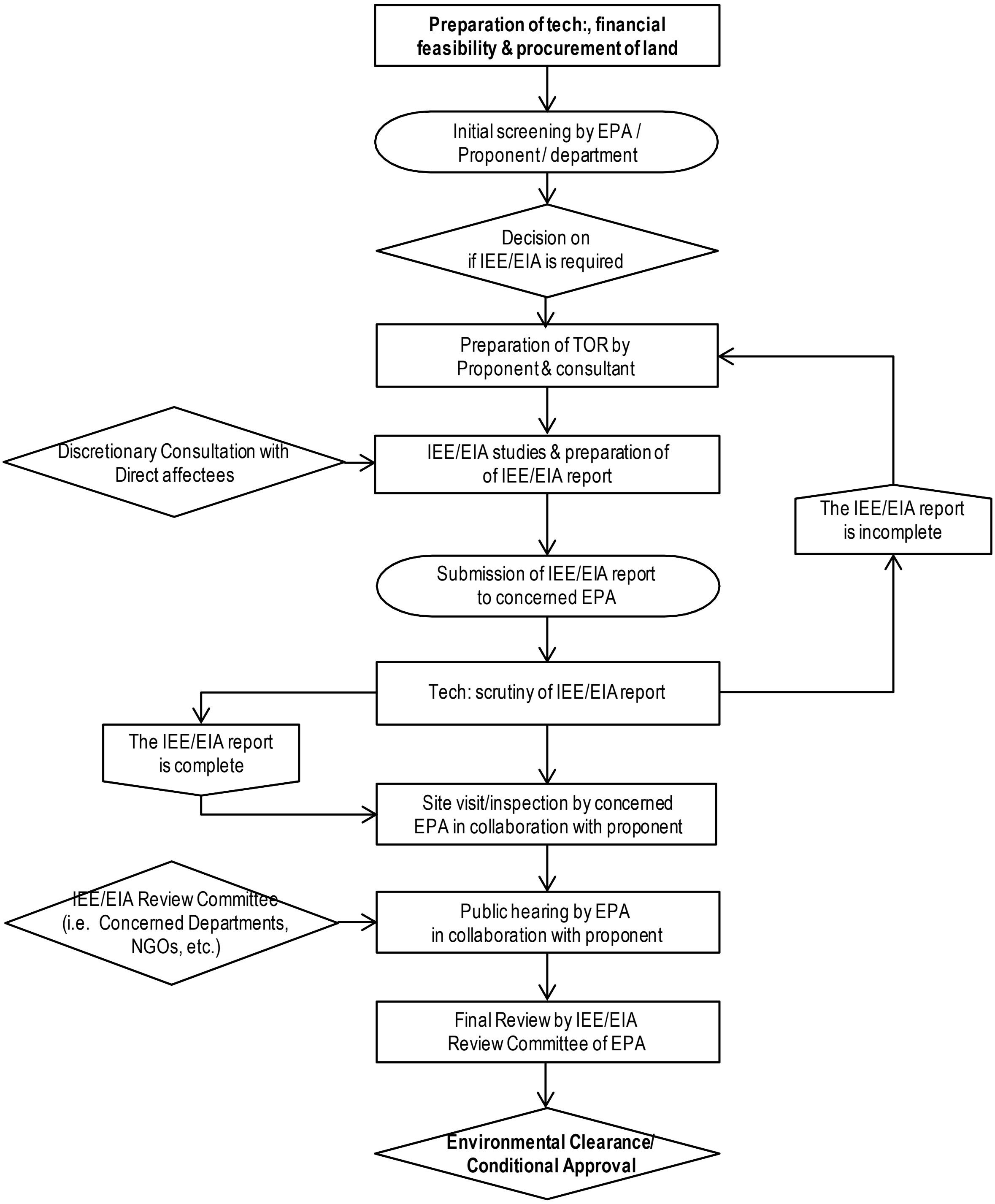
2.3.2 Required Process for Implementing Solar, Wind, and Small Hydro Power Projects

(1) Process of IEE or EIA

The flow chart of the process for IEE/EIA approval is presented in **Figure 2.3.1-1**.

A proponent of project falling into any category listed in the schedule of regulations should execute the IEE or EIA studies and make report. Then, the IEE or EIA report should be submitted to the concerned EPA.

The concerned EPA would confirm the IEE or EIA report as a preliminary examination and then gather public comments. After that, concerned EPA will review the IEE and EIA. During completion review, EPA shall communicate to the proponent.



Source: Prepared by JICA Study Team based on PEPA, 1997 and interview with EPA, 2012

Figure 2.3.2-1 Flow Chart for IEE/EIA Submission and Approval Processes at Federal and Provincial Levels

(2) Applications in Renewable Energy

IEE is required for small hydro power generation projects with less than 50 MW capacities. On the other hand, solar power generation and wind power generation project are not always required to apply the process of IEE or EIA; however, final decision is taken by the Pak-EPA for projects under the jurisdiction of federal territories including Islamabad.

2.3.3 Other related Legislations

(1) National Environmental Quality Standards (NEQS)

NEQS are used in Pakistan as minimum environmental standards. However, in the absence of some standards such as vibration, federal government uses USAID and World Bank guidelines.

All the provinces use the NEQS as minimum standards in Pakistan at present, in the absence of provincial standards. NEQS for noise, which is closely related to RE projects, are given in **Table 2.3.3-1**.

Table 2.3.3-1 NEQS, 2010 for Noise

S.No.	Category of Area / Zone	Effective from 1st July 2010		Effective from 1st July 2012	
		Limit in dB (A) Leq*			
		Day Time	Night Time	Day Time	Night Time
(A)	Residential area	55-60	45-50	55	45
(B)	Commercial area	65-70	55-60	65	55
(C)	Industrial area	75-80	70-75	75	70
(D)	Silence zone	50-55	40-45	50	40

*dB(A) Leq: Time weighted average of the level of sound in decibels on scale A, which is relatable to human hearing.

NOTE:

1: Day time hours: 06.00 am to 10.00 pm.
2: Night time will be hours: 10.00 pm to 06.00 am.
3: Silence zone: Zones, which are declared as such by the competent authority. An area not less than 100 meters around hospitals, educational institutions and courts.
4: Mixed category of areas may be declared as one of the four above-mentioned categories by the competent authority.

Source: Statutory Notifications (S.R.O.) 18th October, 2010

(2) The Forest Act 1927, Forest (Amendment) Act 2010 (XVII of 2010)

This act empowers the province to declare any forest area as reserved or protected. The act also empowers the province to prohibit the clearing of forest for cultivation, grazing, hunting, removing forest produce, quarrying and felling, lopping and topping of trees, branches in reserved and protected forests.

(3) The Antiquities Act

The Antiquities Act of 1975 ensures the protection of cultural resources in Pakistan. The act is designed to protect “antiquities” from destruction, theft, negligence, unlawful excavation, trade, and export. The law prohibits new construction in the proximity of protected antiquities and empowers the GOP to prohibit excavation in any area, which may contain articles of archaeological significance.

(4) The Punjab wildlife Act

The Punjab Wildlife Act was enacted from the provisions of the Punjab Wildlife Ordinance, 1972 (Ordinance No. XXI of 1972), which has already expired. This Act is aimed at providing for the protection, preservation, conservation, and management of wildlife. It extends to the whole province of Punjab.

(5) Sindh Wildlife Protection Ordinance, 1972 and Amendments 2001

This ordinance provides for the preservation, protection, and conservation of wildlife by the formation and management of protected areas, and prohibition of hunting of wildlife species declared protected under the ordinance in Sindh province.

The ordinance also specifies three broad classifications of the protected areas: national parks, wildlife sanctuaries, and game reserves. Activities such as hunting and breaking of land for mining are prohibited in national parks, as well as removing vegetation or polluting water flowing through the park. Wildlife sanctuaries are areas that have been set aside as undisturbed breeding grounds, and cultivation and grazing are prohibited in the demarcated areas.

Two amendments to the ordinance were issued in January and June 2001, respectively, pertaining to oil and gas exploration activities within national parks and wildlife sanctuaries. The first amendment allowed the government to authorize the laying of an underground pipeline through protected areas. The second amendment allowed exploration and production activities within national parks and wildlife sanctuaries. This amendment is not applicable to other development projects including power generation using wind energy.

CHAPTER 3 REVIEW OF THE INSTITUTIONAL CAPACITY

3.1 Alternative Energy Development Board

3.1.1 Organization and Management

The AEDB was established in 2003 with the mandate to explore and implement renewable energy technologies (RET) in Pakistan. AEDB was given further autonomy and their charter was redefined through a legislation approved by the Parliament of Pakistan and signed by the President of Pakistan on May 21, 2010. The act is shown in **Appendix A-1-1**.

The act defines the members of the AEDB, which are the chairman, the members, and the chief executive officer (CEO). The chairman and CEO are appointed by the federal government. The members consist of the principal secretaries of the federal government or their nominees not below the rank of additional secretary, the chief secretaries of the provincial governments, and six members from the private sector. There is no definition of the management board of AEDB in the act. However, the abovementioned members are considered as the de facto members of the management board of the AEDB.

The secretary of the AEDB is appointed by the federal government upon the recommendation of the AEDB.

The functions of the AEDB[10] are as shown below.

b. To develop the national strategy, policies, and plans for the utilization of alternative and renewable energy resources to achieve the targets approved by the federal government in consultation with the Board;

c. To act as a forum for evaluating, monitoring an,d certification of alternative or renewable energy projects and products;

d. To act as the coordinating agency for commercial application of alternative or renewable technology; and

e. To facilitate energy generation through alternative or renewable energy resources by:

   i) Acting as one window facility for establishing, promoting and facilitating alternative or renewable energy projects based on wind, solar, micro-hydel, fuel cells, tidal, ocean, biogas, biomass, etc.;
   ii) Setting up an alternative and renewable energy projects on its own or through a joint venture or partnership with public or private entities in order to create awareness and motivation for the benefit of the general public as well as by evaluating concepts and technologies from a technical and financial perspectives;
   iii) Conducting feasibility studies and surveys to identify opportunities for power generation and other applications through alternative and renewable energy

10 AEDB Act (http://www.aedb.org/Ordinance/aedbact.pdf)

resources;

iv) Undertaking technical, financial, and economic evaluation of the alternative or renewable energy proposals as well as providing assistance in filing the required licensing applications and tariff petitions to the NEPRA.

v) Interacting and coordinating with national and international agencies for the promotion and development of alternative energy;

vi) Assisting in the development and implementation of plans with concerned authorities and provincial governments and special areas for off-grid electrification of rural areas; and

vii) Making legislative proposals to enforce the use and installation of equipment utilizing renewable energy.

3.1.2 Budget

The AEDB is required to file an annual report to the federal government. However, no annual report has been published for the last few years. The Study team could not obtain any budget data from AEDB even though it was requested officially with the letter from JICA Pakistan Office. The non-development budget was obtained from the Ministry of Finance that provides the total fund allocated to AEDB for a fiscal year but it does not have any details about grants and aid from donor agencies and their income from other sources.

The income sources of AEDB except for those from the national budget are shown below.

- Every RE project needs to be registered with AEDB for a fee of US$100.
- For issuance of LOI, AEDB charges a fee of US$5000. There were so many projects that were registered and processed their LOI through AEDB but later these projects were never taken forward even though all of them paid the fees to AEDB.
- For evaluation of feasibility studies, they charged a fee of US$50,000 per study. For the evaluation of these studies, they hired a panel of experts from outside but it is not known exactly how much money was paid to them. Also unknown is how much they spent and how much they saved from each project and also where these savings were spent.
- AEDB also receives grants and aids for their development programs and projects.

3.1.3 Human Resources

The main staff of AEDB is listed in **Appendix A-1-2**. Besides this, there are around 100 general employees in all offices of AEDB. There is a lot of staff in AEDB who has high level of expertise in renewable energy sector.

3.1.4 Review of the Implementation Capacity of Renewable Energy Development Plan

It is appraised that the staff of AEDB individually has a high potential of capacity to promote renewable energy development. However, as institutional capacity of AEDB, it is difficult to appraise it because the financial data and other detailed information were not disclosed to the

Study team.

3.2 Pakistan Council of Renewable Energy Technologies

3.2.1 Organization and Management

(1) Background

The Pakistan Council of Renewable Energy Technologies (PCRET) was established by merging the National Institute of Silicon Technology and the Pakistan Council for Appropriate Technologies on May 8, 2001. It is the primary institution in the country for coordinating research and development, and promotional activities in various renewable energy technologies. PCRET works under the Ministry of Science and Technology.

PCRET has its head office in Islamabad and regional offices in the provisional capitals of Karachi, Lahore, Peshawar and Quetta, as well as field offices in Abbottabad, Muzafarabad, Bhalwalpur and Ghokti. It has close interaction and working relationship with NGOs, the provincial agriculture and social welfares departments, rural development offices, and other organizations working for the socio-economic development of the rural and semi-urban areas of the country.

(2) Mission, Vision, and Work Contents

The mission statement of PCRET states that PCRET is committed to:

- Research, develop, promote, and disseminate renewable energy;
- Impart training for providing energy services to the people living in remote areas; and
- Create renewable energy culture in the country.

The vision of PCRET is shown below.

- Strengthening of linkages with the private/public sector and end users to promote renewable energy in the country.
- Revamping of bilateral collaboration with countries like China, Germany, Japan, etc., for technology transfer.
- Need-based research, development, and deployment of RETs viz. biogas, micro hydro, solar thermal, solar PV, and wind.
- To provide energy services to people living in remote and far-flung areas.
- Collaboration with provincial governments and local governments in the provinces for the promotion, dissemination, and deployment of RE systems.
- Provision of technical advisory services to stakeholders, e.g., industry, potential investors, and end-users.
- Increasing awareness for RET promotion through electronic and print media, exhibitions, seminars, and training workshops.

The work contents of PCRET are shown below.

- To establish facilities, expertise, and to do research and development for suitable technologies.

- To produce materials, devices, and applications in the field of renewable energy.
- To determine polices and make short and long term programs.
- To promote renewable technologies in the country through research and development.
- To organize conferences, seminars, and workshops for the promotion of renewable technologies.
- To establish national and international liaison in the field.
- To advise and assist the government and relevant industries in the area.

3.2.2 Budget

The Study team was unable to get details of the budget as PCRET is not willing to share this information with us. The non-development budget[11] was provided by GOP through the Ministry of Science and Technology. Aside from the budget for any development or research program, PCRET has to file an official request through Planning Commission and only after approval will PCRET gets funds for the requested project.

3.2.3 Human Resource

PCRET has a total of 179 personnel working on permanently on all kinds of positions and levels including skilled, unskilled, and administrative staff.

The Ministry of Science and Technology provides non-development expenditure for the personnel approved by the ministry. Since 2009, there are only 130 people employed by the PCRET and the rest of the positions are vacant. PCRET cannot hire people for these posts as there is a ban by the government on new hiring. The government placed a ban on new hiring in an effort to reduce their non-development expenditures. PCRET hires separate individuals as project team members for the projects, and their contract is linked to the duration of the particular project. Currently, there are some 100 personnel working on projects of PCRET.

Appendix A-2-1 shows the list of staff working for PCRET.

3.2.4 Review of the Implementation Capacity of Renewable Energy Development Plan

PCRET's role is limited to technology research and development.

Through grant aid and with the help of the GOP, PCRET had established and acquired some equipment for solar testing and manufacturing. But the manufacturing is of a very small scale, only producing 50 kW per year of solar PV cells and modules (panels). With this scale of production, PCRET cannot bring about any drastic or significant change in the country. Though PCRET is providing testing services with regards to the performance of solar PV systems and also offers training courses for solar technologies, PCRET has not yet developed any local vendor who can construct and build these systems locally.

[11] Non development budget only covers the payments of salaries to employees, payment of utilities, travel & transportation expenses, maintenance and other day to day expenses.

Similarly, no significant work has been done in the area of wind energy. PCRET has installed some micro wind turbines in some areas but most of them are not in working condition due to lack of proper maintenance and training of operators.

PCRET has done some work in micro hydro field. They have established 5 kW-50 kW micro hydro systems in remote hilly areas on community-sharing basis. There are some micro turbine manufacturers who started making these turbines locally.

PCRET has the manpower and technical skills to carry out any RE project especially solar, biogas, and micro hydel. However, PCRET lacks technical expertise in wind technology. The major hindrance in carrying out the RE development activities is the lack of funds. PCRET can undertake any kind of RE development project provided it is task-oriented.

3.3 Provinces and Territory

3.3.1 Punjab Province

Punjab province is the most populous province in the country. According to the 1998 census of Pakistan, Punjab hosts 55.62% of the country's total population[12]. According to the Economic Survey of Pakistan Report for the year 2010-2011, the electricity consumption for Punjab is almost constant at 62% of the country's total production of electricity.

In the Government of Punjab, Irrigation and Power Department (IPD) is related to the hydro power generation development and Punjab Power Development Board (PPDB) is in charge of all the RE generation development under 50 MW.

(1) Irrigation and Power Department

This department is responsible for the maintenance of canals in the province. The land and the right of way on both sides of canals are also owned by the department. The currently available low-head hydro power sites are mostly located on canal falls. The powerhouse headrace and tailrace may be constructed on a land owned by the department that can either be leased for the project or the department can transfer right of land to the project as an equity participation in the project. In order to establish a hydro power plant, the water use license needs to be obtained from the department and also there is a fee of Rs.0.15/kWh as fixed water use charge.

(2) Punjab Power Development Board

The Government of Punjab approved the establishment of PPDB in 1995 to develop power in all areas and sectors. PPDB has been given the mandate to implement power generation projects through utilization of water resources of canals/rivers and other indigenous/renewable resources. PPDB works as one window office for the facilitation of project sponsors.

(3) Institutional Capacity

PPDB has some experiences to develop small hydro power generation but does not have the

[12] Population Census Organization (http://www.pbs.gov.pk/sites/default/files/other/yearbook2010/Population/16-4.pdf)

experience to develop solar power generation. IPD has a lot of hydrological data but the data is not organized properly for the developers of small hydro power generation to use it efficiently and effectively. It seems that the capacity building to the Punjab province by the technical assistance of JICA is effective.

3.3.2 Sindh Province

Sindh province is the second most populous province in the country and it is also the commercial hub. According to the census of 1998, Sindh hosts about 23% of the country's total population whereas it consumes 20.2% of the total electricity generated in the country. Karachi is the provincial capital where the main commercial sea ports of the country are located.

In the Government of Sindh, Environment & Alternative Energy Department is in charge of all the RE generation development under 50 MW. Land lease and other land acquisition issues are dealt with by the Board of Revenue, Government of Sindh. The Government of Sindh has also established the Sindh Board of Investment as a facilitator for project sponsors.

(1) Environment and Alternative Energy Department

The Environment Department was established in October 2002 through a Cabinet Order to supervise its subordinate directorates including Sindh Environmental Protection Agency and Alternative Energy Wing. At macro level, the department is responsible for the protection, conservation, rehabilitation, and improvement of environment of the province with the support of regulatory documents. On the other hand, its function is to promote alternative energy resources with the judicious use of untapped resources to address the issues of energy shortage.

The administrative secretary heads the department while one additional secretary, one deputy secretary and two section officers are attached to perform the assigned role along with subsidiary and auxiliary staff.

Alternative Energy Wing has been established in the department with the following main objectives:

- Promote in the province of Sindh the alternative energy from all natural sources such as sunlight, wind, water, bio-mass, and ocean waves.
- Assess technical and economic potential of alternative energy sources.
- Disseminate information on alternative energy sources to the communities, private and public sector organizations.
- Advise the Sindh government on policies, rules, and regulations pertaining to the promotion of alternative energy.

(2) Board of Revenue

In Sindh province, the issues of land lease and other issues related to land acquisition for RE projects are dealt with by this department. Initially, the Government of Sindh allocated some land for wind power projects to AEDB but now, sponsors need to apply and deal directly with the Provincial Board of Revenue for any new project.

(3) Sindh Board of Investment

The provincial government established the Board of Investment in January 2010. Sindh Board of Investment (SBI) was established with the responsibility of promoting investment in all sectors of the economy; facilitating local and foreign investments for speedy materialization of projects, enhancing Sindh's international competitiveness, and contributing to economic and social development.

The board is composed of a chairman with seven members from the Government of Sindh and 16 members from the private sector. The private sector members include the presidents of the Chamber of Commerce & Industries in Sindh and the president of Sindh Chamber of Agriculture. Besides these, there are twelve other members who are private entrepreneurs.

The main purpose of establishing this board is to provide one window facility to investors for getting necessary permits from other provincial departments. For RE projects, SBI helps in getting approvals & permits from Environment & Alternative Energy Department and land from Sindh Board of Revenue.

(4) Institutional Capacity

The Environment & Alternative Energy Department is a newly established department that is yet to develop its capacity. The department does not have the capacity, capability or even the kind of resources to implement RE projects on their own but with consultation from the Sindh Board of Investment they can achieve the goals and objectives set out by the provincial government.

Sindh Board of Investment as a facilitator has definitely helped to overcome the shortcomings of provincial departments. The board has 16 private sector members who have very well established businesses. These members from the private sector have the technical knowhow and necessary capacity to implement any project and secure investments.

3.3.3 Islamabad Capital Territory

Being the capital of the country, Islamabad falls under the federal government and is managed through Capital Development Authority (CDA).

CDA was established as a statutory body for the development of Islamabad City. CDA works only in the capital territory. The main purpose of CDA is to plan and develop Islamabad; secondly, to perform functions of municipal corporation and to provide cleanliness, health, education, drinking water, sanitation, etc., for its inhabitants.

CDA does not have any energy wing as it does not come under their domain. Although they have an environment department, it is limited to taking care of the affairs of environment-related issues. Recently, CDA planned to build a 200 MW coal-based power plant in Islamabad territory through the private sector and they have advertised for Expressions of Interest. CDA had not taken any initiative in RE development in capital territory.

For any RE development project, there is no need to involve CDA unless otherwise required. If a new RE project needs land, then CDA has to be involved; otherwise, CDA will have no role in the development of RE projects.

CHAPTER 4 CURRENT SITUATION OF RENEWABLE ENERGY DEVELOPMENT PLAN

4.1 Confirmation of Policy Change: Objectives and Strategy

Currently, the latest government policy for renewable energy is the RE Policy 2006. As stated in **Sub-chapter 2.1.2**, the RE Policy 2006 consists of three-term policies and the detailed and tangible description is prepared only for a short term up to June 30, 2008. The RE Policy 2006 is still in place even after the short term period expired. The formulation process of the medium term policy[13], for the period of July 2008 to June 30, 2012, began in 2007/08. Experts from the Asian Development Bank, GTZ (Now GIZ), and USAID have helped AEDB to shape the new proposed policy; however, the medium term policy has not yet been issued.

The above situation means that there has been no change in the objectives and strategy of the policy for development of renewable energy from the RE Policy 2006.

4.2 Target Indicators and Current Performance

The quantitative indicator of the target in the RE Policy is only the following figure.

- Electricity supply from renewable energy by year 2030: 9,700 MW

In order to accomplish the above target, GOP set a target to develop 3,150 MW of power generated by renewable energy by 2020. This development is planned to be conducted wholly by the private sector, through IPP.

As of November 2012, only 6.4 MW IPP wind power project has been completed and another 100 MW will be in place by the end of January 2013.

4.3 Current Performance of Road Map

The current situation of renewable energy development as appraised is that its performance is seven years behind target because development of wind power generation of 106 MW will be completed only in 2013 while the target completion date of 100 MW was in 2006.

The reasons for slow progress in wind energy development is that AEDB was very optimistic in setting up the RE targets. They set targets at a time when no groundwork has been done. No wind mapping has been done for the wind corridor.

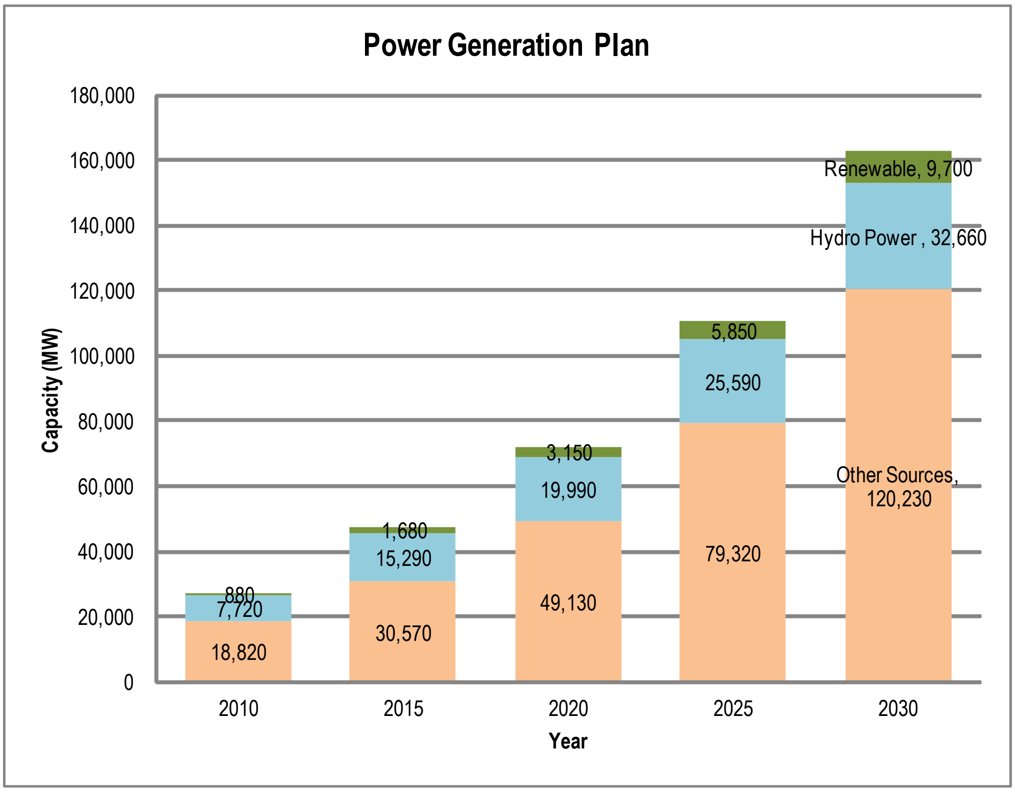
The first wind data collection was conducted by Pakistan Meteorological Department (PMD) and the data was published in March 2007. Though this data helped in the identification of wind corridor in Sindh, the data collected was at heights of 10 m, 30 m, and 50 m only. The commercial project sponsors preferred to have more data at additional heights and the project could not start without having wind data for higher heights. AEDB, with the help of USAID and National Renewable Energy Laboratory (NREL), started the wind study to analyze the wind

[13] Explanation on the policy is available at the website of AEDB (http://www.aedb.org/midtermpolicy.htm).

potential in the country. AEDB, with the help of UNDP, started wind study by installing masts at heights of 10 m, 30 m, 60 m, 80 m, 81.50 m, and 85 m. The data was published in 2010 and after that, investment in wind projects has taken off.

In November 2011, WAPDA published a report detailing their plans for hydro development in the country up to 2030. The report provides complete details of the list of projects and the status of hydro power in the energy mix development plan. As WAPDA deals only with large-scale hydro power projects, the report provided details about large-scale hydro power plants only but briefly mentioned small hydro as well.

The MTDF 2005-2010 indicated the power generation plan for the future as shown in **Figure 4.3-1** below.



Source: Prepared by JICA Study team based on MTDF 2005-2010, Planning Commission

Figure 4.3-1 Power Generation Plan and Energy Mix

The above graph shows the contribution from hydro, renewable, and other sources in the energy mix (electrical energy only). In other sources, traditional thermal power generation such as fossil fuel driven and biomass generation are included.

4.4 Government Commitment to Renewable Energy Development Plan

The major hydro projects above 50 MW, are directly under the federal government who is implementing these projects through WAPDA. These projects are directly undertaken by the government through donors and also by allocating money from the Public Sector Development Plan (PSDP). So far, the government has allocated funds for the development of new hydro power projects.

Provincial governments are actively pursuing the development of small and micro hydro power and wind power plants.

CHAPTER 5 REVIEW OF ELECTRICITY DEVELOPMENT PLAN

5.1 National Policy of Electricity Development

The Power Policy 2002 encourages private sector participation for local and foreign investment in the power sector through Independent Power Producers (IPPs). The salient features of the Power Policy include measures to generate power at least cost option, by avoiding capacity shortfalls, exploitation of indigenous resources, and deploying sustainable technologies by public or private sector or combination of both[14].

In the Medium Term Development Framework (MTDF), it has been envisaged that Pakistan will develop projects intended to generate maximum possible hydro power, and also set up a renewable energy technologies to a minimum of 9,700 MW by 2030, of which approximately 3,000 MW will be achieved by 2020[15].

5.2 Current Long Term Demand Forecast

The Planning (Power) Department of the National Transmission and Dispatch Company Limited (NTDC) is the focal division responsible for developing the latest long term power demand forecast of the country. The current forecast is based on multiple variables from 1970-2010 data. The demand forecast in the report is prepared for PEPCO, KESC, and the whole country from 2010 to 2035[16]. The electric demands of PEPCO, KESC, and auxiliary consumption at power stations are the total demand of the whole country.

(1) Historical Data of PEPCO and KESC

A summary of the historical data on gross energy generation, auxiliary consumption, transmission and distribution loses in the generation plants and electrical grid since 2000 of PEPCO and KESC are given in **Tables 5.2-1** and **5.2-2**, respectively. Moreover, the number of electrical units sold to the customers is also presented on an annual basis in each table.

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14 Policy For Power Generation Projects Year 2002
15 Policy for Deployment of Renewable Energy for Power Generation, 2006
16 Electricity Demand Forecast based on Multiple Regression Analysis, Planning Power NTDC, February 2011

Table 5.2-1 Historical Energy Generation, Electrical Losses and Units Sold to PEPCO

Year	Gross Generation	Auxiliary Consumption		Energy sent out	Transmission Losses		Distribution Losses		Units sold
	(GWh)	(GWh)	(%)	(GWh)	(GWh)	(%)	(GWh)	(%)	(GWh)
2000	55,873	1,201	2.1	54,672	4,017	7.2	9,745	17.4	40,910
2001	58,455	1,173	2.0	57,282	4,594	7.9	9,304	15.9	43,384
2002	60,860	1,315	2.2	59,545	4,600	7.6	9,741	16.0	45,204
2003	64,040	1,346	2.1	62,694	4,908	7.7	10,365	16.2	47,421
2004	69,094	1,397	2.0	67,697	5,054	7.3	11,151	16.1	51,492
2005	73,520	1,850	2.5	71,670	5,467	7.4	11,925	14.9	55,342
GR(2000-2005)	5.6%			5.6%					6.2%
2006	82,225	1,821	2.2	80,404	5,839	7.1	12,160	14.8	62,405
2007	87,837	1,850	2.1	85,987	3,268	3.7	15,239	17.3	67,480
2008	86,269	1,685	2.0	84,584	2,948	3.4	15,097	17.5	66,539
2009	84,377	1,672	2.0	82,705	2,962	3.5	14,457	17.1	65,286
2010	88,880	1,808	2.0	87,072	2,716	3.1	15,478	17.4	68,878
GR(2005-2010)	3.9%			4.0%					4.5%

Source: "Electricity Demand Forecast based on Multiple Regression Analysis", Planning Power, NTDC, February 2011

Table 5.2-2 Historical Energy Generation, Electrical Losses and Units Sold to KESC

Year	Gross Generation	Auxiliary Consumption		Energy sent out	Transmission Losses		Distribution Losses		Units sold
	(GWh)	(GWh)	(%)	(GWh)	(GWh)	(%)	(GWh)	(%)	(GWh)
2000	11,446	512	4.5	10,934	286	2.5	4,218	36.9	6,430
2001	11,677	534	4.6	11,143	292	2.5	3,928	33.6	6,923
2002	12,115	568	4.7	11,547	303	2.5	4,526	37.4	6,718
2003	12,616	581	4.6	12,035	315	2.5	4,744	37.6	6,976
2004	13,392	662	4.9	12,730	335	2.5	4,577	34.2	7,818
2005	13,593	661	4.9	12,932	340	2.5	4,176	30.7	8,416
GR(2000-2005)	3.5%			3.4%					5.5%
2006	14,500	685	4.7	13,815	363	2.5	4,392	30.3	9,060
2007	14,238	639	4.5	13,599	372	2.5	3,860	27.1	9,367
2008	15,189	610	4.0	14,579	381	2.5	4,147	27.3	10,051
2009	15,268	618	4.0	14,650	390	2.5	4,872	31.9	9,388
2010	15,805	591	3.7	15,214	395	2.5	4,914	31.1	9,905
GR(2005-2010)	3.1%			3.3%					3.3%

Source: "Electricity Demand Forecast based on Multiple Regression Analysis", Planning Power, NTDC, February 2011

(2) Consumption per Capita

The consumption per capita from 1980-2010 in Pakistan as shown in **Table 5.2-3** is very low as compared to other developed countries who are within 3,000 kWh in 2006. However, the economic development activity in the country leading further to higher per capita consumption being envisaged in the future is provided in **Table 5.2-4**.

Table 5.2-3 Per Capita Consumption of Pakistan from 1980-2010

Sr.No.	Year	Per Capita Consumption (kWh)
1	1980	125
2	1990	269
3	2000	363
4	2006	494
5	2010	640

Source: "Electricity Demand Forecast based on Multiple Regression Analysis", Planning Power, NTDC, February 2011

Table 5.2-4 Per Capita Consumption of Pakistan in the Future

Sr.No.	Year	Per Capita Consumption (kWh)
1	2015	800
2	2020	1,145
3	2025	1,572
4	2030	2,018
5	2035	2,538

Source: "Electricity Demand Forecast based on Multiple Regression Analysis", Planning Power, NTDC, February 2011

(3) Demand Forecast based on Normal Scenario

The growth rate of the GDP in Pakistan from year 2009 to 2010 was 4.1% and the assumed growth rates of GDP used in the forecast in the NTDC Report are 4.8%, 5.9%, and 6.5% for low, normal, and high scenarios, respectively. In this report, the Study team referred to the analysis of the long term demand forecast based on normal scenario.

The sale forecast of the service providers (PEPCO and KESC) in Pakistan from 2010 to 2035 based on normal scenario is given in **Table 5.2-5**. The detailed analysis gives a separate forecast on the sales targets for various sectors of the economy including domestic, commercial, industrial, agriculture, and others. Another analysis of the load forecast from 2010 to 2035 of PEPCO, KESC, and the whole country is shown in **Table 5.2-6** depicting the sales, generation of energy and the peak electrical power.

(4) Conclusion

The overall electric power generation in Pakistan for 2010 including PEPCO, KESC, and self generation was 118,290 GWh at normal scenario whereas the overall peak load was assumed at 17,413 MW, as depicted in **Table 5.2-6**. The demand forecast for electricity generation in the years 2020 and 2035 are 306,797 GWh and 889,583 GWh, respectively, while the peak load for the same years are 49,824 MW and 107,477 MW, respectively.

Table 5.2-5 Forecast of Electricity Sales in Pakistan

(Unit: GWh)

Year	Domestic		Commercial		Industrial		Agriculture		Public Light		Traction		Bulk		Total		Self Generation		Gross Total		
	PEPCO	KESC	PEPCO	KESC	PEPCO	KESC	PEPCO	KESC	PEPCO	KESC	PEPCO	KESC	PEPCO	KESC	PEPCO	KESC	PEPCO	KESC	PEPCO	KESC	Sum
Base Year (Recorded)																					
2009-10	29,479	4,316	4,465	1,091	16,372	3,387	9,585	104	371	87	5	0	3,388	920	63,665	9,905	8,890	2,797	72,555	12,702	85,257
Energy Shed	9,450	1,005	1,431	263	5,249	816	3,073	25							19,203	2,109			19,203	2,109	21,312
Base Year (Computed)																					
2009-10	38,929	5,321	5,896	1,354	21,621	4,203	12,658	129	371	87	5	0	3,388	920	82,868	12,014	8,890	2,797	91,758	14,812	106,569
Future Projections																					
2010-11	42,732	6,030	6,246	1,540	22,808	4,557	13,881	147	497	118	4	-	3,542	1,065	89,711	13,457	9,420	2,964	99,131	16,421	115,552
2011-12	46,977	6,629	6,739	1,661	24,358	4,866	15,045	160	545	129	4	-	3,802	1,143	97,470	14,589	10,060	3,166	107,529	17,754	125,283
2012-13	51,639	7,287	7,305	1,800	26,178	5,230	16,291	173	598	141	4	-	4,096	1,232	106,111	15,864	10,811	3,402	116,922	19,266	136,188
2013-14	56,853	8,023	7,850	1,935	28,299	5,654	17,723	188	656	155	4	-	4,420	1,329	115,806	17,284	11,687	3,678	127,493	20,962	148,455
2014-15	62,742	8,854	8,476	2,089	30,748	6,143	19,398	206	722	170	4	-	4,789	1,440	126,881	18,902	12,699	3,996	139,580	22,899	162,478
GR(2010-15)	10.02%	10.72%	7.53%	9.06%	7.30%	7.88%	8.91%	9.79%	14.26%	14.35%	-2.90%		7.17%	9.38%	8.89%	9.49%	7.39%	7.39%	8.75%	9.10%	8.80%
2015-16	69,312	9,781	9,148	2,255	33,467	6,686	21,256	226	796	187	4	-	5,196	1,563	139,180	20,697	13,822	4,349	153,001	25,047	178,048
2016-17	76,568	10,805	9,815	2,419	36,448	7,282	23,258	247	876	206	4	-	5,634	1,694	152,603	22,653	15,053	4,737	167,656	27,389	195,045
2017-18	84,482	11,922	10,513	2,591	39,680	7,927	25,349	269	964	226	4	-	6,103	1,835	167,096	24,771	16,388	5,157	183,484	29,928	213,411
2018-19	93,047	13,131	11,238	2,770	43,196	8,630	27,514	292	1,058	247	4	-	6,606	1,987	182,663	27,056	17,840	5,614	200,503	32,670	233,172
2019-20	102,216	14,425	11,904	2,934	46,994	9,389	29,708	315	1,158	270	4	-	7,129	2,144	199,113	29,476	19,408	6,108	218,521	35,584	254,105
GR(2015-20)	10.25%	10.25%	7.03%	7.03%	8.85%	8.85%	8.90%	8.90%	9.89%	9.67%	0.00%		8.28%	8.28%	9.43%	9.29%	8.85%	8.85%	9.38%	9.22%	9.36%
2020-21	112,109	15,821	12,638	3,115	51,073	10,204	32,021	340	1,265	294	4	-	7,691	2,313	216,802	32,086	21,093	6,638	237,895	38,724	276,619
2021-22	122,670	17,311	13,367	3,294	55,455	11,079	34,388	365	1,380	320	4	-	8,281	2,490	235,545	34,860	22,903	7,207	258,448	42,067	300,515
2022-23	133,869	18,892	14,057	3,465	60,197	12,026	36,783	390	1,500	347	4	-	8,896	2,675	255,307	37,796	24,861	7,823	280,168	45,619	325,787
2023-24	145,627	20,551	14,769	3,640	65,301	13,046	39,156	416	1,627	376	4	-	9,540	2,869	276,025	40,897	26,969	8,487	302,994	49,384	352,378
2024-25	157,894	22,282	15,468	3,812	70,826	14,150	41,495	441	1,758	406	4	-	10,210	3,070	297,657	44,160	29,251	9,205	326,907	53,365	380,273
GR(2020-25)	9.09%	9.09%	5.38%	5.38%	8.55%	8.55%	6.91%	6.91%	8.72%	8.49%	0.00%		7.45%	7.45%	8.37%	8.42%	8.55%	8.55%	8.39%	8.44%	8.40%
2025-26	170,572	24,071	16,135	3,977	76,769	15,337	43,756	465	1,894	436	4	-	10,897	3,277	320,028	47,562	31,705	9,977	351,733	57,540	409,273
2026-27	183,592	25,908	16,820	4,146	83,198	16,621	45,930	488	2,033	467	4	-	11,609	3,491	343,186	51,121	34,360	10,813	377,546	61,934	439,480
2027-28	196,836	27,777	17,477	4,307	90,106	18,002	47,978	509	2,174	499	4	-	12,333	3,709	366,909	54,803	37,213	11,710	404,122	66,514	470,636
2028-29	210,224	29,667	18,111	4,464	97,572	19,493	49,894	530	2,316	530	4	-	13,071	3,931	391,193	58,614	40,297	12,681	431,489	71,295	502,785
2029-30	223,665	31,563	18,749	4,621	105,656	21,108	51,667	548	2,459	562	4	-	13,823	4,157	416,023	62,560	43,635	13,731	459,658	76,292	535,950
GR(2025-30)	7.21%	7.21%	3.92%	3.92%	8.33%	8.33%	4.48%	4.48%	6.94%	6.76%	0.00%		6.25%	6.25%	6.93%	7.21%	8.33%	8.33%	7.05%	7.41%	7.10%
2030-31	237,695	33,543	19,510	4,809	114,448	22,865	53,632	569	2,609	596	4	-	14,623	4,397	442,521	66,780	47,267	14,874	489,788	81,654	571,441
2031-32	252,377	35,615	20,277	4,998	123,986	24,770	55,744	592	2,765	631	4	-	15,460	4,649	470,613	71,255	51,205	16,114	521,819	87,369	609,187
2032-33	267,773	37,788	21,064	5,191	134,323	26,835	57,981	616	2,930	668	4	-	16,338	4,913	500,412	76,011	55,475	17,457	555,887	93,469	649,355
2033-34	283,945	40,070	21,934	5,406	145,523	29,073	60,330	640	3,102	707	4	-	17,267	5,193	532,107	81,089	60,100	18,913	592,208	100,002	692,210
2034-35	300,956	42,471	22,828	5,626	157,659	31,498	62,789	667	3,284	748	4	-	18,244	5,486	565,763	86,495	65,112	20,490	630,875	106,985	737,860
GR(2030-35)	6.12%	6.12%	4.02%	4.02%	8.33%	8.33%	3.98%	3.98%	5.96%	5.86%	0.00%		5.71%	5.71%	6.34%	6.69%	8.33%	8.33%	6.54%	7.00%	6.60%
GR(2010-35)	8.52%	8.66%	5.56%	5.86%	8.27%	8.39%	6.62%	6.79%	9.11%	8.98%	-0.59%		6.97%	7.40%	7.99%	8.22%	8.29%	8.29%	8.02%	8.23%	8.05%

Note: Energy Shed in the base year has been added in the major customer categories proportionally

Source Electricity Demand Forecast based on Multiple Regression Analysis, Planning Power NTDC, February 2011

Table 5.2-6 Load Forecast for PEPCO, KESC, and Both

Year		PEPCO			KESC			PEPCO + KESC			Self Generation			Country	
	Sale (GWh)	Generation (GWh)	Peak (MW)	Sale (GWh)	Generation (GWh)	Peak (MW)	Sale (GWh)	Generation (GWh)	Peak (MW)	Sale (GWh)	Generation (GWh)	Peak MW	Sale (GWh)	Generation (GWh)	Peak MW
Base Year (Recorded)															
2009-10	68,873	90,052	13,445	9,905	15,805	2,082	78,778	105,857	15,386	11,687	12,433	2,028	90,465	118,290	17,413
Base Year (Computed)															
2009-10	82,868	108,351	17,847	12,014	19,170	2,562	94,882	127,521	20,223	11,687	12,433	2,028	106,569	139,954	22,251
Future Projections															
2010-11	89,711	115,902	19,115	13,457	20,970	2,827	103,168	136,873	21,743	12,384	13,174	2,148	115,552	150,047	23,891
2011-12	97,470	124,415	20,547	14,589	22,215	3,021	112,058	146,630	23,353	13,225	14,069	2,294	125,283	160,699	25,648
2012-13	106,111	133,839	22,133	15,864	23,617	3,240	121,975	157,456	25,142	14,213	15,121	2,466	136,188	172,577	27,608
2013-14	115,806	144,356	23,904	17,284	25,169	3,484	133,090	169,525	27,139	15,365	16,346	2,666	148,455	185,871	29,804
2014-15	126,881	156,329	25,921	18,902	26,938	3,762	145,783	183,267	29,414	16,695	17,761	2,896	162,478	201,028	32,310
G.R. (2010-15)	8.89%	7.61%	7.75%	9.49%	7.04%	7.99%	8.97%	7.52%	7.78%	7.39%	7.39%	7.39%	8.80%	7.51%	7.75%
2015-16	139,180	171,483	28,472	20,697	29,496	4,157	159,877	199,607	32,332	18,171	19,331	3,152	178,048	218,938	35,485
2016-17	152,603	184,387	30,656	22,653	32,282	4,592	175,256	216,669	34,927	19,790	21,053	3,433	195,045	237,722	38,360
2017-18	167,096	199,966	33,291	24,771	35,301	5,067	191,867	235,267	38,009	21,545	22,920	3,738	213,411	258,186	41,747
2018-19	182,663	218,013	36,344	27,056	38,558	5,587	209,719	256,571	41,549	23,453	24,950	4,069	233,172	281,521	45,618
2019-20	199,113	237,646	39,671	29,476	42,007	6,144	228,589	279,653	45,398	25,516	27,145	4,427	254,105	306,797	49,824
G.R. (2015-20)	9.43%	8.74%	8.88%	9.29%	9.29%	10.31%	9.41%	8.82%	9.07%	8.85%	8.85%	8.85%	9.36%	8.82%	9.05%
2020-21	216,802	258,759	43,253	32,086	45,726	6,752	248,888	304,485	49,550	27,731	29,501	4,811	276,619	333,986	54,361
2021-22	235,545	281,129	47,056	34,860	49,679	7,406	270,405	330,808	53,967	30,110	32,032	5,224	300,515	362,840	59,190
2022-23	255,307	304,715	51,073	37,796	53,863	8,107	293,102	358,578	58,642	32,685	34,771	5,670	325,787	393,349	64,313
2023-24	276,025	329,442	55,293	40,897	58,283	8,859	316,922	387,726	63,568	35,456	37,719	6,151	352,378	425,445	69,719
2024-25	297,657	355,260	59,707	44,160	62,934	9,660	341,817	418,194	68,736	38,456	40,910	6,672	380,273	459,104	75,408
G.R. (2020-25)	8.37%	8.37%	8.52%	8.42%	8.42%	9.47%	8.38%	8.38%	8.65%	8.55%	8.55%	8.55%	8.40%	8.40%	8.64%
2025-26	320,028	381,961	64,282	47,562	67,782	10,509	367,590	449,743	74,110	41,683	44,343	7,231	409,273	494,086	81,342
2026-27	343,186	409,601	69,027	51,121	72,853	11,409	394,307	482,454	79,705	45,173	48,056	7,837	439,480	530,510	87,542
2027-28	366,909	437,915	73,900	54,803	78,101	12,356	421,712	516,016	85,471	48,924	52,047	8,488	470,636	568,062	93,958
2028-29	391,193	466,898	78,898	58,614	83,532	13,351	449,807	550,430	91,410	52,978	56,359	9,191	502,785	606,789	100,601
2029-30	416,023	496,534	84,021	62,560	89,155	14,399	478,583	585,689	97,524	57,367	61,029	9,952	535,950	646,718	107,477
G.R. (2025-30)	6.93%	6.93%	7.07%	7.21%	7.21%	8.31%	6.96%	6.97%	7.25%	8.33%	8.33%	8.33%	7.10%	7.09%	7.34%
2030-31	442,521	528,160	89,495	66,780	95,168	15,532	509,301	623,328	104,071	62,141	66,107	10,781	571,441	689,435	114,852
2031-32	470,613	561,689	95,307	71,255	101,546	16,749	541,868	663,235	111,037	67,319	71,616	11,679	609,187	734,851	122,716
2032-33	500,412	597,254	101,481	76,011	108,325	18,059	576,424	705,579	118,453	72,932	77,587	12,653	649,355	783,166	131,106
2033-34	532,107	635,083	108,057	81,089	115,561	19,475	613,197	750,644	126,372	79,013	84,056	13,708	692,210	834,701	140,080
2034-35	565,763	675,253	115,050	86,495	123,265	21,002	652,258	798,517	134,814	85,602	91,066	14,851	737,860	889,583	149,665
G.R. (2030-35)	6.34%	6.34%	6.49%	6.69%	6.69%	7.84%	6.39%	6.40%	6.69%	8.33%	8.33%	8.33%	6.60%	6.58%	6.85%
G.R. (2010-35)	7.99%	7.59%	7.74%	8.22%	7.73%	8.78%	8.02%	7.61%	7.88%	8.29%	8.29%	8.29%	8.05%	7.68%	7.92%

Note: The sum of PEPCO and KESC Demand (MW) is divided by a diversity factor of 1.009.

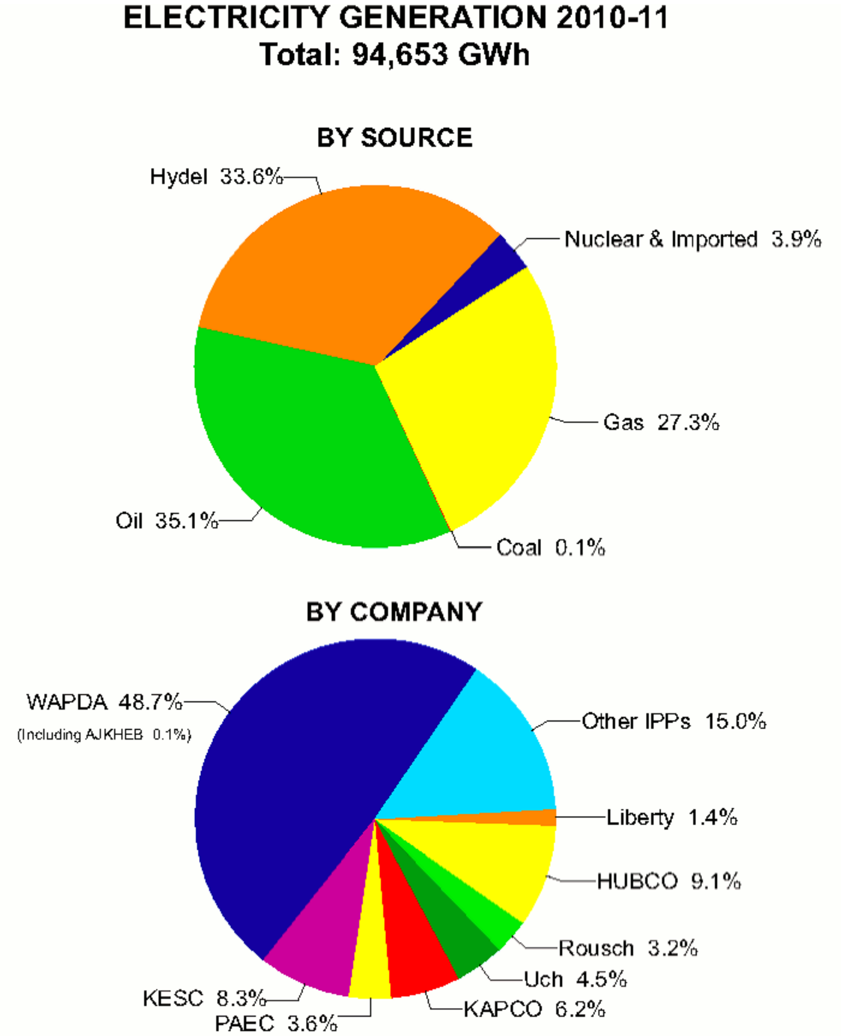
Self Generation demand (MW) is calculated by assuming auxiliary losses of 6% and a load factor of 70% .

Source Electricity Demand Forecast based on Multiple Regression Analysis, Planning Power NTDC, February 2011

5.3 Latest Power Source Development Plan

(1) Present Power Sources

According to the national electricity generation statistics of 2011, the total generation of Pakistan was 94,653 GWh in 2011. Three power sources i.e., hydel, thermal, and nuclear are used for generation of electricity by WAPDA, KESC, and IPPs. The contribution of electric sources as well as the allocation of electricity generation by source with corresponding percentage is given in **Figure 5.3-1**.



Source: Pakistan Energy Yearbook 2011, HDIP Pakistan

Figure 5.3-1 Electricity Generation Capacity by Source

There are three power sources i.e., thermal, hydro, and nuclear. Thermal power plants have a maximum share of nearly 63% of the overall electricity generation, whereas 34% is achieved by hydro power. The remaining 3%-4 % of electricity generated is by nuclear power plants.

The hydro power stations are mostly owned and operated by WAPDA, a public sector organization.

The thermal power plants are owned and operated by public sectors, private sectors or partnership of both. The Hub Power Company (HUBCO) is a thermal fuel-based (oil) power station located in Tehsil Hub, Lasbela District, Balochistan province, and is owned by the first and largest IPP in Pakistan with a gross generation capacity of 1,292 MW. Kot Addu Power Company Limited (KAPCO) is an IPP owned thermal fuel-based (gas) power station with gross generation capacity of 1,638 MW, and is located in Kot Addu, Muzaffargarh District in Punjab province. Liberty Power Project is an IPP owned thermal fuel-based (natural gas) with gross capacity of 235 MW located in Daharki, Ghotki District, Sindh province. Also, Rousch Power Project is an IPP owned thermal fuel-based (oil) with gross generation capacity of 412 MW located in Abdul Hakeem, Khanewal District, Punjab province. Furthermore, Uch Power Project is an IPP owned thermal fuel-based (gas) with gross generation capacity of 586 MW located in Dera Murad Jamali, Nasirabad District, Balochistan province.

Karachi Electric Supply Company (KESC) is a privatized company which owns and operates thermal power plants consisting of Bin Qasim-1 Power Station, Korangi Combined Cycle Power Plant, 560 MW BQPS II Combined Cycle Power Plant, Korangi Thermal Power Plant, Korangi Gas Engine Power Plant, and Site Gas Engine Power Plant.

Pakistan Atomic Energy Commission (PAEC) currently operates three nuclear power plants i.e., Karachi Nuclear Power Plant (KANUPP-I) and Chashma Nuclear Power Complex (CHASNUPP-I and II) with a total gross generation capacity of approximately 800 MW.

(2) Government Planned Projects

There are three thermal power plant projects initiated by the public sector, namely, the 425 MW Nandipur Power Plant, 475 MW Chicho-ki-malian Power Plant, and 747 MW Guddu Power Plant. Moreover, Uch-II Project with 404 MW installed capacity is in the pipeline and expected to be commissioned in 2013. GOP also plans for the rehabilitation of public sector thermal power plants i.e., Generation Company (GENCOs I-IV) which will recapture total generation capacity of 1,220 MW.

The GOP constituted Thar Coal and Energy Board (TCEB) for facilitating investment in large scale coal mining and coal gasification in Thar District, Sindh province. GOP agreed to provide an initial funding of Rs.900 million to the Thar Coal Gasification Project for generating coal gas-based power of 100 MW on experimental basis. The Thar District has immense coal resources with sufficient generation capacity of 100,000 MW of electricity for 30 years.

The Pakistan Atomic Energy Commission (PAEC) has also started CHASNUPP-III and CHASNUPP-IV nuclear power plant projects which would be set up near the already existing CHASNUPP-I and II nuclear power plants, located in the district of Mianwali, Punjab province.

In the hydro power sector, GOP has initiated major public sector projects consisting of 960 MW Neelum-Jhelum, 1,350 MW Tarbela 4th Extension, 4,500 MW Diamer-Bhasha Dam, and 740 MW Munda Dam.

(3) IPP Planned Projects

The Private Power Infrastructure Board (PPIB) is responsible for approving IPP projects that have installed capacity greater than 50 MW for all technologies.

Table 5.3-1 shows the on-going power generation projects by IPP with planned capacity, investment, expected commercial operations date (COD), and latest status of each project.

There are various hydro power projects of the private sector in the implementation phase such as 840 MW Suki Kinari, 720 MW Karot, 84 MW New Bong Escape Hydroelectric Power Complex, 147 MW Patrind located in the Jammu and Kashmir State of Pakistan. The bulk of the hydro power projects are expected to achieve COD in the next 2-3 years.

The RE projects pursued by the private sector in close collaboration with AEDB can be found in the solar/wind power project section.

Table 5.3-1 On-going Private Sector Power Generation Projects

S #	Name of the Project	Capacity (MW)	Investments (Million US$)	Achieved/Expected COD	Latest Status of the Project
A:	OIL/BAGASSE				
1	Attock Gen Power Project	156	177	Achieved on 17th March, 2009	Commissioned
2	Sheikhupura (Atlas) Power Project	214	227	Achieved on 18th December, 2009	Commissioned
3	Nishat Power Project	196	235	Achieved on 9th June, 2010	Commissioned
4	Nishat Chunian Power Project	196	237	Achieved on 21st July, 2010	Commissioned
5	Liberty Power Tech Project	196	241	Achieved on 13th January, 2011	Commissioned
6	HUBCO - Narowal Project	214	288	Achieved on 22nd April, 2011	Commissioned
7	Radian Power Project	150	200	December, 2014	Tariff determined by NEPRA
8	Grange Holding PowerProject	147	251	December, 2014	Under process
9	Gulf-II Power Project	75	75	-	Project registered for processing
10	Attock Oil Power Project	200	200	-	Project registered for processing
11	Asia Petroleum Power Project	90	90	-	Project registered for processing
12	Kohinoor Energy Project	70	70	-	Project registered for processing
13	Technovision Power Project	175	175	-	Project registered for processing
14	SKANS Power Project	90	90	-	Project registered for processing
B:	PIPELINE QUALITY GAS/DUAL-FUEL/LNG				
15	Sahiwal (Saif) Power Project	209	247	Achieved on 30th April, 2010	Commissioned
16	Orient Power Project	213	190	Achieved on 24th May, 2010	Commissioned
17	Muridke (Sapphire) Power Project	212	245	Achieved on 5th October, 2010	Commissioned
18	Bhikki (Halmore) Power Project	209	261	Achieved on 16th June, 2011	Commissioned
19	Odean Power Project	140	140	-	Project registered for processing
C:	DEDICATED GAS FIELDS				
20	Engro Power Project	217	189	Achieved on 27th March, 2010	Commissioned
21	Fauji Daharki Power Project	177	217	Achieved on 16th May, 2011	Commissioned
22	Star Thermal Power Project	126	196	December, 2014	Financial close in progress
23	Uch-II Power Project	375	494	December, 2013	Under construction
24	Kandra Power Project	120	90	June, 2015	Under process
D:	HYDEL				
25	New Bong Escape Hydel Project	84	215	May, 2013	Under construction
26	Patrind Hydropower Project	147	362	December, 2014	Under construction
27	Gulpur Hydropower Project	100	159	June, 2015	Project under financial closing
28	Rajdhani Hydropower Project	132	171	December, 2015	Project under financial closing
29	Kotli Hydropower Project	100	170	June, 2016	Project under financial closing
30	Suki Kinari Hydropower Project	840	1,081	December, 2017	Project under financial closing
31	Sehra Hydel Project	130	344	December, 2015	Under process
32	Karot Hydel Project	720	1,470	June, 2016	Under process
33	Madian Hydropower Project	157	438	June, 2016	Under process
34	Asrit-Kedam Hydel Project	215	405	December, 2016	Under process
35	Kohala Hydropower Project	1,100	2,498	December, 2017	Under process
36	Shogosin Hydropower Project	132	190	December, 2017	Under process
37	Shushgai Zhendoli Hydel Project	144	156	December, 2017	Under process
38	Azad Patan Hydel Project	222	278	December, 2016	Under process
39	Chakothi-Hattian Project	500	1,177	December, 2016	Under process
40	Kaigah Hydel Project	548	822	December, 2017	Under process
E:	COAL				
41	JDW Cogeneration Project	80	80	December, 2014	Under process
42	AES Imported Coal Project	1,200	2,011	June, 2015	Under process
43	Ramzan Cogeneration Project	100	100	June, 2015	Under process
44	Janpur Cogeneration Project	60	60	December, 2015	Under process
45	Fatima Cogeneration Project	100	100	June, 2016	Under process
46	Chishtia Cogeneration Project	65	65	December, 2016	Under process
47	Dewan Cogeneration Project	120	120	December, 2016	Under process
F:	NAPHTHA				
48	Gulf Power Project	241	241	-	Project registered for processing
49	Fatima Power Project	163	163	-	Project registered for processing

Source: "State of Industry Report-2011", NEPRA

5.4 Latest Grid Expansion Plan

NTDC and KESC are the only two companies engaged in the electric power transmission in the whole country. KESC is responsible for the generation, transmission, and distribution of electric power in Karachi City and its suburb area whereas transmission of electric power for the rest of the country is done by the state owned NTDC. The network of transmission lines and grid stations in the range of 500 kV, 220 kV, and 132 kV is owned by NTDC while few 132 kV and lower grid stations are owned by local DISCOs.

(1) NTDC Transmission Lines and Grid Stations

The existing NTDC owned transmission lines and grid stations in 2007 to 2011 is given in **Table 5.4-1**. The list of the NTDC approved on-going development projects of the national grid is given in **Table 5.4-2**.

Table 5.4-1 Existing NTDC Transmission Lines and Grid Stations

Transmission Lines			
	500 kV (Circuit- km)	220 kV (Circuit- km)	Total Transmission Line (Circuit-k m)
2007	4,712	7,318	12,030
2008	4,748	7,318	12,066
2009	5,078	7,325	12,403
2010	5,108	7,337	12,445
2011	5,023	7,765	12,788

Grid Stations					
	500 kV		220 kV		Total No. of Grid Station
	No. of Grid Station	MVA Capacity	No. of Grid Station	MVA Capacity	
2007	10	11,400	26	10,403	36
2008	11	12,000	26	11,190	37
2009	12	13,800	26	14,829	38
2010	12	14,850	27	15,744	39
2011	12	15,990	29	15,762	41

Note: As of June 30 in each year

Source: "State of Industry Report-2011", NEPRA

Table 5.4-2 NTDC's On-going Development Projects

S#	Name of New Sub-Station	T/F Capacity (MVA)	Associated Transmission Lines	Expected Commissioning
1	Ext. at 500 kV, Sheikh Muhammadi	1 x 450	-	31-07-2011
2	Ext. at 500 kV, Tarbela	1 x 237	-	31-07-2011
3	Ext. at 220 kV, Bannu	1 x 160	-	December, 2012
4	Augmentation of 220 kV at NKLP, Lahore	3 x 250	-	T1: December 2011, T2 & T3: Commissioned
5	Upgradation of existing 132 kV to new 220 kV GIS WAPDA Town, Lahore	3 x 160	220 kV Lahore - KLP D/C in/out at WAPDA Town (10+10 km)	June, 2011
6	New 220 kV GIS, Bandala	2 x 160	220 kV Gatti - KSK D/C in/out at Bandala (5+5 km)	December, 2011
7	Installation of SVCs at 220 kV NKLP, Lahore	SVCs	SVC of appropriate capacity	June, 2012
8	Looping in/out of 220 kV Gazi Barotha-S/Bagh T/L at Mardan	-	Looping in and out of one circuit of Ghazi Barotha - Shahi Bagh at Mardan (30 km)	31-07-2011
9	Extension/Augmentation at existing substations:		-	December, 2011
a)	500 kV, Dadu	1x450 & 1x160		
b)	220 kV, Burhan	1 x 160		
c)	220 kV Mardan	1 x 250		
d)	500 kV, Sheikh Muhammadi	1 x 160		
e)	500 kV, New Rewat	1 x 250		
f)	220 kV, Shikarpur	1 x 160		Commissioned
10	220 kV, Okara	3 x 250	22 kV Yousafwala - Sarfaraz Nagar D/C in/out at Okara (5+5 km)	December, 2011
11	220 kV, Toba Tak Singh/Gojra	3 x 250	220 kV Faisalabad - Multan D/C in/out at TT Singh/Gojra (1+1 km)	December, 2011
12	Installation of Static Var Compensators at Quetta	SVC	SVC of appropriatecapacity	December, 2013
13	Ext. at Ghazi Barotha for addition of 600 MVA 500/220 kV T/F	1 x 600	-	31-07-2011
14	220 kV, Loralai	2 x 250	220 kV DG Khan - Loralai (250 km)	June, 2012
15	Augmentation of 220 kV Ravi at Lahore	3 x 250		20-04-2011
16	500 kV DG Khan Substation	2x600 & 2x250	500 kV Guddu - Multan 2nd CCT in/out at DG Khan substation (20+20 km)	June, 2013
17	220 kV Rohri New for interconnection of IPPs at Engro Energy PP and Mari (Daharki) CCPP	2 x 250	22 0 kV D/C T/L Daharki CCPP - Rohri New (115 km)	January, 2012
			132 kV D/C T/L for in/out of Rohri-Khairpur/Gambat D/C T/L at Rohri New (1+1 km)	
			220 kV D/C Rohri New - Shikarpur T/L (50 km)	
			220 kV D/C T/L for in/out of Daharki-Rohri New at Engro CCPP (5+5 km)	
			132 kV Rohri New - Gambat D/C T/L (53 km)	
18	220 kV Grid Station, Khuzdar	2 x 160	220 kV D/C Dadu - Khuzdar Transmission Line (300 km)	February, 2012
19	220 kV Grid Station at Ghazi Road, Lahore	3 x 160	220 kV D/C T/L for in/out of NKLP - Sarfaraz Nagar at Ghazi Road (30 km)	June, 2012
			220 kV D/C T/L for in/out of Ravi KSK at Ghazi Road (30 km)	
20	220 kV Grid Station at Kassowal along with associated 220 kV D/C T/Lines	2 x 160	220 kV D/C T/L for in/out of Vehari-Yousafawal at Kassowal (45+45 km)	December, 2011
21	220 kV GIS Substation at Gwadar	2 x 160	220 kV D/C T/L from Pak-Iran Boarder to Gwadar (100 km)	December, 2012
22	500 kV R.Y.Khan	2 x 600	500 kV Guddu - Multan 3rd Circuit in/out at RYK (30+30 km)	December, 2012
23	220 kV GIS Shalamar (Mehmood Buti)	3 x 250	220 kV Ravi-KSK D/C in/out at Shalamar (9 km long overhead T/L and 3+3 km Cable)	December, 2011

Source:" State of Industry Report 2011", NEPRA

(2) KESC Transmission Lines and Grid Stations

KESC owned transmission system of transmission lines and grid stations from year 2007-2011, which are given in **Table 5.4-3**.

Table 5.4-3 KESC Transmission Lines and Grid Stations

Length of Transmission Lines											
		2006-07		2007-08		2008-09		2009-10		2010-11	
		km		km		km		km		km	
Overhead Lines	220 kV	312		312		321		321		321	
	132 kV	592		598		602		604		n.p.	
	66 kV	164		150		149		149		n.p.	
Underground Lines	220 kV	14		16		16		17		17	
	132 kV	73		88		113		120		n.p.	
	66 kV	3		3		0		0		n.p.	
Number of Grid Stations in KESC Transmission System											
		2006-07		2007-08		2008-09		2009-10		2010-11	
		No.	MVA	No.	MVA	No.	MVA	No.	MVA	No.	MVA
KESCs	220 kV	7	2,750	7	3,000	7	3,000	7	3,000	7	3,000
Owned Grid	132 kV	40	3,574	40	3,853	46	4,223	48	4,363	n.p.	n.p.
Stations	66 kV	4	193	3	60	3	60	3	60	n.p.	n.p.
Consumers	220 kV	-	0	1	40	1	40	1	40	1	40
Owned Grid	132 kV	1	20	1	20	5	20	5	20	n.p.	n.p.
Stations	66 kV	-	0	-	0	3	60	3	60	n.p.	n.p.
Total No. of Grid Station		52	6,537	52	6,973	65	7,403	67	7,543	8	3,040

Source: "State of Industry Report-2011", NEPRA

5.5 Latest Tariff Structure

NEPRA is the focal federal agency in the country for determining rates and tariff for all generation, transmission, and distribution companies to supply electricity to the customers.

(1) Tariff Structure between Electric Utilities and Consumers

The Ministry of Water and Power issued the notification of the amendments in the tariff structure between Distribution Companies (DISCOs) and consumers on May 16, 2012. DISCO is an electricity service provider at the district level. The details of DISCO and its license holders are shown in **Appendix A-3-3**.

The tariff structure of the residential, commercial, industrial, and agriculture sectors for all DISCOs and KESC, as of May 2012, is shown in **Tables 5.5-1** and **5.5-2**, respectively.

Table 5.5-1 NEPRA's Tariff Notification for All DISCOs

Description	5/16/2012	
	Fix Rate	Var Rate
DOMESTIC		
DOMSTIC A-1A(01) 50 UNITS		2.00
1-100 UNITS		5.79
101-300 UNITS		8.11
301-700 UNITS		12.33
ABOV-700 UNITS		15.07
A-1B(03)T PEAK		13.99
A-1B(03)T OFF-PEAK		8.22
E-1i(55) TEMP.		15.50
COMMERCIAL		
COMMERCIAL A-2A (04)		14.77
A-2B(05)	400	9.72
A-2C(06)T PEAK	400	13.20
A-2C(06)T OFF-PEAK	400	8.01
E-1ii(56) TEMP.		15.00
INDUSTRIAL		
INDUSTRIAL B-1(07)		10.51
B-1(09)T PEAK		13.99
B-1(09)T OFF-PEAK	0	8.22
B-2A(10)	400	9.14
B-2B(12)T PEAK	400	12.77
B-2B(12)T OFF-PEAK	400	8.01
B-3(14)T PEAK	380	12.68
B-3(14)T OFF-PEAK	380	7.75
B-4(17)T PEAK	360	12.37
B-4(17)T OFF-PEAK	360	7.46
E-2(58) TEMP.		11.50
BULK SUPPLY		
BULK SUPPLY C-1A(19)		11.55
C-1B(25)	400	10.35
C-1C(26)T PEAK	400	13.01
C-1C(26)T OFF-PEAK	400	8.01
C-2A(28)	380	10.25
C-2B(29)T PEAK	380	12.60
C-2B(29)T OFF-PEAK	380	7.75
C-3B(38)T	360	10.10
C-3B(38)T PEAK	360	12.18
C-3B(38)T OFF-PEAK	360	7.35
AGRICULTURE		
AGRICULTURE D-1A		10.00
D-2	120	6.77
D-1B(T) PEAK	200	13.00
D-1B(T) OFF-PEAK	200	8.00
PUBLIC LIGHT PVT G(72,73)		13.73
RESI. COLONIES H(76,79)		12.92
AJK TARIF K-1 (35)	360	5.63
RAWAT LABORATORY K-2 (15)		11.50

Source: Website of NEPRA (Tariff Section) (http://www.nepra.org.pk/tariff.htm)

Table 5.5-2 MoWP's Tariff Notification for KESC

SCHEDULE OF ELECTRICITY TARIFFS
KARACHI ELECTRIC SUPPLY COMPANY (KESC)

A-1 GENERAL SUPPLY TARIFF - RESIDENTIAL

Sr. No.	TARIFF CATEGORY / PARTICULARS	FIXED CHARGES Rs/kW/M	VARIABLE CHARGES Rs/kWh	
a)	For Sanctioned load less than 5 kW			
i	Up to 50 Units	-		2.00
	For Consumption exceeding 50 Units			
ii	001 - 100 Units	-		5.79
iii	101 - 300 Units	-		8.11
iv	301 - 700 Units	-		12.33
v	Above 700 Units	-		15.07
b)	For Sanctioned load 5 kW & above		Peak	Off-Peak
	Time Of Use	-	13.99	8.22

Under tariff A-1, there shall be minimum monthly charges at the following rates even if no energy is consumed.

a) Single Phase Connections: Rs. 75/- per consumer per month
b) Three Phase Connections: Rs. 150/- per consumer per month

A-2 GENERAL SUPPLY TARIFF - COMMERCIAL

Sr. No.	TARIFF CATEGORY / PARTICULARS	FIXED CHARGES Rs/kW/M	VARIABLE CHARGES Rs/kWh	
a)	For Sanctioned load less than 5 kW	-		14.77
b)	For Sanctioned load 5 kW & above	400.00		9.72
			Peak	Off-Peak
c)	Time Of Use	400.00	13.20	8.01

Under tariff A-2, there shall be minimum monthly charges at the following rates even if no energy is consumed.

a) Single Phase Connections; Rs. 175/- per consumer per month
b) Three Phase Connections: Rs. 350/- per consumer per month

B INDUSTRIAL SUPPLY TARIFFS

Sr. No.	TARIFF CATEGORY / PARTICULARS	FIXED CHARGES Rs/kW/M	VARIABLE CHARGES Rs/kWh	
B1	Less than 5 kW (at 400/230 Volts)	-		10.51
B2(a)	5-500 kW (at 400 Volts)	400.00		9.14
B3(a)	For all loads upto 5000 KW (at 11,33 kV)	380.00		9.21
B4(a)	For all loads upto 5000 KW (at 66,132 kV)	360.00		8.65
	Time Of Use		Peak	Off-Peak
B2(b)	5-500 KW (at 400 Volts)	400.00	12.77	8.01
B3(b)	For All Loads up to 5000 kW (at 11,33 kV)	380.00	12.68	7.75
B4(b)	For All Loads (at 66,132 kV & above)	360.00	12.37	7.46
B5	For All Loads (at 220 KV & above)	340.00	10.66	7.42

For B1 consumers there shall be a fixed minimum charge of Rs. 350 per month.
For B2 consumers there shall be a fixed minimum charge of Rs. 2,000 per month.
For B3 consumers there shall be a fixed minimum charge of Rs. 50,000 per month.
For B4 consumers there shall be a fixed minimum charge of Rs. 500,000 per month.
For B5 consumers there shall be a fixed minimum charge of Rs. 1000,000 per month.

C - SINGLE-POINT SUPPLY FOR PURCHASE IN BULK BY A DISTRIBUTION LICENSEE AND MIXED LOAD CONSUMERS NOT FALLING IN ANY OTHER CONSUMER CLASS

Sr. No.	TARIFF CATEGORY / PARTICULARS	FIXED CHARGES Rs/kW/M	VARIABLE CHARGES Rs/kWh	
C -1	For supply at 400/230 Volts			
a)	Sanctioned load less than 5 kW	-		11.55
b)	Sanctioned load 5 kW & up to 500 kW	400.00		10.35
C -2(a)	For supply at 11,33 kV up to and including 5000 kW	380.00		10.25
C -3(a)	For supply at 132 kV & above, upto and including 5000 kW	360.00		10.10
	Time Of Use		Peak	Off-Peak
C -1(c)	For supply at 400/230 Volts 5 kW & up to 500 kW	400.00	13.01	8.01
C -2(b)	For supply at 11,33 kV up to and including 5000 kW	380.00	12.60	7.75
C -3(b)	For supply at 66 kV & above and sanctioned load above 5000 kW	360.00	12.18	7.35

D - AGRICULTURE TARIFF

Sr. No.	TARIFF CATEGORY / PARTICULARS	FIXED CHARGES Rs/kW/M	VARIABLE CHARGES Rs/kWh	
D-1	For all Loads	200.00		10.00
			Peak	Off-Peak
D-2	For all Loads	200.00	19.22	11.22

Under this tariff, there shall be minimum monthly charges of Rs.350/- per consumer per month, even if no energy is consumed.
Note:- The consumers having sanctioned load less than 5 kW can opt for TOU metering.

E - TEMPORARY SUPPLY TARIFFS

Sr. No.	TARIFF CATEGORY / PARTICULARS	FIXED CHARGES Rs/kW/M	VARIABLE CHARGES Rs/kWh
E-1(i)	Residential Supply	-	17.76
E-1(ii)	Commercial Supply	-	20.66
E-2(i)	Industrial Supply	-	17.36
E-2(ii)	Bulk Supply at 400 Volts		17.76
E-2(ii)	Bulk Supply at 11 KV	-	17.36

For the categories of E-1(i&ii) above, the minimum bill of the consumers shall be Rs. 50/- per day subject to a minimum of Rs.500/- for the entire period of supply, even if no energy is consumed.

F - SEASONAL INDUSTRIAL SUPPLY TARIFF

125% of relevant industrial tariff

Note:

Tariff-F consumers will have the option to convert to Regular Tariff and vice versa. This option can be exercised at the time of a new connection or at the beginning of the season. Once exercised, the option remains in force for at least one year.

G- PUBLIC LIGHTING

Sr. No.	TARIFF CATEGORY / PARTICULARS	FIXED CHARGES Rs/kW/M	VARIABLE CHARGES Rs/kWh
	Street Lighting		13.73

Under Tariff G, there shall be a minimum monthly charge of Rs.500/- per month per kW of lamp capacity installed.

H - RESIDENTIAL COLONIES ATTACHED TO INDUSTRIAL PREMISES

Sr. No.	TARIFF CATEGORY / PARTICULARS	FIXED CHARGES Rs/kW/M	VARIABLE CHARGES Rs/kWh
	Residential Colonies attached to industrial premises	-	12.92

Source: S.R.O 511 (1)/2012, Ministry of Water and Power, Islamabad 16th May, 2012
Note: S.R.O. means "Statutory Regulatory Order".

The tariff for various sectors of the economy i.e., domestic, commercial, industrial, bulk supply, and agriculture also varies. The domestic households or residential tariff starts from Rs.5.79 for the first 100 electrical units (kWh) consumed and goes up to Rs.15.07 for consumption above 700 units. If the total monthly consumption is below 50 units, the tariff is set at Rs.2.0. Moreover, the tariff rate during peak and off-peak time of the day also varies.

(2) Tariff Structure between Generation and Distribution Companies

NEPRA determines tariff for all generation companies (GENCO) based on the rate of return (cost plus basis) for long term, mostly 20-30 years of Power Purchase Agreements (PPA). It determines tariff at the feasibility study (FS) stage, engineering procurement and construction (EPC) stage, and COD stage[17] with an IRR in the range of 15%-18% for projects using thermal, nuclear, hydro, and renewable technologies[18].

(3) Upfront Tariff for Renewable

In addition to the tariff determined by cost plus basis, NEPRA gives provision for relevant agencies (AEDB, PPIB, and etc.) to file petition to NEPRA, for an upfront tariff to a specific technology for which the investor may opt directly. NEPRA itself can also take action by announcing an upfront tariff. In this regard, NEPRA has already announced an upfront tariff for wind energy projects[19].

5.6 Position of Renewable Energy in National Policy of Electricity Development

GOP intends to work on new projects based on large hydro, indigenous fuel-based, and renewable energy sources. In line with that, GOP established the AEDB for exploiting renewable energy resources and attracting local/foreign investments to the projects.

5.7 Other Plans and Information for Electricity Development

GOP is giving incentives to respective private sector for the development of hydro power projects in all potential sites of the country. The hydro power projects with cumulative installed capacity of 13,105 MW, which are expected to achieve COD in the next 6-7 years, are in the pipeline. Moreover, GOP is also working on major hydro power plant projects in the public sector with total installed capacity of 7550 MW.

Pakistan has immense coal reservoir in the Thar District sufficient for generating 100,000 MW of electricity for 30 years, the development of which would provide long term energy security to the country. The Government of Sindh has entered into joint ventures with foreign/local firms to develop and execute a pilot project of coal gasification. Upon the success of the initial pilot project, this will be scaled to a bigger capacity coal gas electricity generation project.

[17] Tariff may be determined at various stages of the project because of the escalation of the project equipment and/or fuel cost.
[18] Annual Report 2010-11, NEPRA
[19] Annual Report 2010-11, NEPRA

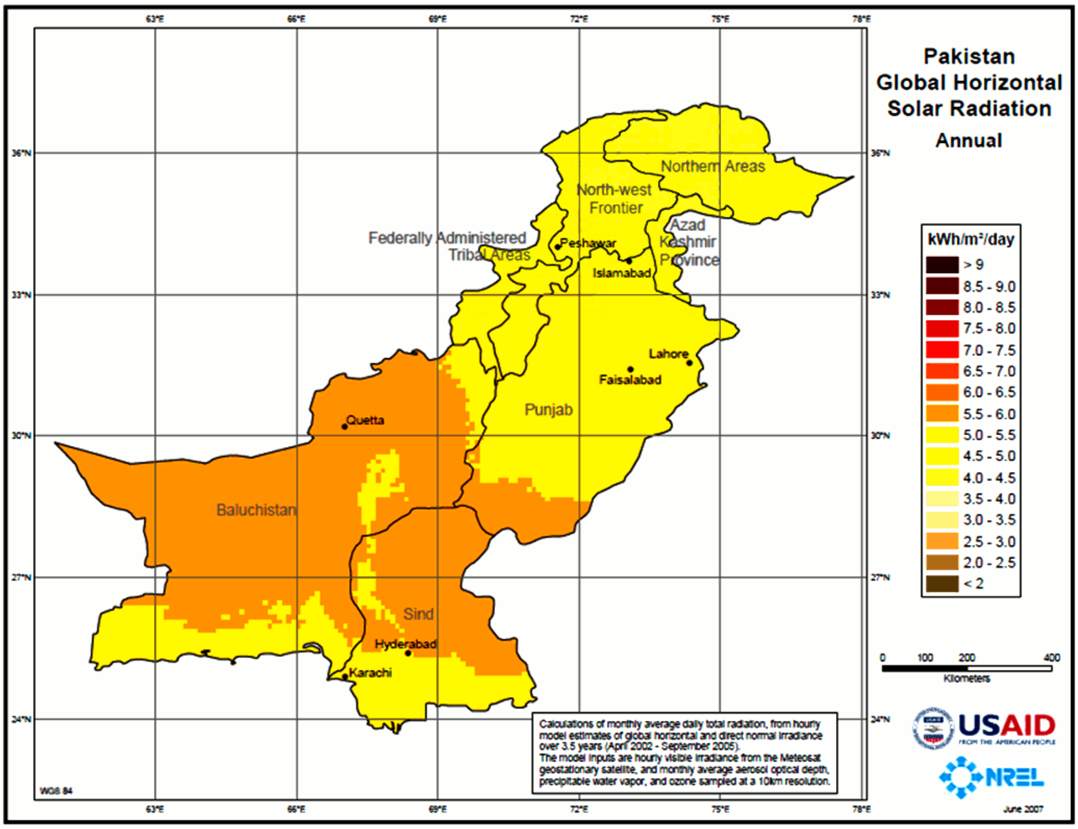
CHAPTER 6 PRESENT SITUATION AND FUTURE PROSPECTS OF RENEWABLE ENERGY PROJECT

6.1 Potential of Renewable Energy

6.1.1 Solar Power Potential

Pakistan lies within latitude 23.45º to 36.75ºN and longitude 61º to 75.5ºE. The Renewable Energy Policy 2006 of AEDB explains that, generally, the entire Pakistan has a high potential for solar energy. Baluchistan, Sindh and Southern Punjab, especially, receive solar radiation of over 2 MWh/m^2 per year. This means that the annual average horizontal solar radiation per day in these areas is more than 5.48 kWh/m^2. For comparison, the highest solar radiation measured in Japan is in Naha of Okinawa Prefecture, in which the annual average solar radiation is around 4.5 kWh/m^2.

In order to develop the solar map of Pakistan, the National Renewable Energy Laboratory (NREL), Golden Colorado USA in collaboration with USAID, Pakistan Meteorology Department (PMD), and AEDB have carried out detailed analysis to determine the solar energy potential in various regions of Pakistan. The developed solar map is based on the satellite data measured over the period from April 2002 to September 2005 (around 3.5 years). **Figure 6.1.1-1** below shows the global horizontal solar radiation level of Pakistan.



Source: AEDB

Figure 6.1.1-1 Global Horizontal Annual Average Solar Radiation Level in Pakistan

From the above figure, it is understood that almost the entire area of Baluchistan province, excluding the coastal area and the northeast province border area, receives 6.0 kWh/m^2 of annual average solar radiation. Northern Sindh to Southern Punjab also receives 6.0 kWh/m^2 of annual average solar radiation. In other regions such as Southern Punjab, the area from the north of Baluchistan to latitude 33ºN, and the coastal area of Pakistan receive annual average solar radiation of around 5.5 kWh/m^2. In the region below latitude 33ºN, except the northern region of North-West Frontier, Northern Areas, and the northern area of Azad Kashmir province, the annual average solar radiation is around 5.0 kWh/m^2. Thus, it can be said that most part of Pakistan receives solar radiation of more than 5.0 kWh/m^2 annually. The annual average solar radiation of Pakistan is around 5.5 kWh/m^2.

Furthermore, as potential solar power generation in Pakistan, AEDB recommends very large-scale solar power generator installation in the following areas: (i) Most part of Baluchistan province, (ii) Thal Desert and Cholistan area in Punjab province, and (iii) Thar Desert in Sindh province. In these areas, barren land is abundantly available and other development activities such as agriculture, livestock, industry, and so on are not possible. Besides the abovementioned potential areas, open spaces in public institutions such as hospitals, universities, airports, and schools are also recommended to be utilized as potential sites for the installation of medium- to large-scale solar power generation plants.

The horizontal annual average radiation data of Islamabad Capital Territory, Punjab province and Sindh province are downloaded from the National Aeronautics and Space Administration (NASA) homepage. The downloaded data show the annual average solar radiation of each latitude and longitude recorded from July 1983 to June 2005 (22 years). The downloaded horizontal solar radiation data are organized in a table and attached as **Appendix B-1** and the earth mean temperature data, which are important for system design, are also attached as **Appendix B-2**.

Even though the annual average global horizontal radiation map of Pakistan is prepared from data collected over a short period, there is not much difference when compared against the downloaded solar radiation data from the NASA website. Therefore, it can be said that the information provided by the solar map of Pakistan is useful for site selection and system design.

Table 6.1.1-1 summarizes the global horizontal annual average solar radiation, and **Table 6.1.1-2** summarizes the earth mean temperature.

Table 6.1.1-1 Global Horizontal Solar Radiation

(Unit: kWh m^{-2} day^{-1})

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Sindh Province													
Average	4.09	4.84	5.57	6.36	6.70	6.60	5.82	5.55	5.53	4.99	4.22	3.80	5.34
Minimum	3.61	4.36	4.77	5.90	6.19	5.97	4.93	4.91	5.10	4.49	3.86	3.40	
Maximum	4.68	5.26	6.14	6.87	7.15	7.14	6.32	6.06	5.91	5.41	4.59	4.24	
Punjab Province													
Average	3.42	4.25	5.09	6.03	6.67	6.78	6.00	5.60	5.31	4.70	3.80	3.20	5.07
Minimum	2.84	3.80	4.37	5.41	5.96	5.90	5.38	5.09	4.75	4.08	3.46	2.83	
Maximum	3.95	4.81	5.89	6.70	7.24	7.37	6.78	6.31	5.85	5.19	4.15	3.67	
Islamabad Capital City													
Average	3.18	3.87	4.95	6.31	7.27	7.54	6.44	5.72	5.69	5.07	3.89	2.99	5.24
Minimum	2.58	3.33	3.91	5.36	6.47	6.64	5.28	4.80	4.67	4.01	3.46	2.57	
Maximum	3.78	4.61	6.29	7.32	7.71	7.92	7.60	6.81	6.37	5.53	4.20	3.68	

Source: NASA website

Note: (1) Data also referred to as global horizontal radiation
(2) Average data for that month over 22 years period (Jul 1983 -Jun 2005)
(3) Minimum and Maximum values is calculated from provided value in percentage
(4) The minimum and maximum values for a given month indicate the difference between the year that has the least (minimum) or most (maximum) monthly averaged insolation and the 22-year monthly averaged insolation.

From the above table, it is understood that the average insolation for all three places is almost similar, which is more than 5.0 kWh/m^2.

Table 6.1.1-2 Earth Mean Temperature

(Unit: ^{O}C)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Sindh Province													
Minimum	4.8	7.2	12.3	17.7	22.3	25.2	26.4	25.3	22.3	16.5	11.4	6.7	
Maximum	39.0	43.1	50.2	53.7	57.4	57.3	52.2	49.6	52.2	49.5	45.2	40.0	
Average	21.9	25.1	31.3	35.7	39.9	41.3	39.3	37.5	37.3	33.0	28.3	23.3	26.3
Punjab Province													
Minimum	-2.2	-0.5	3.7	9.2	13.6	16.9	18.1	17.2	13.7	7.9	3.8	0.1	
Maximum	30.7	35.0	44.0	50.6	55.2	56.9	50.4	44.8	46.1	45.2	38.7	32.6	
Average	14.3	17.3	23.9	29.9	34.4	36.9	34.3	31.0	29.9	26.6	21.2	16.3	29.6
Islamabad Capital City													
Minimum	1.5	3.4	7.6	13.1	17.7	21.1	21.4	20.4	17.1	11.9	7.5	3.4	
Maximum	17.1	20.1	27.2	36.6	42.5	44.4	37.5	34.4	34.1	32.0	26.7	20.2	
Average	9.3	11.7	17.4	24.9	30.1	32.8	29.5	27.4	25.6	22.0	17.1	11.8	21.4

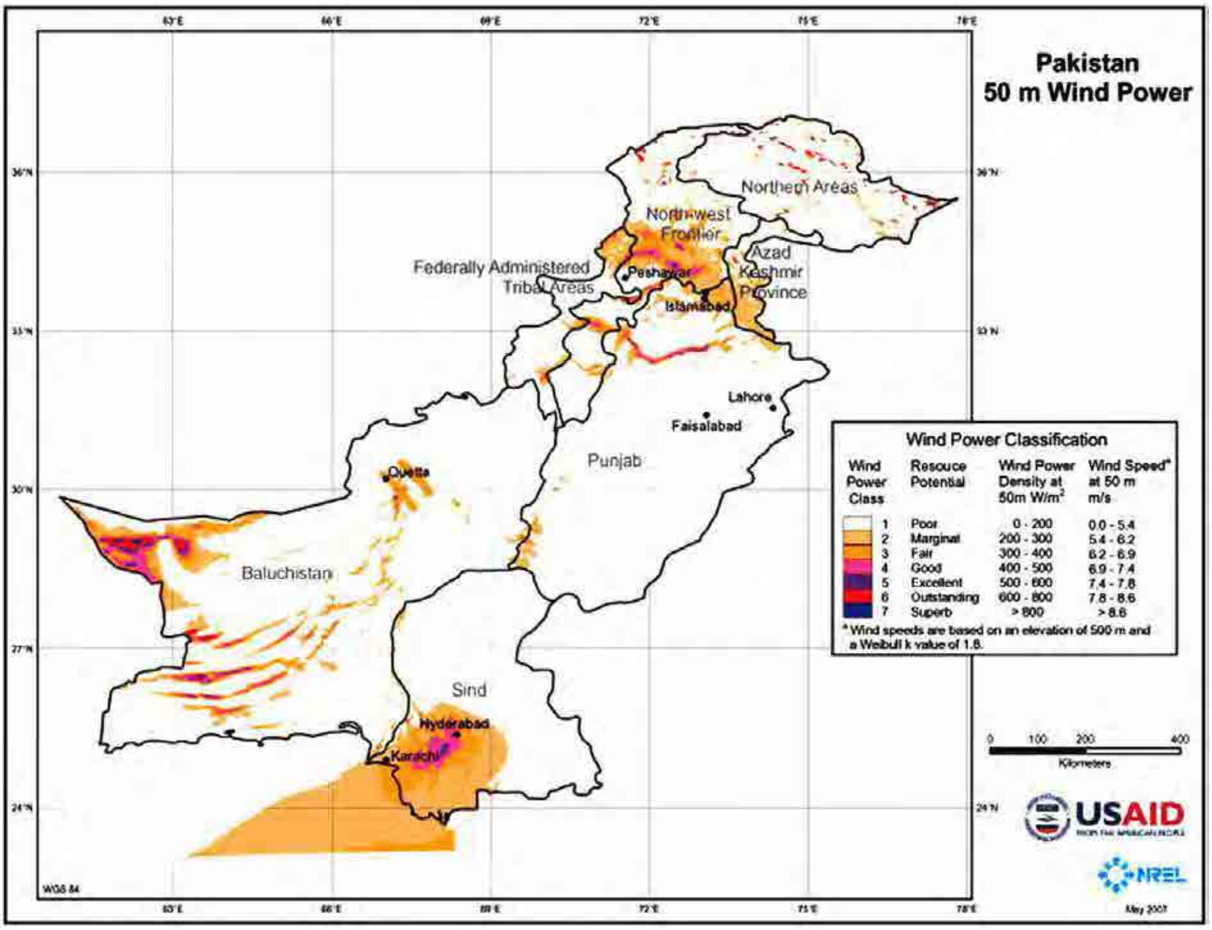
Source: NASA website

Note: (1) The data is over 22-years period (Jan 1983 - Dec 2004)
(2) The data is minimum and maximum of the daily earth's surface temperature for given month.
(3) The average data is derived from Amplitude that is; one half of the difference between the minimum and maximum of 22 years average.

6.1.2 Wind Power Potential

(1) Nationwide Wind Power Potential

The average wind power potential map of Pakistan at 50 m height developed by USAID-NREL is given in **Figure 6.1.2-1**. According to this figure, high potential of wind power is found in the coastal areas of southern Sindh province, the southwestern area of Baluchistan province, the narrow west-to-east belt in the northern part of Punjab province, and the southern area of Khyber Pakhtunkhwa province (formerly North-West Frontier province until April 2010).



Source: Website of AEDB (http://www.aedb.org/downloads.htm)

Figure 6.1.2-1 Average Wind Power Potential Map of Pakistan

NREL indicates the following areas as major wind resource areas in Pakistan (GIS data and tool kit are available at the website of NREL[20].):

- ✓ Southeastern Pakistan, especially:
  - Hyderabad to Gharo Region in southern Indus Valley
  - Coastal areas south of Karachi
  - Hills and ridges between Karachi and Hyderabad
- ✓ Northern Indus Valley, especially:

[20] http://www.nrel.gov/international/ra_pakistan.html

  - Hills and ridges in Northern Punjab
  - Ridges and wind corridors near Mardan and Islamabad

- ✓ Southwestern Pakistan, especially:

  - Near Nokkundi and hills and ridges in the Chagai area
  - Makran area hills and ridges

- ✓ Central Pakistan, especially:

  - Wind corridors and ridges near Quetta
  - Hills near Gendari

- ✓ Elevated mountain summits and ridge crests especially in northern Pakistan

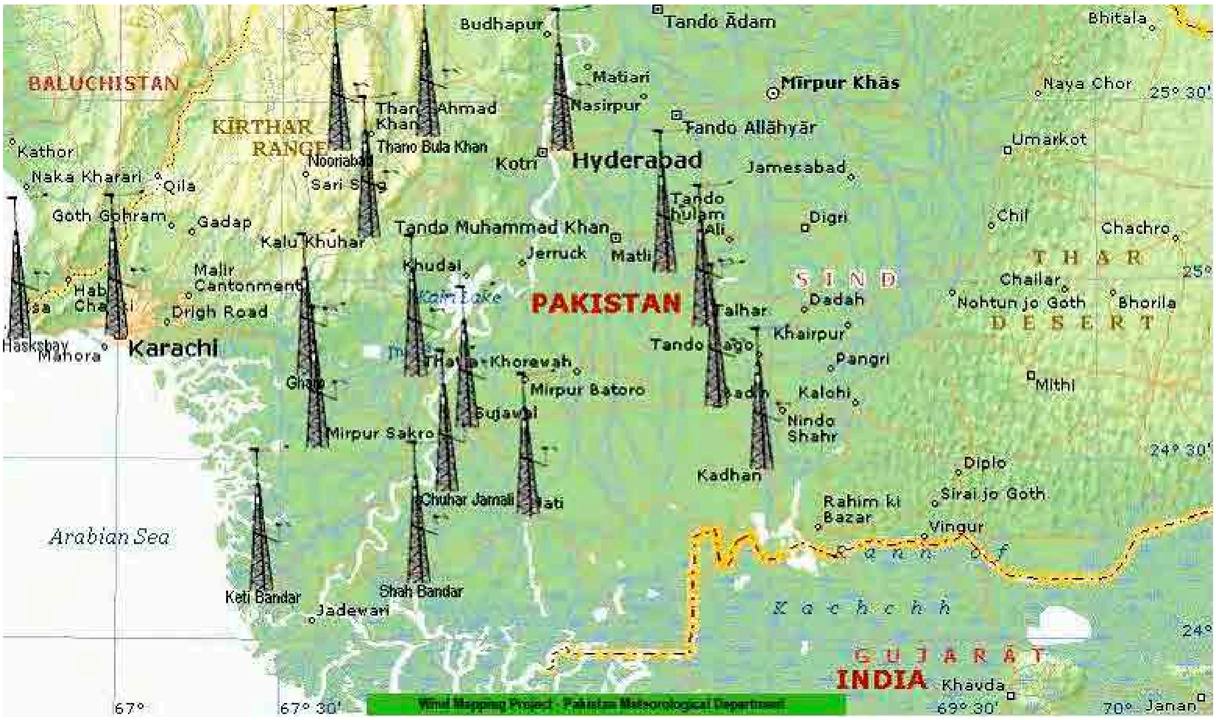
The further detailed study for wind power potential was carried out in the coastal area of Sindh province.

(2) Wind Data in Coastal Area of Sindh Collected by PMD

The Pakistan Meteorological Department (PMD) conducted the Wind Power Potential Survey of Coastal Areas of Pakistan for three years (2002-2005) for which the Ministry of Science and Technology provided the necessary funding. The project area was 1,100 km along Sindh and Balochistan coast spreading over latitude 25ºN approximately and up to 100 km deep northward over land from the coast.

The PMD selected 20 sites in Sindh province for wind measurement[21]. The data were collected for a period of three years (2002-2005) from erected meteorological towers with height of 30 m. The towers were installed at (1) Nooriabad, (2) Kati Bandar, (3) Shah Bander, (4) Jamshoro, (5) Hawks Bay, (6) Hyderabad, (7) Gharo, (8) Chuhar Jamal, (9) DHA Karachi, (10) Thano Bula Khan, (11) Jati, (12) Mirpur Sakro, (13) Golarchi, (14) Sajawal, (15) Baghan, (16) Thatta, (17) Karachi, (18) Badin, (19) Talhar, and (20) Matli. The locations of the towers for wind measurement are shown on the map in **Figure 6.1.2-2**.

[21] "An Investigation on Wind Power Potential of Sindh", PMD



Source: "An Investigation on Wind Power Potential of Sindh", PMD

Figure 6.1.2-2 Locations of Towers in the Sindh Coast for Wind Power Potential Survey

The data acquired included one minute average wind speed and ten minute minimum and maximum wind speeds at 10 m and 30 m heights. The wind vane for recording wind direction was installed at 30 m height only.

The wind speed at 50 m height was calculated at all the stations from the 10 m and 30 m height data using "power law" and "log law" models[22].

Tables 6.1.2-1 to **6.1.2-3** show the monthly mean wind speed recorded at 10 m, 30 m, and 50 m respectively, at all the measuring stations. The detailed measured and calculated data are available at PMD.

PMD investigated on wind speed (annual/diurnal variations and frequency distributions) and wind direction distribution, and identified six stations, namely Jamshoro, Keti Bandar, Nooriabad, Thatta, Gharo, and Hyderabad, as the most windy sites.

[22] "An Investigation on Wind Power Potential of Sindh", PMD

Table 6.1.2-1 Average Monthly Wind Speed Measured at 10 m Height

(Unit: m/s)

No.*	Location Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Mean
1	Nooriabad	3.0	3.2	3.3	5.3	7.2	7.9	7.8	7.3	6.3	2.6	2.5	2.9	5.0
2	Kati Bandar	2.8	3.1	3.0	5.5	6.9	7.1	7.3	6.4	5.0	2.6	1.8	2.8	4.5
3	Shah Bander	2.6	2.9	3.3	4.8	6.3	6.5	6.3	6.1	4.8	2.6	2.2	2.6	4.2
4	Jamshoro	2.4	2.5	2.7	4.0	5.4	6.7	7.7	6.7	5.4	2.3	1.9	2.4	4.2
5	Hawks Bay	2.9	3.3	4.1	5.3	5.7	5.7	5.7	5.1	4.3	2.6	2.1	2.7	4.1
6	Hyderabad	2.2	2.3	2.1	4.0	5.7	6.7	6.5	5.8	5.2	1.9	1.8	1.9	3.8
7	Gharo	1.8	2.0	2.3	4.3	5.9	6.2	5.9	5.7	5.0	1.7	1.2	1.4	3.6
8	Chuhar Jamal	2.8	2.6	2.6	3.9	5.1	5.5	5.3	4.5	3.0	1.6	1.7	2.4	3.4
9	DHA Karachi	2.2	2.5	2.9	3.9	4.8	5.2	5.0	3.7	3.6	2.3	1.7	1.7	3.3
10	Thano Bula Khan	1.6	1.9	1.4	2.8	4.4	5.4	5.7	4.9	3.8	1.0	1.1	1.6	3.0
11	Jati	1.7	2.0	2.3	3.2	4.3	5.1	4.5	4.5	3.2	1.6	1.3	1.6	2.9
12	Mirpur Sakro	0.9	1.1	1.5	3.3	4.9	5.0	4.8	4.6	3.7	0.8	0.5	0.9	2.7
13	Golarchi	1.7	1.8	1.6	2.6	3.4	4.3	3.9	3.4	2.6	1.2	2.0	1.6	2.5
14	Sajawal	1.3	1.4	1.8	3.0	4.2	4.0	3.6	3.7	2.9	1.1	0.9	1.2	2.4
15	Baghan	1.5	1.6	1.9	2.5	3.1	3.2	3.2	3.3	2.8	1.5	1.7	1.7	2.3
16	Thatta	1.0	1.1	1.5	2.4	3.2	3.8	4.1	3.8	2.7	1.0	0.6	0.8	2.2
17	Karachi	0.7	0.7	2.1	2.7	3.7	4.2	3.6	2.6	2.3	0.7	0.4	0.5	2.0
18	Badin	0.4	0.7	0.7	2.2	3.7	4.0	3.8	2.8	2.5	0.4	0.7	0.4	1.9
19	Talhar	1.1	1.1	0.6	1.6	2.6	2.9	2.7	2.0	1.1	0.3	0.4	0.9	1.4
20	Matli	0.9	0.9	0.4	1.1	2.1	2.7	2.4	2.0	1.5	0.5	0.6	0.8	1.3

Note) * : Listed in order of annual mean wind speed

Source: "An Investigation on Wind Power Potential of Sindh", PMD

Table 6.1.2-2 Average Monthly Wind Speed Measured at 30 m Height

(Unit: m/s)

No.*	Location Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Mean
1	Nooriabad	3.7	4.4	5.0	6.7	8.4	10.2	11.6	10.3	8.2	4.5	4.3	4.9	6.9
2	Kati Bandar	4.2	4.3	4.4	6.6	8.6	9.7	9.5	8.8	7.5	3.7	3.7	4.2	6.2
3	Shah Bander	4.1	4.7	5.1	7.4	8.3	8.4	9.1	8.0	6.5	4.2	3.5	4.2	6.1
4	Jamshoro	3.6	3.9	4.2	6.3	8.2	8.3	8.0	7.7	6.8	3.5	3.0	3.5	5.6
5	Hawks Bay	3.6	3.6	3.6	5.6	7.8	8.8	8.8	7.5	6.9	3.2	3.2	3.8	5.5
6	Hyderabad	4.1	4.2	4.5	5.8	7.2	7.6	7.4	7.2	5.7	3.8	3.7	4.2	5.5
7	Gharo	3.8	3.9	4.2	5.4	6.5	7.7	6.8	6.7	5.2	3.3	3.3	3.8	5.1
8	Chuhar Jamal	3.7	3.4	3.9	5.3	6.5	7.1	7.7	7.4	5.5	3.0	3.0	3.6	5.0
9	DHA Karachi	3.6	3.7	4.1	5.5	6.7	7.1	6.6	6.8	5.5	3.2	3.2	3.6	5.0
10	Thano Bula Khan	3.3	3.9	4.5	5.6	6.5	6.8	7.4	6.6	5.5	3.5	2.9	3.1	5.0
11	Jati	3.9	4.0	3.6	5.1	6.6	7.1	6.9	6.4	5.3	3.1	3.3	3.9	5.0
12	Mirpur Sakro	3.3	3.5	3.8	5.2	7.0	7.2	7.2	6.6	5.6	2.9	2.7	3.4	4.9
13	Golarchi	3.6	4.0	4.9	6.0	6.5	6.4	6.5	5.8	5.1	3.3	2.8	3.5	4.9
14	Sajawal	3.8	3.8	3.6	4.7	6.1	7.3	6.8	6.0	4.9	3.0	4.3	3.7	4.8
15	Baghan	3.7	3.8	4.0	5.1	6.0	6.5	6.3	6.4	5.2	3.3	3.3	4.0	4.8
16	Thatta	2.6	3.0	3.4	5.4	7.0	7.3	6.8	6.0	5.0	2.4	2.0	2.4	4.5
17	Karachi	2.6	3.0	2.1	4.4	5.8	7.4	7.4	6.5	5.7	1.8	1.8	2.7	4.3
18	Badin	2.9	2.9	3.0	4.2	5.8	6.4	6.0	5.3	4.5	2.3	2.5	3.0	4.1
19	Talhar	2.0	2.1	2.2	4.9	6.5	6.9	6.1	5.8	4.6	2.3	2.0	1.9	4.0
20	Matli	1.7	1.9	3.2	4.3	5.5	5.8	5.2	4.5	4.1	1.5	1.2	1.8	3.4

Note) * : Listed in order of annual mean wind speed

Source: "An Investigation on Wind Power Potential of Sindh", PMD

Table 6.1.2-3 Average Monthly Wind Speed Calculated for 50 m Height

(Unit: m/s)

No.*	Location Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Mean
1	Nooriabad	5.0	5.6	6.3	8.3	10.1	12.1	13.9	12.5	9.8	5.9	5.8	6.5	8.5
2	Kati Bandar	4.9	5.7	6.2	8.4	9.3	9.3	10.2	8.8	7.2	5.1	4.4	5.0	7.0
3	Shah Bander	4.9	4.8	5.0	7.3	9.3	10.6	10.4	9.7	8.1	4.2	4.4	4.9	7.0
4	Jamshoro	5.2	4.7	5.4	7.2	8.6	9.1	9.8	9.6	7.3	4.1	4.2	5.1	6.7
5	Hawks Bay	4.6	4.9	5.2	7.4	9.4	9.3	9.1	8.8	7.8	4.4	3.8	4.5	6.6
6	Hyderabad	4.4	4.4	4.3	6.5	8.9	10.0	9.9	8.5	7.8	3.9	3.9	4.8	6.4
7	Gharo	4.9	5.0	5.6	7.1	8.4	8.9	7.4	8.6	7.1	4.4	4.5	5.0	6.4
8	Chuhar Jamal	5.1	5.2	5.3	6.7	7.8	9.1	8.0	7.9	6.4	4.4	4.6	5.3	6.3
9	DHA Karachi	5.1	5.1	4.9	6.2	7.7	9.1	8.5	7.5	6.4	4.1	5.6	5.1	6.3
10	Thano Bula Khan	4.9	5.0	5.2	6.7	7.9	8.6	8.3	8.4	6.6	4.2	4.1	5.3	6.3
11	Jati	5.1	5.1	5.2	6.4	7.9	8.3	8.2	7.9	6.2	4.6	4.7	5.3	6.2
12	Mirpur Sakro	3.5	4.1	4.3	7.7	9.9	10.3	9.4	8.8	7.5	3.4	2.7	3.2	6.2
13	Golarchi	4.5	4.7	4.9	6.3	8.2	8.5	8.6	7.7	6.6	3.9	3.8	4.7	6.0
14	Sajawal	4.0	4.6	5.3	6.5	7.4	7.7	9.0	8.1	6.6	4.2	3.6	3.8	5.9
15	Baghan	4.4	4.9	4.3	5.9	7.6	8.0	7.9	7.5	6.5	3.9	4.1	4.7	5.8
16	Thatta	4.0	3.9	4.2	6.1	8.1	8.9	8.3	7.3	6.4	3.1	3.4	4.1	5.6
17	Karachi	4.0	4.4	5.4	6.4	7.1	6.9	7.1	6.2	5.6	3.7	3.2	4.0	5.3
18	Badin	2.9	3.0	3.1	6.4	8.1	8.5	7.6	7.5	5.8	3.3	2.7	2.7	5.1
19	Talhar	3.3	3.6	2.6	5.3	6.8	8.6	8.5	7.6	6.8	2.3	2.4	3.3	5.1
20	Matli	2.3	2.5	3.9	5.2	6.6	6.9	6.5	5.7	5.1	2.0	1.6	2.4	4.2

Note) * : Listed in order of annual mean wind speed

Source: "An Investigation on Wind Power Potential of Sindh", PMD

(3) Benchmark Wind Speeds in Coastal Area of Sindh

Mean monthly wind speed varies with season for climatic reason. Accordingly, the power product of wind power generation system also varies with season. In addition, the “monthly mean” of each month also varies every year. This is a risk for developers because it means that monthly power product of each month differs year to yaer. Therefore, AEDB introduced an innovative structure on “wind risk” which was formulated principally based on the Policy for Development of Renewable Energy for Power Generation 2006.

Wind speed benchmarks were computed and set up by AEDB for specific areas on the basis of the wind data acquired and computed by PMD. These monthly benchmark wind speeds at specific areas (Kuttikun, Bhambore, and Jhimpir sites) provide reference for potential project developers. The balance of electricity sales between generated with benchmark wind speed and generated with actual wind speed at any given month is to be paid by the GOP. The project developers are unfettered from any risk of year-to-year variation of average wind speed at any month of the year. The tables for the monthly benchmark wind speeds for Kuttikun, Bhambore, and Jhimpir sites are shown in **Appendix C-1**.

(4) Wind Data in Coastal Area of Sindh Collected by AEDB-UNDP

Wind measuring masts were installed at the Gharo-Keti Bandar Wind Corridor under the Wind Energy Program (WEP), which is a collaboration of AEDB and UNDP.

The three wind masts located at Baburband, Hawksbay-Karachi, and Keti-Bandar were started for data collection from June 2008, March 2009, and February 2009, respectively. The data collected from the three wind masts include wind speed data at heights of 10 m, 30 m, 60 m, 80 m, and 81.5 m and wind direction data at heights of 28.5 m and 78.5 m. AEDB published a report[23] in April 2010 which contained wind data acquired from the three mast sites.

The wind data recorded have been analyzed and tables for the monthly mean wind speeds at all recorded heights are mentioned in the report which is available at AEDB website free of charge.

Tables 6.1.2-4 to **6.1.2-6** show the monthly wind speeds with other data at the three sites.

As of November 2012, there are 11 wind measuring masts in the area. The locations of these masts are indicated in **Appendix C-2**.

Table 6.1.2-4 Monthly Wind Speeds at 81.5 m Height at Baburband Mast

Year	Month	Records	Recovery Rate (%)	Mean Wind Speed (m/s)	Min. Wind Speed (m/s)	Max. Wind Speed (m/s)	Std. Dev. (m/s)	Weibull k	Weibull c (m/s)
2008	Jun	4,319	100	8.529	1.165	27.69	2.569	3.553	9.420
2008	Jul	4,464	100	9.308	0.308	16.91	2.873	3.704	10.300
2008	Aug	4,464	100	8.984	2.817	15.69	2.191	4.458	9.830
2008	Sep	4,320	100	7.134	0.593	15.28	3.059	2.527	8.040
2008	Oct	4,464	100	5.334	0.126	12.11	2.284	2.537	6.020
2008	Nov	4,320	100	5.840	0.552	13.42	2.536	2.475	6.590
2008	Dec	4,464	100	6.084	0.000	15.01	2.925	2.188	6.860
2009	Jan	4,464	100	6.967	0.573	15.14	2.858	2.669	7.840
2009	Feb	4,032	100	5.705	0.008	12.81	2.583	2.364	6.430
2009	Mar	4,464	100	5.651	0.526	16.70	2.615	2.308	6.390
2009	Apr	4,320	100	6.484	0.202	15.11	2.797	2.485	7.310
2009	May	2,980	66.8	8.137	1.152	16.68	2.404	3.774	9.000
2009	Jun	4,319	100	8.159	0.523	19.38	2.829	3.254	9.100
2009	Jul	4,321	96.8	8.614	0.657	16.55	3.009	3.203	9.610
2009	Aug	4,463	100	8.492	0.250	20.39	2.309	4.280	9.320
2009	Sep	4,320	100	8.012	0.980	13.32	2.066	4.381	8.790
2009	Oct	4,033	90.3	4.840	0.063	14.75	1.938	2.680	5.450
2009	Nov	4,319	100	5.651	0.593	14.62	2.633	2.280	6.390
2009	Dec	4,177	93.6	5.603	0.592	12.55	2.299	2.671	6.300
2010	Jan	4,463	100	5.516	0.001	13.16	2.508	2.351	6.220
2010	Feb	4,032	100	5.525	0.000	14.23	2.669	2.203	6.250
2010	Mar	4,464	100	5.816	0.412	14.16	2.473	2.523	6.560

Source: "Analysis of Data of AEDB-UNDP(WEP) Wind Masts Installed in Gharo-Keti Bandar Wind Corridor", AEDB, 2010

Note:
1) Records: Numbers of measured 10 minutes data
2) Recovery Rate: Data acquisition rate
3) Std. Dev.: Standard deviation
4) Weibull k: Weibull Shape Parameter
5) Weibull c: Weibull Scale Parameter

[23] "Analysis of Data of AEDB-UNDP(WEP) Wind Masts Installed in Gharo-Keti Bandar Wind Corridor", AEDB, 2010

Table 6.1.2-5 Monthly Wind Speeds at 80 m Height at Hawksbay-KPT Mast

Year	Month	Records	Recovery Rate (%)	Mean Wind Speed (m/s)	Min. Wind Speed (m/s)	Max. Wind Speed (m/s)	Std. Dev. (m/s)	Weibull k	Weibull c (m/s)
2009	Mar	1,778	100	5.502	0.219	12.33	2.325	2.556	6.195
2009	Apr	4,320	100	6.235	0.197	14.93	2.482	2.746	7.009
2009	May	4,464	100	6.716	0.547	14.01	2.287	3.284	7.489
2009	Jun	4,320	100	6.791	0.508	15.77	2.471	3.018	7.605
2009	Jul	4,464	100	7.707	1.150	19.47	2.105	3.932	8.480
2009	Aug	4,464	100	7.258	0.270	12.48	2.157	3.957	8.016
2009	Sep	4,320	100	6.606	0.896	12.80	1.768	4.091	7.269
2009	Oct	4,464	100	4.388	0.200	12.48	2.063	2.258	4.958
2009	Nov	4,320	100	5.017	0.049	16.37	2.867	1.868	5.675
2009	Dec	4,032	90.3	4.779	0.212	11.64	2.214	2.291	5.400
2010	Jan	4,176	93.5	4.318	0.000	11.06	1.811	2.539	4.852
2010	Feb	4,032	100	5.175	0.159	12.70	2.284	2.414	5.840
2010	Mar	4,464	100	5.672	0.484	13.20	2.438	2.497	6.392
2010	Apr	3,312	100	6.704	0.355	15.50	2.798	2.558	7.556

Source: "Analysis of Data of AEDB-UNDP(WEP) Wind Masts Installed in Gharo-Keti Bandar Wind Corridor", AEDB, 2010

Note:
1) Records: Numbers of measured 10 minutes data
2) Recovery Rate: Data acquisition rate
3) Std. Dev.: Standard deviation
4) Weibull k: Weibull Shape Parameter
5) Weibull c: Weibull Scale Parameter

Table 6.1.2-6 Monthly Wind Speeds at 85 m Height at Keti-Bandar Mast

Year	Month	Records	Recovery Rate (%)	Mean Wind Speed (m/s)	Min. Wind Speed (m/s)	Max. Wind Speed (m/s)	Std. Dev. (m/s)	Weibull k	Weibull c (m/s)
2009	Feb	2,402	100	5.914	0.557	11.60	1.999	3.232	6.590
2009	Mar	4,464	100	6.336	0.777	12.33	1.997	3.509	7.024
2009	Apr	4,320	100	7.084	0.622	14.17	1.942	4.104	7.794
2009	May	4,464	100	7.994	1.480	13.48	1.920	4.738	8.720
2009	Jun	4,320	100	7.545	0.748	13.96	2.323	3.684	8.365
2009	Jul	4,464	100	8.307	1.338	20.94	2.217	4.087	9.142
2009	Aug	4,464	100	7.685	1.193	13.30	1.991	4.404	8.425
2009	Sep	4,320	100	7.068	2.197	13.21	1.711	4.459	7.733
2009	Oct	4,378	98.1	5.516	0.686	13.15	1.791	3.199	6.134
2009	Nov	4,318	100	6.269	0.326	15.57	2.664	2.525	7.078
2009	Dec	4,430	99.2	6.671	0.452	15.02	2.843	2.536	7.526
2010	Jan	4,407	98.7	6.059	0.672	12.88	2.551	2.552	6.836
2010	Feb	4,032	100	6.438	0.356	13.09	2.401	2.878	7.215
2010	Mar	4,461	99.9	6.936	1.456	12.18	1.827	4.307	7.623
2010	Apr	3,929	100	7.850	1.269	14.21	2.042	4.187	8.622

Source: "Analysis of Data of AEDB-UNDP(WEP) Wind Masts Installed in Gharo-Keti Bandar Wind Corridor", AEDB, 2010

Note:
1) Records: Numbers of measured 10 minutes data
2) Recovery Rate: Data acquisition rate
3) Std. Dev.: Standard deviation
4) Weibull k: Weibull Shape Parameter
5) Weibull c: Weibull Scale Parameter

(5) Wind Data in Coastal Area of Sindh Collected by Project Developers

In addition to PMD and AEDB-UNDP, private investors and wind project developers have also independently installed wind masts at potential sites in Sindh province. The data from the PMD-and AEDB-UNDP-installed wind masts are available at AEDB's website for one to five years depending upon the erection date of the wind mast. However, the data from the wind masts installed by the private investors, which can be requested from AEDB, are solely at the discretion of the owner.

A list of the wind masts installed by PMD, AEDB-UNDP, and the private project developers is given in **Appendix C-2**.

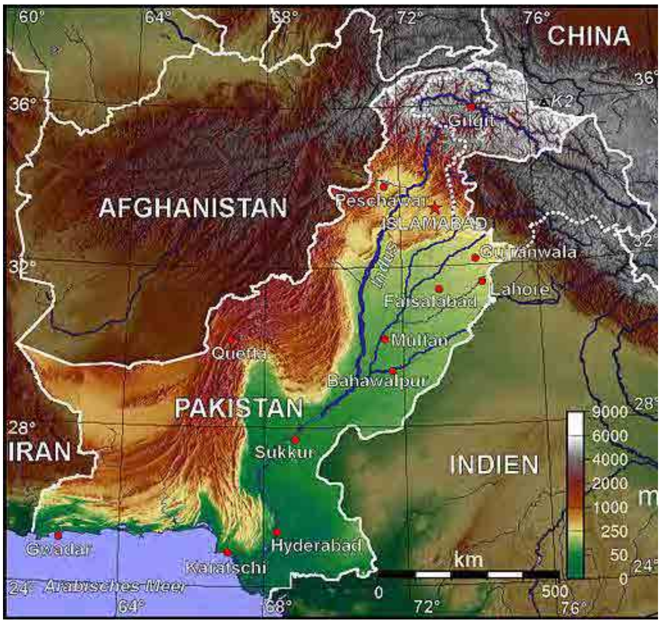
(6) Topographic Maps

Topographic maps of all areas in Gharo, wherein the wind projects exist, are being developed. Digital versions of these maps are available from the AEDB office upon request of interested parties.

Currently, there is no available offshore topographical data at the coastal belt of Sindh province.

6.1.3 Hydro Power Potential

Pakistan is divided into three major geographic areas, namely: the northern highlands, the Indus River plain with two major subdivisions corresponding roughly to the provinces of Punjab and Sindh, and the Baluchistan Plateau. Pakistan is comprised of several mountains in the north and steady plains in the central and southern part. It also comprises a long sea line in the south. **Figure 6.1.3-1** shows a geographic map of Pakistan.



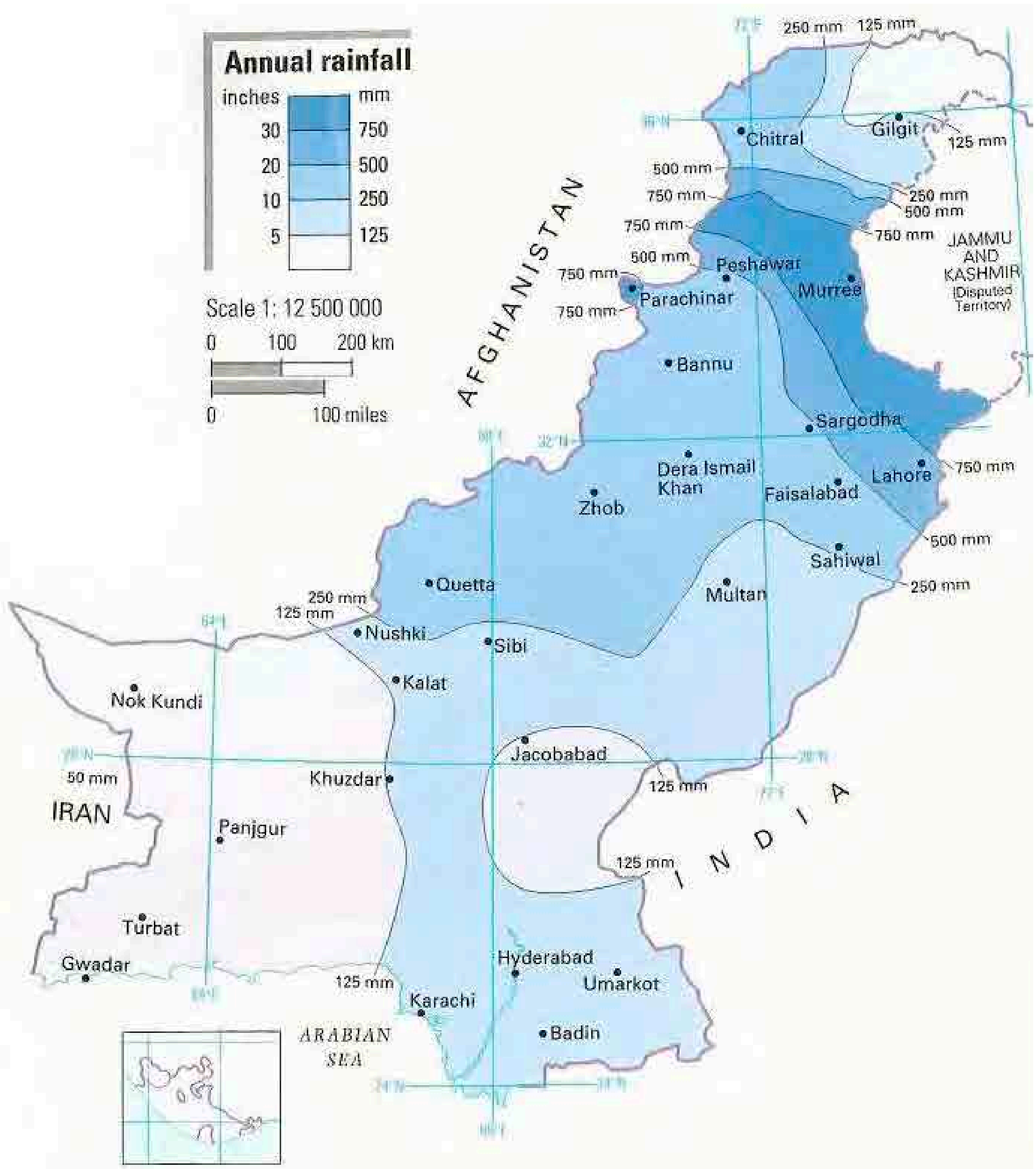
Source: http://commons.wikimedia.org/wiki/File:Paktopo_de.jpg

Figure 6.1.3-1 Geographic Map of Pakistan

Figure 6.1.3-2 shows an isohyetal map of the mean annual precipitation in Pakistan. The mean annual precipitation ranges from less than 100 mm in parts of the Lower Indus Plain to over 750 mm near the foothills of the Upper Indus Plain. The Upper Indus Plain has large hydro power potential.

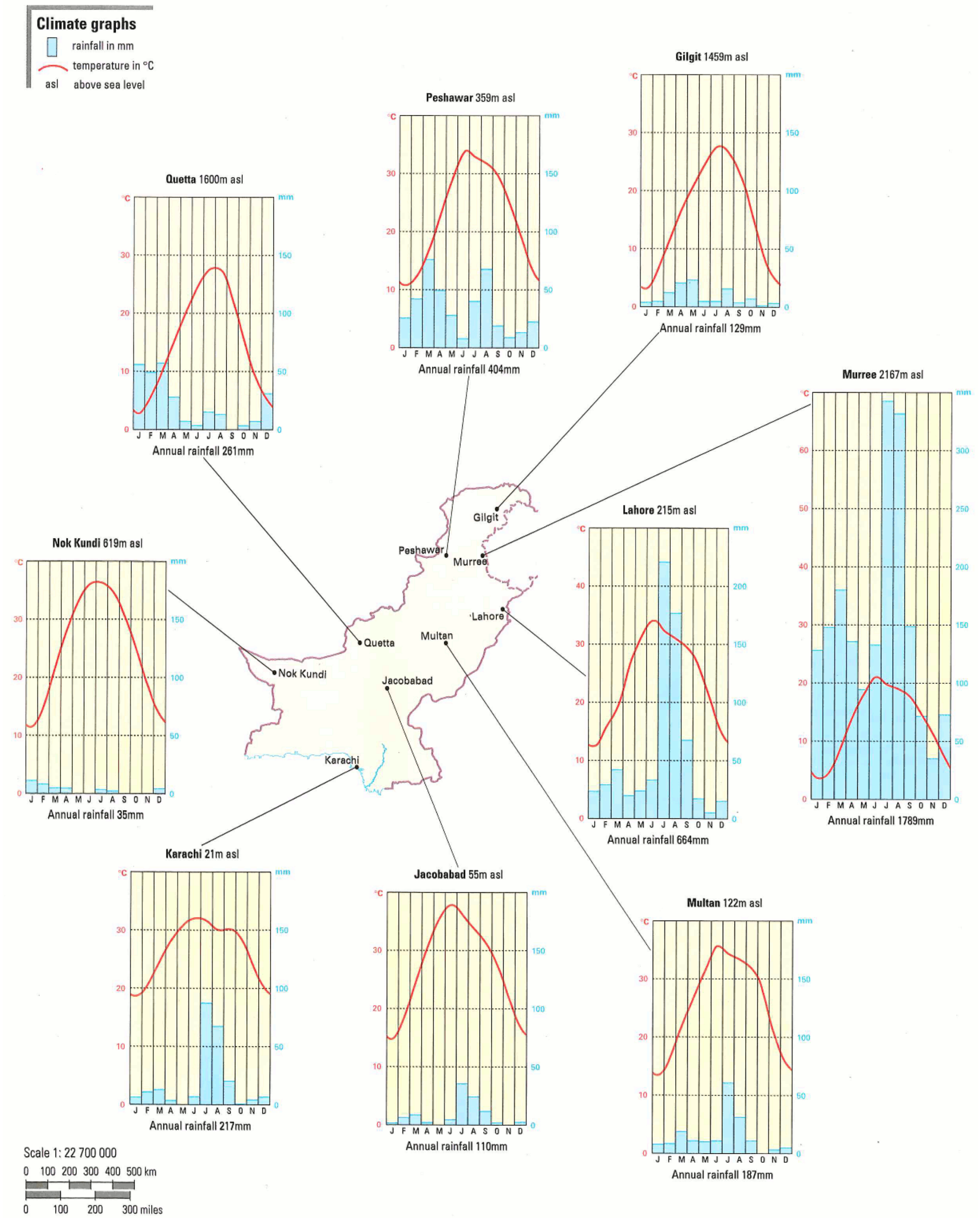
Figure 6.1.3-3 shows the mean monthly precipitation and temperature in Pakistan. Pakistan has four seasons, namely: a cool, dry winter from December through February; a hot, dry spring from March through May; the summer rainy season or southwest monsoon period from June through September; and the monsoon period from October to November.

There are four major rivers (Ravi, Chenab, Jehlum, and Indus) in Pakistan that have large potential for electricity generation.



Source: Oxford School Atlas for Pakistan, Oxford University Press, 2008

Figure 6.1.3-2 Isohyetal Map of Mean Annual Precipitation in Pakistan



Source: Oxford School Atlas for Pakistan, Oxford University Press, 2008

Figure 6.1.3-3 Mean Monthly Precipitation and Temperature in Pakistan

Considering the large potential and the intrinsic characteristics of hydro power in promoting the country's energy security and flexibility in system operation, the government accelerates hydro power development. The hydro power potential of Pakistan is estimated at around 60,000 MW in which around 57,000 MW is above 50 MW and around 2,300 MW fall below 50 MW. Such details are given in **Table 6.1.3-1**.

Table 6.1.3-1 Potential of Hydro Power in Pakistan

S.No	River/Tributary	Power (MW)
A	Hydro Power Potential above 50-MW	
1	Indus River	38,608
2	Tributary of Indus in Gilgit-Baltistan	1,698
3	Tributary of Indus in Khyber-Pakhtunkhwa	4,028
4	Jehlum River	4,341
5	Kunhar River	1,455
6	Neelum River & Its Tributaries	1,769
7	Poonch	462
8	Swat River & Its tributaries	2,297
9	Chitral River & Its tributaries	2,285
	Total A (Above 50-MW)	56,943
B	Hydro Power Projects below 50-MW	
1	On Tributaries	1,591
2	On Canal	674
	Total B (Below 50-MW)	2,265
	Total (A + B)	59,208

Source: Hydro Potential Report of WAPDA Pakistan

The current total nominal power generation capacity of Pakistan as of June 30, 2011 is 23,412 MW, of which 16,070 MW (68.64%) is thermal, 6,555 MW (28.00%) is hydro, and 787 MW (3.36%) is nuclear. The installed hydro power generating capacity of Pakistan from 2007 to 2011 is given in **Table 6.1.3-2**.

Table 6.1.3-2 Installed Generation Capacity by Type

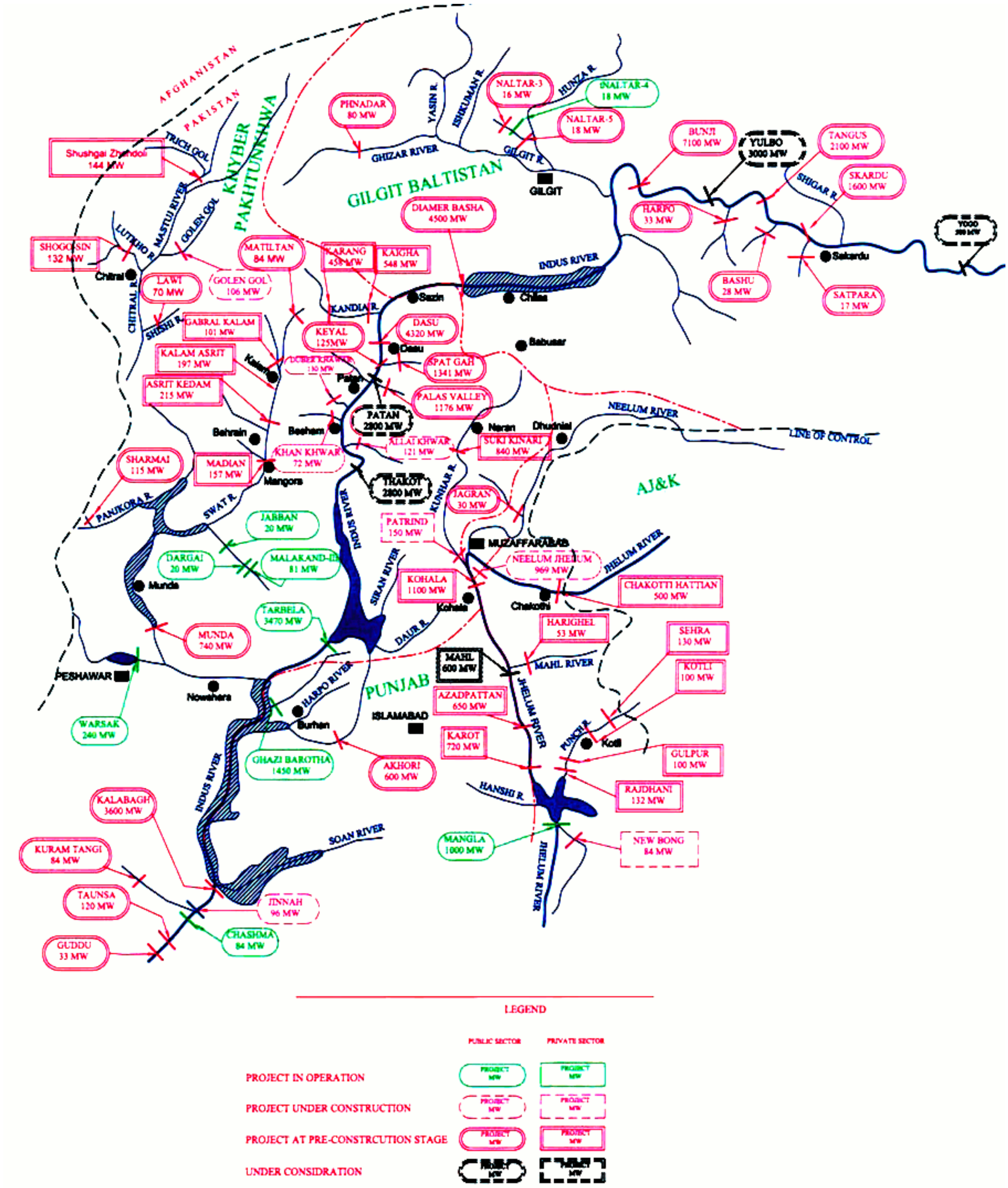
(Unit: MW)

	2007	2008	2009	2010	2011
Hydro Power					
WAPDA Hydro	6,444	6,444	6,444	6,444	6,444
IPPs Hydro	30	111	111	111	111
Sub Total	6,474	6,555	6,555	6,555	6,555

As of June 30 in each year

Source: State of Industry Report 2011 Pakistan

The locations of existing hydro power plants and proposed hydro power projects are shown in **Figure 6.1.3-4**.



Source: "Hydro power Resources Pakistan", Private Power and Infrastructure Board, February 2011

Figure 6.1.3-4 Existing and Proposed Hydro Power Plants in Pakistan

6.2 Solar Power Project

6.2.1 Existing Solar Power Project

Table 6.2.1-1 summarizes the existing projects installed through the national budget.

Table 6.2.1-1 Existing Projects Installed through the National Budget

S #	Name of Project	Installed Capacity	Quantity / Sets	Installed Date	Organization	Installation Area (Place name)	Budget Source	Project Cost (Rs)
1	Solar Village Electrification Programme[*1, *2]	Information not available	3000 Solar Home Systems (SHS)	2006-2007	AEDB	49 villages of Tharparkar District, Sindh Province	GOP Fund	1,168 million
2	Village Electrification Programme, Parliamentarian sponsored[*1, *2]	Information not available	Information not available	Information not available	AEDB	Baluchistan and Sindh Province	GOP Fund	40 million
3	Solar LED Lights	Information not available	Information not available	Information not available	Environmental Protection Agency (EPA)	Race course park (Jail road, Lahore)	GOP Fund	Information not available
4	Prime Minister Initiative for Solar Power (PMISP)[*3]	More than 100 kW	System Capacity ranging from 5 kW to 10 kW	2006-2011	Pakistan Engineering Council (PEC)	Different areas of Sindh Province and Islamabad	GOP Fund	164 million
5	Electrification of Mosque, School and Community Centers in Remote Areas[*4]	100 kW	Different capacity systems, Total 500 sets	July, 2005	Pakistan Council for Renewable Energy Technology (PCRET)	Remote Areas Mosques, Community Centers and	GOP Fund	28.59 million
6	Rural Electrification[*4]	5 kW	500 households were facilitated	Feb, 2005	PCRET	Rural area households, Sindh Province	GOP Fund	37.5 million

Source:
*1 Alternative Energy Development Board (AEDB), Website
*2 Associated Press of Pakistan, Website
*3 Prime minister initiative for solar power report
*4 Document from Pakistan Council for Renewable Energy Technologies (PCERT) and their Website

Regarding the organizations, the details of AEDB and PCRET are mentioned in **Sub-chapter 3.1** and **Sub-chapter 3.2,** respectively. Pakistan Engineering Council (PEC) is an autonomous body for the engineering associations, which also promote solar power generation project to assist the GOP's policy on renewable energy.

In the above table, all projects are off-grid systems.

The Solar Village Electrification Program (No. 1 in the table above) under the prime minister's directive has been initiated, under which 3,000 solar home systems (SHS) have been installed in 49 villages of Tharparkar District of Sindh province. Under this program, another 51 villages in Sindh province and 300 villages in Baluchistan province are also approved and will be implemented upon release of funds.

Under the Parliamentarian Sponsored Village Electrification Program (No. 2 in the table), 32 feasibility studies have been prepared and submitted, and for which funds were released. Funds for three schemes have so far been released under People Works Programme (PWP-II) formally known as Khushal Pakistan Programme (KPP-II) and the schemes are being implemented.

The project of LED lights (No. 3 in the table) is the project on street light system.

Table 6.2.1-2 summarizes the existing projects installed through collaborations of international organization/donor agencies.

Table 6.2.1-2 Existing Projects Installed through the Collaborations of International Organization/Donor Agencies

S. No.	Project Type	Name of Project	Installed Capacity	Quantity / Sets	Installed Date	Organization	Installation Area (Place Name)	Donor Agency	Project Cost
1	Grid connected[*5]	The Project for Introduction of Clean Energy by Solar Electricity Generation System in Pakistan	356.16 kW	178.08 kW x 2 sets	Completed Mar, 2012	Responsible Organization: Planning Commission (PC) and Implementing Organization: PEC	Two Locations: 1) PC, P Block, Islamabad 2) PEC Head Quarter, Islamabad	JICA (Japanese Grant Aid)	480 Million Japanese Yen
2	Stand alone, Water pumping[*6]	Solar pumping project	4,800 W	Six sets of different capacity were installed	Nov, 2006	Solar Energy International (US based non-profit Organization) with National university of Science and Technology (NUST)	Six different village of Federal Administrated Tribal Areas (FATA)	USAID supported	Information not available
3	Off grid, LED Lights[*7]	Information not available	Information not available	28 Households	Sep, 2005	National Rural Support Program	Talagang, Chakwal District, Punjab Province	USAID supported	Information not available
4	Pilot project, Water pump for irrigation purpose[*8]	Introduction/promotion of Solar Water Pump Technology for irrigation and drip irrigation in Pakistan	Information not available	Information not available	Jan 24, 2011	Zarai Taraqati Bank Ltd. (ZTBL)	Kasur, Punjab province	M/s Shaanxi Xintong Intelligent Company, Chinese	Information not available

Source:
*5 Website of Japan International Cooperation Agency (JICA)
*6 Website of National University of Science and Technology (NUST)
*7 Monthly Programme Report (2012) downloaded at Website of National Rural Support Program (Pakistan)
*8 Website of Zarai Taraqati bank Ltd. (Pakistan)

Besides the existing projects, there were projects initiated by IPPs. **Table 6.2.1-3** below summarizes the projects in which AEDB issued the letter of intent (LOI) in favor of IPPs.

Table 6.2.1-3 IPP Projects that received LOI from AEDB

S. No	Name of Company	Capacity (MW)	Letter of Intent (LOI) Status	Location	Status
1	Solar Energy Pakistan Ltd., (Pakistan)	37	Iissued	Dhabeji, Thatta District, Sindh Province	FS result submitted to AEDB for review
2	First Solar, (Germany)	2	Iissued	Southern Punjab Province	FS result submitted to AEDB for review
3	AM Pak Energy, (Pakistan)	50	Iissued	Southern Punjab Province	FS on process
4	DACC LLC Canada	50	Iissued	Southern Punjab Province	FS result submitted to AEDB for review
5	Wah industries Ltd. (Organization of GoP)	1	Iissued	Pakistan Ordinance Factory (POF) Sanjwal, Attock District, Punjab Province	FS result submitted for tariff petition to NEPRA
6	China International Water and Electric (CWE) Department, (China)	50	Iissued	Bahawalpur, Cholistan District, Punjab Province	FS on process
7	Roshan Power (Pvt) Ltd., (Pakistan)	1	Iissued	Kasur, Punjab Province	FS on process
8	Buksh Energy (Pvt) Ltd., (Pakistan)	20	Iissued	Kasur, Punjab Province	FS on process
9	AVS Group / Tapal Energy (Pvt) Ltd., (Pakistan)	2	Iissued	Information not available	FS on process
10	M/s Techaccess FZ LLC (Dubai, UAE)	10	Iissued	Information not available	FS result submitted to AEDB for review
11	M/s Silicon CPV (Pvt) Ltd., (UK)	1	Iissued	Information not available	FS on process
12	M/s Associated Technologies (Pvt) Ltd., (Pakistan)	20	Iissued	Information not available	FS on process

Source: Alternative Energy Development Board (AEDB)

The projects in the above table are all grid connected solar power generation systems initiated by IPPs.

Besides the projects that already received LOI, there are other projects in the pipeline expecting to receive LOI from AEDB. **Table 6.2.1-4** summarizes the projects in the pipeline awaiting the issuance of LOI.

Table 6.2.1-4 Projects in the Pipeline Waiting for LOI

Till: November 28, 2012

Status of Pending Solar PV Projects								
S. No.	Name of Company	Request Submission Date		Result of Submitted Document	Completion of Modalities		LOI Status	Remarks
		Initial Request	Completion of Proposal		AEDB's Letter	Status		
1	Integrated Power Solutions	May 2, 2012	May 2, 2012	Accepted	May 15, 2012	Modalities are to be completed by company		-
2	Solar Blue	May 2, 2012	May 2, 2012	Accepted	May 15, 2012	Modalities are to be completed by company		-
3	Jafri Associates and Consulting Engineers	May 2, 2012	May 2, 2012	Accepted	May 15, 2012	Modalities are to be completed by company		-
4	Associated Technologies	May 25, 2012	May 25, 2012	Accepted	Jun 20, 2012	July 2, 2012	Issued	LOI milestones are to be achieved by the company
5	Solar Europa	June 3, 2012	To be submitted	Pending	To be issued	Financial document to be submitted	Not Yet	-
6	Avelar Solar	Oct 27, 2012	Aug 20, 2012	Accepted	Nov 22, 2012	-	Issued	-
7	Akash Solar Engineering Ltd.	Oct 29, 2012	To be submitted	-	-	-	Not Yet	-

Source : Alternative Energy Development Board (AEDB)

6.2.2 Future Prospects of Solar Power Project

The electricity demand in Pakistan is steadily increasing every year.

As the electricity shortage continues, abundant and indigenous renewable energy resources count as a sustainable solution in order to meet the growing demand. Solar is one of the solutions.

Furthermore, AEDB's report concludes that there is high potential for solar power generation. Pakistan lies on the sunny belt, and receives high solar radiation in most parts of the country, and has enough available space for installation of solar power generation plant. Places such as most parts of Baluchistan province, Thal Desert and Cholistan area in Punjab province, and Thar Desert in Sindh province have huge potential for solar power generation. Baluchistan province is particularly rich in solar energy, having an average daily global radiation of 19 MJ/m^2 to 20 MJ/m^2 per day (around 5.3 kWh/m^2 to 5.6 kWh/m^2).

As shown in **Tables 6.2.1-3** and **6.2.1-4**, private sector is much active for the promotion of solar power generation. **Table 6.2.1-3** shows that LOI was already given to 12 projects, which means the developers of the projects are allowed to proceed with the feasibility studies of the projects. Total capacity of 12 projects is of 244 MW.

Besides that, regarding the five projects out of the above 12 projects, the feasibility studies have been completed and the results of those were submitted to AEDB for the review. The total capacity of the above five projects is of 100 MW. After the results of feasibility studies are approved by Panel of Experts (POE) appointed by AEDB and/or provincial agency, the developers will apply to NEPRA for determination of power purchase tariff and grant of generation license.

According to the RE Policy, the typical allowance period for the determination of power purchase tariff is 90 days from the date of approval on the feasibility study. Subsequent to determination of power purchase tariff by NEPRA, Letter of Support (LOS) is to be issued to the developers by AEDB or provincial agencies upon posting performance guarantee by the developers. LOS will govern the projects until the financial close of the project is achieved. After the financial close, the project implementation actually starts.

Considering the above situation and the process, the aggregate capacity of the solar power generation projects by private sector which commence their implementation in 2013 may become more than 100 MW.

Furthermore, the seven projects in **Table 6.2.1-3** are on the process of feasibility study and the seven projects indicated in **Table 6.2.1-4** will proceed with the feasibility study soon. The number of the project applying for LOI is expected to surely increase. These projects are promoted by private developers. This situation makes it envisage the drastic increase of private investment into solar power generation from now on.

6.2.3 Solar Electricity Generation System Installed by Japan's Grant Aid

(1) Outline

The Government of Japan provided grant aid for the implementation of the Project for Introduction of Clean Energy by Solar Electricity Generation System to the GOP. Under the program, two systems were installed in Islamabad, namely, one system at the Planning Commission (PC) and the other system at the Pakistan Engineering Council (PEC). The installation of both projects started in March 2011 and was completed in March 2012. Since then, they are operating as the first grid-connected solar power generation systems in Pakistan.

Figure 6.2.3-1 shows the installed grid-connected solar systems at PC and PEC.

Solar System at PC

Solar System at PEC

Source: JICA Study Team

Figure 6.2.3-1 View of Installed Grid-connected Solar Systems by Japan's Grant Aid

The purposes of this grant aid project are to promote clean energy introduction by demonstrating grid-connected solar generation, build technical experience on solar system and its grid connection, and contribute to the mitigation of greenhouse gas emission.

The salient features of the solar system are shown in **Table 6.2.3-1** below.

Table 6.2.3-1 Salient Features of the Solar Generation System

	System at PC	System at PEC
Installation Place of PV Module	over Existing Car Parking Rooftop	on 3-meters-height Pillars in Greenbelt Park
PV Module Capacity	178 kW	178 kW
Grid Connection Voltage	400 V	400 V
Major Equipment at Each Site	PV Module, Power Conditioner, Data Collecting System, and Display Panel	
Categories of Generation and Electricity Metering for Grid Connection	Captive Power Generation (Self-use Generation) and Net Metering *	
*Note * : At the time of generation by the solar system, only surplus electricity is supplied to the grid, and at other time, PC and PEC receive electricity from the grid. The payment of the electricity is settled monthly based on the balance of supplied and received units of electricity using applicable retail tariff.*		

Source: JICA Study Team

(2) Review of Operation Record

(a) Initial Problems after Taking Over

Just after the taking over of the solar power generation system in March 2011, some problems were detected which were needed to be solved.

(i) Recording Problem of Bidirectional Energy Meter

The newly installed bidirectional energy meter at PEC is accumulating both import and export units together; therefore, the units recorded were exceptionally higher than usual. The problem was found when the data were compared with the recorded units from the existing energy meter at PEC. Based on the problem, the bidirectional meter of PC was also checked and the same problem was found. The recording program of energy meter was readjusted to measure both export and import energy separately after April 2012.

(ii) Recording Problem of Data Collection System

Due to the problem on the software program to collect and record the system performance and operation data of the installed solar power generation system, the recorded data were not accurate at both PC and PEC sites.

The software program was rectified from June to July 2012 at both sites.

(b) Data Review by the Study Team

The data recorded at PC and PEC were collated and reviewed to understand the actual operation status of the system by the Study team in October 2012.

Despite the rectification of the software from June to July 2012, the Study team found that the data seemed to be not recorded properly. Two samples of the problem are shown below.

- Regarding the recorded data of the insulation/step-up transformer which is connected to the power conditioner, the data of output power is larger than the data of input power.
- Regarding the recorded data of the power conditioner which is supposed to generate power when the voltage of the DC input power of the power conditioner is 200 V or higher, the generation data is recorded with the DC input voltage lower than 200 V.

It is recommended to check the data collection system carefully.

(c) Power Generation and Efficiency

Although there are some doubts on the reliability of the recorded data of the solar power generation system, it does not seem to be crucial to review the operation of the system.

The monthly energy of DC power to the power conditioner and AC power to the facility of both PC and PEC sites, which are recorded in August, September, and October 2012, and the efficiency of power conditioner are shown in **Table 6.2.3-2** below.

Table 6.2.3-2 Working Efficiency of Power Conditioner

(Unit: kWh)

	Aug 2012	Sep 2012	Oct 2012	Total
PC (Planning Commission)				
Supplied DC Power to Power Conditioner	13,066	14,904	19,806	47,776
Supplied AC Power to the Facility	11,764	13,503	18,085	43,352
Working Efficiency (DC Input/AC Output) at PCS	90.04%	90.60%	91.31%	90.74%
PEC (Pakistan Engneering Council)				
Supplied DC Power to Power Conditioner	15,812	20,537	20,417	56,766
Supplied AC Power to the Facility	14,297	18,597	18,532	51,426
Working Efficiency (DC Input/AC Output) at PCS	90.42%	90.55%	90.77%	90.59%

Source: Prepared by JICA Study Team based on the collected Data at the Solar PV Power Generation Systems

From the table above, the working efficiency of power conditioner is around 90% on average at both PC and PEC. The PC site is generating a little lower than PEC. This is mainly due to the difference in solar insolation and the fact that more shadows of trees are falling over the solar PV module at PC than at PEC.

(d) Electricity Received from the Grid

Tables 6.2.3-3 and **6.2.3-4** summarize the electricity received from the grid based on bills from the distribution company to PC and PEC, respectively.

From the table for PC below, except for April and August, the received electricity from the grid increased from February to October 2012 compared to that in 2011. The solar power generation system started generation in March 2012. By the data, the effect of the system is not confirmed; the electricity received from the grid should supposedly decrease after the system started generation.

Two reasons for the above situation are considered. One is the refurbishment of the existing system of PC and the other is load shedding. At the same time of the taking over of the solar power generation system, the refurbishment work of the receiving cubicles and transformer of PC was completed. It is reasonable to consider that the electricity consumption at PC was increased by the new cubicle and transformer for receiving electricity from the grid. As for the load shedding, the fact to be addressed is that the potential electricity demand is depressed by load shedding. If the load shedding total time is reduced to PC in 2012 compared in 2011, the received electricity will surely increase.

With the above consideration, the data do not need to evaluate whether or not the solar power generation system is properly working.

Table 6.2.3-3 Electricity Received from the Grid at PC

(Unit: kWh)

Year\Month	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Average	Total
Year 2011	59,800	66,820	84,000	78,200	79,600	84,100	74,000	67,160	57,280	72,329	650,960
Year 2012	61,200	62,080	84,400	85,260	129,600	90,080	74,000	78,060	64,000	80,964	728,680

Source: Prepared Prepared by JICA Study Team based on Electric Bills of Utility Company provided by PC

In case of PEC, from the table below, it is clearly seen that the electricity received from the grid in 2012 decreased except for August and October, compared to the same months in 2011.

From this, it can be said that the installed solar power generation system is contributing to reduce the received electricity from the grid.

Table 6.2.3-4 Electricity Received from the Grid at PEC

(Unit: kWh)

Year\Month	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Average	Total
Year 2011	18,120	20,280	21,360	24,480	21,960	21,120	15,000	18,360	11,640	19,147	172,320
Year 2012	9,000	17,160	10,800	15,240	18,120	12,480	16,800	15,360	19,080	14,893	134,040

Source: Prepared by JICA Study Team based on Electric Bills of Utility Company provided by PEC

(e) Solar Radiation

The data recording period is very short to give any rationalized view on the status of system operation. To understand the actual solar radiation received at the site and to see the differences from the 22-year average solar radiation data recorded by satellite, which is downloaded from the NASA website, the recorded data at both PC and PEC sites and the satellite data are shown in **Table 6.2.3-5** below.

Table 6.2.3-5 Horizontal Solar Radiation Recorded at PC and PEC and Downloaded Satellite Data

(Unit: kWh m^{-2} day^{-1})

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Satellite Data (22 years average)													
	3.18	3.87	4.95	6.31	7.27	7.54	6.44	5.72	5.69	5.07	3.89	2.99	5.24
Recorded Data at PC (Year 2012)													
	***	***	4.13	5.03	6.20	***	***	3.31	3.59	3.44	***	***	4.28
Recorded Data at PEC (Year 2012)													
	***	***	4.01	5.26	6.34	***	***	3.67	4.10	3.87	***	***	4.54

Source: Prepared by the JICA Study Team
based on provided Data from PC and PEC, and Data downloaded from NASA Website

Note: (1) The NASA data is 22 years average data.
(2) The installed system started to operation from March 2012.
(3) In March the number of operation in PC is 22 days and at PEC is 25 days.
(4) In June and July the system was under maintenance/adjustment process.

Even though the recorded data only consider a few months, if monthly data is compared, then the recorded solar radiation at PC and PEC is around 17% to 20% less than the 22-year average data in March and April. However, in May, the difference is less than 15% at both sites. In August, September and October, the received solar radiation is around 24% to 36% less at PEC and 32% to 42% less at PC compared to the satellite data. The average annual differences with the satellite data are around 13% at PEC and 18% at PC.

6.3 Wind Power Project

6.3.1 Existing Wind Power Project

In Jhimpir site of Sindh province, two investors, namely, FFC Energy (Ltd) and Zorlu Enerji, almost finished their construction of wind farms. They are supposed to achieve commercial operations date (COD) within 2012: combined installed capacity of 106 MW.

To accomplish a wind power project, a long process is needed according to the regulations of the GOP as shown in Section 2.2.3 and **Appendix A-3-1**.

By July 19, 2012, AEDB has issued the LOI to 37 wind farm project developers with generating capacities in the range of 2.4 to 350 MW each. The list of the 37 LOI holders including project capacity is mentioned in **Appendix C-3**.

AEDB, in alliance with the Government of Sindh, has leased land to 16 wind farm IPPs. Moreover, NEPRA issued the generation license to 16 project developers. A list of project developers with leased land and a list of developers which are given with the generation licenses are shown in **Tables 6.3.1-1** and **6.3.1-2**, respectively.

Table 6.3.1-1 List of Project Developers with Leased Land for Wind Farm in Sindh Province

S.No	Name of Developer	Location of Land
1	Tenaga Generasi Ltd.	Kuttikun
2	Foundation Wind Energy – II Pvt Ltd. (Green Power Pvt Ltd)	Kuttikun
3	Dawood Power Ltd.	Bhambore
4	Master Wind Energy Ltd	Jhimpir
5	Zephyr Power Ltd	Bhambore
6	Foundation Wind Energy – I Ltd. (Beacon Energy Ltd)	Kuttikun
7	Sachal Energy Development Pvt Ltd	Jhimpir
8	Fauji Fertilizer Company (FFC) Energy Ltd.	Jhimpir
9	Yunus Energy Limited	Jhimpir
10	Metro Power Company (Pvt) Ltd.	Jhimpir
11	Gul Ahmed Energy Ltd,	Jhimpir
12	Zorlu Enerji Pakistan Ltd.	Jhimpir
13	Wind Eagle I Ltd.	Jhimpir
14	Wind Eagle II Ltd.	Jhimpir
15	Sapphire Wind Power Company (Pvt) Ltd,	Jhimpir
16	Three Gorges First Wind Farm Pakistan Pvt. Ltd (CWE)	Jhimpir

Source: AEDB

Table 6.3.1-2 List of Developers Given with Generation Licenses

S.No.	Name of Developer
1	Tenaga Generasi Ltd.
2	Dawood Power Ltd.
3	Zorlu Enerji Pakistan Ltd.
4	FFC Energy Ltd.
5	Foundation Wind Energy -I Ltd
6	Foundation Wind Energy -II Pvt Ltd
7	Three Gorges First Wind Farm Pakistan Pvt. Ltd.
8	Pakistan Wind Energy Generation Company (Pvt.) Ltd.
9	New Park Energy Ltd. (project cancelled)
10	Sachal Energy Development (Pvt.) Ltd.
11	Sapphire Wind Power (Pvt.) Ltd.
12	Zephyr Power Pvt. Ltd.
13	Yunus Energy Ltd.
14	Master Wind Energy Ltd
15	Metro Power Company (Pvt) Ltd.
16	Gul Ahmed Energy Ltd

Source: AEDB

NEPRA, being the authority to approve the tariff of the electricity generated by the wind farm, announced the approved tariffs for 14 projects. The approved tariffs and announcement dates are given in **Table 6.3.1-3**.

Table 6.3.1-3 List of Developers with Approved Tariff by NEPRA

S. No.	Name of Developer	Approved Tariff (US Cents per kWh)	Date announced
1	Dawood Power Ltd.	11.87	Dec 6, 2008
2	Zorlu Enerji Pakistan Ltd.	13.3456	Dec 13, 2011
3	FFC Energy Limited	16.109	Aug 10, 2010
4	Three Gorges First Wind Farm Pakistan Pvt. Ltd.	13.9399	Dec 15, 2011
5	Yunus Energy Ltd.	17.3672	Feb 15, 2012
6	Foundation Wind Energy - I Ltd.	14.1359	Mar 16, 2012
7	Foundation Wind Energy - II Pvt. Ltd.	14.1164	Mar 16, 2012
8	Tenaga Generasi Ltd.	13.6202	Apr 26, 2012
9	Gul Ahmed Wind Power Ltd.	14.6098	May 8, 2012
10	Sapphire Wind Power Company Ltd.	13.2483	May 8, 2012
11	Metro Power Company (Pvt) Ltd.	14.5236	May 15, 2012
12	Zephyr Power Pvt. Ltd.	15.9135	May 24, 2012
13	Master Wind Energy Ltd	14.532	Jun 29, 2012
14	Arabian Sea Wind Energy (Pvt.) Ltd.	11.9201	May 12, 2010

Source: AEDB

Meanwhile, NEPRA announced an upfront tariff of US Cent 14.6628 per kWh for any wind farm project on October 6, 2012. So far, Yunus Energy Ltd. and Pakistan Wind Energy Generation Company (Pvt) Ltd. have accepted the upfront tariff. The wind firms have the option to either choose the upfront tariff or file a petition for tariff determination to the NEPRA office. This upfront tariff will only be applied to companies that will achieve financial close by December 31, 2012, if the validity period is not extended.

The firms for which the tariff has been approved by NEPRA are in the process of getting the letter of support (LOS), and signing the energy purchase agreement (EPA) and implementation agreement (IA) from the concerned agencies/departments. As of October 2011, FFC Energy (Ltd.) and Zorlu Enerji were able to achieve financial close (FC)[24] for their projects. Both firms are in the process of accomplishing commercial operations at the end of 2012[25].

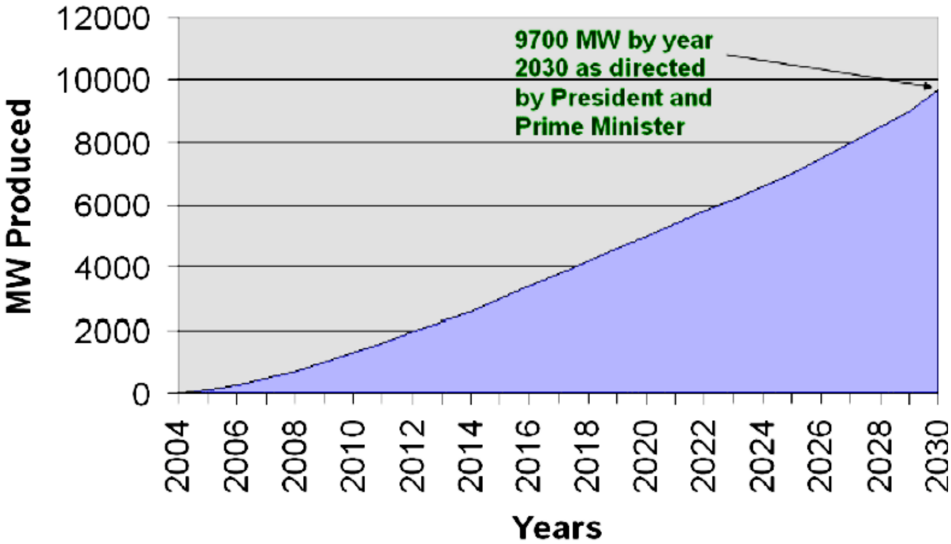
Details of the existing projects are summarized in **Appendix C-4**.

6.3.2 Future Prospects of Wind Power Project

As described in **Sub-chapter 4.2**, the GOP has a medium-term plan (2011-2020) for wind energy development. The target in 2020 was set at 3,150 MW.

Further into the future, GOP also has a Long-Term Vision up to 2030 as shown in **Figure 6.3.2-1**. The target capacity of RE including wind power in 2030 was set at 9,700 MW

[24] The time when the documentation has been executed and conditions have been satisfied or waived.
[25] Source: AEDB



Source: "Renewable Energy in Pakistan: Status and Trends" downloaded at http://www.aedb.org/pub.htm

Figure 6.3.2-1 Long-Term Vision for Renewable Energy Development up to 2030

The transfer of authority to develop renewable energy from the central government to the provincial governments is ongoing in Pakistan. Therefore, the Government of Sindh is aggressive to introduce wind farms and other renewable energies into the province. The Environment and Alternative Energy (E&AE) Department of Sindh and the Sindh Board of Investment (SBI) are key organizations in the government on this issue.

They suggest that Jamshoro area (near Hyderabad) is vacant for any potential wind farm projects whereas Gharo and Keti Bandar lands are already leased to the investors. They also expressed their intention to expand the candidate area in the wind corridor eastward up to Islamkot (250 km east of Gharo) because there is a huge vacant land where the wind condition is comparable with that in the Gharo-Keti Bandar area.

As long as such conditions are considered, the wind power in the country will have a bright future, depending of course on the power demand of the area and the development of power transmission systems.

6.4 Small Hydro Power Project

6.4.1 Existing Small Hydro Power Project

Pakistan has hydro power potential of around 60,000 MW, whereas the installed hydro power capacity of Pakistan at the end of fiscal year 2011 was at 6,555 MW as presented in **Table 6.1.3-2**. The share of existing installed hydro power capacity to the total installed generation capacity of the country is only 28%.

Most of the existing hydro power plants of the country are owned by the public sector (WAPDA) and only 111 MW of installed hydro power capacity is by the private sector.

The existing hydro power plants in Punjab province are listed in **Table 6.4.1-1**.

Table 6.4.1-1 Hydro Power Plants Operating in Punjab Province

S.No	Plantt Name	Location	Dealing Entity	Capacity (MW)
1	Ghazi Barotha	Ghazi Barotha, Distt. Attock	WAPDA	1,450.00
2	Chashma	Chashma/Distt. Mianwali	WAPDA	184.00
3	Rasul Rasul	Distt. Mandi Bahuddin	WAPDA	22.00
4	Shadiwal	Shadiwal near Gujrat	WAPDA	14.00
5	Nandipur	Nandipur near Gujranwala	WAPDA	14.00
6	Chichoki Hydel	Upper Chenab Canal,	WAPDA	13.00
7	PAEC Chashma Hydel	Outlet of Cooling Water Disposal Channel, CASHNUP-1, Distt. Mianwali	WAPDA	1.20
8	Renala	Renala-Khurd,-Distt. Dkara	WAPDA	1.00
Total				1,699.00

Souce: "Hydro power Resources Pakistan", Private Power and Infrastructure Board, February 2011

Data on the monthly variation of maximum hydro power generation capacity during the past five years has been collected by the National Power Control Centre (NPCC), Islamabad, NTDC. Such data are provided in **Table 6.4.1-2**.

Table 6.4.1-2 Monthly Maximum Hydro Generating Capability

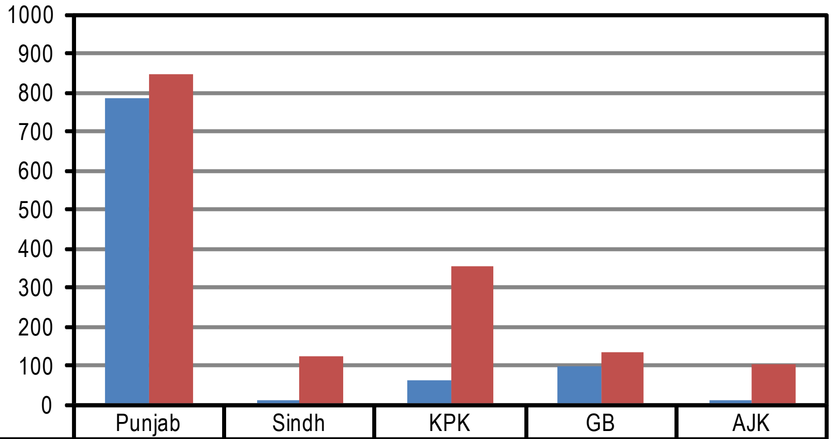
(Unit: MW)

S #	Month	Year	Tarbela	Mangla	Ghazi Barotha	Warsak	Chashma	Small Hydro	Total
1	July	2006	3,567	930	1,250	200	176	57	6,180
		2007	3,680	1,150	1,450	207	176	55	6,718
		2008	3,489	1,035	1,450	208	179	55	6,416
		2009	3,552	1,000	1,450	203	184	53	6,442
		2010	3,546	1,150	1,450	205	176	55	6,582
2	August	2006	3,692	1,150	1,425	195	184	62	6,708
		2007	3,702	1,150	1,450	207	184	54	6,747
		2008	3,682	950	1,450	206	184	54	6,526
		2009	3,638	1,150	1,450	210	170	53	6,671
		2010	3,594	1,150	1,450	207	86	48	6,535
3	September	2006	3,692	1,150	1,450	200	184	66	6,742
		2007	3,702	1,150	1,450	207	181	41	6,731
		2008	3,672	920	1,450	206	184	51	6,483
		2009	3,642	1,120	1,450	213	178	55	6,658
		2010	3,600	1,150	1,450	215	184	54	6,653
4	October	2006	3,497	1,150	1,450	200	178	71	6,546
		2007	3,442	1,150	1,450	207	184	39	6,472
		2008	3,121	1,150	1,450	206	184	37	6,148
		2009	3,348	1,090	1,450	213	181	52	6,334
		2010	3,395	1,150	1,450	215	176	54	6,440
5	November	2006	3,120	1,150	1,160	170	72	69	5,741
		2007	2,957	1,089	1,450	140	160	39	5,835
		2008	2,890	1,126	1,450	137	184	37	5,824
		2009	2,738	1,058	1,450	178	170	45	5,639
		2010	3,056	1,035	1,450	180	161	44	5,926
6	December	2006	2,482	997	1,450	133	184	45	5,291
		2007	2,401	808	1,450	173	140	35	5,007
		2008	1,921	850	1,450	137	140	42	4,540
		2009	2,425	942	1,450	178	147	38	5,180
		2010	2,914	980	1,450	150	136	34	5,664
7	Janaury	2006	1,434	840	1,600	136	48	28	4,086
		2007	1,068	609	1,100	173	128	30	3,108
		2008	1,455	666	1,450	137	120	15	3,843
		2009	1,160	516	960	176	133	12	2,957
		2010	1,440	754	1,450	150	154	16	3,964
8	February	2006	2,186	440	1,160	171	87	19	4,063
		2007	1,771	694	1,350	173	115	32	4,135
		2008	2,080	981	1,450	170	100	42	4,823
		2009	2,126	677	1,450	143	161	55	4,612
		2010	2,420	776	1,450	150	161	74	5,031
9	March	2006	2,263	640	1,160	171	161	19	4,414
		2007	1,675	576	1,450	173	107	32	4,013
		2008	2,044	759	1,450	170	154	42	4,619
		2009	2,064	606	1,450	143	147	55	4,465
		2010	2,182	714	1,450	150	126	74	4,696
10	April	2006	2,493	1,146	1,450	210	184	52	5,535
		2007	1,466	732	1,450	207	138	45	4,038
		2008	2,272	810	1,450	217	174	54	4,977
		2009	1,606	836	1,450	178	161	61	4,292
		2010	1,800	889	1,450	182	184	118	4,623
11	May	2006	2,925	1,150	1,450	210	184	53	5,972
		2007	2,024	880	1,450	207	161	55	4,777
		2008	2,160	1,034	1,450	214	184	56	5,098
		2009	2,031	1,036	1,450	210	184	54	4,965
		2010	2,590	1,060	1,450	205	184	120	5,609
12	June	2006	2,652	1,150	1,450	210	149	55	5,666
		2007	3,149	1,070	1,450	208	181	56	6,114
		2008	2,234	1,104	1,450	200	184	50	5,222
		2009	2,512	1,128	1,450	210	184	54	5,538
		2010	2,662	1,097	1,450	205	184	115	5,713

Source: National Power Control Centre (NPCC)

6.4.2 Future Prospects of Small Hydro Power Projects

A number of sites for small/micro/mini (below 50 MW) hydro power potential were identified in Punjab, Khyber Pakhtunkhwa (KPK), Azad Jammu & Kashmir (AJK) and the northern mountain region of the country as shown in **Figure 6.4.2-1**.



	Punjab	Sindh	KPK	GB	AJK
Number of Raw Sites (Numbers)	786	13	63	98	11
Cumulative Capacity (MW)	846.397	126	356	133	106

Source: Prepared by JICA Study Team base on the data of PPDB-Punjab and Private Power and Infrastructure Board (PPIB), February 2011 (<50MW)

Figure 6.4.2-1 Small Hydro Power Potential in Pakistan (<50 MW)

The hydro power potential of Punjab province is higher than that of Sindh province, i.e., approximately 780 sites of micro, mini, and small projects have been identified in Punjab province (**Appendix D-1**).

The hydro power projects under implementation in Punjab are shown in **Table 6.4.2-1**. There are seven public projects and 31 private projects under implementation. Most of these proposed small hydro power projects are located at irrigation canals and planned to use relatively low head and irrigation water at irrigation intake structures or intake weirs.

Table 6.4.2-1 Hydro Power Projects under Implementation in Punjab

[Public Sector]

S.No	Project Name	Location	Dealing Entity	Capacity (MW)
A. WAPDA				
1	Jinnah	Jinnah Barrage on Indus River	WAPDA	96.00
2	Akhori	Indus	WAPDA	600.00
			SubTotal	696.00
B. Punjab Power Development Company Ltd (PPDCL)				
1	Marala	Upper Chenab Canal Lower RD 0+000	PPCL	7.20
2	Chianwali	Upper Chanab Canal Lower RD (28+000 & RD 164+4500	PPCL	5.00
3	DegoutFall	Upper Chenab Canal RD 283+100	PPCL	5.00
4	Dkara	Lower Bari Doab Canal RD 196+954	PPCL	4.00
5	Pak Patan	Pak Pattan Canal RD 112+350 to 124+950	PPCL	3.20
			SubTotal	24.00
			Total	720.00

[Private Sector]

S.No	Project Name	Location	Dealing Entity	Capacity (MW)
A. PPIB				
1	Karot HPP	River Jhelum, Near Kahota	PPIB	720.00
			Sub Total	720.00
B. PPDB				
1	Taunsa HPP	Taunsa Barrage at Indus River	PPDB	120.00
2	C.J.Link Canal	Canal Tail Fall	PPDB	44.30
3	Marala	River Chenab	PPDB	20.00
4	Rasul	River Jhelum	PPDB	20.00
5	Punjanad	River Chenab	PPDB	15.00
6	B.S. Link-1 Canal	RD 106+250	PPDB	11.00
7	T.P.Link Canal	RD 182+000	PPDB	10.00
8	B.S.Link -1 (Tail)	RD 266+000	PPDB	9.00
9	L.B.D.C	RD 329+058 to RD340+850	PPDB	4.80
10	Abbasia Canal	RD 0+000	PPDB	4.70
11	S.M.B Link	RD 0+014	PPDB	4.48
12	TP Link Canal	RD 60+000	PPDB	4.23
13	TP Link Canal	RD 131+500	PPDB	4.04
14	L.B.D.C	RD 461+550	PPDB	3.30
15	Gujrat Branch Canal	RD 0+000 to RD2+500	PPDB	3.20
16	B.R.B.D. Link Canal	RD 509+712	PPDB	3.14
17	Thal Canal	RD 0+000 to RD68+500	PPDB	3.13
18	B.R.B.D Link Canal	RD 433+958 to RD481+760	PPDB	2.75
19	Muzaffargarh Canal	RD 127+300 to RD147+500	PPDB	2.64
20	Upper Gogera	RD 214+000 to RD219+000	PPDB	2.57
21	L.B.D.C	RD 285+454	PPDB	2.43
22	L.B.D.C	RD 589+000 to RD640+200	PPDB	2.40
23	Lower Chenab Canal (lower)	RD 140+050 to RD182+950	PPDB	2.40
24	Pakpattan	RD 304+344 to RD354+172	PPDB	2.18
25	B.R.B.D Link Canal	RD 0+000	PPDB	2.00
26	Jhang Branch	RD 68+830	PPDB	1.80
27	Lower Jhelum Canal	RD 024+320	PPDB	1.00
28	Jhang Br. Canal	RD 216+000 to RD306+000	PPDB	1.00
29	Koranga Fazaal shah Feeder	RD 6+000	PPDB	0.60
30	8-R Distributary	RD 6+000	PPDB	0.40
			Sub Total	308.00
			Total	1,028.00

Souce: "Hydro power Resources Pakistan", Private Power and Infrastructure Board, February 2011

There are only few small hydro power projects available in Sindh province as shown in **Tables 6.4.2-2** and **6.4.2-3**.

Table 6.4.2-2 Solicited Small Hydro Power Sites in Sindh

S.No	Project Name	Location	Capacity (MW)
1	Guddu barrage HPP	Guddu Barrage	33.00
2	Rohri HPP	Rohri Canal RD 15+000	16.00
3	Rohri HPP	Rohri Canal RD 205+160	5.75
4	Rohri HPP	Rohri Canal RD 496+500	7.80
5	Rohri HPP	Rohri Canal RD 705+000	4.31
		Total	67.00

Souce: "Hydro power Resources Pakistan", Private Power and Infrastructure Board, February 2011

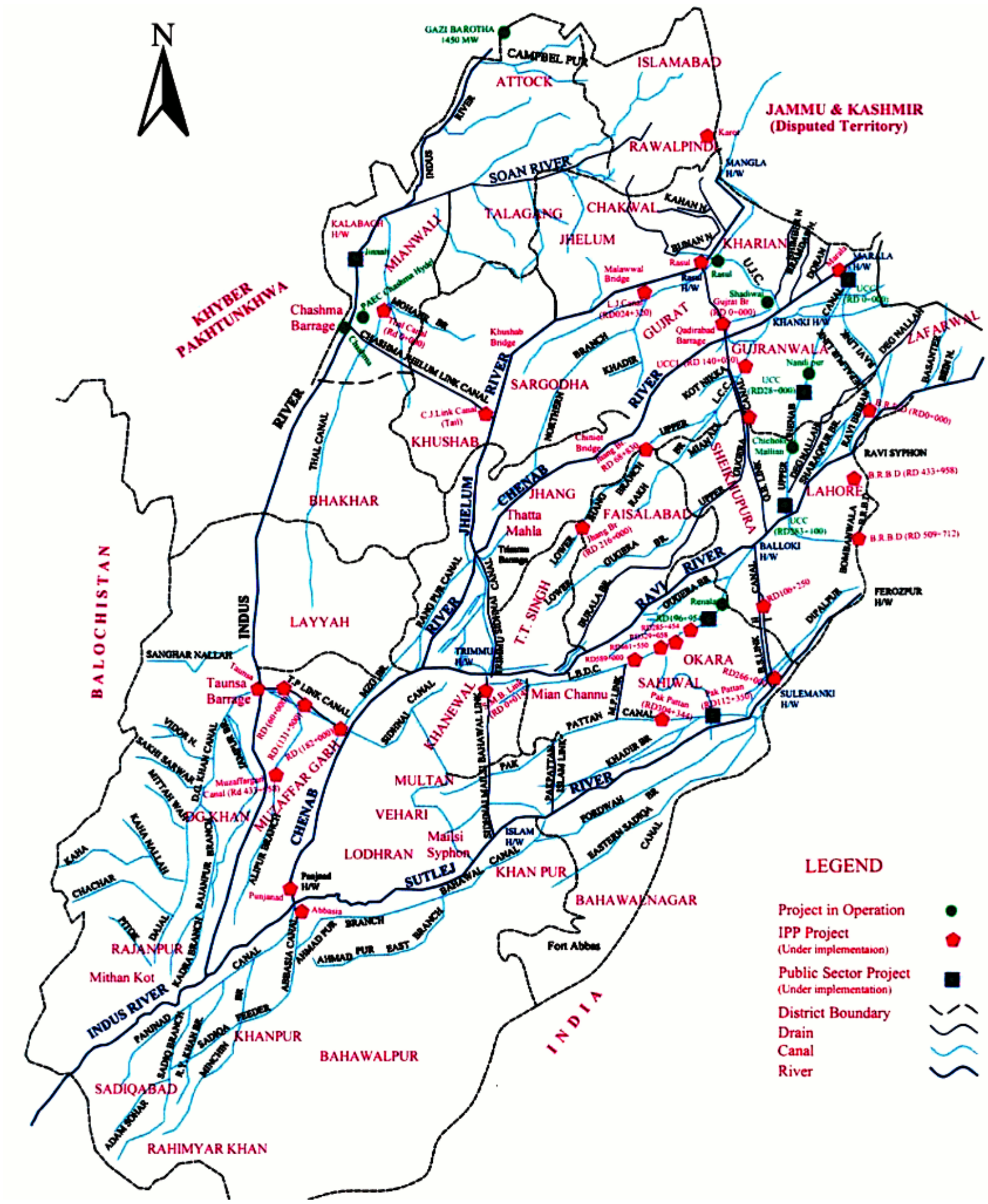
Table 6.4.2-3 Identified Hydro Power Resources (Raw Sites) in Sindh

S.No	Project Name	Location	Capacity (MW)
1	Kotri HPP	Kotri Barrage	29.00
2	Sukkur HPP	Sukkur Barrage	15.50
3	Rohri Canal HPP	Rohri Canal RD 328+256	2.29
4	Rohri Canal HPP	Rohri Canal RD 578+522	1.47
5	Nara Canal HPP	Nara Canal RD 0+000	2.69
6	Nara Canal HPP	Rohri Canal RD 25+000	13.02
7	Nara Canal HPP	Rohri Canal RD 135+000	7.63
8	Nara Canal HPP	Rohri Canal RD 139+000	14.00
9	Nara Canal HPP	Rohri Canal RD 335+000	9.93
10	Nara Canal HPP	Rohri Canal RD 395+000	7.31
11	Nara Canal HPP	Rohri Canal RD 472+000	9.61
12	Nara Canal HPP	Rohri Canal RD 560+000	9.52
13	Nai Gaj Fall HPP	Nai River,KirtherMountain	4.20
		Total	126.00

Souce: "Hydro power Resources Pakistan", Private Power and Infrastructure Board, February 2011

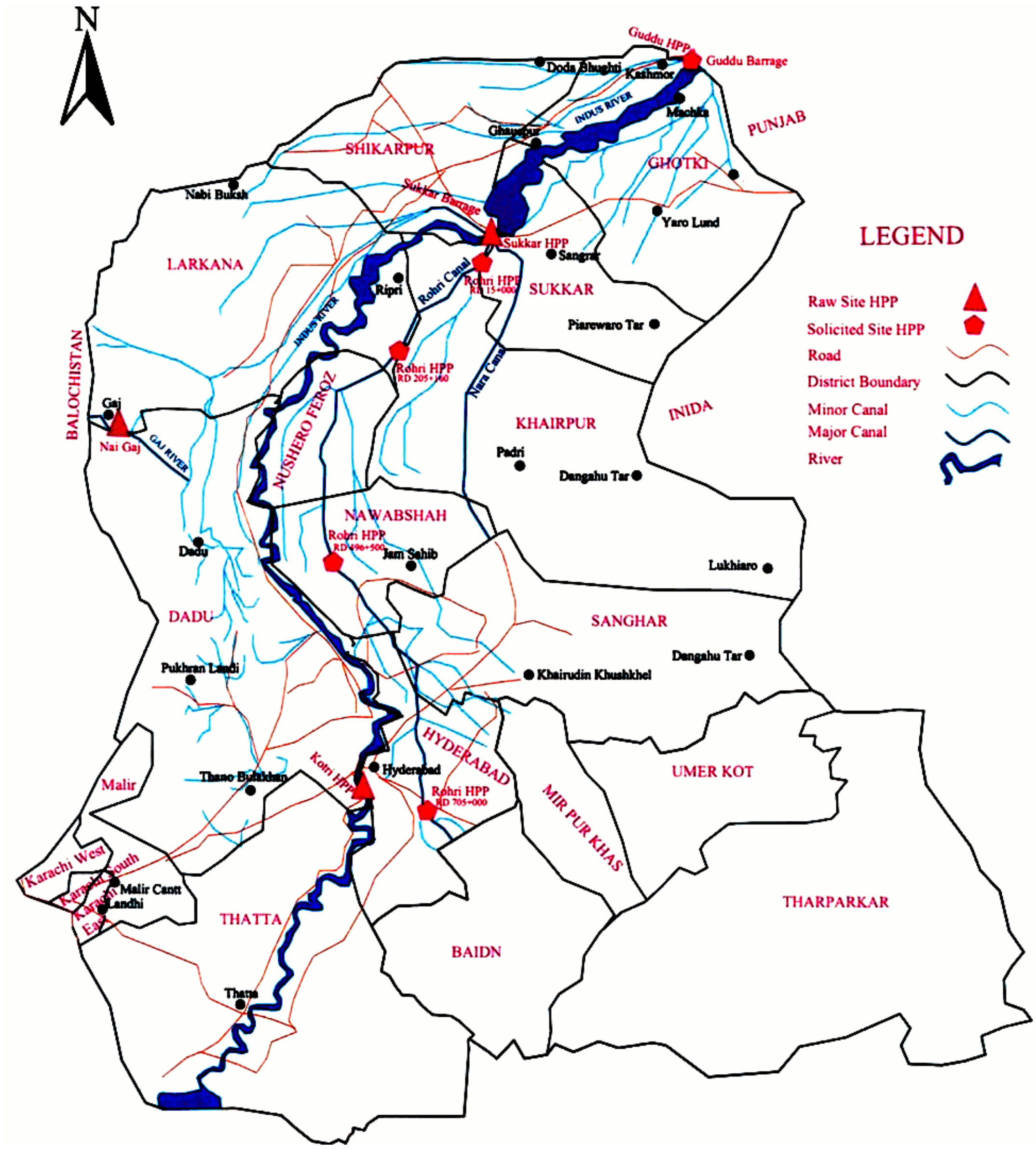
The existing and proposed sites for small hydro power projects in Punjab province and the proposed sites for the same in Sindh province are shown in **Figures 6.4.2-2** and **6.4.2-3**, respectively.

There are a lot of potential sites for small hydro power generation in Punjab province using irrigation canals. However, the annual amount of actual power generation energy of the potential sites will be dependent on the availability of water flows.



Source: “Hydro power Resources Pakistan”, Private Power and Infrastructure Board, February 2011

Figure 6.4.2-2 Existing and Proposed Small Hydro Power Projects in Punjab Province



Source: "Hydro power Resources Pakistan", Private Power and Infrastructure Board, February 2011

Figure 6.4.2-3 Proposed Small Hydro Power Projects in Sindh Province

6.5 Donor's Activities for Renewable Energy

The international donor agencies, e.g., Asian Development Bank (ADB), German Agency for International Cooperation (GIZ) formerly known as GTZ, United Nations Development Program (UNDP), Global Environment Facility (UNDP-GEF), European Union (EU-Asia), U.S. Agency for International Development (USAID) and Japan International Cooperation Agency (JICA), have launched various projects for the promotion, utilization and development of renewable energy technologies within the country.

The major activities of donors are shown as follows:

(1) ADB

Renewable Energy Development

- ✓ Cost: US$0.55 million (Technical Assistance (TA))
- ✓ Duration: 2004 to 2006
- ✓ To prepare a project that will develop indigenous, nonpolluting and renewable sources of energy to help meet the shortage of power supply, and improve the quality and reliability of the power system through: (i) review of renewable energy potential in each province; and (ii) feasibility studies.

Renewable Energy Development Sector Investment Program (formerly Renewable Energy Development Facility)

- ✓ Cost: US$510 million (Loan)
- ✓ Duration: 2007 to 2017
- ✓ (1) Construction of small- to medium-sized hydro power stations and other sources of renewable energy generation units, (2) Feasibility studies and other due diligence work on new RE schemes, and (3) Capacity development program at federal, provincial, and project levels

Renewable Energy Policy Formulation and Capacity Development of the Alternative Energy Development Board

- ✓ Cost: US$0.8 million (TA)
- ✓ Duration: 2007 to 2008
- ✓ Formulation of renewable energy policy and capacity development

(2) GIZ

GTZ (currently GIZ) provided technical expertise and capacity building through PAK-German Tech Cooperation Programme (EUR 3.5 million) on the following[26]:

- Rural Electrification
- Centre of Excellence for Renewable Energy and Environment (CEREE)
- Balochistan University of IT and Management Sciences
- Wind Power Generation
- Strengthening 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)

[26] Pakistan Renewable Energy Report APCTT-UNESCAP

(3) UNDP/GEF

Productive Use of Renewable Energy (PURE) Project

- ✓ Cost: US$1.17 million
- ✓ Duration: May 2008 to April 2013
- ✓ Improve living standards of the local communities by removing barriers to the adoption of renewable energy technologies (RETs) by promoting productive uses of energy in one of Pakistan's remotest areas: Gilgit-Baltistan province and Chitral District in Khyber Pakhtunkhwa province (construction of small hydro power plants).

Sustainable Development of Utility-Scale Wind Power Production Project (Phase I)

- ✓ Cost: US$3.4 million
- ✓ Duration: January 2006 to June 2012
- ✓ To reduce greenhouse gas emissions through the facilitation of commercial-scale exploitation of renewable wind energy for power production in Pakistan (installation of utility-scale wind turbines in Sindh province and Baluchistan province).

(4) EU-Asia Invest

EU-Pakistan – Renewable Energy Capacity Building and Matchmaking Project

- ✓ Funding: 80% by EU-Asia Invest, 10% each by participating companies and project partners
- ✓ Duration: April 2007 to July 2008
- ✓ This joint project of European and Pakistani partners aims to stimulate mutual business encounters of companies in the field of renewable energies between Pakistan and Europe. It also aims to transfer technical experience on how to build and operate renewable energy applications in a successful and sustainable manner. The project milestones are as follows:
  - Accumulation of market information about renewable energy technology in Pakistan, like solar PV, solar thermal applications, wind power generation, and small hydro plants
  - Capacity building seminars for engineers and technicians in Pakistan
  - Business matchmaking between European and Pakistani companies

(5) USAID

- ✓ After Pakistan joined the South Asia Initiative in Energy (SARI/E), USAID provided small grants for solar lamps and solar-powered pumps in Balochistan.[27]
- ✓ In 2007, National Renewable Energy Labs (NREL), USA has carried out a wind resources study of Pakistan and developed a mesoscale map showing the wind speed potential available at 50 m altitude under USAID assistance programme[28] as well as solar PV power generation.

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27 Energy Sector Assessment for USAID/Pakistan, June 2007, USAID
28 Pakistan Renewable Energy Report APCTT-UNESCAP

(6) World Bank

The World Bank has historically been involved in all segments of Pakistan's power sector by financing specific investment projects, supporting the reform program, and undertaking the development of an adequate policy and governance framework for off-grid rural electrification.

(7) JICA

Project for Introduction of Clean Energy by Solar Electricity Generation System

- ✓ Cost: JP¥ 480 million (Grant)
- ✓ Duration: 2011 to March 2012
- ✓ The system installed at PC and PEC is the first on-grid solar power generation system in Pakistan. The capacity of each system is 178.08 kW.

(8) Recent Movement of Foreign Investment Regarding Renewable Energy

Besides the donors' activities, the following were announced in 2012 regarding solar power generation: 1) Conergy (German) will construct a 50 MW solar power generation plant in Cholistan Desert in Punjab province and it will be jointly operated with DACC Power Generation Company Limited (DPGCL) and the GOP; 2) Suntech Power (China) proposed five 20 MW solar power generation systems (100 MW in total); and 3) Board of Investment (BOI), the GOP and Concentrix Solar Company (Korea) signed a Memorandum of Understanding (MoU) to construct a 300 MW solar power generation system in Balochistan province.

6.6 Market Situation of Renewable Energy Equipment

The Study team visited Lahore from November 18 to 20, 2012 to find out about the availability of renewable energy equipments in the market. Equipments for solar PV power generation are locally available at the market area. Photographs are attached as **Appendix E-3**.

(1) Solar PV Power Generation

As standalone solar systems are easy to install and people can start with a smaller unit, these are the most popular and easily available products in the market. There are many distributors in the market who are selling these systems either from one place or there are also separate distributors for each kind of equipment. These standalone systems especially picked up pace in the country after the earthquake of 2005 when these systems were installed to fulfill the needs of internally displaced people. The standalone system provides a very quick solution to the replacement of existing electricity needs considering the time required for their installation is very minimal. The importers are allowed to import such equipment into the country duty free, therefore helping keep their prices low. Prices of related equipment in the market area in Lahore are shown in **Appendix E-1**.

Besides, there are a few system integrators who are putting up the whole system as either residential or non-residential facility. Most of these projects are financed or sponsored by international donors. Moreover, there are no requirements or permissions from any government institution for the installation of these systems and this makes it more convenient to go for standalone solar systems in the country. The project cost roughly estimated for a megascale solar project and the prices of packaged system by system integrators and in the market in Lahore are shown in **Appendix E-2**.

Unfortunately, even for these standalone solar systems, there are no standard guidelines or supervision from the government. The price is the only mechanism that dictates the market at the moment and people are offering systems that are very inferior in quality. Some known solar system providers in the market are afraid that this will lead to the loss of confidence of consumers on the technology in the future.

(2) Wind Power Generation

There are several local manufacturers of windmill for water pumping and power generation in Pakistan; however, the capacity of their product is in the range of 0.5 to 15 kW[29]. MW class windmills are not manufactured in Pakistan and all such large-scale windmills are imported from abroad at present. There are a few local experienced experts/engineers capable of installing such large windmills.

Several windmill manufacturers abroad have a plan to manufacture their products locally in Pakistan for the future development of wind farms in Pakistan as a big market.

(3) Small Hydro power Generation

There are several small capacity turbine manufacturers in Pakistan; however, the manufacturers are at an early stage of technology development. The capacity of their products range from 5 to 100 kW[30].

Small hydro power turbines with much more capacity are imported from abroad, mainly from China.

6.7 Economic and Financial Problem of the Electricity Sector

The preset energy deficit in Pakistan is caused by economic and financial problems of the energy sector. The problems are multifold and explained as follows:

(1) Too Much Reliance on Thermal Energy

The policy adopted during the 1990s relied too much on thermal-based IPPs without taking into account the possibility of future oil price hikes. Since then, no major hydro-based or other renewable energy-based power plant has been installed in the country. The unprecedented increase in fuel prices especially from 2006 to 2007 badly hampered the GOP’s ability to pay the IPPs. This not only affected the overall availability of electricity but also resulted to other liquidity issues. According to the report of the Economic Survey of Pakistan 2011-2012, thermal share of the total energy mix stands at 35.1%.

(2) Circular Debt Issue

The main hurdle in the supply of energy was the accumulation of massive circular debt. The

[29] Pakistan Renewable Energy Report APCTT-UNESCAP
[30] Pakistan Renewable Energy Report APCTT-UNESCAP

major problems which caused the accumulation of circular debt include the partial transfer of tariff as determined by NEPRA, heavy line losses (present level of line losses are almost 20%), incomplete corporatization, weak governance, and costly fuel mix putting extra financial burden on meeting the cost of fuel oil due to constant increase of oil prices. The government has made all possible attempts to address the issue. It has transferred bank loan liabilities of Rs.216.0 billion (as of June 30, 2009) and Rs.85.114 billion from the books of power companies and placed these amounts with Power Holding (Pvt) Ltd (PHPL) (currently Pakistan Power Holding Company Ltd.(PPHC)) in November 2011. Then, it has repaid these loans to the bank along with the markup. But this circular debt seems to be a never ending problem and according to the Economic Survey of Pakistan, the circular debt stands at Rs.398 billion as of April 2012.

(3) Low Recovery of Receivables

Distribution companies are unable to recover their receivables from consumers. According to the Economic Survey of Pakistan, the outstanding dues to the distribution companies stands at Rs.354 billion as of February 2012. In order to expedite recovery and unpaid bills, 1) the disconnection time has been reduced to 45 days from 90 days, and 2) a security deposit for two months is required for new connections as well as reconnections.

(4) Subsidy on Electricity

Due to costly thermal energy and its sizeable share in the overall energy mix, the GOP has to pay a significant amount of subsidy to consumers to make electricity affordable to them. According to the Economic Survey of Pakistan, the overall subsidy was estimated at Rs.91-125 billion for 2012. This subsidy coupled with outstanding receivables by distribution companies are putting pressure on the GOP for its payments to the electricity generation companies, both public and private. The GOP aims to phase out subsidies to the power sector but its implementation will depend on the reduction on reliance on costly thermal electricity and enactment of renewable energy-based power projects in the energy mix.

(5) Transmission and Distribution Losses

Transmission and distribution losses are another factor that is further deteriorating the power sector in the country. Presently, transmission losses are 3.0% for 500 kV and 220 kV (the system of NTDC), which is planned to be reduced to 2.5% by 2014-2015. Also, transmission losses are 2.6% for 132 kV (DISCOs System) and distribution losses are 14.6%. According to the Economic Survey of Pakistan, these losses stand at 20%. The transmission losses are planned to be reduced to 2.4% by 2014-2015 and distribution losses to 8% by 2018-2019[31].

6.8 Bottleneck in Disseminating Renewable Energy

The barriers in disseminating renewable energy are listed as follows:

(1) Administrative Barriers

Although the GOP claims it is offering one window operation to facilitate the developers of the

[31] Electricity Demand Forecast for year 2011-2035

project, it is far from the actual situation in reality. The GOP has established AEDB as a body to realize one window operation but it fails to achieve the target. Renewable energy project developers have to deal with both federal government and provincial governments causing further delay. Renewable energy projects under 50 MW can be dealt with directly by the provincial governments. If a project sponsors opt to go through the provincial government, they have to go to the federal government again later to obtain further approval. If they opt to process their project through the federal government, they still need to apply for lease of land from the provincial government.

(2) Technical Expertise Barriers

Although renewable energy technologies are recognized in the world for quite some time now, they are still relatively new in Pakistan. Therefore the country lacks the necessary technical knowhow and expertise causing dismay to project developers.

At the same time, there is lack of quality standards and codes for RE products. Although with time people are getting aware of the usefulness of RE technologies, people cannot select the qualified products.

(3) High Capital Investment Cost Barriers

The capital investment costs of the most RE technologies are expensive compared with those of conventional generation technologies. This high capital hinders the rapid and significant growth of renewable energy projects in the country.

(4) Law and Order and Political Instability Barriers

Pakistan is considered to be a high risk country due to the law and order situation prevailing in the country over the last decade or so. At the same time, due to the political instability in the country, investors are reluctant to invest as they are afraid that with the change of government, the policies may change. These two factors are also barriers in the development of renewable energy-based power projects in the country.

(5) High Risk Barriers

The government's inability to pay existing IPPs created a perception that the GOP will not be able to pay the new power generators. This makes investors reluctant to carry out high capital investments in renewable energy projects as they are afraid that the GOP may not be able to pay them.

CHAPTER 7 JAPAN'S TECHNOLOGY RELATED TO RENEWABLE ENERGY

7.1 Solar Power Generation

7.1.1 Competitiveness of Japanese Technology

In the solar power generation sector, Japan is one of the pioneer countries in producing quality products using solar cells. Manufacturers in Japan have many years of experience and are still working hard to provide much better quality products and services. In this regard, the products from Japan are well known around the world. Even though competition is very high in terms of the base of unit costs of related products, Japanese companies still export their products around the world. This means that there are still strong needs to the total system of quality products guaranteed by Japanese companies with reliable technology and extensive experience.

If some legislation and/or certification system to avoid low quality products and services are introduced, Japanese technology becomes more competitive.

Regarding the cost competitiveness of solar power generation system, before comparing the cost of Japanese product with the same of foreign product, it refers to the comparison of generation cost of solar power and the same of conventional electricity generation sources.

Since the major electricity generation source in Pakistan is oil thermal generation, the generation cost of oil thermal is selected as conventional electricity source for the comparison with solar power generation. As benchmark of generation cost of oil thermal power generation, the fuel cost of oil thermal power generation of Tokyo Electric Power Company in 2012 is simply applied, which is JP¥15.80/kWh and is equivalent to US$0.203/kWh at the rate of JP¥0.01286/US$1.0.

On the other hand, in order to calculate the generation cost of solar power generation, the following data and assumption are applied.

- Installation capacity: 10 MW
- Construction unit cost: US$2,000/kW
- Operation and maintenance cost: 1% of construction cost per year
- Life period: 20 years
- Discount rate: 10%
- Annual average solar radiation: 5.24 kWh m^{-2} day^{-1}
  (The value of Islamabad Capital Territory)
- System efficiency: 75%

From the above data and assumption, the generation cost of solar power generation system is worked out as follows.

- Construction cost: US$20 million
- Capital recovery factor: 0.1175
- Annualized construction cost: US$2,350,000/year
- Operation and maintenance cost: US$200,000/year

- Total annual cost: US$2,550,000/year
- Total annual generation: 14,344,500 kWh/year
- Generation cost: US$0.178/kWh

The generation cost of solar power generation is US$0.178/kWh and the fuel cost of oil thermal power generation is US$0.203/kWh. This comparison shows that the generation cost of the solar power generation is less than that of oil thermal power generation.

The construction unit const of US$2,000/kW for solar power generation is present international price. The unit cost of solar power generation in Japan recently reached the level of JP¥250,000/kW and is still decreasing. The cost competitiveness of Japanese product is improving accordingly.

7.1.2 Possibility of Applying Japanese Technology

Photovoltaic (PV) modules are products installed outdoor and such products need to withstand natural weather conditions and generate power continuously during long periods. In general, considering the characteristics of solar cells, this product generates power when exposed to sunlight. However, there are some products which degrade within a short period of time and do not generate the expected power. In general it is very difficult to notice this phenomenon of degradation and it requires an expert and test equipment to understand the actual operating conditions. Therefore, the trend is that whenever quality power is required, reliable technical support is required from manufacturers/suppliers, even if the cost is a little higher.

In Pakistan, based on the point of view of already established manufacturers, the long years of experience in manufacturing and installation, and quality of support, it is highly possible for financially strong firms to select Japanese products.

The cost of solar power generation system has been drastically decreasing for the past three to four years, and its market is growing very fast around the world. Feed-in tariff (FIT) was introduced in July 2012 in Japan. After the introduction of FIT, the cost of solar power generation system of Japanese manufacturers has further decreased, and then the cost competitiveness of Japanese solar power generation system has improved much with more improvements being done.

Considering the above, there is a possibility to apply Japanese technology.

Besides, the current situation of dissemination of solar power generation in Pakistan is the situation of the time just before expanding of it. Especially for large scale grid-connected solar power generation in this timing, the role of the introduction model is important. If the introduction model of the same in this stage is not properly functioned, the other developers and investors will lose their drive to proceed with the projects of solar power generation being afraid of failure of the project. The quality of Japanese product is high and the product is reliable. In order to make the role model of grid-connected solar power generation, the system needs to be comprised of Japanese products. For handling the initial risk and withstanding the relatively high prices of Japanese products, implementing grid-connected solar power generation project with Japanese products by Japanese grant aid scheme is recommendable.

7.2 Wind Power Generation

Several names of manufacturer are stated in this Sub-chapter, however it is not intended to support specific companies(s) stated in the Sub-chapter hereafter.

7.2.1 Competitiveness of Japanese Technology

There are three major manufacturers in Japan with MW class large-scale wind power generation systems.

Japan has a complex terrain and wide variations of climates in which severe natural disasters, such as typhoons, thunderstorms, tornados, and earthquakes, occur. Under such difficult situation, Japanese manufacturers have been developing their wind turbine technologies to world-class levels.

Therefore, the specifications of Japanese wind turbines have exceeded world standards as represented by IEC 61400-1. For example, the survival wind speed of Japanese wind turbines can reach 80 m/s, which is higher than IEC “class I”. Regarding the lightning protection system, Japanese wind turbines need to have high performance against strong lightning in Japan, especially winter lightning along the Sea of Japan having characteristics of positive discharge, which is ten times stronger than in Europe

Table 7.2.1-1 IEC Wind Turbine Classes

(Unit: meter/sec)

Class \ Wind Speed Parameters	I	II	III	IV
Reference Wind Speed (V_{ref})	50	42.5	37.5	30
Annual Average Wind Speed (V_{ave})	10	8.5	7.5	6
50-year Return Gust Speed (1.4V_{ref})	70	59.5	52.5	42
1-year Return Gust Speed (1.05V_{ref})	52.5	44.6	39.4	31.5

Source: IEC 61400-1

7.2.2 Possibility of Applying Japanese Technology

(1) Japanese Wind Turbine Manufacturers

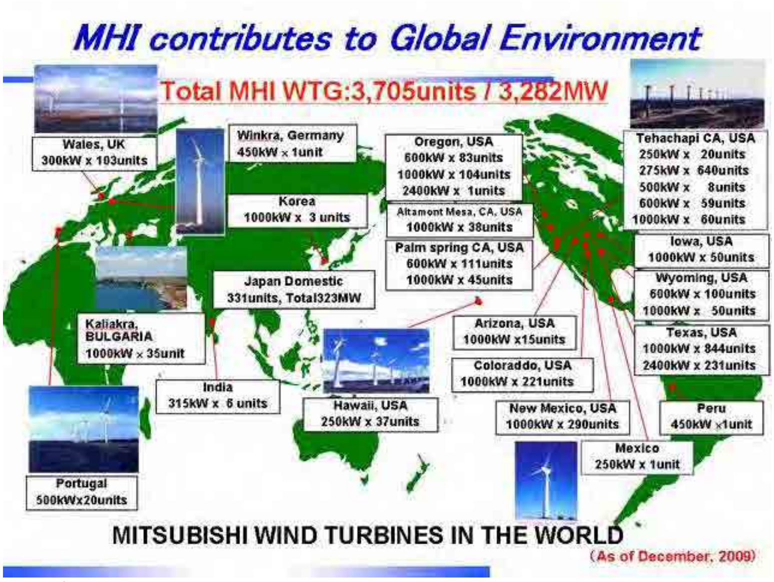
As described in previous sections, Japan has three major wind turbine manufacturers as follows:

- Mitsubishi Heavy Industries Ltd. (MHI)
- Hitachi, Ltd.
- The Japan Steel Works, Ltd. (JSW)

A brief overview of each company and its products is as follows:

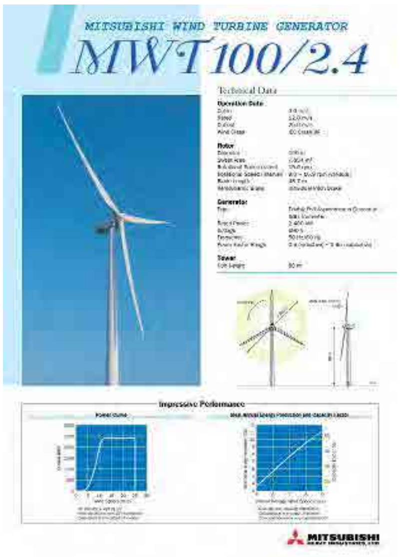
i) Mitsubishi Heavy Industries, Ltd. (MHI)

MHI is a leading wind turbine manufacturer in Japan and has extensive experience in the export of wind turbines. They have supplied more than 3000 wind turbines worldwide up to this date (refer to **Figure 7.2.2-1**). Their flagship products are 2.4 MW to 2.5 MW wind turbines (sample is shown in **Figure 7.2.2-2**).



Source: MHI

Figure 7.2.2-1 MHI Wind Turbines in the World



Source: MHI

Figure 7.2.2-2 MHI Catalog (Sample)

ii) Hitachi, Ltd.

Hitachi is the successor of technology of "SUBARU" brand wind turbine that was originally manufactured by Fuji Heavy Industries Ltd. The SUBARU 2.0 MW wind turbine is their main product (refer to **Figure 7.2.2-3**).

The best feature of SUBARU is its downwind type rotor, which is located at the leeward (downwind) side of the mast. One of the advantages of this rotor type is exhibited in time of power failure. The downwind rotor can rotate toward a stable position according to wind direction without power. Another advantage of this type is that it utilizes the upstream wind effectively, as shown in **Figure 7.2.2-4**.

The other advantages of this system are the following:

- ✓ sealed type step-up gear, which has a high-grade feature of anti-hot and humid climate as well as anti-salinity; and
- ✓ ease of maintenance of power conditioning system (PCS) located at the ground level of the tower, which is usually installed in the nacelle.

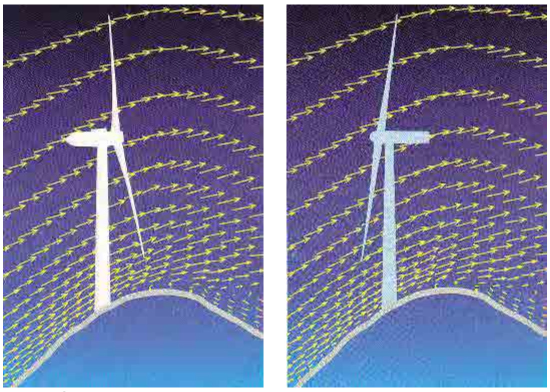
Hitachi is developing a 5 MW wind turbine as the next generation model. According to their plan, it will be available by 2015.

Source: Hitachi

Figure 7.2.2-3 SUBARU Catalog (Sample)

SUBARU Downwind Rotor

Upwind Rotor



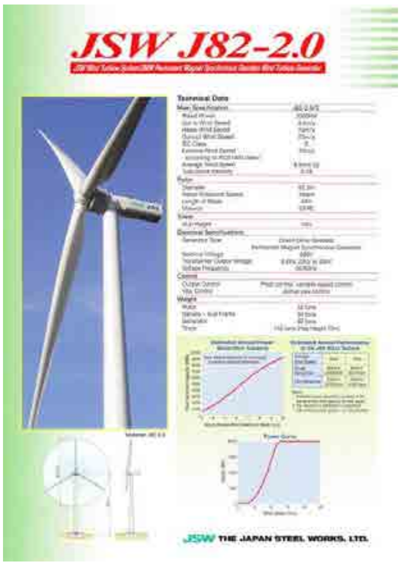
Source: Hitachi

Figure 7.2.2-4 Effective Use of Upstream Wind

iii) The Japan Steel Works, Ltd. (JSW)

The JSW's main wind turbine product is the "Gearless" 2 MW type wind turbine as shown in **Figure 7.2.2-5**. The "Gearless" type has its rotor and generator connected directly without step-up gear. It is advantageous in the maintenance stage since problems, which occasionally occur in the step-up gear, would be avoided.

For JSW's next generation product, a 3 MW wind turbine is in the development stage. A prototype of the 3 MW wind turbine, which only has a 2.7 MW capacity, is planned to be installed in the middle of 2013.



Source: JSW

Figure 7.2.2-5 JSW Catalog (Sample)

(2) Total System Strategy

Once Japanese products are introduced as total systems, the operation, maintenance and service systems will also be introduced at the same time. This is similar to the case of the bullet train or the "Shinkansen". Therefore both countries will benefit if Japanese technology will be introduced in the field of wind power generation in Pakistan. In order to introduce the total packaged system of Japan, the scale of the project needs to be large so as for the project to be the major electricity power source of the national grid of Pakistan. In such case, it is recommended that the project of wind power generation be implemented with Japanese Yen Loan.

7.3 Small Hydro Power Generation

Several names of manufacturer are stated in this Sub-chapter, however it is not intended to support specific companies(s) stated in the Sub-chapter hereafter.

7.3.1 Competitiveness of Japanese Technology

The Study team interviewed the Japanese hydro power companies listed below in order to check the availability of installation of small hydro power turbines, generators, and other electrical and mechanical facilities in the study area of Pakistan.

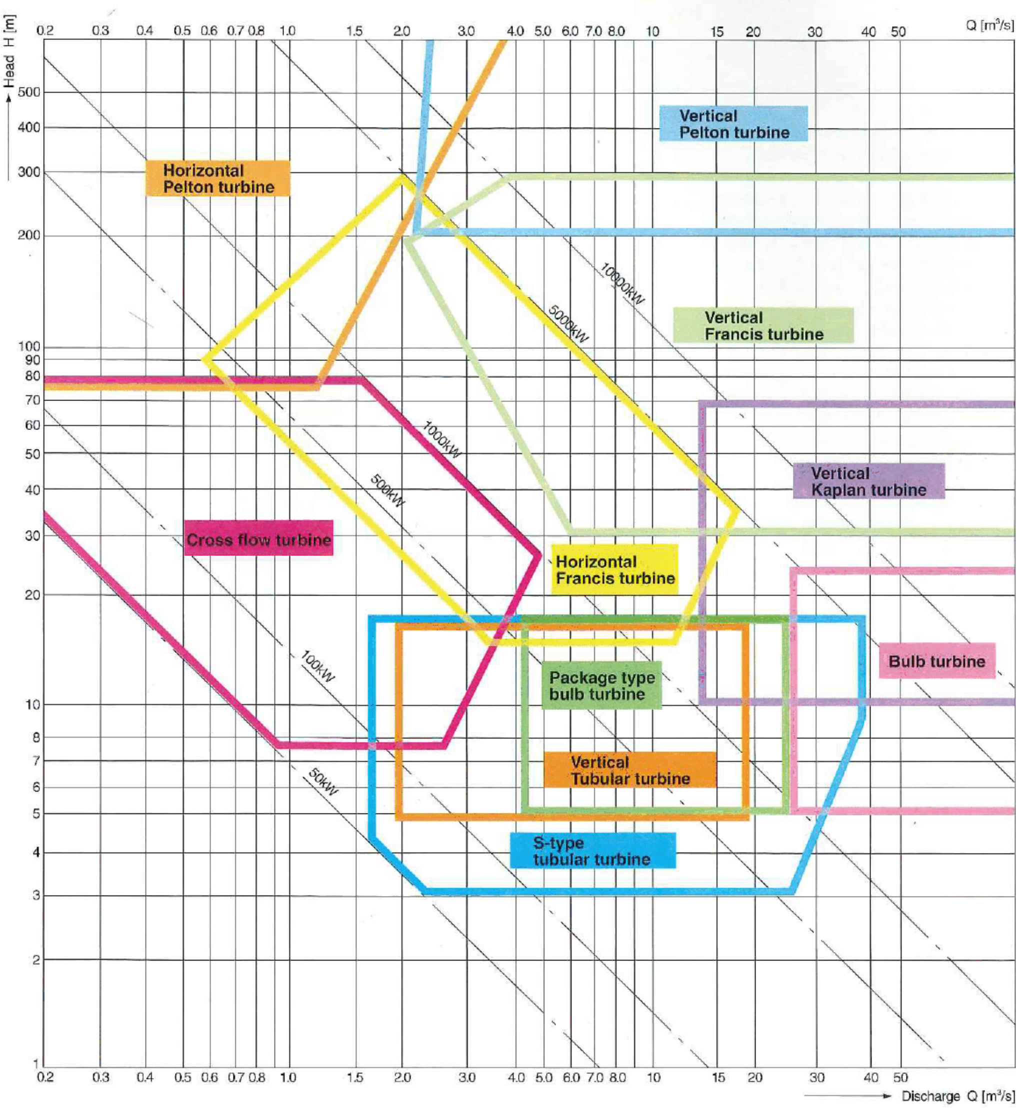
- Fuji Electric Co., Ltd.
- Toshiba Corporation Power System Company
- Hitachi Mitsubishi Hydro Corporation
- Nippon Koei Co., Ltd. Fukushima Works

(1) Fuji Electric Co., Ltd.

According to the interview survey, Fuji Electric Co., Ltd. has experience in the installation of small hydro power systems (Kaplan turbine of 23.5 MW x 8 units with head of 13.8 m) for WAPDA for low head and large discharge hydro in the Chashma irrigation canal in Punjab province. Also, Fuji Electric Co., Ltd. has experience in the installation of 30 systems of small hydro power turbines and electrical systems of bulb turbine type in the irrigation canals in India. The capacities of the installed turbines range from 5 MW to 17 MW (total of 300 MW).

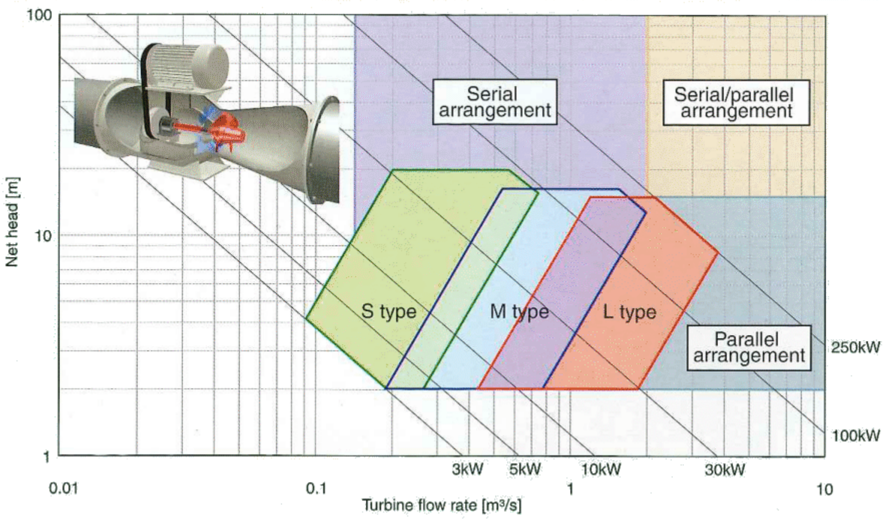
The available types of low head turbine by Fuji Electric Co., Ltd. are as follows and shown in **Figures 7.3.1-1** and **7.3.1-2**:

- S-type Tubular Turbine (head: 3 m to 18 m; capacity: 50 kW to 5,000 kW),
- Vertical Axis S-type Tubular Turbine,
- Package Type Bulb Turbine (head: 5 m to 18 m; capacity: 150 kW to 3,500 kW),
- Bulb Turbine (head: 5 m to 25 m; capacity: above 1 MW) ,and
- Micro Tubular Turbine (head: 2 m to 20 m, capacity: 3 to 250 kW)



Source: Fuji Electric Co., Ltd.

Figure 7.3.1-1 Selection Table of Fuji Standard Hydraulic Turbines



Source: Fuji Electric Co., Ltd.

Figure 7.3.1-2 Selection Table of Fuji Micro Tubular Turbine

The unit cost of the vertical axis bulb turbine and electrical system is JP¥200,000 to JP¥300,000 per kW. Also, the unit cost of the micro tubular turbine and electrical system is JP¥400,000 to JP¥500,000 per kW.

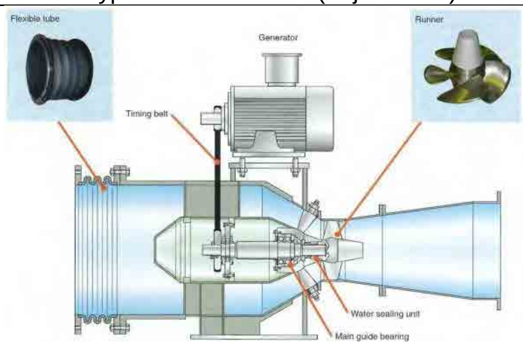
The competitive technologies of Fuji Electric Co., Ltd. are as follows:

- Operations of more than half a century
- High efficiency and high reliability
- Compact design
- Maintenance-free technology (ventilation of the generator cooling system, PTFE bearing, oil-less turbine, water-lubricated bearing system, etc.)
- Experiences of implementation in Pakistan, India, etc.

The examples of products of Fuji Electric are shown in **Figure 7.3.1-3**.

S-type Tubular Turbine (Fuji Electric)

Package Type Bulb Turbine (Fuji Electric)



Micro Tubular Turbine (Fuji Electric)

Example of Serial Arrangement with 2 units of Micro Tubular Turbine (Fuji Electric)

Source: Fuji Electric Co., Ltd.

Figure 7.3.1-3 Products of Fuji Electric

(2) Toshiba Corporation Power System Company

The Toshiba Corporation Power System Company started to install hydro power facilities in 1894 in Kyoto, Japan. Their experience in hydro power spans for more than 100 years. For low head, small hydro power turbines, Toshiba provides standard units of horizontal small bulb turbines called “Hydro-eKIDS” with power ranging from 1 kW to 200 kW and design heads from 2 m to 12 m. For other sizes, design and manufacturing are made-to-order. The bulb turbine will be designed and manufactured individually. The minimum applicable design head of the bulb turbine of Toshiba is 5.5 m. Toshiba does not make cross-flow turbines and S-type tubular turbines at present.

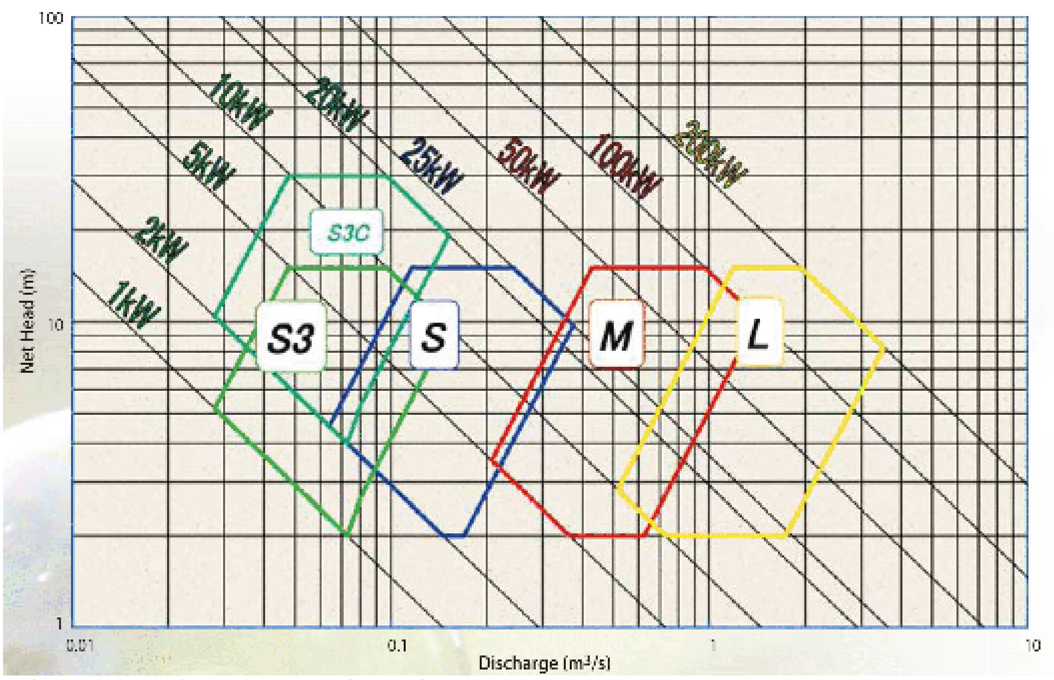
Toshiba has a subsidiary in China for manufacturing hydro power turbines and generators. The name of this subsidiary is Toshiba Hydro Power (Hangzhou) Co., Ltd. and it started in 2005. In addition, the local production of turbines and generators is made based on the design of Toshiba in India.

The approximate cost of Hydro-eKIDS (L-type, 200 kW) if made in Japan is JP¥100 million per unit. This price includes the turbine and generator unit and all electrical and mechanical systems. The price of the same product will be reduced about 1/2 if it would be made in India. Also, the price would be further lowered if ordered by bulk.

The competitive technologies of the Toshiba Corporation Power System Company are as follows:

- Manufacturing record of more than 100 years
- Long life and efficient operation (long-term stable operation)
- Easy maintenance and same useable spare parts (standard unit Hydro-eKIDS)
- Wide range of applications
- Small space and easy installation
- Low maintenance
- Local production in China and India (competitive prices)

The selection table of Toshiba "Hydro-eKIDS" is shown in **Figure 7.3.1-4** and the photographs or images of Toshiba products are shown in **Figure 7.3.1-5**.

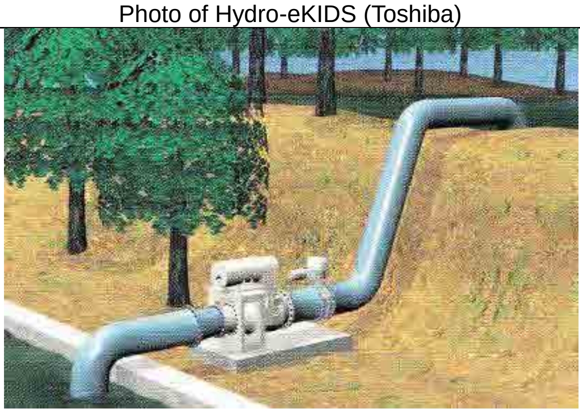


Source: Toshiba Corporation Power System Company

Figure 7.3.1-4 Selection Table of Toshiba's Hydro-eKIDS

Photo of Hydro-eKIDS (Toshiba)

Installation of Hydro-eKIDS (Toshiba)



Example of Installation of Hydro-eKIDS

Example of Installation at Gate of Weir

Source: Toshiba Corporation Power System Company

Figure 7.3.1-5 Photographs/Images of Toshiba's Products

(3) Hitachi Mitsubishi Hydro Corporation

Hitachi, Ltd., Mitsubishi Electric Corporation, and Mitsubishi Heavy Industries, Ltd. established Hitachi Mitsubishi Hydro Corporation in October 2011 by consolidating the hydroelectric power generation systems of the three companies. From the founding of Hitachi and Mitsubishi, their history of hydroelectric power generation systems spans almost a century, and to date, they have provided society with 91,000 MW of power from 2,000 power generation facilities.

Source: Hitachi Mitsubishi Hydro Corporation

Figure 7.3.1-6 1.4 MW Bulb Turbine/1.3 MVA Generator for Hitokita HPP, Japan

They deal with all types of high-performance turbines and pump turbines, such as the Francis type, and they have been active in the development of cutting-edge technology in the field of pumped-storage power generation. For low head hydro power, the following turbines are available:

- Horizontal Bulb Turbine (Head : 3 m to 9 m, Discharge: 300 m^3/s to 400 m^3/s)

- Tubular Turbine (Head: 3 m to 20 m, Discharge: 2 m^3/s to 30 m^3/s, Capacity: 400 kW to 1,000 kW)

The bulb turbine is also available to correspond to fluctuation of discharge by adjusting the moveable blade. The approximate price of the turbine, generator, and control system is JP¥200,000 per kW. Photograph of the horizontal Bulb turbine by Hitachi Mitsubishi is shown in **Figure 7.3.1-6**.

They have experience in the installation of small hydro power facilities in India such as the Kosi Hydro power Plant with 22.4 MW (5.6 MW x 4 turbines, H = 6.1 m) capacity in 1970. Also in Japan, they installed several low head small hydro power plants with design head ranging from 3.61 m to 12.1 m. Furthermore, they have experience in the installation of bulb turbines small hydro power plants in Thailand and China.

The competitive technologies of Hitachi Mitsubishi Hydro Corporation are as follows:

- Manufacturing record of more than 100 years
- Long life and efficient operation (long-term stable operation)
- Extensive experience in the installation of hydro power facilities in Japan and other parts of the world
- Low maintenance

(4) Nippon Koei Co., Ltd. Fukushima Works

Nippon Koei Co., Ltd. was established in 1946. Nippon Koei undertakes investigations, planning and construction management of transformer substations, electricity control plants, and overhead and underground transmission lines and manufacturing of hydro power facilities such as turbines, electrical and mechanical control systems, etc...

Nippon Koei Fukushima Works has manufactured small hydro power turbines, but for low head and large flow turbines are not manufactured much.

For low head hydro power, siphon type turbines or propeller type turbines such as bulb tubular and S shape tubular are available.

The available low head turbine types by Nippon Koei are as follows and shown in **Figure 7.3.1-7**:

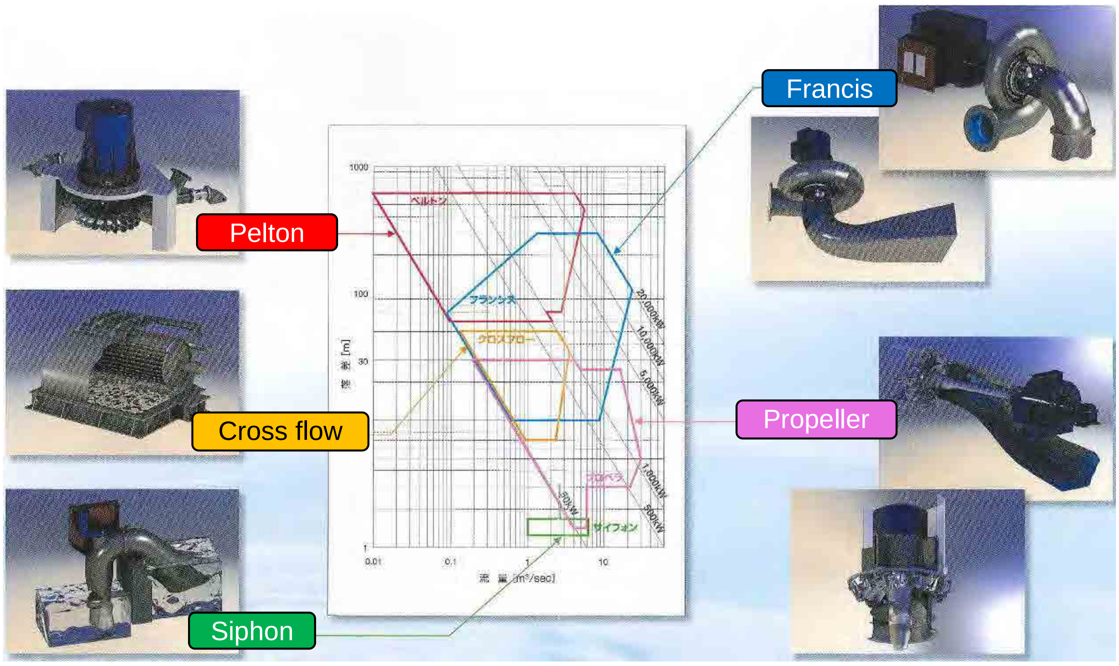
- Siphon type turbine (Head: 1.2 m to 1.8 m, Discharge: 1 m^3/s to 6 m^3/s, Capacity: about 50 kW)
- Propeller type turbine (S-type tubular or bulb turbine, Head: 1.5 m to 30 m, Discharge: 0.2 m^3/s to 12 m^3/s, Capacity: 50 kW to 4 MW)

The turbine uses “magnetic bearing” in order to achieve oilless maintenance. In order to reduce the maintenance cost, the electric servo motor guide governor is used to adjust the flow to the turbine and the system to match the frequency of the system.

The competitive technologies of Nippon Koei are as follows:

- Manufacturing record of more than half a century

- Long life and efficient operation (long-term stable operation)
- Extensive experience in the installation of hydro power facilities in Japan and other parts of the world
- Low maintenance (oilless magnetic bearing system)



Source: Nippon Koei Co., Ltd.

Figure 7.3.1-7 Selection Table of Nippon Koei

7.3.2 Possibility of Applying Japanese Technology

Japanese made small hydro power turbines, generators and electrical systems are more expensive compared to such products made in China, but from a long-term perspective, Japanese products are reliable and easier to maintain. Also, these Japanese turbines and generators have high efficiency.

The package type bulb turbines of Fuji Electric and the Hydro-eKIDS of Toshiba have competitive prices. If it is possible to conduct local production by using Japanese design under Japanese guidance in Pakistan, further reduction of costs would be expected.

Bulk production of the same design and size of turbines and generators would reduce the cost of systems.

Japanese small hydro power turbines have compact design and utilize technologies for less maintenance. These technologies could be applied in Pakistan. In the same manner of solar power generation, Japanese technologies of small hydro power generation could materialize the role model of low head small hydro power generation in the irrigation canals. For handling the initial risk of introduction of small hydro power generation and withstanding the relatively high prices of Japanese products, implementing small hydro power generation project with Japanese products by Japanese grant aid scheme is recommendable.

CHAPTER 8 FIELD SURVEY AND POTENTIAL PROJECT

8.1 Solar Power Generation

8.1.1 Field Survey of the Pakistan Institute of Medical Sciences

The Pakistan Institute of Medical of Sciences (PIMS) is part of the public sector and lies within the Islamabad Capital Territory. It is located 7 km southwest from the center of the city. It provides medical facilities to the public; not only for patients from the capital city but also for patients from the surrounding areas of the capital city.

(1) Organization

The PIMS is divided into seven sectors under the executive director/dean. Out of the seven sectors, all medical treatments and technical related subjects including operations and maintenance (O&M) belong to the Islamabad Hospital. The Electrical Engineering Department (EED), a sector of the Islamabad Hospital, is responsible for technical and daily O&M. A detailed organization chart of PIMS and EED is shown in **Appendix B-3-1**.

(2) Existing Power Supply System and Electricity Consumption

There are five substations (SSs) located in the premises of PIMS which supply electricity to the facilities of the different sectors of PIMS. Each SS is connected with two different 11 kV feeders coming from Tarbela and Mongala grid SSs. These 11 kV feeders from the grid SSs to the SSs in PIMS are dedicated feeders for PIMS and are exempted from the scheduled load shedding.

The recorded monthly average power consumption of the SSs according to the electricity bill of the distribution company is summarized below in **Table 8.1.1-1**.

Table 8.1.1-1 Power Consumption of Each SS

Substation (SS)	2011 (12 months)		2012 (11 months: Jan to Nov)	
	Average (kWh/Month)	Total (kWh)	Average (kWh/Month)	Total (kWh)
SS No.1	461,503	5,538,040	449,740	4,947,140
SS No.2	360,027	4,320,320	361,815	3,979,960
SS No.3	142,417	1,709,000	241,000	2,651,000
SS No.4	71,307	855,680	101,386	1,115,250
SS No.5	199,250	2,391,000	213,352	2,346,873
Total of all SS	1,234,503	14,814,040	1,367,293	15,040,223

Source: Prepared by JICA Study Team based on Monthly Electricity Bill of PIMS

From the above table, the total power consumption of PIMS' facilities in 2011 was 14,814,040 kWh. The total consumption for 11 months from January to November 2012 was 15,040,223 kWh. The total electricity consumption in 2012 (from January to November) exceeds the total amount of electricity consumption in 2011.

Out of the five SSs, SS No. 1 has the largest capacity and supplies power to the main facilities such as the Children Hospital, Mother and Child Health Center including OPD Building, service blocks, etc.

Details of the layout of facilities and SSs are shown in **Appendix B-3-2**, and the monthly power consumption of each SS is shown in **Appendix B-3-3**.

The capacity of transformers installed at each SS is shown in **Table 8.1.1-2**, and the detailed single line electric diagram of each SS is shown in **Appendix B-3-4**.

Table 8.1.1-2 Transformer Capacity of Each SS

Substation (SS)	Capacity of Existing Transformer (kVA)	Quantity (Unit)
SS No. 1	1,000	1
	1,500	1
	2,000	1
SS No. 2	1,500	2
SS No. 3	1,250	1
	630	1
	250	1
	200	2
SS No. 4	1,000	1
SS No. 5	630	1

Source: Prepared by JICA study team based on provided information by PIMS

(3) Changeover Operation of 11 kV Feeders

There is a changeover switch installed at the grid SS to select which feeder would supply electricity to the SS in PIMS. If any changeover is required at the 11 kV supply feeder (source), then the changeover is done outside PIMS at the main supply cabinet by the power distribution company. In case there is any disturbance at the 11 kV distribution feeder inside the PIMS' premises that connects to the SS of PIMS, there is manual changeover switch to select the 11 kV feeder at each SS.

Source: JICA Study Team

Figure 8.1.1-1 Existing Changeover Switch and Energy Meter Panel

Figure 8.1.1-1 shows the existing 11 kV changeover switches and energy meter panel at the SS of PIMS.

(4) Emergency Power Supply

At each facility of PIMS, a diesel generator (DG) is installed as a backup power source that would supply low voltage electricity (three phase, 400 V) in case of emergency.

Normally, DGs are not in use and remain as emergency backup. Even though DGs run only in case of emergency, they require frequent idling in order to keep them in working conditions. During idling operation, a DG consumes fuel. According to information provided by PIMS, it is understood that the average cost to maintain DGs in operating condition is around Rs.40,000 per generator per month. The installed capacity of DG varies from 100 kVA to 750 kVA depending on the minimum requirement in an emergency. The capacities of existing DGs for emergency purposes are summarized below in **Table 8.1.1-3**.

Table 8.1.1-3 Capacity of Existing Diesel Generator of PIMS

Substation (SS)	DG Capacity (kVA)	Connected Facility / Equipment
SS No. 1	500	Old Angiography Unit of Islamabad Hospital, Services Block, Chillers & Boilers
	500	Children Hospital
	500	Mother & Children Health Center
	400	Feeding to Burn Care Center (BCC) Building
SS No. 2	750	Accident Emergency, Inpatient Ward, OT, CCU, X-Rays, Surgical ICU, Medical ICU, OPD, Pathology Dept., Blood Bank, Cardiology Ward, Private Rooms, Admin & Accounts
	100	
	300	64 Slices CT Scan
	150	MRI Unit
SS No. 3	630	Cardiac Surgery Unit
	400	Feeding to Laundry and Burn Care Center (BCC)

Source: Prepared by JICA Study Team based on provided Information by PIMS

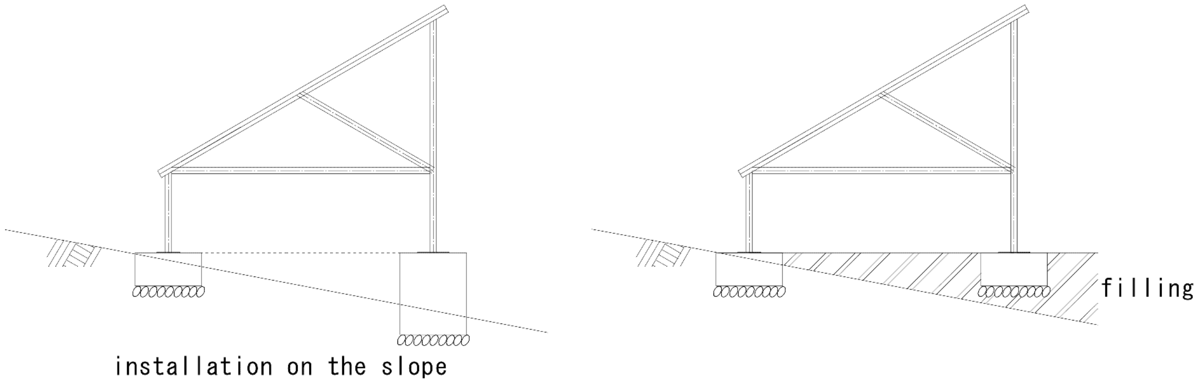
Aside from the DGs shown in the above table, uninterruptible power supply (UPS) units are connected to equipment that require continuous stable power supply or to equipment for medical treatment which cannot lose power supply. Such equipment supported by UPS are mainly used in operating theatres, scanning equipment and so on in the main hospital building where power is supplied from SS No. 2.

(5) Estimated Available Open Space

The total area of PIMS is around 140 acres (57 hectares) and within this area, there is unutilized open space which PIMS does not have any future plan to use for construction or for any other purpose. The available open space for installation of PV modules is situated southwest of the Motor Workshop. It starts from the east fence of the premises of PIMS going southwest nearby the “B type” residential buildings along Hanna Road as shown in **Appendix B-3-2**.

The open space mentioned above includes a waterway, wherein stream water mixed with drain water flows from the northeast to the southwest corner of the open space. There is a slope and differences in the level of land toward the waterway from both the southwest and northeast. At present, most parts of the open space are covered with thick bushes. Therefore, in order to identify the actual available space, a topographic survey was conducted. The overall layout of the building within the PIMS premises and the proposed open space is shown in **Appendix B-3-2**, and the results of the topographic survey and pictures of the present status are shown in **Appendix B-3-5** and **Appendix B-3-6**, respectively.

According to the topographic survey, the depth of the valley is approximately 8 m to 10 m from the waterway to the upper land level. There are slopes on both sides of the waterway. Generally, the equipment for solar power generation consist of PV array and frame structure. Some types of frames for solar power generation are identified. Ground mounting is a typical example. This frame type has multiple legs and foundations. Ground mounting is needed to adjust the top level of the foundations. It seems very difficult to adjust these levels in this undulating site (see **Figure 8.1.1-2**). Therefore, it is favorable to level the ground for ground mounting. In this situation, some of the ways to level the ground are as follows:



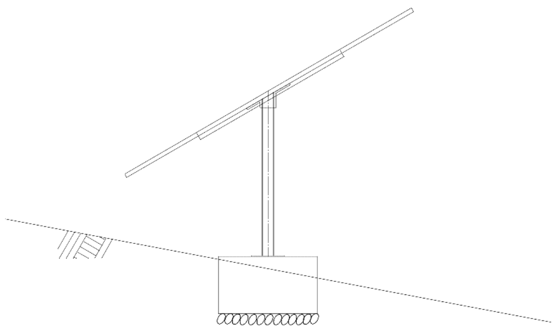
Source: JICA Study Team

Figure 8.1.1-2 Installation of Ground Mounting on the Slope

- Filling: Constructing culvert and filling
- Staging: Constructing stage by steel structure

Filling has a lower construction cost but is unfavorable for river management. On the other hand, staging is more expensive than filling but river management would be the same as before. In addition, staging requires regular repainting or the use of anti-corrosion steel for the structure.

As compared with ground mounting, pole mounting is able to correspond with the natural topography. It seems easier to construct because this type has only one foundation and there is no to need to adjust between foundations. However, pole mounting is not recommended on steep slopes. According to the topographic survey, there are steep slopes in the site, therefore, further consideration to such steep slopes is required in the detailed design (see **Figure 8.1.1-3**).



Source: JICA Study Team

Figure 8.1.1-3 Installation of Pole Mounting on the Slope

For the installation of solar power generation facilities in this site, the following studies and surveys are required:

- ✓ Detailed topographic survey
- ✓ Geological survey for detailed design
- ✓ Structural study of the steep slopes
- ✓ Study of construction method including types of construction machinery
- ✓ Planning of site road for construction machinery and trucks

According to the topographic survey and layout planning, the open space area which can be utilized for PV module installation was estimated at approximately 18,944 m^2 in total. The available open space is not on flat land and the stream is running in between. In order to estimate the total available area, the different lots of open spaces were estimated. **Table 8.1.1-4** summarizes the estimated open space available for PV module installation.

Table 8.1.1-4 Estimated Open Space for PV Module Installation

Zone	Area	Unit	Property
①	6,449.0	m^2	ground
②	12,495.0	m^2	ground
Total	18,944.0	m^2	---

Source : Prepared by JICA Study Team based on Topography Survey

Details of the above estimated available space for installation are provided in **Appendix B-3-7**.

(6) Estimated Installation Capacity

According to the estimated total available open space including spaces for O&M, and considering the avoidance of shadows cast over the PV modules during the winter solstices from 9:00 a.m. to 3:00 p.m., it was estimated that the possible installation capacity is from 1.25 MW to 1.45 MW if the total space utilized is as shown in **Table 8.1.1-4**. Depending on the inclined angle of PV arrays and the conversion efficiency of PV modules, the installation capacity varies as mentioned above.

(7) Estimated Amount of Total Power Generation and Supply

In order to understand the estimated amount of generation more clearly, two different installation capacities are compared. If the installation capacity within the open space is assumed to be either 1 MW or 1.5 MW and the total system efficiency is estimated to be around 75%, with the available annual average global solar radiation (5.2 kWh m^{-2} day^{-1}) data in Islamabad as recorded by the satellite considered in the calculation, the results will be as shown in **Table 8.1.1-5**.

Table 8.1.1-5 Estimated Amount of Power Generation

(Unit: MWh)

Subjects	PV Array Capacity	
	1 MW	1.5 MW
Daily Average	4	6
Monthly	117	176
Yearly	1,424	2,135

Source: Prepared by JICA Study Team

Compared to the yearly consumption of the whole PIMS facility in 2011, around 9% of the consumption will be generated by the 1 MW system and around 14% of the consumption will be generated by the 1.5 MW system. This means that around 9% to 14% of electricity consumption will be available in a year, and then the same unit of electricity (tariff) will be saved per year on average.

(8) Estimated Amount of Savings

The total savings of PIMS from payment of electricity tariff once the solar power generation system is installed are estimated as shown below.

✓ In case of 1 MW installation:

- Yearly: Rs.16,300,875 per year

✓ In case of 1.5 MW installation:

- Yearly: Rs.24,451,313 per year

The estimation was made for two cases, namely, the case of 1 MW installation and the case of 1.5 MW installation.

The electricity tariff consists of variable charge and fixed charge. The variable charge is levied on the amount of consumed electricity (kWh) and the fixed charge is levied on the maximum demand (kW).

For the estimation of the above payment savings, the following tariff rates were applied from the tariff table of the Islamabad Electric Supply Company (IESCO):

- for variable charge: Rs.10.25/kWh
- for fixed charge: Rs.380/kW

In order to calculate the amount of savings in the portion of the variable charge, it is rational to consider that the electricity generated by the solar power system is equal to the amount of savings of electricity consumption of PIMS. For the estimated amounts of solar power generation, the values indicated in **Table 8.1.1-5** were applied. From these values of solar power generation and the variable charge tariff of Rs.10.25/kWh, the estimated amount of savings of electricity payment in the variable charge portion was calculated as shown below.

Table 8.1.1-6 Estimated Amount of Payment Savings in Variable Charge Portion

(Unit: Rs.)

Subjects	PV Array Capacity	
	1 MW	1.5 MW
Daily Average	39,975	59,963
Monthly	1,199,250	1,798,875
Yearly	14,590,875	21,886,313

Source: Prepared by JICA Study Team

In order to calculate the amount of savings in the portion of the fixed charge, the following were assumed:

- Peak electricity demand of PIMS is recorded from 9:00 a.m. to 3:00 p.m.
- In the above time period, the solar power system generates electricity.
- The electricity generated by the solar power system caters to the peak portion of PIMS' demand; the maximum demand is decreased by viewing from IESCO.
- The decreased amount of maximum demand is the amount of savings in the portion of the fixed charge.

- Minimum solar insolation is assumed to be around 0.5 kW/m^2 from 9:00 a.m. to 3:00 p.m. (estimated at half of standard insolation considering that peak demand appears in the time of bad weather, in the morning, or in the evening).

According to the above way of thinking, the monthly amount of savings in the portion of the fixed charge in case of 1 MW solar system installation was calculated using the following formula:

- 1,000 kW/(kW/m^2) x 75% x 0.5 kW/m^2 x Rs.380/kW

With the above formula, the estimated amount of savings in electricity payment in the fixed charge portion was calculated as shown below.

✓ In case of 1 MW installation:

- Monthly: Rs.142,500 per month
- Yearly: Rs.1,710,000 per year

✓ In case of 1.5 MW installation

- Monthly: Rs.213,750 per month
- Yearly: Rs.2,565,000 per year

(9)Project Cost Estimation

As described in **Sub-chapter 8.1.2 (5)**, pole mounting is suitable for the natural topography of PIMS. Therefore, the project cost is estimated for this type. This estimation, however, has low accuracy, because it was calculated without geological and detailed topographic surveys. The estimation is assumed in three capacities, which are 1 MW and 1.5 MW, as shown in **Sub-chapter 8.1.2 (7),** and 2.0 MW by utilizing higher efficiency PV panel. **Table 8.1.1-7** summarizes the estimated project cost of the three different capacities.

Table 8.1.1-7 Estimated Project Cost

In Japanese Yen (Unit: Yen)

Item	PV Array Capacity		
	1MW	1.5MW	2MW
a) PV Module, Other Equipment and Installation Works	400,000,000	600,000,000	800,000,000
b) Equipment Transportation (Japan to Pakistan)	62,000,000	93,000,000	124,000,000
c) Foundation	41,700,000	62,520,000	62,520,000
d) Design & Execution Management	50,370,000	75,552,000	98,652,000
Total	554,070,000	831,072,000	1,085,172,000

In Pakistan Rupee (Unit: Rs.)

Item	PV Array Capacity		
	1MW	1.5MW	2MW
a) PV Module, Other Equipment and Installation Works	486,200,000	729,300,000	972,400,000
b) Equipment Transportation (Japan to Pakistan)	75,361,000	113,041,500	150,722,000
c) Foundation	50,686,350	75,993,060	75,993,060
d) Design & Execution Management	61,224,735	91,833,456	119,911,506
Total	673,472,085	1,010,168,016	1,319,026,566

Note:
1) 15% is assumed as PV module efficiency for 1 MW and 1.5 MW system, and 20% is assumed for 2 MW system.
2) 10% of costs of a), b) and c) is assumed as "Design & Execution Management" cost.
Source: Prepared by JICA Study Team

8.1.2 Field Survey of Other Potential Sites

In this study, the target areas of the field survey for solar power generation are public facilities, such as airports, hospitals, and universities, located in the urban areas of Islamabad (the federal capital city), Lahore (the capital city of Punjab province), and Karachi (the capital city of Sindh province).

(1) Site Selection for Field Survey

(a) Longlisted Candidate Sites for Field Survey

International airports in each city were selected as candidate sites for the field survey. Among the hospitals and universities, the candidate sites were selected through research of information in websites of relevant organizations, such as the Higher Education Commission (HEC), provincial governments, etc.

The numbers of candidate sites included in the long list for field survey are as follows:

- ✓ Airports: 4 sites
- ✓ Hospitals: 41 sites
- ✓ Universities: 15 sites

The long list of candidate hospitals and universities for field survey are given in **Appendix B-4-1** and **Appendix B-4-2**, respectively.

(b) Shortlisted Candidate Sites for Field Survey

The short list of candidate sites for field survey was prepared by screening the long list. The criteria for screening are as follows:

- Security situation
- Location within the study area
- Availability of open space on the ground for the installation of PV modules

The criterion "availability of open space on the ground" means that the candidate sites only accept installation of PV modules on the ground. The plan to install PV modules on the rooftop or within existing building is excluded because detailed examination of existing buildings regarding structural strength is required and data and information for the examination are not enough.

The shortlisted candidate airports for field survey (same sites as in the long list) are shown in **Table 8.1.2-1**.

Table 8.1.2-1 Shortlisted Candidate Airports for Field Survey

S #	Name	Location
1	Benazir Bhutto International Airport (Existing airport)	Rawalpindi, Punjab Province (10 km from Islamabad)
2	New Benazir Bhutto International Airport (Under construction)	Fateh Jang, Attock District, Punjab Province (20 km from Islamabad)
3	Jinnah International Airport	Karachi, Sindh Province
4	Allama Iqbal International Airport	Lahore, Punjab Province

Source: Prepared by JICA Study Team

Out of the 41 hospitals in three cities, 12 hospitals were shortlisted based on the screening criteria. The PIMS in Islamabad was excluded from the short list and this is explained separately in **Sub-chapter 8.1.1**. The shortlisted candidate hospitals for field survey are shown in **Table 8.1.2-2**.

Table 8.1.2-2 Shortlisted Candidate Hospitals for Field Survey

S #	Name of Hospital	Address	Status	Remarks
Islamabad (Capital City)				
1	National Institute of Health (NIH)	G- 10, Islamabad	Space available, approx. 30 min. one way drive from city.	Basic information not provided
Lahore, Punjab Province				
2	Gulaab Devi Hospital Chest Hospital	Flying Club Road, Lahore	Space available, approx. 60 min. one way drive from city.	Basic information provided
3	Sheikh Zaid Hospital	University road, canal bank, Lahore	Space available, approx. 40 min. one way drive from city.	Basic information provided
4	Jinnah Hospital & Allama Iqbal Medical College	Allama Shabbir Ahmed Usmani Road, Lahore	Space available, approx. 60 min. one way drive from city.	Basic information provided
5	Mayo Hospital	Hospital Road, Lahore	Space available, approx. 20 min. one way drive from city.	Basic information provided
6	Shaukat Khanum Memorial Hospital	Johar Town, Lahore	Space available, approx. 60 min. one way drive from city.	Basic information not provided, Charity hospital for cancer patients.
7	Children Hospital	Flying Club Road, Lahore	Space available, approx. 40 min. one way drive from city.	Basic information provided
Karachi, Sindh Province				
8	National Institute of Child Health	Cantonment, Karachi	Space available, approx. 20 min. one way drive from city.	Basic information not provided
9	Children Hospital	Sector 15-A/3, Karachi	Space available, approx. 50 min. one way drive from city.	Basic information not provided
10	Jinnah Postgraduate Medical Centre (JPMC) Karachi	Sir Ghulam Road, Karachi	Space available, approx. 20 min. one way drive from city.	Basic information provided
11	Ojha Institute of Chest Diseases	Gulshan-e- Iqbal town, SUPARCO head quarter, Karachi	Space available, approx. 50 min. one way drive from city.	Basic information provided
12	Karachi Institute of Heart Diseases (KIHD), Federal B. Area	Federal B Area, Karachi	Space available, approx. 50 min. one way drive from city	Basic information not provided

Source: Prepared by JICA Study Team based on Information collected from:
(1) List of Hospitals in Lahore collected from the Website of the Government of Punjab
(2) List of Hospitals in Karachi collected from the Website of the Government of Sindh

Out of the 15 universities in three cities, eight universities were shortlisted based on the screening criteria. The shortlisted candidate universities for field survey are shown in **Table 8.1.2-3**.

Table 8.1.2-3 Shortlisted Candidate Universities for Field Survey

S #	Name of University	Address	Status	Remarks
Islamabad (Capital City)				
1	Federal Urdu University of Arts, Sciences & Technology (FUUAST)	G-7/1, Islamabad	New campus under construction, 15 min. one way drive from city	Information on open space was of new facility, which is in the process of construction, Excluded.
2	Pakistan Institute of Engineering & Applied Sciences	P.O. Nilore, Islamabad	Space available, approx.. 40 min. one way drive from city.	Present security condition is not favourable, Excluded.
3	Quaid-i-Azam University	3rd Avenue, Islamabad	Space available, approx.. 20 min. one way drive from city.	Basic information provided
4	National University of Sciences and Technology (NUST)	H-8, Islamabad	Space available, approx.. 20 min. one way drive from city.	Basic information provided
Lahore, Punjab Province				
5	University of Engineering & Technology (UET), Lahore	G.T. Road, Lahore	Space available, approx.. 20 min. one way drive from city.	Basic information provided
6	Punjab University (PU), Lahore	Campus Road, Lahore	Space available, approx.. 40 min. one way drive from city.	Basic information provided
Karachi, Sindh Province				
7	Nadirshaw Eduljee Dinshaw (NED) University of Engineering & Technology	Karachi	Space available, approx.. 45 min. one way drive from city.	Basic information provided
8	University of Karachi	Karachi	Space available, approx.. 60 min. one way drive from city.	Basic information is incomplete

Source: Prepared by JICA Study Team based on Information collected from the Website of Higher Education Commission (HEC)

(2) Field Survey of Candidate Sites and Major Findings of Field Survey

Questionnaires were sent to the shortlisted candidate sites for the field survey. After examining the replies to the questionnaires, the sites to be visited for the field survey were decided.

(a) Airport

The selected airports for field survey (same in the short list) are shown in **Table 8.1.2-4**.

Table 8.1.2-4 Selected Airports for Field Survey

S #	Name	Location
1	Benazir Bhutto International Airport (Existing airport)	Rawalpindi, Punjab Province (10 km from Islamabad)
2	New Benazir Bhutto International Airport (Under construction)	Fateh Jang, Attock District, Punjab Province (20 km from Islamabad)
3	Jinnah International Airport	Karachi, Sindh Province
4	Allama Iqbal International Airport	Lahore, Punjab Province

Source: Prepared by JICA Study Team

The major findings of the field survey of the selected airports are given below.

i) Benazir Bhutto International Airport (existing), Rawalpindi, near Islamabad
From the visit, it was confirmed that after the construction of the New Benazir Bhutto International Airport, all commercial operations will be shifted to the new airport. Therefore, this airport was excluded from the potential sites for the solar power generation project.

ii) New Benazir Bhutto International Airport (under construction), Fateh Jang, Attock District in Punjab province, near Islamabad
The new airport is presently under construction. The airport authority is also in the process of land acquisition for future plans. After the acquisition of land, it is possible to have enough open space at one location for a solar power generation system of more than 100 MW. The proposed area is nearby the planned 132 kV grid SS of the airport.

iii) Jinnah International Airport, Karachi
The recommended open space for installation of PV modules is nearby the 132 kV grid SS of the airport. It is possible to install at one location a solar power generation system of more than 30 MW.

iv) Allam Iqbal International Airport, Lahore
In this airport, the available spaces are scattered and it is possible to install at one location a solar power generation system of only 3 MW at maximum. The total possible installation capacity was estimated at around 10 MW for the scattered areas. The possible installation capacity of solar power generation system is rather small compared to the other two abovementioned airports.

The sketches and pictures of the open spaces proposed for the installation of PV modules are provided in **Appendix B-4-3**.

(b) Hospitals

Out of the 12 shortlisted hospitals, seven hospitals were selected to be visited. The selected hospitals for field survey are shown in **Table 8.1.2-5**.

Table 8.1.2-5 Selected Hospitals for Field Survey

S #	Name	Location
1	Jinnah Post Graduate Medical Center (JPMC)	Karachi, Sindh Province
2	Ojha Medical Hospital	Karachi, Sindh Province
3	Children Hospital	Lahore, Punjab Province
4	Gulaab Devi Hospital	Lahore, Punjab Province
5	Jinnah Hospital & Allama Iqbal Medical Collage (AIMC)	Lahore, Punjab Province
6	Mayo Hospital	Lahore, Punjab Province
7	Sheikh Zaid Hospital	Lahore, Punjab Province

Source: Prepared by JICA Study Team

The major findings of the field survey of the selected hospitals are given below.

Table 8.1.2-6 Major Findings of the Field Survey of Selected Hospitals

S #	Name	Electricity Supply Feeder	Load Shedding	Installation Space	Estimated Installation Capacity of PV Module	Remarks
1	Jinnah Post Graduate Medical Center (JPMC)	2 x 11 kV	Not exempted	Open space (scattered)	Around 1 MW in total	One energy meter at 11 kV side
2	Ojha Medical Hospital	2 x 11 kV	Exempted	Two open spaces	Little less than 1 MW in total	Energy meters at 11 kV and 400 V side
3	Children Hospital	2 x 11 kV	Not exempted	Open space	Little less than 1 MW	One energy meter at 11 kV side
4	Gulaab Devi Hospital	2 x 11 kV	Not exempted	Two open spaces	3 MW in total	Three energy meters at 400 V side
5	Jinnah Hospital & Allama Iqbal Medical Collage	2 x 11 kV	Not exempted	Two open spaces	More than 3.5 MW in total	One energy meter at 11 kV side
6	Mayo Hospital	2 x 11 kV	Exempted (one line only)	Four open spaces (one is a park.)	Less than 1 MW in total	One energy meter at 11 kV side
7	Sheikh Zaid Hospital	2 x 11 kV	Exempted (one line only)	Existing parking area	Around 1MW	One energy meter at 11 kV side

Source: Prepared by JICA Study Team

In each hospital, DGs are installed as emergency backup sources of power at the 11 kV SSs and/or buildings in the respective hospital's premises. Aside from DGs, UPS units are connected to vital medical equipment which needs uninterruptible and stable supply of power.

The sketches and pictures of the open spaces proposed for the installation of PV modules are provided in **Appendix B-4-4**.

(c) Universities

Out of the eight shortlisted universities, six universities were selected to be visited. The selected universities for field survey are shown in **Table 8.1.2-7**.

Table 8.1.2-7 Selected Universities for Field Survey

S #	Name	Location
1	National University of Sciences and Technology (NUST)	Islamabad
2	Quaid-i-Azam University	Islamabad
3	NED University of Engineering & Technology	Karachi, Sindh Province
4	University of Karachi	Karachi, Sindh Province
5	Punjab University	Lahore, Punjab Province
6	University of Engineering and Technology	Lahore, Punjab Province

Source: Prepared by JICA Study Team

The major findings of the field survey of the selected universities are given below.

Table 8.1.2-8 Major Findings of the Field Survey of Selected Universities

S #	Name	Electricity Supply Feeder	Load Shedding	Installation Space	Estimated Installation Capacity of PV Module	Remarks
1	National University of Sciences and Technology	1 x 11 kV	Not exempted	Open space	3 to 5 MW	One energy meter at 11 kV side
2	Quaid-i-Azam University	3 x 11 kV	Not exempted	One (uneven) and two (flat)	5 MW each (15 MW in total)	Energy meters at 400 V side
3	NED University of Engineering & Technology	2 x 11 kV	Exempted (one line only)	Three open spaces and roof top on the building	2 MW in total for open space	Energy meters at both 11 kV and 400 V side
4	University of Karachi	2 x 11 kV	Exempted (one line only)	Several open spaces	a few to 5 MW each space	Energy meters at both 11 kV and 400 V side
5	Punjab University	2 x 11 kV	Exempted (one line only)	Several open spaces	More than 10 MW	One energy meter at 11 kV side
6	University of Engineering and Technology	2 x 11 kV	Not exempted	Open space, but structure erection needed	1 to 2 MW	One energy meter at 11 kV side

Source: Prepared by JICA Study Team

Each university is equipped with DG to supply power in case of power cutoff. The capacity of DG varies depending upon the minimum requirement of the university's facilities. The DG is installed either near the substation or near each facility needing power supply. The DGs supply power at three phase, 400 V in all universities except UET. In case of UET, there are two types of supply, one DG supplies power at 11 kV and the other at three phase, 400 V.

The sketches and pictures of the open spaces in universities confirmed in the site visits are provided in **Appendix B-4-5**.

A summary of information collected from hospitals and universities is given in **Appendix B-4-6**.

8.1.3 Potential Project

The availability of open spaces is a major factor in selecting potential sites for solar power generation projects based on the field survey. Based on the site visits conducted, it was confirmed that most of the public institutions, like hospitals and universities within the city, encountered difficulty in securing open spaces for the installation of large capacity of PV module on ground. There is no other remarkable obstruction except for space availability to implement solar power generation project at the visited sites.

As potential projects for Japanese official assistance, the projects are selected in two categories as shown below.

- ✓ Large-scale of Solar Power Generation: more than 20 MW
  The scale of the project is more than 20 MW, thus, it is recommended for implementation through Yen Loan. Also, it can be regarded as a Japanese grant-aid project as smaller size: medium-scale project. If the project is realized through Japanese grant aid as medium-scale project, further expansion is possible because there are still available spaces. Moreover, there is a possibility that the expansion project might be conducted through Yen Loan based on the experience during the grant aid project.

- ✓ Medium-scale of Solar Power Generation: 5 MW to 20 MW
  The scale of the project is around from 5 MW to 20 MW, and regarded as Japan's grant aid project in the future after three years, considering a price decrease in solar power generation.

According to the above categories, potential projects of solar power generation are selected as shown below.

- ✓ Large-scale Solar Power Generation Project:
  - New Islamabad International Airport
    The airport is currently under construction, and there is available ground space for solar power generation of more than 100 MW in capacity.
  - Karachi International Airport
    There is available ground space for solar power generation of more than 30 MW in capacity.
- ✓ Medium-scale Solar Power Generation Project:
  - Lahore International Airport
  - Punjab University
  - National University of Sciences and Technology (NUST)
  - Qaid-e-Azam University
    Each site has available ground space for solar power generation of more than 5 MW in capacity.

8.2 Wind Power Generation

8.2.1 Field Survey at Gharo-Keti Bandar Wind Corridor

(1) Introduction

The Study team for wind power generation carried out their field survey of Karachi and Gharo-Keti Bandar Wind Corridor, Sindh province from November 12 to November 15, 2012.

During the scheduled four day site survey, the Study team visited two wind farms in Jhimpir and wind masts erected in Gharo, Bhambore and Kuttikun area in Gharo-Keti Bandar Wind Corridor. In addition, they also held meetings with the Environment and Alternative Energy (E&AE) Department and the Sindh Board of Investment (SBI) of the provincial government, and the AEDB Karachi Office and the Pakistan Meteorological Department (PMD) of the federal government.

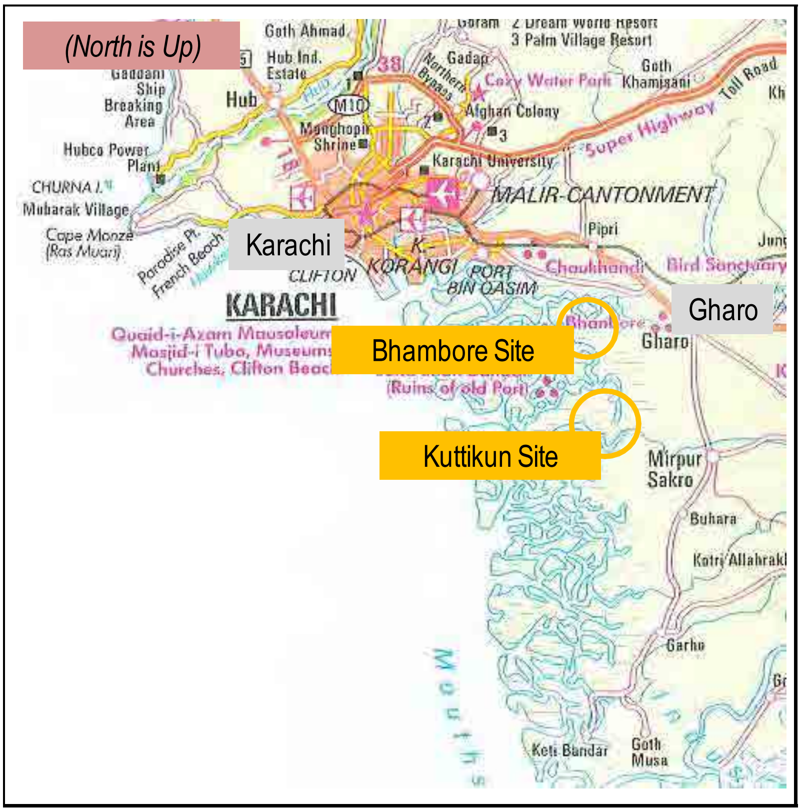
(2) Wind Farms in Jhimpir

Jhimpir is located 125 km northeast of Karachi. There are two project developers that are expected to achieve commercial operation date (COD) in the coming one to two months for their wind farms with a combined installed capacity of 106 MW of wind turbine generators (WTGs).

The FFC Energy Limited has a wind farm with a total installed capacity of 49.5 MW (33 units of Nordex S77, 1.5 MW WTG). All the WTGs on site are erected. Zorlu Enerji Limited has a wind farm with a total installed capacity of 56.4 MW (five units of VENSYS62, 1.2 MW WTG and 28 units of VESTAS V90, 1.8 MW WTG). There are only three WTGs remaining which are expected to be commissioned in one week's time. Moreover, another project developer, Three Gorges First Wind Farm with project capacity of 49.5 MW (33 units of of 1.5 MW GW1500/77) will start erection of wind turbines next month. Photographs of the wind farms in Jhimpir are shown in **Appendix C-5-1**.

(3) Wind Masts in Gharo Area

The Study team visited the wind mast installed at PMD station in Gharo City and the wind masts erected by private investors on their leased land in surrounding areas of Gharo such as Bhambore and Kuttikun. Gharo City is located 100 km east of Karachi.



Source: Prepared by JICA Study Team based on Effectiveness of Wind Farms in Pakistan downloaded at AEDB and the "Nelles Map" Pakistan

Figure 8.2.1-1 Wind Farm Sites in Bhambore and Kuttikun

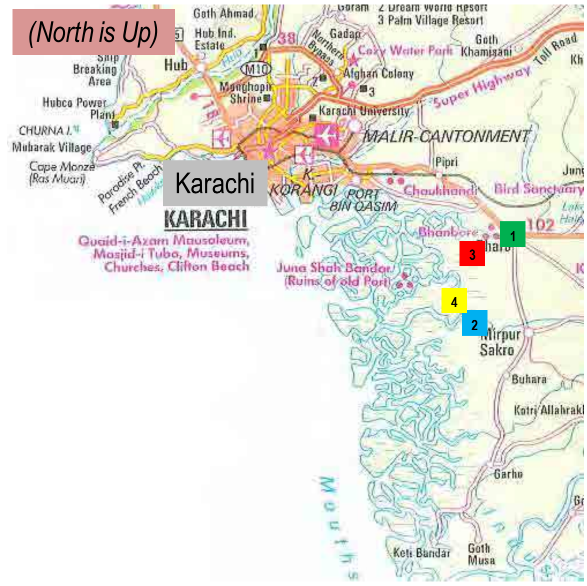
Figure 8.2.1-2 shows the wind masts in Sindh province which were erected by PMD (blue colored triangles), AEDB-UNDP (green colored triangles), and private investors (red colored triangles). The two wind masts owned by PMD were installed in 2002, and the benchmark wind speeds developed by AEDB for these two areas were based on their measurements.

Note: Brue, Green and Red are installed by PMD, AEDB-UNDP and Investors respectively.

Source: Prepared by JICA Study Team based on the Map provided by AEDB and the "Nelles Map" Pakistan

Figure 8.2.1-2 Wind Masts in Sindh Province

The Study team visited a total of four wind masts in Gharo as shown in **Figure 8.2.1-3**. Of the four, one is owned by the PMD at Gharo while the other three are owned by private investors (Foundation II (Green power), Zephyr and Nordex). Photographs of the wind masts visited during the survey are shown in **Appendix C-5-2**.



Wind Masts visited during the Site Survey

		North	East
1	Gharo MET Wind Mast	24.737080	67.592100
2	Foundation II Wind Mast	24.573330	67.498600
3	Zephyr Wind Mast	24.685500	67.500300
4	NORDEX Wind Mast	24.584194	67.472194

Source: Prepared by JICA Study Team based on Data provided by AEDB and the “Nelles Map” Pakistan

Figure 8.2.1-3 Survey Visits of the Four Wind Masts in Gharo

(4) Natural Environmental Conditions of the Areas

Of course, the wind power resource around the site is the most important item for consideration, however, the environmental and geophysical conditions are also a big issue for site selection of a project. The Study team visited Gharo area and Jhimpir area as described above. The locations of each area are shown in **Figure 8.2.1-4**.

Source: Prepared by JICA Study Team based on information provided by AEDB and the “Nelles Map” Pakistan

Figure 8.2.1-4 Wide Area of Wind Corridor

These issues were studied well in the Regional Environmental Assessment Study of the Gharo Wind Corridor in Pakistan (AEDB-UNDP, 2009). The main items discussed in **Chapter 3**:

Environmental Baseline-Physical include location, physiography, geology, soil classification, land capability, land use, natural hazards, and climate. Such items were described separately for “coastal Gharo” and “inland Jhimpir”.

According to the report, “coastal Gharo” has many tidal creeks and is geologically a tidal delta marsh. Of the wind farm area, 89% is affected by high tides and remains under water for some time during each month. The soil is loamy saline, silty and clayey.

On the other hand, “inland Jhimpir” is mostly rocky and gravelly with some poor loamy grazing land. A geological map of the wind corridor area and wind farm areas is provided in **Appendix C-6**.

Regarding earthquake hazard, the area of the wind corridor is classified as moderate hazard zone with minor damaging effect.

Tropical cyclones also hit the coastal area of Sindh. It is not frequent, but it should be noted as a recent experience that a wind speed in excess of 170 miles/hour (approximately 76m/s) is recorded near Gharo by cyclone in 1999, according to the above report.

(5) Meeting with Relevant Authorities

The Study team held meetings with the federal and provincial department representatives in Karachi explaining the content of the survey. The AEDB representative informed that a new draft policy on renewable energy was sent to the Cabinet Division for approval a year ago. After implementation of the new policy, wind developers with LOI would choose between the old and new policies. The new policy also contains other renewable energy technologies.

Currently, the Land Utilization Department under the umbrella of the Board of Revenue of the Government of Sindh is responsible for leasing land to project developers. In the near future, the Government of Sindh will become independent of the federal government in leasing land to investors. In this regard, land grant policy may be approved which will lease footprint areas for wind turbines instead of entire pieces of land. The Government of Sindh has already allocated 32,000 acres of land in the wind corridor for renewable energy projects.

The Jamshoro area is vacant for any potential projects whereas Gharo and Keti Bandar lands are already leased to investors. The Government of Sindh has an upcoming plan to conduct an extensive study of wind energy assessment in the coastal area of Gharo to Islamkot.

The NEPRA may announce upfront tariff for solar PV power generation in the coming three months. Solar power generation can be installed inside the wind farm by private investors. In this regard, FFC may install a 15 MW solar power generation plant inside the wind farm area.

It was found that there are needs to strengthen the institutional and human capacity of provincial government departments and to assist the preparation of legislations/policies and laws which can help the department in its further development.

8.2.2 Potential Project

Potential wind power generation projects in Pakistan, especially in Sindh province, are discussed in this section in accordance with the results of this survey.

(1) Project Area

Gharo-Keti Bandar Wind Corridor spreads from the coastal area to the inland area. In Gharo area and Jhimpir area, lands were already allocated for a number of project investors, however, there is still vacant land in these areas. Moreover, already allocated land could be cancelled occasionally if the investor could not start its project due to some reasons. In these two areas, Jhimpir will be preferable for a new project because of its ground condition and accessibility as compared to Gharo. Such advantages will minimize the project cost.

Other areas such in as Jamshoro or Islamkot might also be allocated to investors in the near future. Comparing between Jamshoro and Islamkot where the Study team could not visit in this survey, the former is supposed to have an advantage in terms of accessibility and ease of transport of equipment and materials.

Offshore wind power generation projects cost 1.5 to 2 times higher than land-based ones. As long as land is available for projects, offshore wind power might be impractical.

(2) Size of Project

For the first choice, there are two options: less than 50 MW or more than 50 MW project capacity. The 50 MW threshold for hydroelectric power generation given in the EPA Review of IEE and EIA Regulations, 2000 has also been applied in general for wind power generation projects. Therefore, a wind farm with less than 50 MW capacity could expect to be an IEE-applicable project, while EIA will be applied for a project with more than 50 MW capacity. Actually, this is not certain but it depends on the area and decision of EPA of each province. In fact, however, most of the existing and planned wind farm projects are 50 MW or less (see **Appendix C-3** and **Appendix C-4**). On the other hand, large-scale projects will be advantageous in terms of cost efficiency, and their ratio has been increasing in recent years. Therefore, both conditions should be considered in designing a project.

(3) Project Cost

A discussion with Japanese wind turbine manufacturers was conducted to determine the estimated appropriate project cost for wind power project. The international average cost is assumed at US$2,000/kW (EPC[32] cost). It means the cost for a 50 MW wind power project is US$100 million.

On the other hand, actual project costs in Pakistan are available at the website of NEPRA. Each investor submits their tariff petition document to NEPRA, and NEPRA discloses the document in the website. This information is also a good reference for estimating project costs.

Summary of the information is shown in **Appendix C-4**. A few samples of projects almost in the commissioning phase in Jhimpir area are as follows:

[32] Engineering, Procurement and Construction

- ✓ Sample 1:
  Company: Zorlu Enerji Pakistan Ltd.
  Capacity of wind turbines: 56.4 MW (1.2 MW x 5 units and 1.8 MW x 28 units)
  Total project cost: US$161.880 million (US$138.801 million in EPC)
- ✓ Sample 2:
  Company: Fauji Fertilizer Company Energy Ltd.
  Capacity of wind turbines: 49.5 MW (1.5 MW x 33 units)
  Total project cost: US$133.557 million (US$112.979 million in EPC)

(4) Possibility of Japanese Yen Loan Project

Assuming a Yen Loan project, the implementing organization must be in the public sector. The most possible candidate to be the implementing organization in the wind corridor area will be the Local Government of Sindh. Actually, the local government showed interest and emphasized that there are no obstacles to implement such project.

Normal project costs in Pakistan described above may be appropriate level for Japanese Yen Loan project, but it will become an entry barrier if the specifications impose stringent conditions for investors to abide.

Hybrid power plant project including PV and wind power generation systems is an idea proposed by the Sindh government personnel as described in **Sub-chapter 8.2.1**. If PV cost will be decreased in the near future, the hybrid project will also be an option for Yen Loan project.

A grant-aid project might be considered to be able to introduce Japanese wind turbines in Pakistan.

8.3 Small Hydro Power Generation

8.3.1 Field Survey of the Northern Area of Punjab Province

(1) Site Selection for Field Survey

There are 786 sites listed by the Punjab Power Development Board (PPDB) as potential sites for small hydro power in Punjab province. Among these potential sites, 11 sites in the northern Punjab province were selected for field survey based on the following selection criteria:

<u>[Selection Criteria for Field Survey]</u>

- ✓ Fall Head (Head > 1.5 m)
- ✓ Full Supply Discharge (Discharge > 10 m^3/s)
- ✓ Power Potential (Capacity > 500 kW)
- ✓ Sponsored /Non Feasible Project (if there is sponsor, then site was excluded)
- ✓ Distance from Major City (< four hour drive from Lahore or Islamabad)

<u>[Ranking Study]</u>

Among the selected sites subject to the above criteria, the following formula for ranking was used for the selection of field survey:

(Total Ranking Point for Selection)
= (Ranking of Head) + (Ranking of Discharge) + (Ranking of Power) + (Ranking of Distance from City)

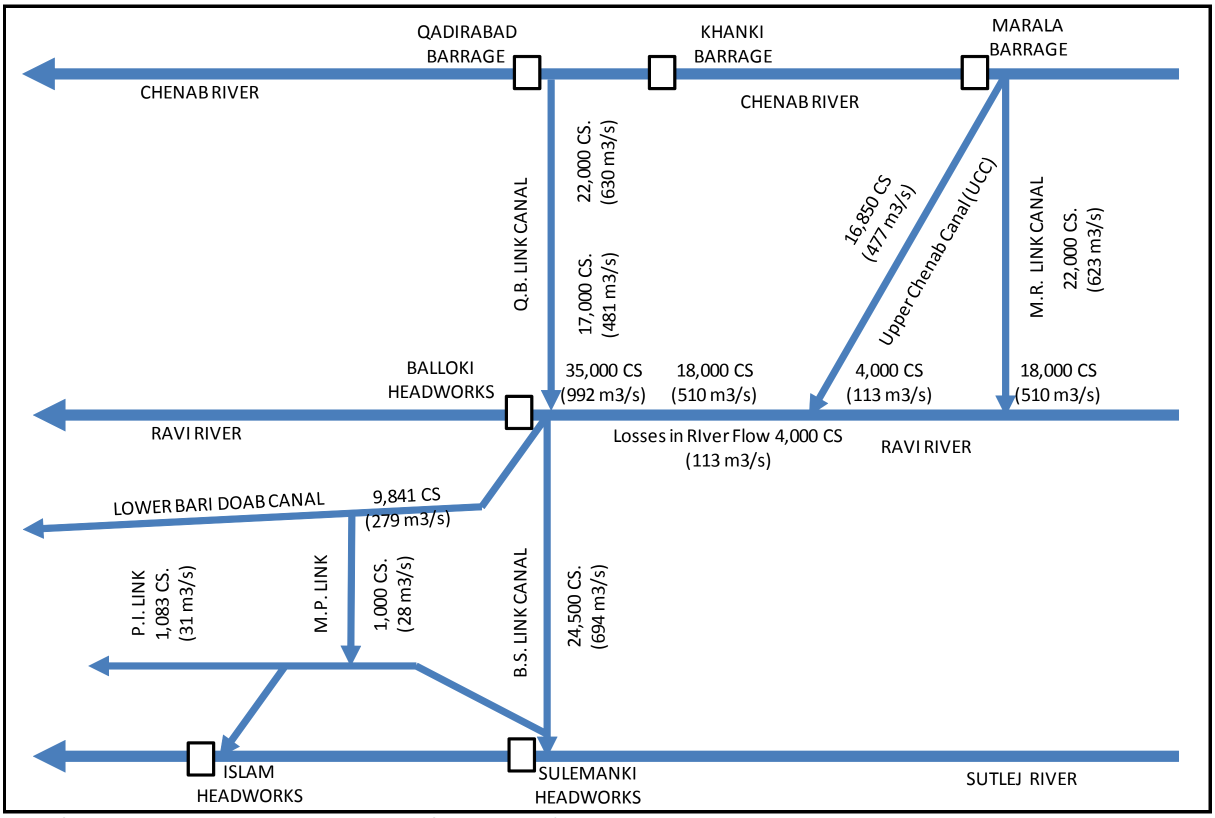
Total ranking was used in order from small "Total Ranking Point for Selection". Selected field sites are shown in **Appendix D-2**. The actual study sites were investigated, including the additional recommended sites (i.e., five sites of ADB-F/S conducted sites and existing Renala Khurd 1.1 MW HPP by WAPDA) from PPDB and the vicinity of potential sites nearby selected sites.

(2) Field Survey

The field survey of small hydro power potential sites in the northern part of Punjab province was conducted from November 10 to November 16, 2012 (total of 7 days) at total 20 sites including selected 11 sites by ranking study and nearby selected sites. In the field survey, the following survey and data/information collection were carried out:

- ✓ Leveling survey by hand level or auto level (from upstream to downstream water level)
- ✓ Discharge measurement by current meter or float method
- ✓ Collection of daily water level gauging data and daily discharge data
- ✓ Collection of drawings and measurement of existing hydraulic structures (diversion weirs, irrigation canals, etc.)
- ✓ Field survey on proposed intake site, proposed powerhouse sites, downstream outlet site, etc.
- ✓ Visual inspection of geological conditions

A schematic diagram of canal systems in Northern Punjab is shown in **Figure 8.3.1-1**. The field survey sites are shown in **Figure 8.3.1-2**.



Source: Irrigation and Power Department, Government of Punjab

Figure 8.3.1-1 Schematic Diagram of Canal Systems in Northern Punjab

The results of the field survey are summarized in **Table 8.3.1-1**, and the major findings are described below.

- ✓ A total of 20 sites of the 786 sites listed by PPDB were investigated for the field survey on small hydro power potential.
- ✓ It is recommended to implement the project site No.4 (serial #602, ADB-5) “Qaiderabad Balloki Link Canal RD 304+985” among the five sites of the feasibility study conducted by ADB-NESPAK.
- ✓ For the other four ADB-F/S candidate sites (site Nos. 10, 12, 13 and 14), there is some concern about the economic feasibility from the point of view of instability of flow, sedimentation, flood control measures, and geology of the sites.
- ✓ Seven sites (site Nos. 2, 3, 5, 6, 7, 9 and 16) out of the 15 candidate locations in the raw sites are considered suitable sites in terms of stability of the water flow throughout the year, head, conditions of waterways, land availability, and geology. In the future, more detailed study and planning are required for these candidate sites.
- ✓ Among the natural river water intake sites (such as site Nos. 1, 10, and 14), there is only little flow available during the dry season. In these sites, there is only about one to four months a year available to intake water from the river due to the limited downstream water release from the headworks.
- ✓ These sites were said to be not suitable in terms of plant factor, flood control measures and sedimentation. However, it is possible to increase power generation when there is high demand for electricity such as for air conditioning in the summer (rainy season).

- ✓ For about one month in January or February, the water flows of almost all irrigation canals were stopped for maintenance of weirs and canals.
- ✓ Distribution lines (11 kV or 33 kV) or transmission lines exist nearby almost all sites.
- ✓ It was confirmed in the field survey that the discharge and head of some potential sites listed by PPDB are not as high. In some places, water was not flowing at all. Detailed examination is needed in the future.