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Pakistan Engineering Council
Islamic Republic of Pakistan

# Preparatory Survey
# on
# the Project for Clean Energy Promotion
# using
# Solar Photovoltaic System
# in
# Islamic Republic of Pakistan

June 2010

JAPAN INTERNATIONAL COOPERATION AGENCY

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NIPPON KOEI CO., LTD.

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# PREFACE

Japan International Cooperation Agency (JICA) conducted the preparatory survey on the Project for Clean Energy Promotion using Solar Photovoltaic System in Islamic Republic of Pakistan.

JICA sent to Pakistan a survey team from July 6th to July 18th and October 21st to November 27th, 2009.

The team held discussions with the officials concerned of the Government of Pakistan, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Pakistan in order to discuss a draft outline design, and as this result, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of Islamic Republic of Pakistan for their close cooperation extended to the teams.

June 2010

Kazuhiro YONEDA
Director General, Industrial Development Department
Japan International Cooperation Agency

# Letter of Transmittal

June, 2010

We are pleased to submit to you the preparatory survey report on the Project for Clean Energy Promotion using Solar Photovoltaic System in Islamic Republic of Pakistan.

This survey was conducted by Nippon Koei Co., Ltd., under a contract to JICA, during the period from June 2009 to June 2010. In conducting the survey, we have examined the feasibility and rationale of the project with due consideration to the present situation of Pakistan and formulated the most appropriate outline design for the project under Japan's Grant Aid scheme.

Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,

Tomoyasu FUKUCHI
Project manager
Preparatory Survey team on
the Project for Clean Energy Promotion using Solar Photovoltaic System
Nippon Koei Co., Ltd.

# Summery

## 1. Contents of the Project

In the Islamic Republic of Pakistan (Pakistan), the power generation and supply mainly involve thermal (fossil fuel, natural gas, and coal), hydro and nuclear power plants. The power deficit in fiscal year 2007/08 was 4,000 MW. To balance the demand, scheduled power cutoff is conducted.

In Pakistan, there are existing small standalone photovoltaic (PV) systems. However, the grid-connected PV system is not yet implemented at present.

Environment protection is one of the catchphrases of the renewable energy for power generation policy developed in 2006. The substitution of low efficiency biomass fuel and coal for power generation with renewable energy resources is expected to reduce adverse effects as well as improve the living environment and public health of the local people. Furthermore, in the same policy, the Pakistan government is enthusiastically looking forward to the reduction of green house gases (GHGs) by implementing the action plan under the "Environment and Climate Change Treaty" and presenting it as a catchphrase.

In fiscal year 2007/08, the institutional body of the Pakistan government which is the National Electric Power Regulatory Authority (NEPRA), issued licenses to ten power-generating entrepreneurs with total capacity of 1,536 MW to deal with the power shortage within the country. However, the power is still not enough to fulfill the demand. As a solution to cope with the power shortage and also to promote available renewable energy resources, the Alternative Energy Development Board (AEDB) was established in 2003 to develop the Renewable Energy Policy in the country. Under this policy, small hydropower (less than 50 MW), wind power and PV power generations are targeted for implementation. Apart from the policy, the Pakistan government is also putting high emphasis on renewable energy and has set a target of 10% share of renewable energy or 2,700 MW in the country's energy mix by 2015.

This project promotes the mitigation of GHG emission, awareness of the PV system and mitigates the electricity cost of the Planning Commission (PC) and Pakistan Engineering Council (PEC) facilities by providing PV system and related equipment on the site. The project also promotes the interconnection of the power generation using "clean" renewable energy to the Islamabad Electricity Supply Company Ltd. (IESCO) grid. It also presents countermeasures against air pollution and climate change.

In this assistance plan, from the procurement to the implementation stage, the project implementing agency, its responsible department, and responsible organization of Nepal are as follows.

- Responsible Organization: Planning Commission (PC)
- Implementing Agency: Pakistan Engineering Council (PEC)

The existing car parking area is the selected installation site for the PV system. The area is around 4,108 $m^2$ at the PC and 4,752 $m^2$ at the PEC. In both sites, the PV array is to be installed by erecting supporting structure that will provide parking space. In the case of the PC, the installation site lies nearby the main entrance gate of government offices toward the west of the PC building. In the case of the PEC, the installation site is opposite of the existing road which is exactly in front of the PEC building towards the west.

The PV system will connect to the 400 V side of the incoming 11 kV feeder of IESCO supplying power to the facility. The remaining surplus power will flow towards the grid network of IESCO. The feed-in-tariff is based on the power purchase agreement (PPA) contracts between PC and IESCO, and between PEC and IESCO.

## 2. Result of Survey

The term of the dispatch of the study team was as follows.

- 1st Site Survey: July 6th to July 18th
- 2nd Site Survey: October 21st to November 27th
- 3rd Site Survey March 29th to April 2nd

From Pakistani side, installations of the system were requested for the Planning Commission (PC) facility and 14 different sites of the Pakistan Engineering Council (PEC). However the proposed installation space was on the rooftop of PC's 5-storey building, which will not be possibly seen from ground level. Moreover, in case of installation at a university, management will be difficult as it will involve several sites at the same time, being the first case for implementation. Therefore, implementation of the design criteria for site selection such as (1) realization of long-term demonstration impact and (2) enough space for large capacity installation will not possibly be possibly fulfilled as targeted. Thus, as an option for fulfilling the site selection criteria (1) to (4), the existing parking space of PC and the existing parking space opposite PEC building inside Islamabad is selected. These serve as alternatives to the requested installation site.

| Design Criteria |
|---|
| Basic Concept (Site Selection) |
| (1) Realization of Long Term Demonstration Impact |
| (2) Securing Enough Space for Installation |
| (3) Existence of Distribution Network for Interconnection |
| (4) For Smooth O/M near by Existence of Implementing Agency |
| |
| Basic Concept (Facility Selection) |
| (1) Anticipation of Demonstration Impact |
| (2) Anticipation of Surplus Power Sales |

The decided installation capacity for each site is 110 kWp (Total 220 kWp). The size of the system is good enough to achieve effective demonstration impact. Meanwhile, the required installation space for 110 kWp is around 1,700 $m^2$ for crystalline and around 3,200 $m^2$ for amorphous type modules in the case of normal installation (without parking space). The annual average power consumption of PC and PEC facility from November 2008 to October 2009 are around 1,751.5 kWh/day and 934.9 kWh/day, respectively. The average calculated power generation is 432.3 kWh/day (average solar hour 5.24 h/day[1] x 110 kWp x system efficiency 75%) is lower than consumption requirements. Hence, even though time for generating surplus power is limited, it is still expected to have reverse power sales toward existing grid when power consumption is low or during holidays.

## 3. Implementation Schedule

The total period from the initial stage of planning, preparation of drawings for inspection, execution of works until the project hand over is planned to be completed with ten months.

[1] Based on 22 years NASA data (1983 to 2005)

# Location Map


Source: Central Intelligence Agency (CIA)

# Abbreviations

| | |
|---|---|
| A/P | Authorization to Pay |
| B/A | Banking Arrangement |
| CDA | Capital Development Authority |
| E/N | Exchange of Notes |
| EIA | Environmental Impact Assessment |
| GHG | Green House Gas |
| IEC | The International Electrotechnical Commission |
| IEE | Initial Environmental Evaluation |
| IEEE | The Institute of Electrical and Electronics Engineers, Inc. |
| IESCO | Islamabad Electric Supply Company Ltd. |
| JEC | Japanese Electrotechnical Committee |
| JIS | Japanese Industrial Standards |
| JPY | Japanese Yen |
| NEPRA | National Electric Power Regulatory Authority |
| NTDC | National Transmission & Dispatch Company Ltd. |
| O/M | Operation & Maintenance |
| PC | Planning Commission |
| PEC | Pakistan Engineering Council |
| PKR | Pakistani Rupee |
| PPA | Power Purchase Agreement |
| PV | Photovoltaic |
| S/S | Substation |
| TTS | Telegraphic Transfer Selling |
| USD | U.S. Dollar |

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# Chapter 1 Background of the Project

## 1-1 Present Condition and Needs of the Concerned Sectors

### 1-1-1 Present Condition and Needs

In the Islamic Republic of Pakistan (Pakistan), the power generation and supply mainly involve thermal (fossil fuel, natural gas, coal), hydro and nuclear power plants. The power deficit[2] in fiscal year 2007/08 was 4,000 MW. To balance the demand, scheduled power cutoff is conducted.

In Pakistan, there are existing small standalone photovoltaic (PV) systems. However, the grid-connected PV system is not yet implemented at present.

### 1-1-2 National and Sector Development Plan

Environment protection is one of the catchphrases of the renewable energy for power generation policy developed in 2006. The substitution of low efficiency biomass fuel and coal for power generation with renewable energy resources is expected to reduce adverse effects as well as improve the living environment and public health of the local people. Furthermore, in the same policy, the Pakistan government is enthusiastically looking forward to the reduction of green house gases (GHGs) by implementing the action plan under the "Environment and Climate Change Treaty" and presenting it as a catchphrase.

In fiscal year 2007/08, the institutional body of the Pakistan government which is the National Electric Power Regulatory Authority (NEPRA), issued licenses to ten power-generating entrepreneurs with total capacity of 1,536 MW to deal with the power shortage within the country. However, the power is still not enough to fulfill the demand. As a solution to cope with the power shortage and also to promote available renewable energy resources, the Alternative Energy Development Board (AEDB) was established in 2003 to develop the Renewable Energy Policy in the country. Under this policy, small hydropower (less than 50 MW), wind power and PV power generations are targeted for implementation. Apart from the policy, the Pakistan government is also putting high emphasis on renewable energy and has set a target of 10% share of renewable energy or 2,700 MW in the country's energy mix by 2015[3].

### 1-1-3 Socio-Economic Conditions

The agriculture sector, which is highly influenced by natural weather condition, shares 20% of the gross domestic product (GDP) and 40% of the labor population of the country. The achieved GDP growth rate in fiscal year 2007/08 is 5.8%, which is 6.8% of that in fiscal year 2006/07 and 7.2% lower than the target. The main reason for this is the limited growth rates in the agriculture and manufacturing sectors which are 1.5% and 5.4%, respectively. Moreover, this is highly affected by the reduction of growth rate by 3% in the agriculture sector. In terms of manufacturing, textile is the main industry in Pakistan.

The GDP shares of the 1st, 2nd and 3rd industries in the country are 19.6%, 26.8% and 53.7%, respectively[4].

In Pakistan, the per capita gross national income is around USD1,085 (fiscal year 2007/08) and the percentage of poverty is 22.3% (fiscal year 2005/06). The country's economic development is highly dependent on international support and investment.

[2] State Industry Report 2008
[3] State Industry Report 2009
[4] Due to rounding, the total is not 100% (World Bank)

## 1-2 Background of the Grant Aid

### (1) Background of the Grant Aid

In January 2008, Japan established the Cool Earth Partnership, which is an activity for developing countries that are aiming to achieve both GHG emission reductions and economic growth and working to contribute to climate stability. Through this, Japan cooperates actively with developing countries to reduce GHG emissions, e.g., by enhancing energy efficiency. A new grant aid scheme named "Program Grant Aid for Environment and Climate Change" has been created in 2008 as a component of this package to support a developing country which is willing to contribute to climate stability but facing shortages in implementing capacity as well as funds.

As a policy of the Japanese Government, JICA decided to promote clean energy including renewable energy to be promoted as a "co-benefit" cooperation case and utilize Japanese advanced technology including technology of the private sector.

As mentioned in the background, positive utilization of PV technology, in which Japan has high advantage, is required. Moreover, the Ministry of Foreign Affairs conducted surveys about the needs and ideas for the "Program Grant Aid for Environment and Climate Change" using PV power generation and other technology.

The "Program Grant Aid for Environment and Climate Change" aims to address climate change and other environmental challenges. The "Program" intends to combine several components like equipment provision, capacity building and others. Because of this, the program is implemented with the dual aims of equipment provision and installation. However, the soft component is also implemented to establish the operation and maintenance scheme for the smooth operation of the provided equipment.

### (2) Purpose of the Grant Aid

This project promotes the mitigation of GHG emission, awareness of the PV system and mitigates the electricity cost of the Planning Commission (PC) and Pakistan Engineering Council (PEC) facilities by providing PV system and related equipment on the site. The project also promotes the interconnection of the power generation using "clean" renewable energy to the Islamabad Electricity Supply Company Ltd. (IESCO) grid. It also presents countermeasures against air pollution and climate change.

### (3) Over all Plan

1) Responsible Organization

Planning Commission (PC)

2) Implementing Agency

Pakistan Engineering Council (PEC)

3) Installation Site of PV System

The existing car parking area is the selected installation site for the PV system. The area is around 4,108 $m^2$ at the PC and 4,752 $m^2$ at the PEC. In both sites, the PV array is to be installed by erecting supporting structure that will provide parking space. In the case of the PC, the installation site lies nearby the main entrance gate of government offices toward the west of the PC building. In the case of the PEC, the installation site is opposite of the existing road which is exactly in front of the PEC building towards the west.

The PV system will connect to the 400 V side of the incoming 11 kV feeder of IESCO supplying power to the facility. The remaining surplus power will flow towards the grid network of IESCO. The feed-in-tariff is based on the power purchase agreement (PPA) contracts between PC and IESCO, and between PEC and IESCO.

# Chapter 2 Concept of the Project

## 2-1 Basic Concept of the Project

### (1) National Target and Project Target

In the Islamic Republic of Pakistan (hereinafter referred to as Pakistan), the renewable energy promotion program is targeted for rural electrification, stabilization of power supply in rural areas and diminishing of air pollution caused by coal fired thermal plants. Furthermore, implementing the renewable energy program is expected to result in energy savings.

The main aim of the renewable energy policy established in 2006 is to develop and adopt the framework for the implementation and promotion of renewable energy resources, targeting to diminish pollution created by low efficiency coals utilized to generate power. Furthermore, under the basis of the commitments made during the United Nations Framework Convention on Climate Change (UNFCCC), Pakistan is enthusiastically struggling to reduce Green House Gas (GHG) effects within the country.

The National Electric Power Regulatory Authority (NEPRA) is an institutional body of the Pakistan government. In order to cope with the power shortage in the country, NEPRA issued licenses in fiscal year 2007/08 to ten power-generating entrepreneurs for operation of a total capacity of 1,536 MW. This is still however not enough to meet the demands. To solve the power shortage to some extent and promote the available renewable energy resources, the Alternative Energy Development Board (AEDB) was established in 2006. The renewable energy policy was then developed, under which, small hydro plants (less than 50 MW), wind power generation, and PV power generation are targeted to be developed and implemented in actual practice. The renewable energy policy also defines the renewable power generating system that could possibly be connected to the distribution network. Moreover, it is mandatory for an electric distribution company to operate with the grid-connected system, if the entrepreneur could generate power that will fulfill all the requirements of power distribution companies.

From this concept, the photovoltaic power generation system (hereinafter referred to as PV system) is being considered to be installed within Islamabad City for the demonstration and promotion of the renewable energy implementation scheme.

### (2) Project Outline

The PV system and its related components are targeted to be installed under this assistance plan. To achieve the mentioned target, PV system is decided to be installed at the existing parking facility of the Planning Commission (PC) and at the parking space of Pakistan Engineering Council (PEC), situated in front of the PEC facility at the opposite side of the road. The generated power is planned to supply the PC and PEC facilities, and to the grid distribution network of Islamabad Electric Supply Company (IESCO). From this, it is expected to reduce the electrical burden of PC and PEC, promote renewable energy, as well as reduce GHG emission.

For this assistance, the responsible organization and implementing agency is PC and PEC, respectively.

## 2-2 Outline Design of the Requested Japanese Assistance

### 2-2-1 Design Policy

#### (1) Basic Policy

On the basis of the Pakistan Government’s request, the basic concepts as mentioned below were

established and site selection was carried out.

(i) Scope of Assistance Plan: Grid-connected PV system with large capacity is the first of its kind in Pakistan. Hence, most of the required components and installation works are included in the scope of assistance plan.

(ii) Site Selection: The basis of site selection are as follows: (1) Longer and wider demonstration impact; (2) Enough installation space for planned large capacity; (3) Nearby existing grid distribution network for grid connection; and (4) Nearby existence of implementation agency considering smooth support of operation management.

(iii) Facility Outline: The realization of reverse power sales through grid interconnection is the basic concept. Thus, (1) there is a possibility for grid connection (not too large) and achievement of maximum demonstration impact; and (2) the generated power is established to supply energy to PC and PEC facilities and reverse flow of surplus power towards grid distribution network is realized.

**(2) Natural Conditions**

The system is developed to meet the local building standards and will also determine soil bearing capacity at the site, local meteorological conditions, seismic coefficient and others. For the selection of the materials to develop the system and considering that the PV array will be installed at an elevated structure, the following criteria is established:

(Weather Conditions)

- Maximum ambient temperature : 46.6 degree Celsius
- Minimum ambient temperature : -3.9 degree Celsius
- Maximum wind speed : 20.58 m/s (40 Knots)
- Average humidity : 88%
- Average daily Solar insolation : 5.24 kW/$m^2$/day
- Altitude : 750 meter

(Design Conditions)

- Design wind speed : 40 m/s
- Soil bearing capacity : 1 ton/$ft^2$
- Depth of concrete foundation : -5 ft
- AC circuit : 3 Phase 4 Wire 400/230V, 50 Hz
- Earth resistivity : PC 27.02 Ohm-m (GL -4.23 m) / PEC 68.99 Ohm-m (GL -9.25 m)
- Replanting: The trees that create shadows are considered to be replanted and trimmed at both sites, and will be the responsibility of the recipient country.

**(3) Environmental Condition**

Prior to the implementation of the power generation and supply projects, the requirement for Initial Environment Evaluation (IEE) and Environment Impact Assessment is required to be confirmed.

**(4) Basic Policy for Grid-Connection**

A grid-connected system through renewable energy resources is the first of its kind in Pakistan. The PV array capacity of this assistance is 110 kWp for each site and its implementation is mainly essential to: (1) arrange PPA contract with IESCO and (2) submit license application to National Electric Power Regulatory Authority (NEPRA) prior to interconnect with the grid network. It is also important to realize the grid-connection and reverse the power flow towards the grid.

**(5) Social Economic Environment**

To avoid cases of robbery or accidents to the maximum extent, such issues should be considered at the planning stage. In the case of PEC, the system installation site being at the green belt along a public road, exterior light is included under this assistance.

**(6) Basic Policy for Supply / Construction**

The basic design for the construction of concrete foundations and buildings are based on Pakistani Standard or British Standard, which is normal practice in Pakistan. The designs of equipment are based on international standards like IEC and IEEE. However, considering that the PV system is a product of Japan, the standard of components shall be designed in accordance with JIS and JEC.

**(7) Policy for Operation and Maintenance (O/M)**

The implementing agency, PEC, does not have experience on grid-connected PV system, being the responsible organization for management of technology. PEC has experience in carrying out related works and technical expertise, and has basic knowledge in the management of equipment and electrical facilities. However, the grid-connected PV system with large capacity is the first of its kind in Pakistan and to operate the system smoothly, technical know-how on initial startup, O/M processes and the application procedure of a grid-connected system shall be covered through the soft component activities under this assistance plan.

**(8) Policy for Equipments and Facility**

To gain long-term demonstration impacts from the installed grid-connected PV system, selection of equipment and related components are based on strongly built and longer durability. Furthermore, the equipment and components are selected to ensure high accuracy and quality, targeting absolute model of grid-connected PV system under the assistance plan.

**(9) Policy for Construction Works and Supply**

The construction for foundation and other construction items, including the structure and frame work to support PV structure are planned to be procured locally, which should comply with local building standards and technical guidelines. Meanwhile, other materials and components shall be procured from Japan.

To implement this assistance, an agreement shall be drafted between the PC and a representative procurement agent who will represent the Pakistan Government and handle the contract with the consultant and supplier during the implementation.

**(10) Policy for Local Contractor**

In Pakistan, there is no experience gained on grid-connected PV system. Hence, being the first of its kind, the local contractor for construction and installation need to be supervised and rendered with technical guidance. The construction of concrete foundations, installation of equipment and components under the supervision of a Japanese consultant, is possible. On the other hand, local consultants also have the ability to supervise the installation works under the support of a Japanese consultant. Therefore, utilization of local contractors, under the supervision of Japanese technical experts and consultant is planned.

### 2-2-2 Basic Plan (Construction Plan / Equipment Plan)

For the requested assistance from Pakistan, the basic design policy for deciding the plan and based on the results gained, the assistance plan is summarized in Figure 2-2-2-1 below.

| Request from Pakistan Side | |
|---|---|
| Requested Equipments: | PV Grid Interconnected System |
| Installation Site: | (1) Rooftop of Planning Commission (PC) Building |
| | (2) 14 Sites (Pakistan Engineering Council (PEC) and Universities) |
| Facility Scale: | (1) 150kWp |
| | (2) Total 400 kWp (20 to 100 kWp Each) |

⇩

| Design Criteria |
|---|
| Basic Concept (Site Selection) |
| (1) Realization of Long Term Demonstration Impact |
| (2) Securing Enough Space for Installation |
| (3) Existence of Distribution Network for Interconnection |
| (4) For Smooth O/M near by Existence of Implementing Agency |
| Basic Concept (Facility Selection) |
| (1) Anticipation of Demonstration Impact |
| (2) Anticipation of Surplus Power Sales |

⇩

| Assistance Plan | |
|---|---|
| Assistance Components: | PV Grid Interconnected System |
| Responsible Agency: | Planning Commission (PC) |
| Implementation Agency: | Pakistan Engineering Council (PEC) |
| Installation Site: | Both of PC and PEC |
| Facility Scale: | Total 220 kWp (110 kWp Each) |

Source: JICA Study Team

Figure 2-2-2-1 Contents of Japanese Assistance Plan

From Pakistani side, installations of the system were requested for the Planning Commission (PC) facility and 14 different sites of the Pakistan Engineering Council (PEC). However the proposed installation space was on the rooftop of PC's 5-storey building, which will not be possibly seen from ground level. Moreover, in case of installation at a university, management will be difficult as it will involve several sites at the same time, being the first case for implementation. Therefore, implementation of the design criteria for site selection such as (1) realization of long-term demonstration impact and (2) enough space for large capacity installation will not possibly be possibly fulfilled as targeted. Thus, as an option for fulfilling the site selection criteria (1) to (4) in Figure 2-2-2-1, the existing parking space of PC and the existing parking space opposite PEC building inside Islamabad is selected. These serve as alternatives to the requested installation site.

The decided installation capacity for each site is 110 kWp (Total 220 kWp). The size of the system is good enough to achieve effective demonstration impact. Meanwhile, the required installation space for 110 kWp is around 1,700 $m^2$ for crystalline and around 3,200 $m^2$ for amorphous type modules in the case of normal installation (without parking space). The annual average power consumption of PC and PEC facility from November 2008 to October 2009 are around 1,751.5 kWh/day and 934.9 kWh/day, respectively. The average calculated power generation is 432.3 kWh/day (average solar hour 5.24 h/day[5] x 110 kWp x system efficiency 75%) is lower than consumption requirements. Hence, even though time for generating surplus power is limited, it is still expected to have reverse power sales toward existing grid when power consumption is low or during holidays.

In case default value 0.486 t-$CO_2$/MWh in Pakistan is applied correspondingly, the amount of the reduction of the carbon dioxide exhaust by the accumulated power generated from PV system during the year becomes 153 t-$CO_2$/year. (= 432.3 kWh/day x 365-day/year x 0.486 t-$CO_2$/MWh x 2 sites)

[5] Based on 22 years NASA data (1983 to 2005)

**(1) Overall Plan**

The selected installation site for the PV system is at the existing parking space of PC and PEC. At both sites, there exist some trees which form shadows over the installation site, which needs to be removed or trimmed. Besides those, there are no other obstacles at the installation site.

The selected site for installation at PC is under its control while that at PEC is under the control of the Capital Development Authority (CDA). CDA has approved the land utilization for the installation of a PV array at the existing parking space. For reference, Figure 2-2-3-1 (PC) and Figure 2-2-3-5 (PEC) present the overall layout plan while Figure 2-2-3-2(PC) and Figure 2-2-3-6 (PEC) summarize the single line electrical diagram of the PV system.

The selected installation is inclined at an angle is 30 degrees[6] at which PV system can generate maximum accumulated power in a year.

The PV array at PC is planned to be installed on an elevated structural steel frame above an existing roof, which holds the main load while it also covers the parking space. In the case of PEC the elevated structural steel frame is built to cover the parking space underneath. For reference, Figure 2-2-3-3 (PC) and Figure 2-2-3-7 (PEC) present the PV structural plan. With this arrangement, there will be space for parking and installation will be accomplished.

The installed PV system connects to the lower voltage (400 V) side of the existing transformer with the incoming line from ISECO at both sites. The surplus power will flow towards the grid network of ISECO. The feed-in-tariff shall be based on Power Purchase Agreement (PPA) contract signed between IESCO and PC, and IESCO and PEC.

There is no burden on the installation and grid-connection to IESCO. All the required installations are covered by this assistance plan. The responsibility of IESCO is the high voltage side of the existing transformer.

**(2) Equipment Plan**

Although there are two sites, both are similar in terms of view on the system design concept. The outline information of equipment to be procured is summarized in Table 2-2-2-1 below.

Table 2-2-2-1 List of Components (Unit Price above JPY 1,000 Thousand)

| Components | Specification | Qty. | Unit | Purpose |
|---|---|---|---|---|
| PV Module | Total capacity 110 kWp and above at each site with no. of series and parallels to match the system voltage 3 Phase 400 V to be decided by supplier | 1 | Set | To generate power by receiving solar insolation |
| PV Structure | Galvanized finishing | 1 | Set | To support PV module at required height and angle |
| Junction Box | Outdoor use with reverse power flow protection, circuit breaker and surge absorber | 1 | Set | To collect and arrange the strings of modules at PV site |
| Connection Box | Outdoor use with reverse power flow protection, circuit breaker and surge absorber | 1 | Set | To connect and arrange the strings from junction box to match the input of power conditioner |

[6] By adjusting the inclined angle of PV array at latitude, it will be possible to generate the maximum accumulated power in a year and as the site is located at around 33N, the maximum power generation will be at around inclined of 33 degree and by few degree adjustments differences on power generation is negligible. From this consideration of the manufacturer and installation, 30-degree inclination is selected.

| Components | Specification | Qty. | Unit | Purpose |
|---|---|---|---|---|
| Power Conditioner | Indoor self standing, 110kW and above in total, output AC 400 V 3 Phase 4 Wire, efficiency 90% and above at rated capacity, with grid-connecting facility and safety protection relays (UVR, OVR, UFR, OFR) | 1 | Set | To convert the DC power generated by PV array to AC power and to match and supply power to load and grid. |
| Distribution Board | Indoor self-standing, 3 Phase 3Wire, 50 Hz with protection relays | 1 | Unit | To connect the 400 V distribution network |
| Low Voltage Switching Panel | Indoor self-standing, 400 V, 3 Phase, 4 Wire, 50 Hz with no. of circuit breaker. | 1 | Unit | To connect several power conditioner to the main 400 V system |
| Outdoor Cubicle | Outdoor self-standing, dust, insects and vermin proof | 1 | Unit | To install power conditioner, 400 V distribution board, 400 V distribution panel and data collection system |
| 400 V Distribution Board | Indoor self standing with power distribution circuit breaker | 1 | Unit | To connect the main feeder, existing load and distribution panel |
| 400 V Distribution Panel | Indoor self standing with power distribution circuit breaker | 1 | Unit | To connect PV system and distribution board, and supply power to equipment |
| Display Board | Outdoor display board of size W1,200 x L800 mm | 1 | Unit | To display PV power generation system information |
| Data Monitoring, Recording and Display System | Meteorological data and system data collection units for data management. | 1 | Unit | To collect and manipulate the system information for providing information to general public and for system O/M management. |

Source: JICA Study Team

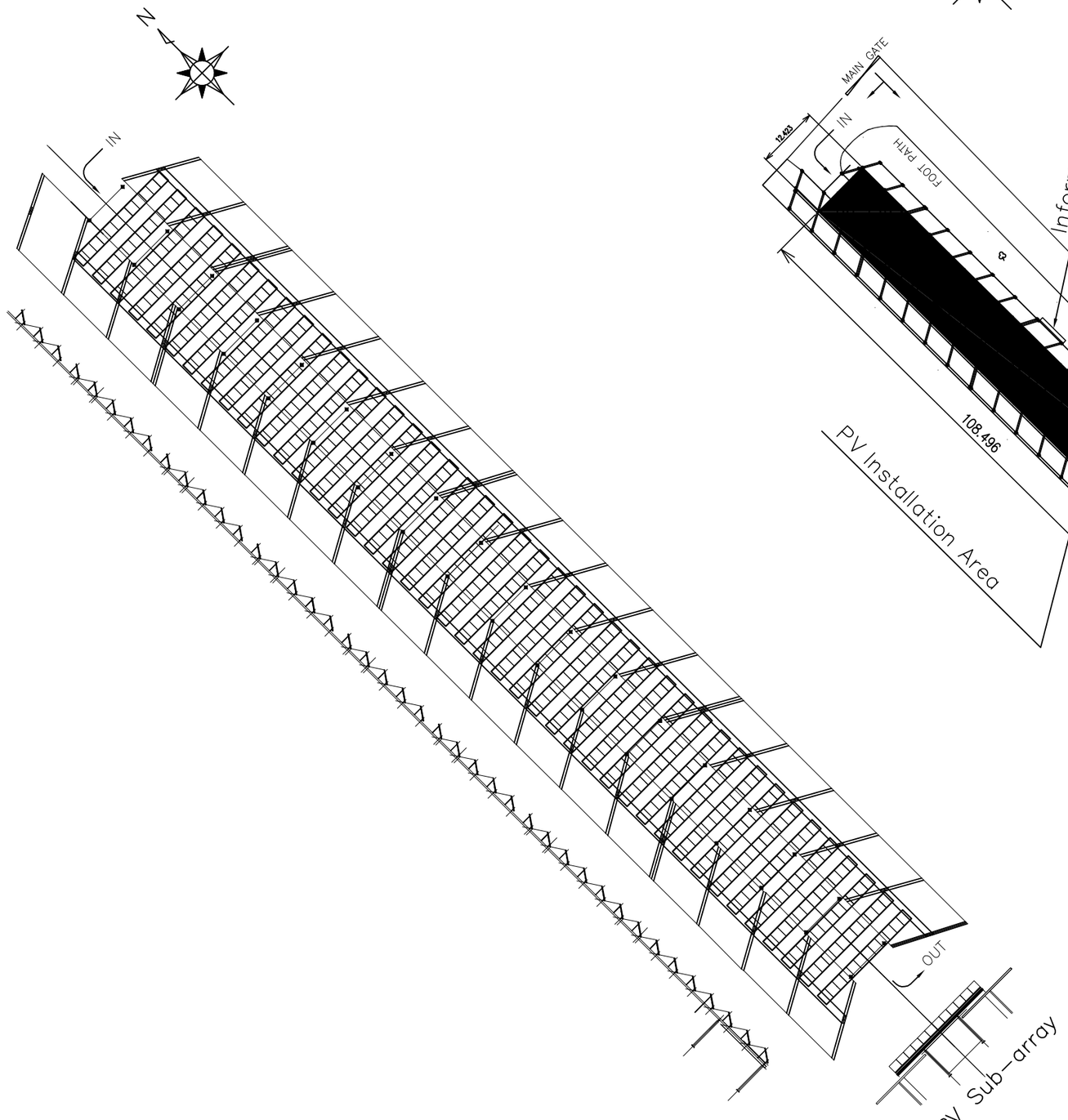
The contents of procurement plan is summarized as follows;

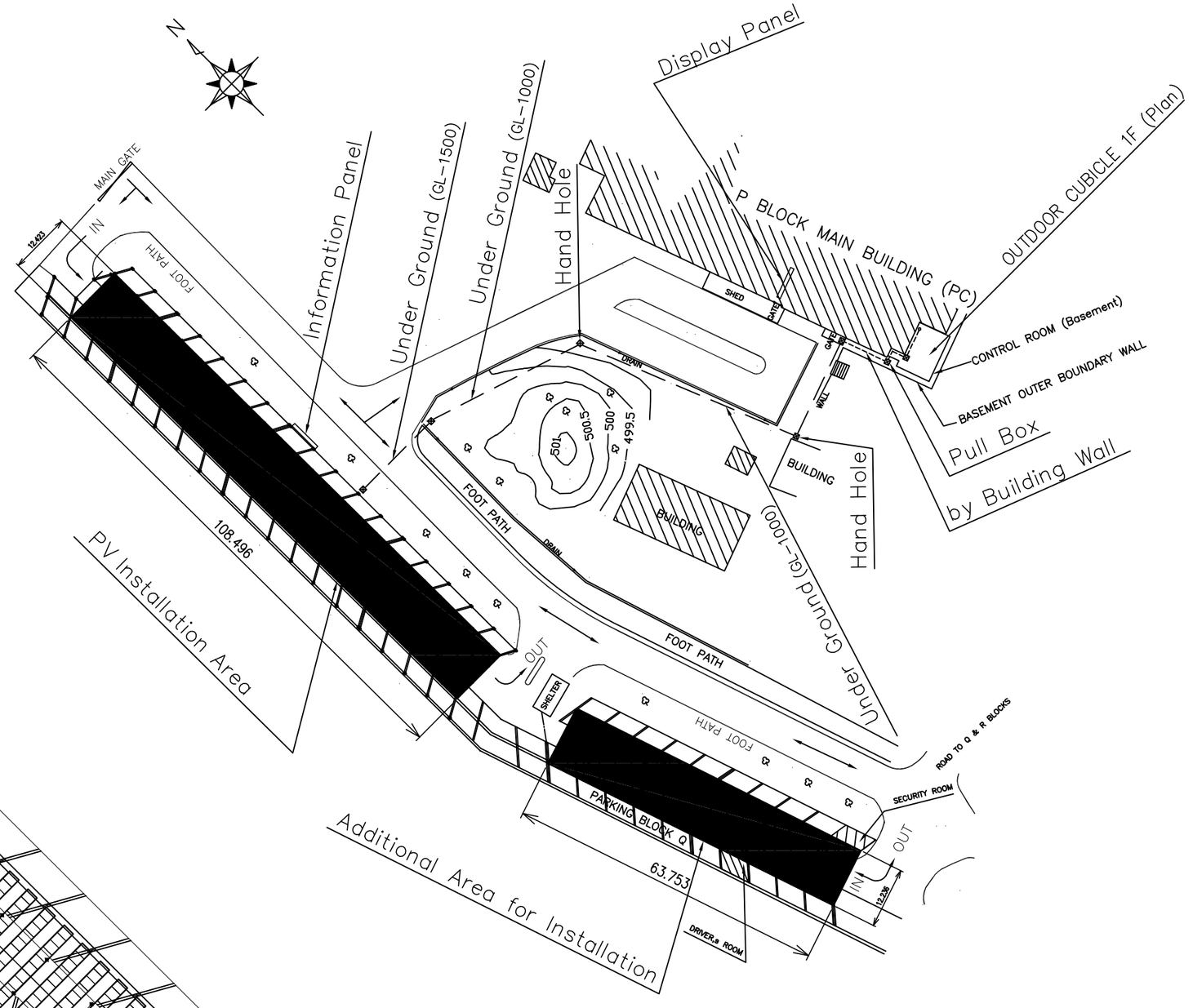
- Demonstration impact: To accelerate the demonstration impact, components are also included in the procurement plan. To view the details of the grid-connected PV system operating status and information, a display panel is included in the equipment procurement plan. On the display panel, five items will be displayed, i.e,. the main related condition for power generation such as the (1) solar insolation (2) ambient temperature, and as power output, (3) generated power (kW) (4) accumulated power (kWh) and (5) expected possible amount of reduction of carbon dioxide by the generated power.
- Measurement and Quantification of Assistance Plan: For the continuous measurement, data recording and management device is included in the procurement of equipments to record meteorological and power generation data. From the measured data using precision instruments, the technical impacts of assistance will be possibly for measured and quantified.
- Guarantee of Durability: Since storage battery is not essential in grid-connected system, the electric circuit is the unit most possibly subjected to higher damage probability. The most possible cause of circuit failure is due to induced spike voltage from lightning and switching action. The counter measures to prevent this induced spike voltage invading the electric circuit are considered to the possible extent. Such measures involve installation of arrester and earthing works.

### 2-2-3 Outline Design Drawing

The overall PV system layout, PV System single line diagram, PV structure and foundation plan are shown in Figure 2-2-3-1 (PC) to 2-2-3-4 (PC) and Figure 2-2-3-5 (PEC) to 2-2-3-8 (PEC).

For Reference




PV System Capacity 110 kWp

| | |
|---|---|
| Preparatory Survey on the Project for Clean Energy Promotion Using Solar Photovoltaic System in Pakistan | |
| Figure 2-3-1 (PC) | |
| PV System Layout Drawing | |

# For Reference

PV Array
(Parallel number × Series number = More than 110kWp)

PV MODULE/ARRAY 1
Junction box 1
EC
PV MODULE/ARRAY n
Junction box n
Connection box No 1
Connection box No n
(Required number)

Power Conditioner (P C)
minimum two Units
Transformer 3ϕ 400V/400V
Control Circuit Part
OVR UVR OFR UFR OCR
* DATA

Low Voltage Switching Panel
Spare
AC Output 3ph 400V 50Hz
W/TD
* DATA
Spare

FROM IESCO (11kV)
Existing
3-PHASE 4 WIRE
KWH METER
KVARH METER
CT 3x25/5A
PT 3x11/√3/0.11/√3
FUSE
REMARKS : METERS ARE NOT IN OPERATION
11/0.4KV, 500kVA TRANSFORMER INDOOR MOUNTED
Transformer Room

3PHASE 3WIRE 4ELEMNT ENERGY METER IMPORT/EXPORT
MCCB 3P 800A, 50kA
CT
PT
VS V W Var PF AS A
DMH
DATA
400V Distribution board (Main Breaker)
ELB 3P 300A, 50kA
MCCB 3P 800A, 50kA
MCCB 3P 300A, 50kA
400V ELB 3P 300A
3PHASE 3WIRE 4ELEMNT ENERGY METER
400V Distributer Panel (Cubicle)
Spare
For ventilation
For lighting and outlet
Spare
Spare

Existing
MCCB 3P 1250A
HRC FUSES
LOADS
Transformer Room

Solar Irradiation Sensor
Temperature Sensor
Wind Speed/Direction Sensor
T/D
* DATA * DATA
Data collecting system
AC Output
Signal
Display panel

| SYMBOL | EXPLANATION | SYMBOL | EXPLANATION |
|---|---|---|---|
| OVR | Over Voltage Relay | T/D | Transducer |
| UVR | Under Voltage Relay | W/TD | Watt Transducer |
| OFR | Over Frequency Relay | V | Volt Meter |
| UFR | Under Frequency Relay | W | Watt Meter |
| EC | Earth Connection | ELB | Earth Leakage Breaker |
| CT | Current Transformer | PT | Potential Transformer |
| RPR | Reverse Power Protection Relay | | |

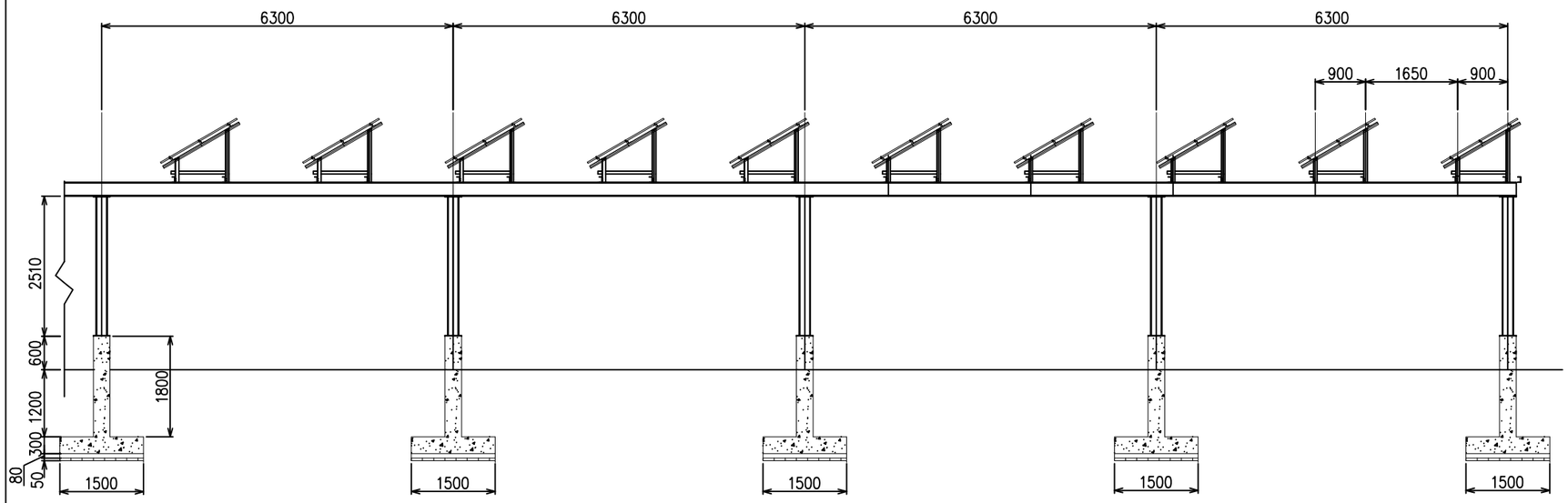
PV System Capacity 110kWp

Preparatory Survey on the Project for Clean Energy Promotion Using Solar Photovoltaic System in Pakistan

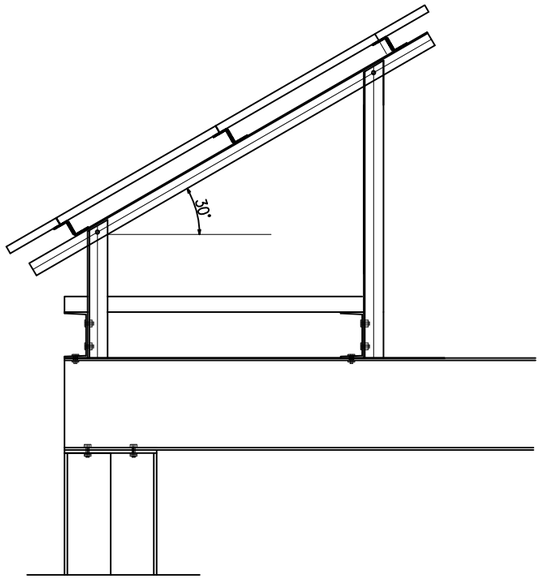
Figure2-3-2(PC)

PV System Single Line Diagram

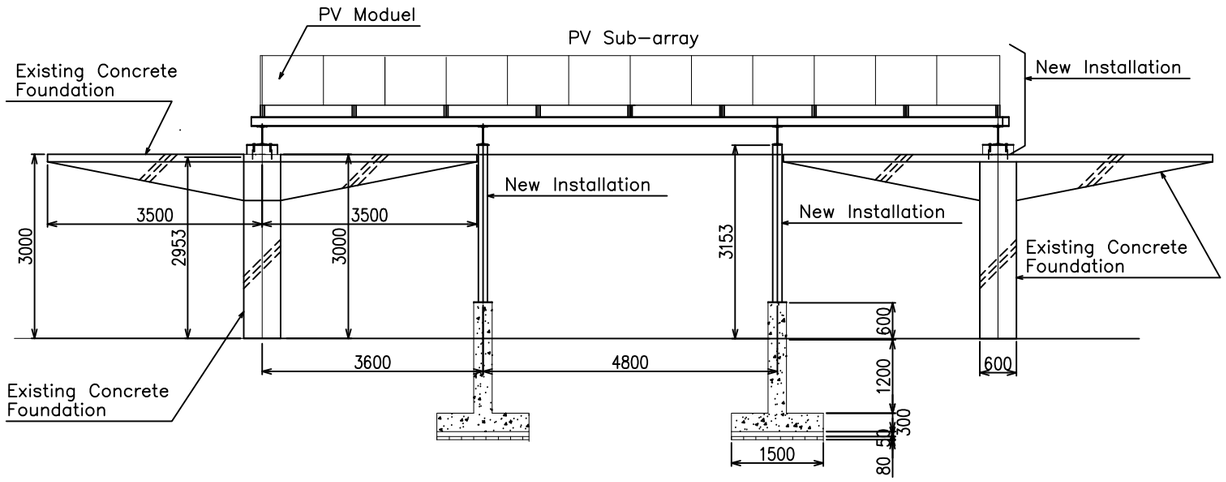
# For Reference



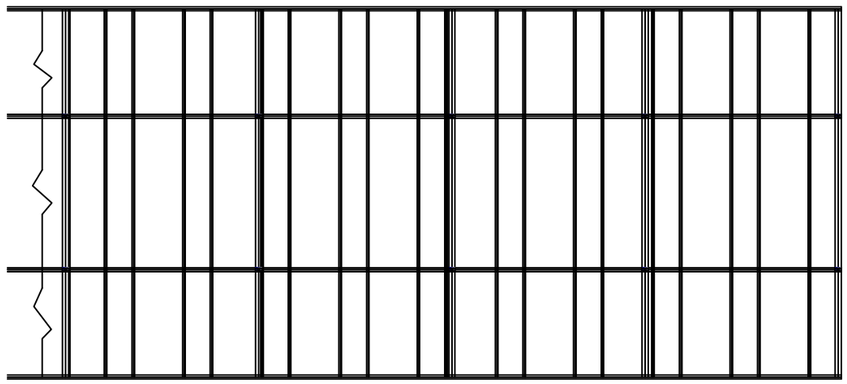

LONGITUDINAL ELEVATION




PV SUPPORT SECTION



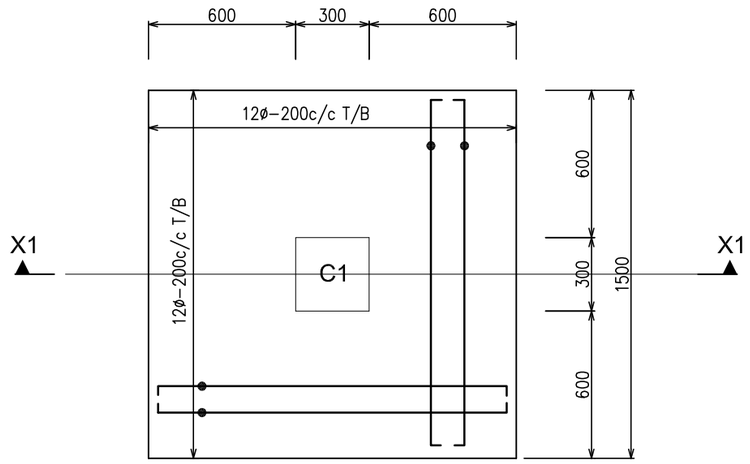

SECTIONAL ELEVATION



BEAM FRAMING PLAN AT FLOOR LEVEL

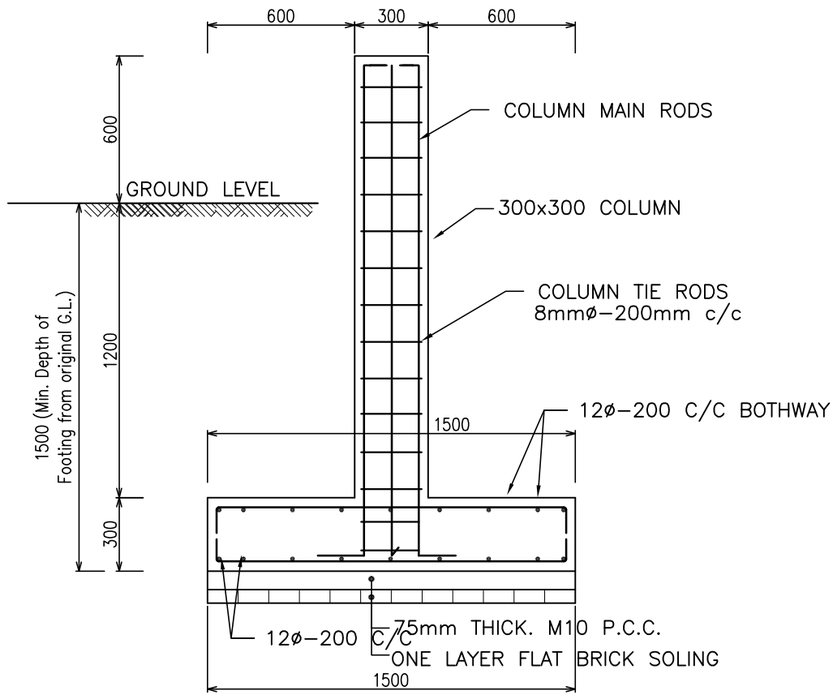
| |
|---|
| Preparatory Survey on the Project for Clean Energy Promotion Using Solar Photovoltaic System in Pakistan |
| Figure 2-3-3 (PC) |
| PV Structure |

For Reference



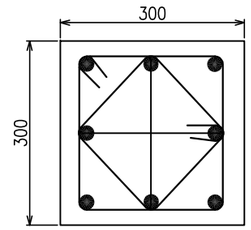

FOOTING PLAN

SCALE = 1:25




FOOTING SECTION AT X1

SCALE = 1:25

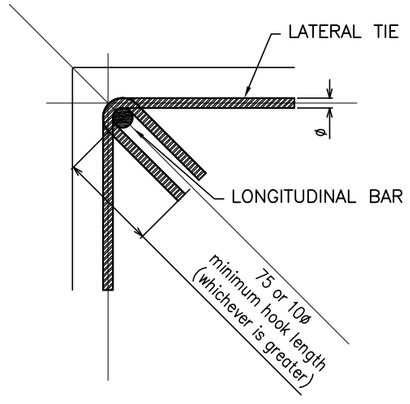



8–12ø MAIN BARS

NOTES FOR COLOMN STIRRUPS:–
1. Columns with 8 mm main bars: Use 8 mm dia stirrups bars @ 200mm C/C.

COLUMN DETAILS

SCALE = 1:10

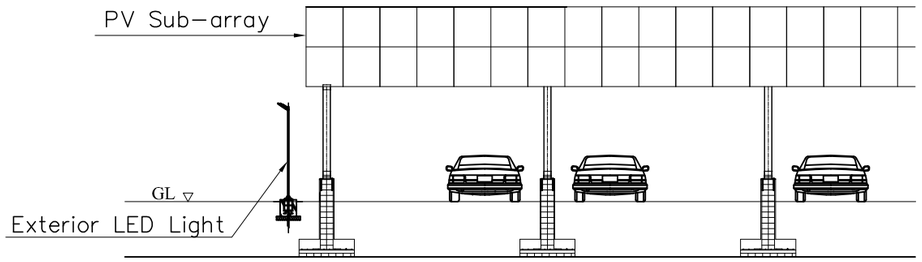



DETAIL A–135°HOOK DETAIL FOR STIRRUPS & TIES

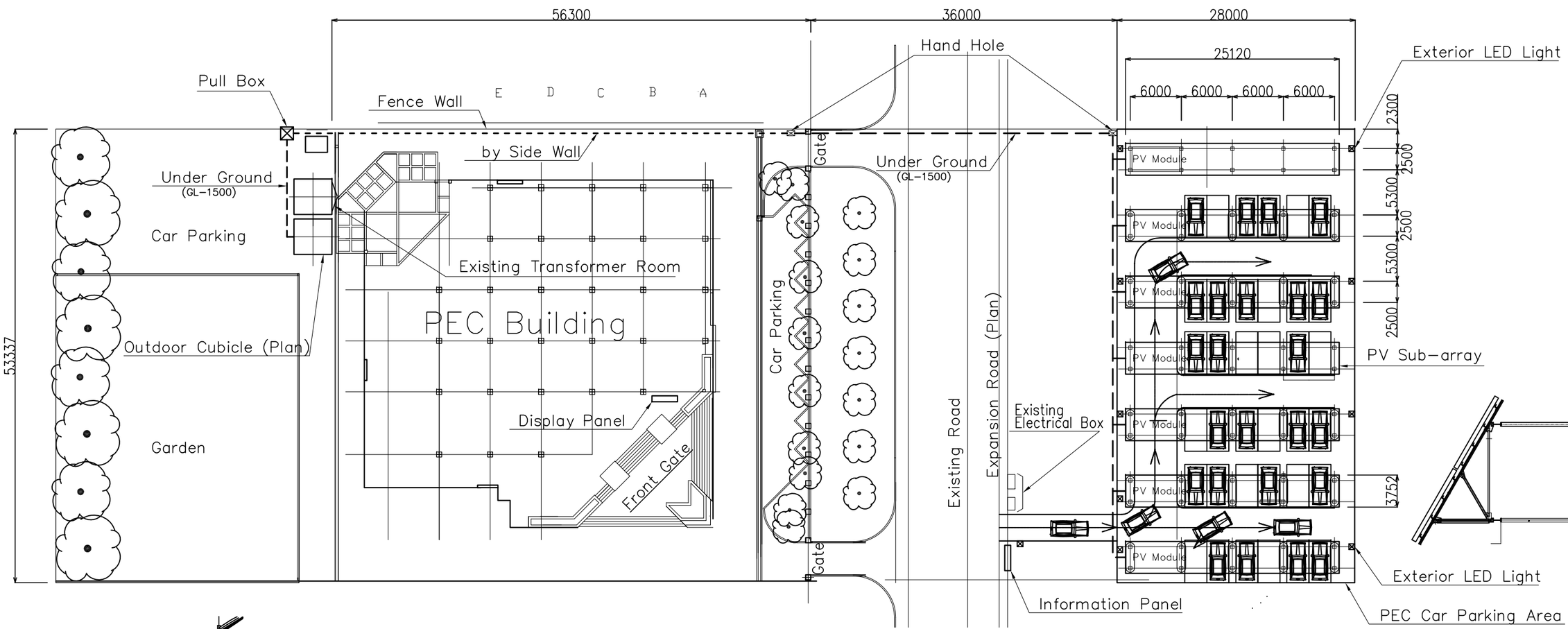
SCALE=NTS

| |
|---|
| Preparatory Survey on the Project for Clean Energy Promotion Using Solar Photovoltaic System in Pakistan |
| Figure 2–3–4 (PC) |
| PV Foundation plan |

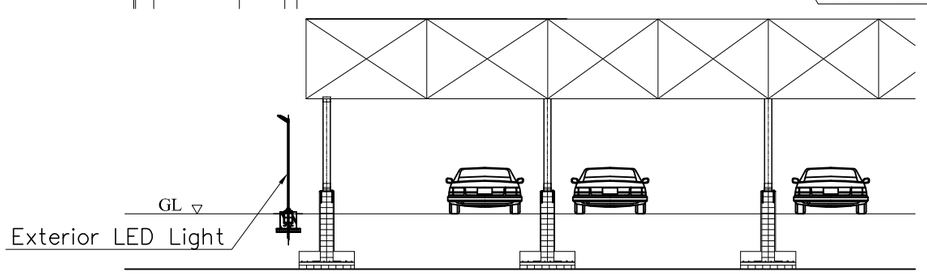
# For Reference




Front Elevation of 110 kW PV system




Exterior LED Light

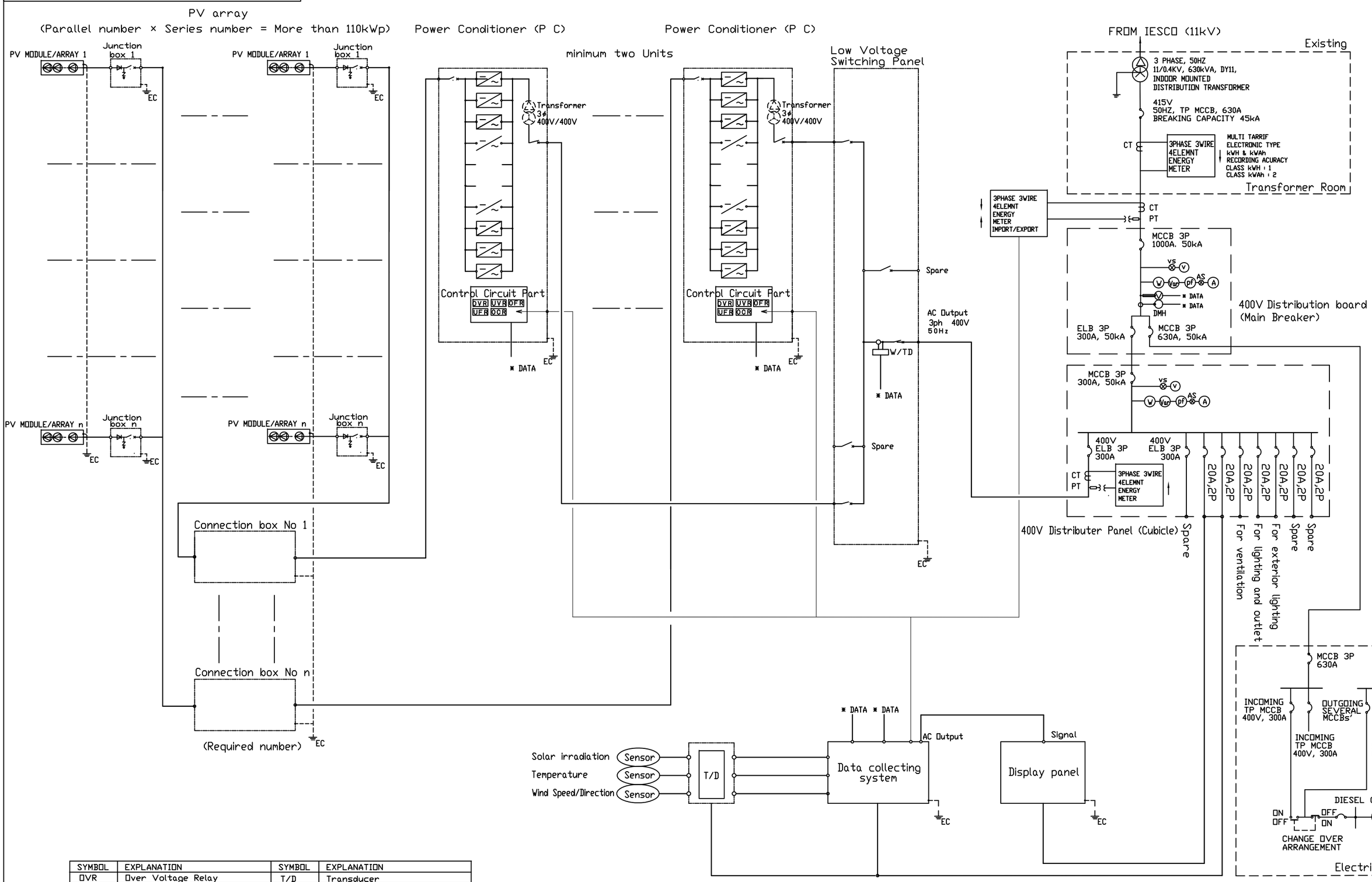



Back Elevation of 110 kW PV system

## PV System Capacity 110 kWp

| |
|---|
| Preparatory Survey on the Project for Clean Energy Promotion Using Solar Photovoltaic System in Pakistan |
| Figure 2-3-5 (PEC) |
| PV System Layout Drawing |

# For Reference




| SYMBOL | EXPLANATION | SYMBOL | EXPLANATION |
|---|---|---|---|
| OVR | Over Voltage Relay | T/D | Transducer |
| UVR | Under Voltage Relay | W/TD | Watt Transducer |
| OFR | Over Frequency Relay | V | Volt Meter |
| UFR | Under Frequency Relay | W | Watt Meter |
| EC | Earth Connection | ELB | Earth Leakage Breaker |
| CT | Current Transformer | PT | Potential Transformer |
| RPR | Reverse Power Protection Relay | | |

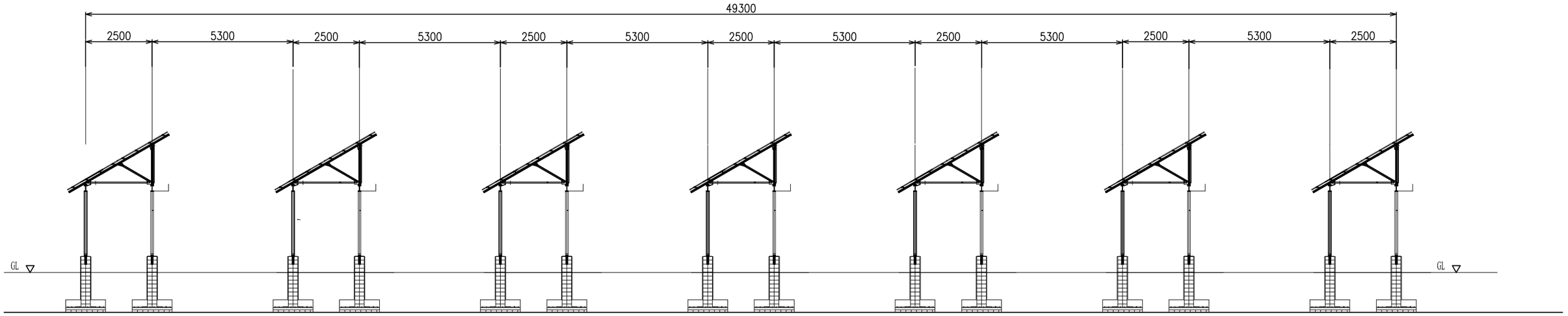
PV System Capacity 110kWp

Preparatory Survey on the Project for Clean Energy Promotion Using Solar Photovoltaic System in Pakistan

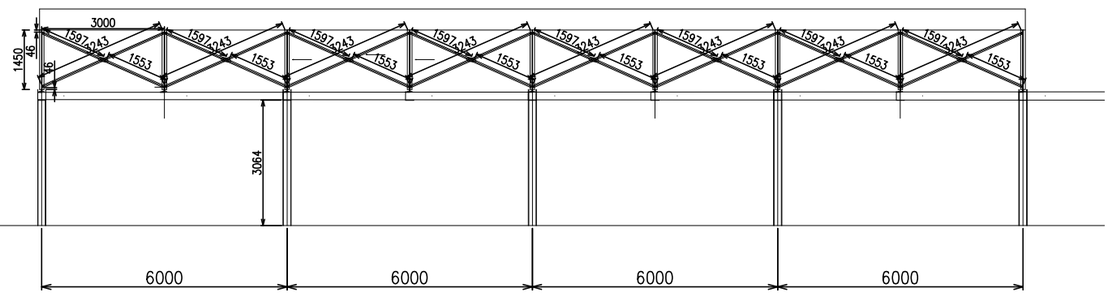
Figure2-3-6(PEC)

PV System Single Line Diagram

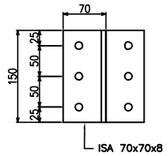
# For Reference

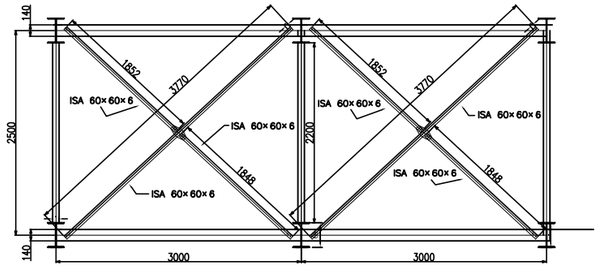



Sectional Elevation of PV Structur

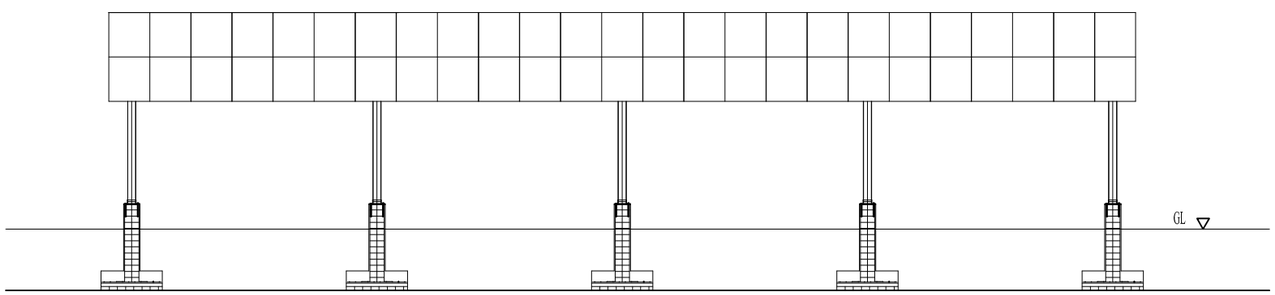



Back side Elevation

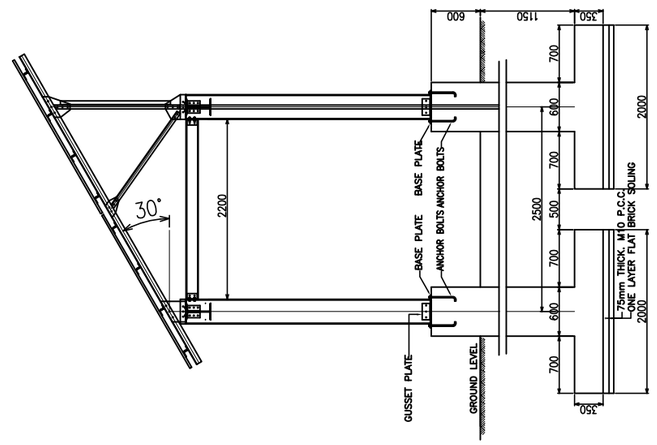



Horizontal Bracing of Solar support



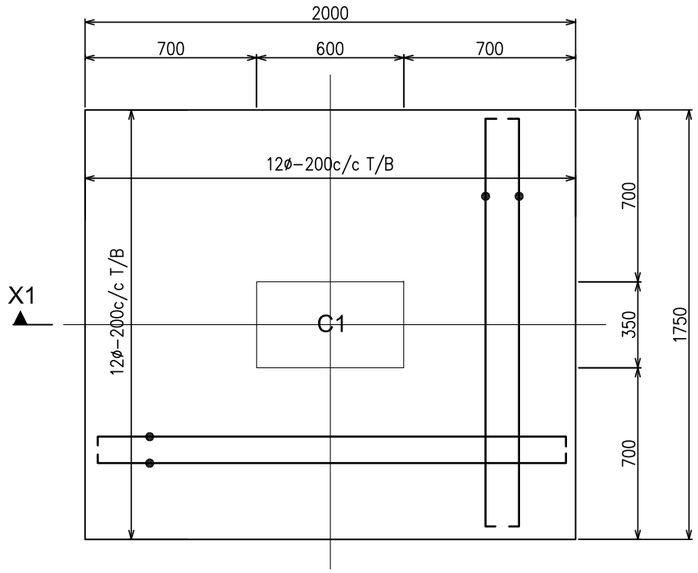

Front elevation of 110 KW PV system




Support Section Details (SECTIONAL)

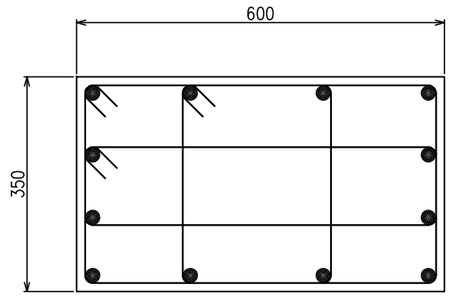
| | |
|---|---|
| Preparatory Survey on the Project for Clean Energy Promotion Using Solar Photovoltaic System in Pakistan | |
| Figure 2-3-7 (PEC) | |
| PV Structure | |

For Reference




FOOTING PLAN

SCALE = 1:25

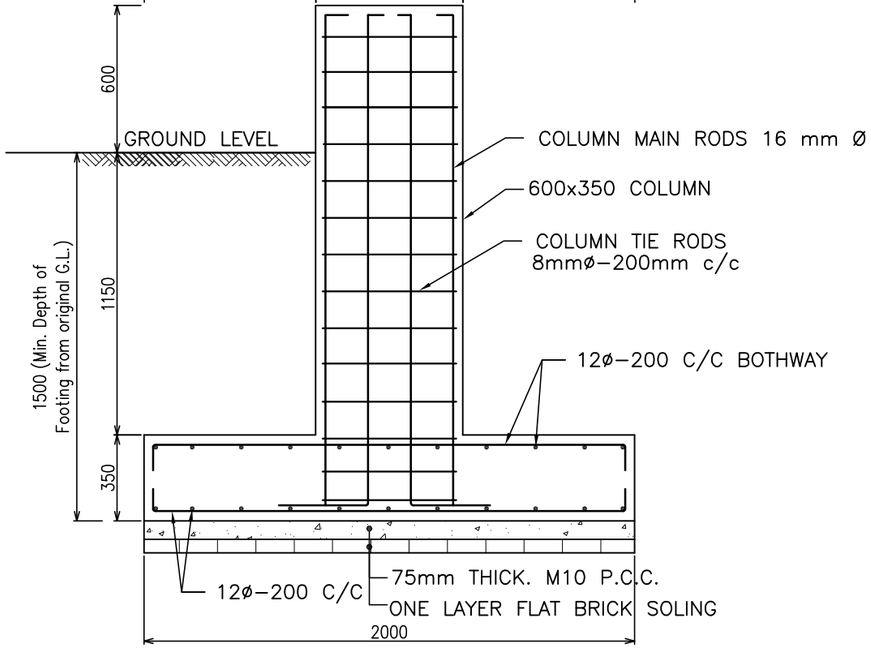



12–16ø MAIN BARS

NOTES FOR COLOMN STIRRUPS:–
1. Rectang. Columns with 12 bars: Use 8 mm dia bars @ 200mm C/C.

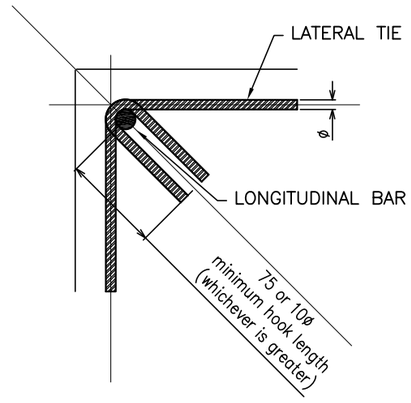
COLUMN DETAILS

SCALE = 1:10




FOOTING SECTION AT X1

SCALE = 1:25




DETAIL A-135°HOOK DETAIL FOR STIRRUPS & TIES

SCALE=NTS

| |
|---|
| Preparatory Survey on the Project for Clean Energy Promotion Using Solar Photovoltaic System in Pakistan |
| Figure2–3–8(PEC) |
| PV Foundation Plan |

## 2-2-4 Implementation Plan

### 2-2-4-1 Implementation Policy

The implementation of this assistance is in accordance with the Japanese Grant Aid scheme. For implementation after exchange of notes (E/N), Pakistan government drafts an agent agreement. Consequently, the representative procurement agent selects and handles the contracts with the consultant for system deign, execution and supervision, and with the contractor for construction, procurement and installation of components.

**(1) Responsible Organization and Implementing Agency**

In this assistance plan, from the procurement to the implementation stage, the project implementing agency and responsible organization of Pakistan are as follows.

- Responsible Organization: Planning Commission (PC)
- Implementing Agency: Pakistan Engineering Council (PEC)
  Responsible Department and Section: Admin & Pers. Department, Admin Section

To execute this assistance plan the PC and PEC need to appoint a person responsible for the implementation. The appointed responsible person submits documents and coordinates with institutions like CDA, NEPRA, IESCO, AEDB and so on, for smooth implementation of the projects.

**(2) Representative Procurement Agent**

The representative procurement agent selects the consultant to perform supervision of implementation and execution, and a contractor to execute procurement and installation. The representative procurement agent controls the budget of the project and will represent the Pakistan government. It authorizes payment based on the work progress of the selected consultant and contractor.

**(3) Consultant**

The selected consultant enforces the procurement plan, construction schedule, implementation and supervision. The consultant also prepares the technical documents and supports the representative procurement agent in selecting the contractor for supply and implementation. Safety, quality, schedule and construction drawings are also checked and controlled by the consultant. Furthermore, consultant will provide technical advice and support for document controls related to grid-connection documents, and also performs field inspections, commissioning and handover of the project.

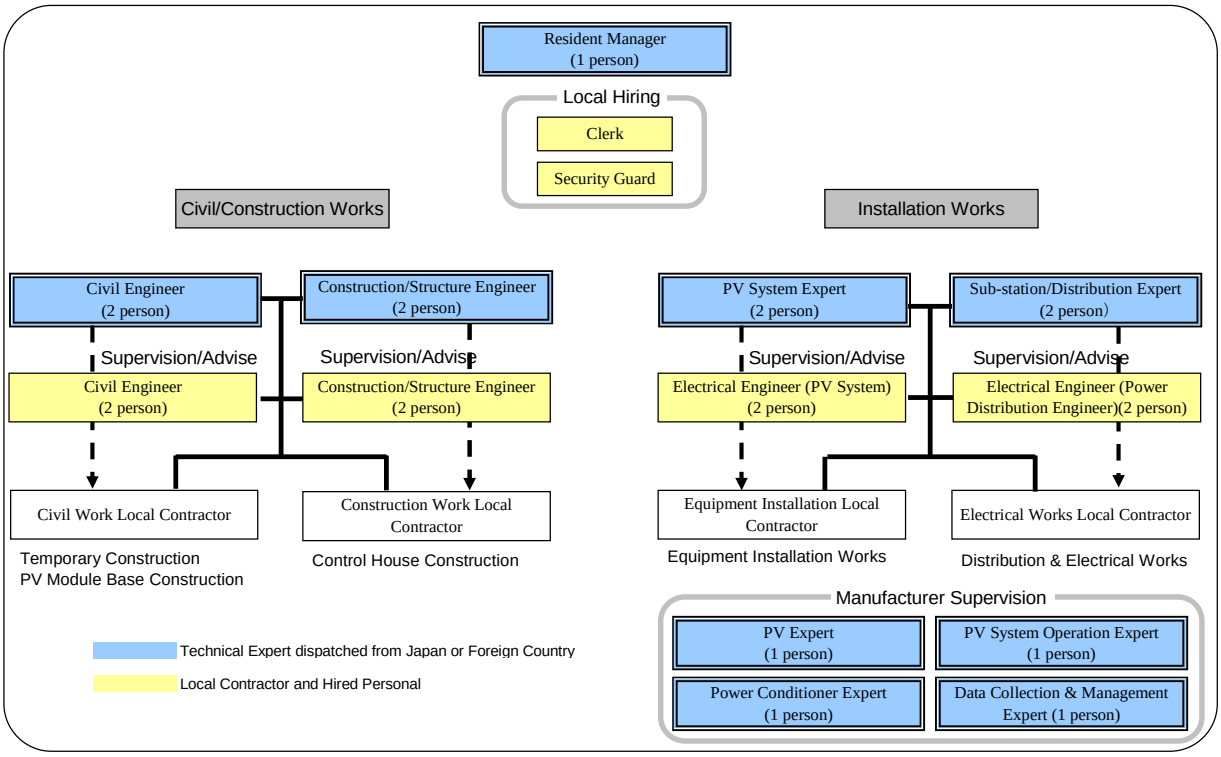
**(4) Supplier/Contractor**

The supplier/contractor is selected through an open tender method and required related components are procured in accordance with the agreement made.

Furthermore, the selection procedure for local assistance and dispatching of Japanese technical expert for the project is summarized as follows:

- Local Consultant and Construction Company: Both are supposed to be in the field of electricity and civil engineering works, and will work as assistants under the Japanese consultant and technical experts of the project.
- The Japanese Technical Export: The grid-connected PV system is the first case to be introduced in Pakistan. Hence, dispatching of Japanese technical experts is essential to cover fields like PV system, grid-connection and distribution, civil and construction works.

The administrative structure of procurement contractor is shown in Figure 2-2-4-1.




Source: JICA Study Team

Figure 2-2-4-1 Structure of Procurement Contractor

The dispatched Japanese technical expert acts as a residence manager involved in the entire field including PV system, grid-connection and distribution, civil and construction works. Besides, the operation management and initial start up is part of the tasks of the supplier's technical expert.

### 2-2-4-2 Implementation Conditions

The main points of concern for construction and procurement are as follows:

- Safety Management of Material and Equipment: During the installation works, the security of the procured material and component shall be ensured by employing a security guard. After completion of the works, security shall be maintained by PC and PEC.
- Safety Precautions: The PV module structure is installed above 3 m high at PC and above 2.5 m at PEC. Hence, stable scaffolding and working platform is necessary to prevent workers from falling and from accidentally dropping objects. Furthermore, since the PEC site is near the public road, it is essential to take precaution to avoid causing harm or accidents to pedestrians or passing vehicles.
- At both sites, the PV module is installed at an elevated structure, and thus, the implementing schedule and positioning of workers for smooth execution of the project shall be planned.

### 2-2-4-3 Scope of Works

This is the first case of grid-connected PV system to be implemented in Pakistan. Hence, the procurement, construction and installation works are planned to be covered by this assistance plan. Other essential works like securing land for installation, license application for power generation and supply, application and processing for grid-connection and finalization of feed in tariff, and so on are the responsibility of Pakistan.

### 2-2-4-4 Consultant Supervision

The outline of procurement management and construction plan is as follows:

- Basic Concept: Since implementation of the grid-connected PV system is Pakistan's first experience, the procurement management and supervision works are planned for the entire construction period under this assistance plan.
- Notes of Priority: Due to the elevated working place, qualified workers and reliable supervision are required. Ensuring that the works are progressing properly needs to be studied carefully as this is very important for safe and smooth project execution.
- Management Structure: The resident management system is adopted to manage the continuous work process from procurement to the end of construction period, as mentioned in the basic policy.
- Content of Work and Specialty: The fundamental works related to civil works like concrete foundation, fence construction, construction of control house, and so on during the first part is managed by the civil engineer acting as a resident manager. In the succeeding year, the installation of PV module, power conditioner and grid-connection will also take place. For this, the resident manager needs to be knowledgeable in grid-connection, and should not just be an electrical engineer. Furthermore, the PV power generation specialist needs to be on site as his presence is indispensable during inspection of concrete foundation for the PV structure, installation of PV module, final inspection of installation and operation test.

### 2-2-4-5 Quality Control Plan

To manage the quality control of construction works, supply of construction materials and equipment, the following procurement inspection works are planned to be executed under this assistance plan.

#### (1) Inspection of Drawings

Submission of drawings for the construction equipment under this execution procurement plan is required from the supplier, while verification of the conformity of the materials with the as well as the quality according to the contract is executed by the consultant.

#### (2) Factory Inspection

The concept is that the inspection of procured components is executed at the factory before shipment packing. The main equipment such as the switch panel and distribution board, PV module, power conditioner and others are subject to acceptance test at the factory before shipment, witnessed by the consultant to confirm compliance with the approved drawings and specifications.

#### (3) Inspection before Shipment

A third party inspection is executed to confirm if the procurement component, materials packed and loads are as per procurement document for shipment.

#### (4) Field Inspection

The inspection of construction and installation components is to be performed at the installation site. The inspection of individual equipment and complete system is executed under the presence and responsibility of the procurement contractor. The inspection at the field is witnessed by the consultant's personal in charge and designated person form the Recipient country.

### 2-2-4-6 Procurement Plan

#### (1) Origin of Material

Basically, the procured materials and equipment for the PV system are selected considering durability, ensured high accuracy and quality. The supply of materials and components like construction materials for civil works are locally procured while others procured from Japan. The energy meter is required to be procured from NTDC[7]. The existing transformer is to be used at both sites. In the case of civil and construction works, locally available materials shall be used under this

[7] The procured energy meter by NTDC is inspected and supplied to costumer is the process adopted in Pakistan

assistance plan.

The countries where the main equipment will be procured are summarized in Table 2-2-4-1.

Table 2-2-4-1 Countries Where Main Equipment will be Procured

| Material List | Procurement Country (Country of Origin) | | |
|---|---|---|---|
| | Local | Japan | Third Country |
| PV Module | | X | |
| Power Conditioner | | X | |
| Step up Transformer | Used existing transformer for both sites | | |
| Insulation Transformer | | X | |

Source: JICA Study Team

**(2) Transportation Route**

All required equipment and components for this assistance plan are products of Japan. The transportation routes from Japan to the site, process and shipment duration are summarized in Table 2-2-4-2[8].

Table 2-2-4-2 Shipment Plan

| Transportation Route | Shipment Step | Shipment Duration |
|---|---|---|
| Port of Japan | | |
| \| | Sea Shipment | 20 to 30 Days |
| Pakistan / Port of Karachi | | |
| \| | Land Transportation | 2 to 3 Days |
| Installation Site (Islamabad) | | |

Source: JICA Study Team

**(3) Components for Replacement and Tools**

The components and parts of PV system are difficult and complicated to repair locally, and it may influence largely the system's operation. In case of damage or break down, the component and accessories for replacement are as mentioned below

(i) PV module (3%[9] of Total)

Even though it may not influence the PV system largely, the following items, which might differ depending on the manufacturer and may not be obtained easily, are also subject for replacement to realize a long term smooth operation. As there are two sites planned, procurement for each site shall be separate.

(ii) Fuses
(iii) Display Lamp of Control Panel
(iv) Circuit Breakers
(v) Meteorological Instruments (Thermometer, Pyranometer, Anemometer/Wind Vane)

The required tools for daily O/M shall also consist of two sets.

(i) Insulation Resistance Tester
(ii) Clamp Meter
(iii) Multi-meter

**(4) Warranty**

A warranty period of one year is required for supplied components, equipment and facility.

[8] Required days for custom clearance are not included.
[9] For the replacement of module for accidental break down. The possibility of break down may be whole string. The actual number of module at one string is depends upon the system deigning, normally one strings contains around 10 to 15 module. It will be around 3% of the whole capacity if several strings are considered for replacement.

### 2-2-4-7 Operation Guidance Plan

After the finalization of installation, technical transfer to the system operator designated to perform daily O/M is planned. The method of operation adjustment of each individual component, initial start up, and O/M are executed by the supplier/manufacturer's expert. The operation and other technical know-how of the complete PV system are executed under the soft component program.

The O/M of the installed PV system also needs to be managed by the O/M team of PC/PEC for both sites. It is therefore essential to appoint a daily operator for each site.

Table 2-2-4-3 summarizes the specialty of experts, contents of technology transfer and implementation period.

Table 2-2-4-3 Initial Operation Guide and Management Plan

| Specialty of Expert | Contents of Technology Transfer | Implementation Period |
|---|---|---|
| PV Technology Expert | Basic know-how of PV technology, daily operation and maintenance | Around 2 Weeks |
| Power Conditioner Expert | Initial start up, operation producer, emergency management, fault findings and initialization, daily operation and maintenance | Around 2 Weeks |
| Data Collection and Management Expert | Initial start up, management of data, fault finding, daily operation and maintenance | Around 2 Weeks |
| PV System Operation Expert | Initial start up, operation method, emergency management, daily operation and maintenance, fault finding and restoring | Around 2 weeks |

Source: JICA Study Team

### 2-2-4-8 Soft Component (Technical Assistance) Plan

Application of grid-connected PV system in utilizing renewable energy resource under this assistance plan is the first case in Pakistan. There is no such experience in Pakistan in the past that are related to the smooth operation of grid-connected PV system. Thus, to execute the system installation smoothly and with the aim of sustaining smooth and durable operation, provision of support under the soft components is deemed necessary.

The proposed contents of the soft components are summarized and attached in the soft component plan.

### 2-2-4-9 Implementation Schedule

The implementation schedule is summarized in Table 2-2-4-4.

Table 2-2-4-4 Implementation Schedule

(Detail Design)

| Months | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Domestic Works | | | | | | | | | | | | | |
| 2 Site Survey | | | | | | | | | | | | | |

(Procurement & Implementation)

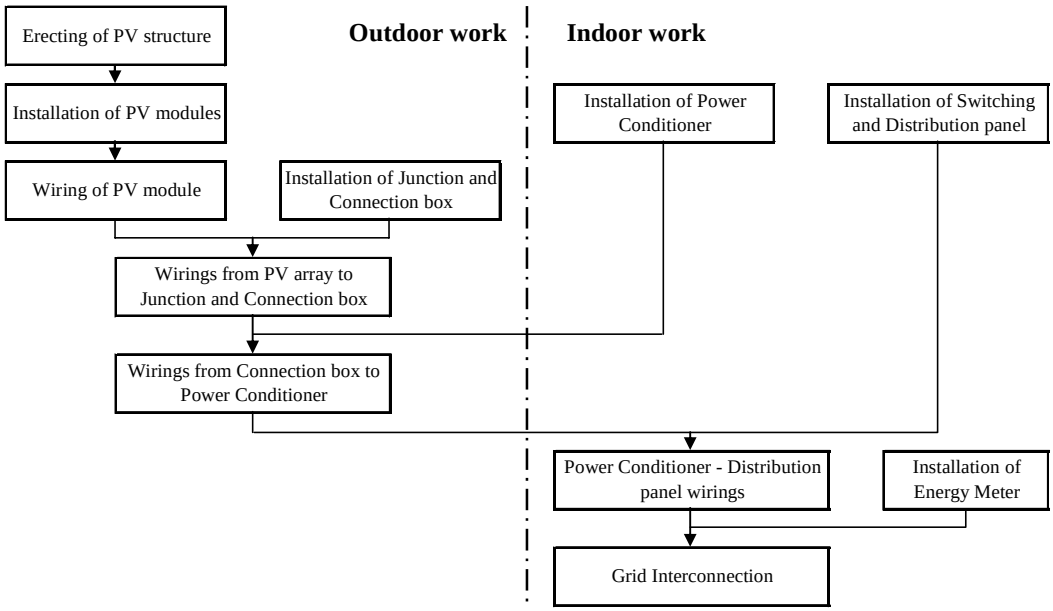
| Months | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Designing & Approval | | | | | | | | | | | | | |
| 2 Structure Manufacturing | | | | | | | | | | | | | |
| 3 Equipment Manufacturing | | | | | | | | | | | | | |
| 4 Shipment, Inland Transport & Entry | | | | | | | | | | | | | |
| 5 Civil & Construction Work | | | | | | | | | | | | | |
| Temporary Works | | | | | | | | | | | | | |
| PV Structure Concrete Base Works | | | | | | | | | | | | | |
| Construction of Control House | | | | | | | | | | | | | |
| 6 Equipment Installation Works | | | | | | | | | | | | | |
| PV Structure Erecting Works | | | | | | | | | | | | | |
| PV Module Installation Work | | | | | | | | | | | | | |
| Sub-station Equipment Installation | | | | | | | | | | | | | |
| Other Works | | | | | | | | | | | | | |
| 7 Commissioning | | | | | | | | | | | | | |
| 8 Inspection, Completion and Hand Over | | | | | | | | | | | | | |

: Site Works : Domestic Works : Site or (and) Domestic Works

Source: JICA Study Team

The total period from the initial stage of planning, preparation of drawings for inspection, execution of works until the project hand over is planned to be completed with ten months.

The installation work is divided into outdoor and indoor woks; the complete flow is presented in Figure 2-2-4-2 below.




Source: JICA Study Team

Figure 2-2-4-2 Installation Work Flow

## 2-3 Obligation of Recipient Country

For the execution of this assistance plan, the obligations of the Pakistan government are as follows:

(i) Acquisition of land for system installation by PEC.
(ii) Acquisition of the power generation and supply license from NEPRA
(iii) The PPA contract with IESCO for realization of reverse power sales and grid-connection

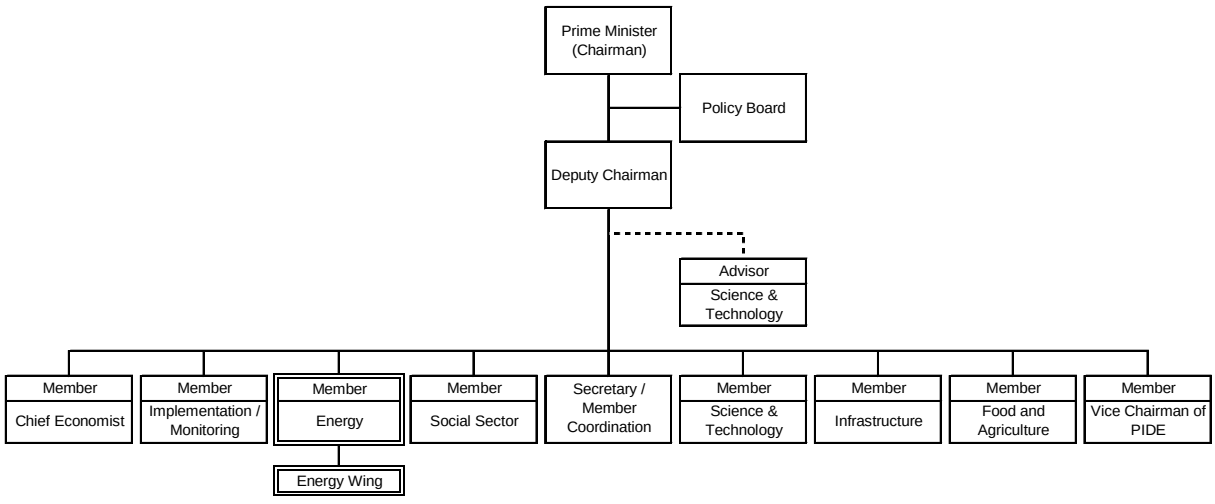
(iv) The procedure for environmental and social consideration
(v) The bank commissioned to establish an account in Japan and procedure for this assistance plan.
(vi) The arrangement on tax exemption for materials supplied, process of entry of materials and domestic transportation.
(vii) The required legal action for entry and sojourn in Pakistan, for Japanese and third country experts involved in this assistance plan.
(viii) The exemption of taxes for equipment and service parts, and necessary purchases for the Japanese experts engaged in this assistance plan.
(ix) The smooth and appropriate management of supplied equipments.
(x) The necessary expenses, except those from the Grant Aid of Japan.
(xi) The assistance and cooperation to solve any conflicts that may transpire between the inhabitants and any third person while executing this assistance plan.

## 2-4 Project Operation Plan

In this project, administration and maintenance operation is planned to be implemented by PEC.

The installation site at PC is within the government complex premises where O/M is being managed by CDA for the whole complex. In the case of PEC, an operator is appointed to perform daily operation management. Meanwhile, for the regular maintenance of equipment such as diesel generator, a maintenance contract is made with the supplier to perform said task. Both PC and PEC do not have experience on O/M management of grid-connected PV system. PEC is the institution that maintains records regarding the contractor, supplier, engineers and regularly communicates with them. Thus, a designated daily operator is essential at both sites and the technical in-charge from PEC also needs to cover both sites on a regular basis. Aside from the technical in-charge, a senior engineer needs to control the operation and management of both sites. Even though the scale of the PV system is large and operates by connecting to the IESCO grid, it is judged that the created technical team can perform the O/M works smoothly with appropriate technology transfer.

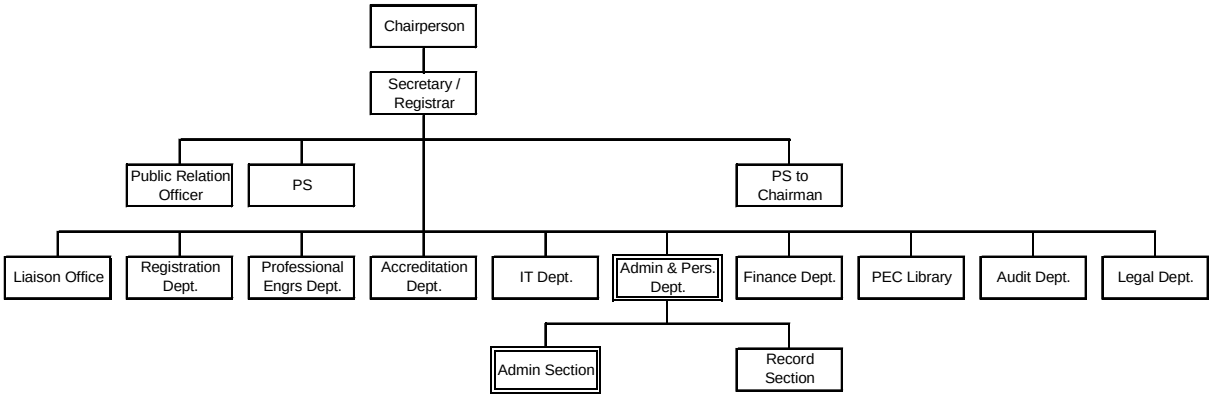
The organization chart of PC and PEC is summarized in Figure 2-4-1 and Figure 2-4-2, respectively.




PIDE: Pakistan Institute of Development Economics

Source: JICA Study Team based on material from PC

Figure 2-4-1 Organization Chart of PC




IT: Information Technology
PEC: Pakistan Engineering Council

Source: JICA Study Team based on material from PEC

Figure 2-4-2 Organization Chart of PEC

The instruments and replacement parts related to O/M management are procured under this assistance plan. A soft component is executed for the technical personnel of PEC, to transfer the technical know-how on procured instruments and to respond (troubleshoot) during system breakdown.

The necessary maintenance management items are summarized in Table 2-4-1.

Table 2-4-1 Main Items of Management and Maintenance

| Contents of Inspection | Type of Inspection | Item for Inspection |
|---|---|---|
| General inspection (Once in a month) | | |
| PV Array | Visual | - Damage, Corrosion, Lose Connections |
| Junction and Connection Boxes | Visual | - Damage, Corrosion<br>- Damage of Cable Connections |
| Power Conditioner | Visual | - Damage and Corrosion<br>- Damage of Cable Connections<br>- Ventilation<br>- Odd Sounds, Odor, Vibration, Overheating<br>- Fault / Error Lamp<br>- Operating Condition |
| Regular Inspection (Annually, but if any abnormal defect is observed, then inspection and maintenance are carried out) | | |
| PV Array | Visual | - Disorder, Color Change, Cracks of Cables<br>- Tightness of Earth Connection Terminal |
| Junction and Connection Boxes | Visual | - Disorder, Color Change, Cracks of Cables<br>- Tightness of Earth Connection Terminal |
| | Measurement and tests | - Insulation Resistance Test<br>- Measurement of Outputs |
| Power Conditioner | Visual | - Disorder, Color Change, Cracks of Cables<br>- Plugging of Ventilation Filter |
| | Measurement and Test | - Power generation and display condition<br>- Operation and Error test |

Source: JICA Study Team

## 2-5 Project Cost Estimation

### 2-5-1 Initial Cost Estimation

The initial costs of procurement, shipment, installation and so on are covered by this assistance plan.

**(1) Estimation Condition**

(i) Estimate Period: December, 2009
(ii) Exchange Rate: USD 1.00 = JPY 93.97, PKR 1.00 = JPY 1.28
The estimation is based on the average exchange for six months from June 1, 2009 to November 30, 2009. These rates are the TTS rates announced by the Bank of Tokyo-Mitsubishi UFJ.
(iii) Construction Period: As mentioned in the execution schedule
(iv) Others: The accumulation of estimation is based on the administrative system of the Japanese Grant Aid.

**(2) Cost Sharing of Pakistan**

Table 2-5-1-1 shows the breakdown of cost share of Pakistan.

Table 2-5-1-1 Estimated Overall Project Cost Share of Pakistan

| Cost Item | Amount |
|---|---|
| 1. Fence at PV Installation Site of PEC[10] (L=190 meter) | PKR 288,885 (JPY 370 thousand) |
| 2. Land Preparation of PEC Site[11] | PKR 26,458 (JPY 34 thousand) |
| 3. Replanting of Trees (assumed around 20 no. and trimming)[12] | PKR 140,000 (JPY 179 thousand) |
| Total | PKR 455,343 (JPY 583 thousand) |

Source: JICA Study Team

The construction of fence mentioned as item 1 is planned for security purposes.

Furthermore, depending on the type of PV module selected, PEC may request for additional space from CDA for the installation requirements.

Besides the above-mentioned costs, expenses like application for underground road crossing cables, Banking Arrangement (B/A) procedure, Authorization to Pay (A/P) and import permit shall also be covered by the Pakistan side.

## 2-5-2 Operation and Maintenance Cost

The yearly maintenance management expenses for grid-connected PV system are calculated as shown in Table 2-5-2-1.

Table 2-5-2-1 Maintenance Management Expenses of PV Grid Interconnected System

| Item | Yearly Maintenance/Management Cost |
|---|---|
| 1. Routine Administrative Cost | PKR 462,000 (JPY 591 thousand) |
| 2. Equipment (Reserve Fund) | PKR ***,*** (JPY *** thousand) |
| Total | PKR ***,*** (JPY *** thousand) |

Source: JICA Study Team

Basically, the grid-connected PV system is maintenance-free and therefore, the required frequency of daily O/M management is minimal. In actual practice, the requirement on O/M management at the engineering level and technical level is assumed to be 0.5 of their monthly salaries. Since the monthly salary of a senior engineer and technician is around PKR 65,000/month and NPR 12,000/month[13] respectively, the total salary expense is PKR 462,000 ((PKR 65,000/month x 0.5 MM + 0.5 MM) x 12 months) per year.

The parts or components of the grid-connected PV system that are required for replacement in short-term are not included. Therefore, replacement costs are not calculated by piling the

[10] Based on CSR 2009 issued by NHA (National Highway Authority), Pakistan
[11] Based on CSR 2009 issued by NHA, Pakistan
[12] Based on CSR 2009 issued by NHA, MRS 4Q 2009 issued by Punjab Govt. and Estimation by JICA Study Team
[13] The calculation is based on cost hearing from local contractors through the Pakistan Institute of Cost & Contracts (PICC) and PEC.

components or parts cost. Instead, the O/M and administrative management expenses are assumed to be covered by the saved amount from the electric bills of PC and PEC. Hence, it is the amount of payment being possibly reduced by generated power from the installed grid-connected PV system and reverse power sales to IESCO. If it is not necessary to procure any equipment or parts, the savings can be allotted for replacement of components in the future, and as reserved fund for emergency breakdown of equipment or parts.

## 2-6 Other Relevant Issues

The PV module structure is installed at a height of above 3 m. Therefore, a stable scaffolding and working platform is necessary to prevent workers from falling and dropping objects during installation. At present, people can freely enter the planned installation site of PEC. Therefore, access control and 24 hour security are required during the construction period. Similarly, visitors can also access the PC site. Therefore, security management is necessary especially during office working days.

These matters should be described in the tender document.

# Chapter 3 Project Evaluation and Recommendations

## 3-1 Project Effect

### (1) Direct Impact

Power generation by the PV system will be 315 MWh/year.

| |
|---|
| = 5.24 kWh/$m^2$-day x 220 kWp x 365 days x 0.75 (System Efficiency)<br>(5.0 kWh/$m^2$-day: Average Solar Insolation at the Site (NASA data))<br>(http://eosweb.larc.nasa.gov/cgi-bin/sse/) |

1) Reduction of Electricity Cost

The yearly power consumption of PC and PEC is 980 MWh from November 2008 to October 2009. The 315 MWh to be generated by the PV system is around 32% of this power consumption. The estimated electricity cost reduced by the PV system is PKR1.77 million (Approximately JPY2.28 million/year = 315,000 KWh x PKR5.62/kWh).

2) Reduction of $CO_2$ Emission

In case the default value of 0.486 t-$CO_2$/MWh in Pakistan is applied, the amount of the reduction of $CO_2$ emission by the accumulated power generated from the PV system during the year becomes 153 t-$CO_2$/year ( = 315 MWh/year x 0.486 t-$CO_2$/MWh).

3) Demonstration Impact

PC is the conference venue for all sectors of the Central Development Working Party (CDWP). Therefore, representatives from ministries/agencies visit PC every month. Many domestic and international visitors also visit PC since meetings/conferences attended by the President and Prime Minister are also held at the PC. Hence, it is difficult to quantify those who visit the PC.

More than 160,000 engineers, engineering firms and other related firms are registered at the PEC. There are 10,000 new/renewed registrations at the PEC. There are 20,000 or more visitors to the PEC to receive technical or any other information. Registration is required even for a foreign firm if it runs a project in Pakistan.

An information board shall be installed to show the effect of this project to domestic/international visitors.

### (2) Indirect Impact

1) Promotion of Renewable Energy

This project is the first case of grid-connected PV system in Pakistan. Therefore, familiarization and promotion of power generation through renewable energy and power trade with power grid are expected.

Since PEC will become the implementation agency of the Prime Minister's Initiative for Solar Power (PMISP), which is a project to install PV systems in Pakistan, the experience of installation/operation and management that will be gained by the PEC in this project will be useful and effective for the implementation of the PMISP.

Additionally, the soft component done as part of this project can serve as capacity development for engineers not only on the PV power generation side but also on the grid side since the component contains technology transfer of operation and maintenance of grid-connected PV system and troubleshooting.

2) Awareness

The chairperson of the PC is the prime minister. It is the place where the formulation and discussion of national plans, seminars and conferences with foreign officials are held. Therefore, dissemination of the effectives of renewable energy to high officials as decision makers in Pakistan and foreign countries is expected.

On the other hand, the PEC is the place for registration/renewal of licenses by related firms and engineers, scheduled meetings and seminars. Thus, it has many persons/engineers involved in the power sector as visitors. It can be expected that these firms/engineers will understand the grid-connected PV system. The PEC site is also located beside a public road with traffic and pedestrian. Therefore, public awareness on the PV system can also be expected.

Through the soft component implemented as part of this project, the role of the PV system and countermeasures against global warming will be well recognized. Also, the thinking of the people regarding effective energy use will be improved.

## 3-2 Recommendation

This project is the first case of grid-connected PV system in Pakistan. Therefore, there are lots of problems to be solved. The following are the major problems and corresponding recommendations:

**Problems**

- There is no current technical standard for grid-connected PV system.
- There is no available technician for grid-connected PV system.
- There is no existing scheme to promote renewable energy.

**Recommendation**

- It is necessary to establish technical standard for grid-connected PV system.
- It is necessary to develop training manuals for engineers.
- It is necessary to organize environmental scheme and organization for promoting activities using the installed facilities.