ShamsPower

July 17th, 2017

The Registrar

National Electric Power Regulatory Authority

Subject: **Application for Modification of Generation License (License No: SPGL/18/2017)**

I, Usman Hamid Malik, Chief Executive Officer, being the duly authorized representative of Shams Power (Private) Limited by virtue of Board Resolution dated 3rd April 2017, hereby apply to the National Electric Power Regulatory Authority for the modification of Generation License (License No: **SPGL/18/2017** Licensee: **Shams Power (Private) Limited**) pursuant to section 10 of the National Electric Power Regulatory Authority Licensing (Application and Modification Procedure) Regulations, 1999.

I certify that the documents-in-support attached with this application are prepared and submitted in conformity with the provisions of the National Electric Power Regulatory Authority Licensing (Application and Modification Procedure) Regulations, 1999, and undertake to abide by the terms and provisions of the above-said regulations. I further undertake and confirm that the information provided in the attached documents-in-support is true and correct to the best of my knowledge and belief.

A Bank Draft in the sum of Rupees One Hundred and Fifty Thousand only (Rs 150,000), being the non- refundable license application fee calculated in accordance with Schedule II to the National Electric Power Regulatory Authority Licensing (Application and Modification Procedure) Regulations, 1999, is also attached herewith.

Date: ____________________

Signature

Shams Power (Private) Limited 19-Davis Road Lahore

Usman Hamid Malik

Chief Executive Officer

Shams Power (Private) Limited
2nd Floor, Al Maalik, 19 Davis Road, Lahore, Pakistan
Phone +92 42 36313235 & 36
Fax +92 42 36312959

SHAMS POWER (PRIVATE) LIMITED (SPPL)

Application for the Modification of Generation License,

License No SPGL/18/2017

By Usman Hamid Malik

Chief Executive Officer, SPPL

SECTION 1:

GENERATION LICENSE MODIFICATION APPLICATION

Index

ShamsPower

<u>TRUE COPY OF THE RESOLUTION OF BOARD OF DIRECTORS SHAMSPOWER (PRIVATE) LIMITED</u>

Board of Directors of Shams Power Private Limited, by the resolution in circulation dated <u>3rd of April 2017</u>, has passed to resolve as under:

"**Resolved,** *that the Company shall proceed with all acts necessary to comply with the legal and Regulatory requirements in relation to its business objectives and activities, inter alia, of the sale of electricity through the Generation Facilities to be provided by the Company at site(s) of Buyer(s).*

Further Resolved, *that in order to modify the Generation License number SPGL/18/2017 issued by National Electric Power Regulatory Authority* ***(NEPRA)*** *on 9th of January 2017, the Chief Executive Officer of the Company* ***(Usman H. Malik)*** *shall be authorized to submit the application for modification and / or to seek or submit any details, documents, evidence, clarification, or request as well as to represent the Company for the purposes of soliciting the Modification of the aforementioned Generation License for the following 10 sites, either before NEPRA or any other appropriate forum and to do all or any other act that a man of ordinary prudence will do for the purposes mentioned above, including appearance before any department or forum or body, whether judicial or quasi-judicial, and to obtain the permission or no objection certificate where and when required.*

1. *METRO Cash and Carry, Islamabad*
2. *METRO Cash and Carry, Thokkar Niaz Baig, Lahore*
3. *METRO Cash and Carry, Airport Road, DHA, Lahore*
4. *METRO Cash and Carry , Ravi Road, Lahore*
5. *METRO Cash and Carry, Model Town, Lahore*
6. *METRO Cash and Carry, Sargodha Road, Faisalabad*
7. *METRO Cash and Carry, Manghopir Road, Karachi*
8. *METRO Cash and Carry, Near Stargate, Karachi*
9. *METRO Cash and Carry, Near Safari Park, Karachi*
10. *AkzoNobel, Head Office, Lahore*

It is also resolved *that Usman H. Malik, the Chief Executive Officer named above, may further delegate the powers so vested in him, in writing to one or more persons to the extent of the purposes as shall be mentioned in the deed of delegation.*

Moreover, it is resolved *that Usman H. Malik, the Chief Executive Officer named above, is authorized and empowered for and on behalf of the Company to sign, execute and file the Petition for the modification of Generation License to NEPRA/other appropriate forum along with the documents essential to be filed.*

Company Secretary
Certified to be a true copy

Stamp of the Company

ShamsPower

CERTIFICATION

I hereby certify that the above resolution was duly passed on 03 April 2017 in circulation by the Board of Directors of Shams Power (Private) Limited comprising of:

1. Usman H. Malik
2. Omar M. Malik
3. Zainul Abideen
4. Faisal Islam

I also certify that the Resolution has been entered in the minute's book of the company in accordance with the Articles of Association of the company.

SHAMS POWER (PRIVATE) LIMITED

Stamp of the Company

Company Secretary

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S141652

100
Rupees

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روپیہ

OATH COMMISSIONER
LAHORE

<u>BEFORE THE NATIONAL ELECTRIC POWER REGULATORY AUTHORITY</u>

<u>AFFIDAVIT</u>

I, Usman Hamid Malik S/O Dr. Saleem Hamid Malik, Chief Executive Officer of Shams Power (Private) Limited, Al-Maalik, 2nd Floor, Davis Road, Lahore, the duly authorized representative of the Applicant Company depose on oath that the contents of the accompanying Application for Modification of Generation License (License No: SPGL/18/2017) and the supporting documents thereto are true and correct to the best of my knowledge and belief.

Deponent

Verification

The Affidavit is verified on this 17th day of July, 2017 at Lahore that the contents of the Affidavit are true and correct to the best of my knowledge and belief and that nothing, material and relevant, has been kept concealed by design.

Deponent

ATTESTED
M. ABID ADVOCATE
OATH COMMISSIONER
LAHORE

نذیر [illegible] اشٹام فروش [illegible] روڈ لاہور
لائسنس نمبر 1214

تاریخ 17 نمبر 6890 [illegible]

نام [illegible]

بذریعہ [illegible] برائے [illegible]

دستخط اشٹام فروش

ShamsPower

Modification Purpose & Relevant Details

Subject: ***Application for Modification of Generation License (License No: SPGL/18/2017)***

1.0 Background:

1.1 Shams Power Private Limited (**SPPL**) was incorporated on January 15, 2015 under Section-32 of the companies' ordinance, 1984, with corporate universal identification No. 0091515. The business office of the company is at 2nd Floor, AL-Maalik building, 19-Davis Road Lahore.

1.2 It is a joint venture of three of Pakistan's leading energy companies (Saba Power Limited, PITCO Private Limited and Orient Operating Company Limited), involved in setting up power projects in Pakistan since 1996.

1.3 Shams Power aims to pioneer solving the Pakistan's energy problems by accelerating the adoption of distributed solar energy. Our team is committed to excellence in every aspect of solar design, construction, and operations and maintenance.

1.4 Shams Power offers a complete range of solar energy services to commercial and industrial sector customers across the Pakistan. Backed by more than 20 years of industry experience and a dedicated technical team, SPPL handle every aspect of solar power installations—including financing, technology evaluation, engineering and design, construction, monitoring, and ongoing maintenance and support—to ensure the most efficient and reliable solution.

2.0 Proposed Modification

2.1 In response to the Application for grant of Generation License (vide **Letter No. RC/GP/S.01** dated 9th of July 2015) Sham Power Private Limited was conferred with a Generation License (**License No: SPGL/18/2017**, dated 09 January 2017) by the Authority (**NEPRA**) for 0.07956 MW Solar Generation Facility located on the roof-top of Al-Maalik Building, 19 Davis Road, Lahore. SPPL is operating and maintaining the above mentioned facility since January 2017 and has kept the performance of the Power Plant very high (details provided later in this document).

2.2 After successful commissioning and efficient operation of its model Solar Power Plant at Al-Maalik building, SPPL has been busy in preparing feasibility studies and proposals for its various potential clients. Due to SPPL's profound technical expertise, a very reasonable financial model and a state of art model Power Plant (roof top Al-Maalik Building) it has been able to secure Memorandum of Understanding Agreements with two of Pakistan's leading companies. SPPL has signed one Memorandum of Understanding (MOUs) with Metro-Habib group for their 9 sites throughout Pakistan and another MOU with AkzoNobel Pakistan for their Head Office at Ferozepur Road, Lahore.

2.3 In accordance with National Electric Power Regulatory Authority Licensing (Application & Modification Procedure) Regulations, 1999, Shams Power Private Limited (SPPL) intends

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to modify its existing generation license of **0.07956 MW** and enhance it to **3.5571 MW** in order to commission its 10 new Solar Power Plants, and in order to enter into Power Purchase Agreements with its customers. It will enable SPPL to fulfil its commitment of providing reliable clean energy solution to its above mentioned clients.

2.4 A brief summary of technical details of each site is as follows:

2.4.1 METRO Cash and Carry, Islamabad

SPPL has proposed and designed 300 KWp AC (356.40 KWp DC) Solar Power Plant to be installed at roof top of Metro Cash and Carry Store I-11/4, Islamabad. A total of 1080 Canadian Solar Polycrystalline PV Modules (CS6U-330P), of 330 Watt each, will be connected to 12 SMA Sunny Tri power 25000TL inverters (each inverter having Power rating of 25 KW) to attain the above mentioned DC and AC peak capacity. The plant is estimated to produce around 428361 KWh of Energy (in its first year of operation) which translates to Net Capacity Factor of 16.30% and will result in offsetting approximately 149 tons of carbon dioxide annually.

2.4.2 METRO Cash and Carry, Thokkar Niaz Baig, Lahore

SPPL has proposed and designed 350 KWp AC (388.08 KWp DC) Solar Power Plant to be installed at roof top of Metro Cash and Carry Store, Thokkar Niaz Baig, Lahore. A total of 1176 Canadian Solar Polycrystalline PV Modules (CS6U-330P), of 330 Watt each, will be connected to 14 SMA Sunny Tri power 25000TL inverters (each inverter having Power rating of 25 KW) to attain the above mentioned DC and AC peak capacity. The plant is estimated to produce around 474170 KWh of Energy (in its first year of operation) which translates to Net Capacity Factor of 15.46% and will result in offsetting approximately 166 tons of carbon dioxide annually.

2.4.3 METRO Cash and Carry, Airport Road, DHA Lahore

SPPL has proposed and designed 300 KWp AC (356.40 KWp DC) Solar Power Plant to be installed at roof top of Metro Cash and Carry Store, Airport Road, DHA Lahore. A total of 1080 Canadian Solar Polycrystalline PV Modules (CS6U-330P), of 330 Watt each, will be connected to 12 SMA Sunny Tri power 25000TL inverters (each inverter having Power rating of 25 KW) to attain the above mentioned DC and AC peak capacity. The plant is estimated to produce around 423195 KWh of Energy (in its first year of operation) which translates to Net Capacity Factor of 16.10% and will result in offsetting approximately 147 tons of carbon dioxide annually.

2.4.4 METRO Cash and Carry, Ravi Road, Lahore

SPPL has proposed and designed 300 KWp AC (332.64 KWp DC) Solar Power Plant to be installed at roof top of Metro Cash and Carry Store, Ravi Road, Lahore. A total of 1008 Canadian Solar Polycrystalline PV Modules (CS6U-330P), of 330 Watt each, will be connected to 12 SMA Sunny Tri power 25000TL inverters (each inverter having Power rating of 25 KW) to attain the above mentioned DC and AC peak capacity. The plant is estimated to produce around 399522 KWh of Energy (in its first year of

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operation) which translates to Net Capacity Factor of 15.20% and will result in offsetting approximately 140 tons of carbon dioxide annually.

2.4.5 METRO Cash and Carry, Model Town, Lahore

SPPL has proposed and designed 225 KWp AC (249.48 KWp DC) Solar Power Plant to be installed at roof top of Metro Cash and Carry Store, Model Town, Lahore. A total of 756 Canadian Solar Polycrystalline PV Modules (CS6U-330P), of 330 Watt each, will be connected to 9 SMA Sunny Tri power 25000TL inverters (each inverter having Power rating of 25 KW) to attain the above mentioned DC and AC peak capacity. The plant is estimated to produce around 309084 KWh of Energy (in its first year of operation) which translates to Net Capacity Factor of 15.68% and will result in offsetting approximately 111 tons of carbon dioxide annually.

2.4.6 METRO Cash and Carry, Sargodha Road, Faisalabad

SPPL has proposed and designed 250 KWp AC (297.00 KWp DC) Solar Power Plant to be installed at roof top of Metro Cash and Carry, Sargodha Road, Faisalabad. A total of 900 Canadian Solar Polycrystalline PV Modules (CS6U-330P), of 330 Watt each, will be connected to 10 SMA Sunny Tri power 25000TL inverters (each inverter having Power rating of 25 KW) to attain the above mentioned DC and AC peak capacity. The plant is estimated to produce around 348433 KWh of Energy (in its first year of operation) which translates to Net Capacity Factor of 15.91% and will result in offsetting approximately 121 tons of carbon dioxide annually.

2.4.7 METRO Cash and Carry, Manghopir Road, Karachi

SPPL has proposed and designed 200 KWp AC (237.60 KWp DC) Solar Power Plant to be installed at roof top of Metro Cash and Carry Store, Manghopir Road, Karachi. A total of 720 Canadian Solar Polycrystalline PV Modules (CS6U-330P), of 330 Watt each, will be connected to 8 SMA Sunny Tri power 25000TL inverters (each inverter having Power rating of 25 KW) to attain the above mentioned DC and AC peak capacity. The plant is estimated to produce around 315797 KWh of Energy (in its first year of operation) which translates to Net Capacity Factor of 18.02% and will result in offsetting approximately 112 tons of carbon dioxide annually.

2.4.8 METRO Cash and Carry, Stargate, Karachi

SPPL has proposed and designed 300 KWp AC (356.40 KWp DC) Solar Power Plant to be installed at roof top of Metro Cash and Carry Store, Stargate, Karachi. A total of 1080 Canadian Solar Polycrystalline PV Modules (CS6U-330P), of 330 Watt each, will be connected to 12 SMA Sunny Tri power 25000TL inverters (each inverter having Power rating of 25 KW) to attain the above mentioned DC and AC peak capacity. The plant is estimated to produce around 478607 KWh of Energy (in its first year of operation) which translates to Net Capacity Factor of 18.21% and will result in offsetting approximately 170 tons of carbon dioxide annually.

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2.4.9 METRO Cash and Carry, Safari Park, Karachi

SPPL has proposed and designed 375 KWp AC (445.50 KWp DC) Solar Power Plant to be installed at roof top of Metro Cash and Carry Store, Safari Park, Karachi. A total of 1350 Canadian Solar Polycrystalline PV Modules (CS6U-330P), of 330 Watt each, will be connected to 15 SMA Sunny Tri power 25000TL inverters (each inverter having Power rating of 25 KW) to attain the above mentioned DC and AC peak capacity. The plant is estimated to produce around 593365 KWh of Energy (in its first year of operation) which translates to Net Capacity Factor of 18.10% and will result in offsetting approximately 210 tons of carbon dioxide annually.

2.4.10 AkzoNobel, Head Office, Lahore

SPPL has proposed and designed 400 KWp AC (458.04 KWp DC) Solar Power Plant to be installed at the premises of AkzoNobel's Head Office. A total of 1,388 Canadian Solar Polycrystalline PV Modules (CS6U-330P), of 330 Watt each, will be connected to 16 SMA Sunny Tri power 25000TL inverters (each inverter having Power rating of 25 KW) to attain the above mentioned DC and AC peak capacity. The plant is estimated to produce around 559040 KWh of Energy (in its first year of operation) which translates to Net Capacity Factor of 15.95% and will result in offsetting approximately 190 tons of carbon dioxide annually.

3 Reasons In Support of Modification of Generation License

3.1 As mentioned earlier in this document, Shams Power Private Limited is a Clean Energy Solution Provider which provides turnkey solutions to its customers, and takes care of CAPEX & OPEX (for time period agreed in PPA) making it the most feasible financial model, for customers, to switch to cleaner energy without upfront capital investment. This business model has an inherent requirement of ever increasing generation capacity i.e. the total generation capacity of SPPL will increase with signing-off of each new PPA.

3.2 Keeping this issue in mind, SPPL had initially applied for 50 MW generation license to cater to this ever increasing generation capacity requirement. However, since at that time SPPL did not have MOUs to back its application, therefore it was declined by the Authority (NEPRA) and a Generation License was only granted for 0.07956 MW at the Al Maalik Building site.

3.3 SPPL is glad to report to the Authority (NEPRA) that it has been successful in signing two MOUs with Metro Habib Pakistan and AkzoNobel Pakistan respectively. According to these MOUs, SPPL will be installing 9 Solar power plants on 9 Metro Cash and Carry Stores in different cities of Pakistan totaling to 3.0195 MWp DC (2.600 MWp AC) and 1 Solar power plant in AkzoNobel's Head Quarter in Lahore, of capacity 0.45804 MWp DC (0.400 MWp AC). In order to accomplish this SPPL needs to modify its existing 0.07956 MW Generation License and upgrade its capacity to 3.5571 MW (i.e. 0.07956 MWp + 3.0195 MWp + 0.45804 MWp).

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4 Statement of Impact on the Tariff, Quality of Service and Performance.

4.1 Impact on the Tariff

SPPL has signed an MOU with Metro-Habib Pakistan and AkzoNobel Pakistan and under this memoranda both customers will be charged a mutually agreed tariff (agreed between SPPL and customer) throughout the agreement period. This is a B2B setup where each site has different energy requirements, building constraints and PV structure layout subsequently cost incurred for plant erection varies from site to site hence each site/customer has a unique tariff independent of other sites/customers. Therefore there will be no impact in the existing facility's tariff due to increase in Generation Capacity as well as it will not affect tariff of any DISCO.

4.2 Impact on Quality of Service and Performance

Shams Power had designed and installed a 0.07956 MW Solar Power Plant at rooftop of Al-Malik Building. The system was commissioned on 1st February 2017. SPPL has been taking care of operation and maintenance of this facility from the date of commissioning and has a dedicated staff for routine maintenance and troubleshooting of the PV plant, 24/7 available at site.

Furthermore, to avoid soiling losses as much as possible, SPPL had scheduled weekly cleaning of the PV modules, which it has followed strictly. All insulations, cable joints, fuses, SPDs, cable trays and PV modules are inspected monthly for any fault or break. Similarly inverters are serviced i.e. filters cleaned once every two months to keep the system trouble free and efficient.

Open circuit voltage and short circuit current of PV modules and arrays are tested quarterly to check their conformity with the manufacturer's provided specification sheet. Due to these rigorous measures the PV plant has been running flawlessly since it's commissioning and not even a single major break down has occurred during this time. It can be seen from the plant's generation data, provided below, that the plant has been operating in excellent condition.

PV Energy Production at Al-Malik Building	
Month	**Solar Power (KWh)**
February	2,667.87
March	3,476.31
April	5,629.55
May	6,815.38
June	6,612.06
July	2,438.36

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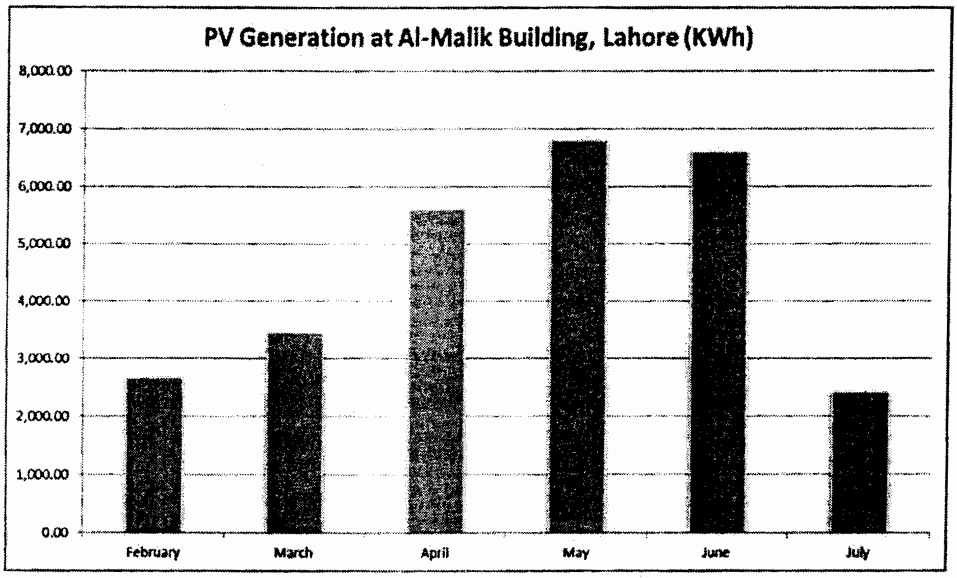

Impact of increase in generation capacity on performance of the existing facility can be analysed from two different perspectives.

i- To look at how this increase impacts the operational efficiency of new and existing systems.
ii- To scrutinize impact on SPPL's plant maintenance efficiency.

As discussed already, each plant is independent from others that mean efficiency of existing plant will not be affected in any way by increasing overall capacity. In the same way efficiencies of new facilities are only dependent on the equipment and plant design of that specific site irrespective of other plants/facilities.

Second issue at hand is to look at SPPL's efficiency to deal with increase in Generation Capacities under their portfolio. At present SPPL has only a single plant to maintain and operate and it has performed it with utmost professional efficiency. Signing of these new PPAs will add 10 additional generation facilities in different cities of Pakistan to be maintained and operated. To keep its performance efficiency to its current standard, SPPL has strategized to decentralise its maintenance resources, hence it has collaborated with both of its customers to use their storage facilities to keep the cleaning stock available at site. Similarly hiring and training of new maintenance personnel, from the local suburbs of the facility, is in progress which will result in 24/7 availability for plants O&M.

Apart from increase in resources SPPL has also planned to schedule a quarterly inspection by HQ team to keep the local personnel in check and maintain highest standard of quality for all its facilities.

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ShamsPower

5 Prayer

SPPL has performed an in-depth technical and financial analysis for above mentioned 10 proposed sites. Findings from these analyses suggest that the proposed sites are suitable for installation of PV based power plant.

PV plants at each site have been specifically designed to cater its power requirements and keeping in view technical & financial constraints pertaining to that site. Technical details of each site along with their feasibility reports have been attached as Section 2 and Section 3 (Schedule I and Schedule II) with this application.

As considerable amount of effort and attention to minute details have been put into PV plant designing and proposal preparation, SPPL is confident that, if it is allowed to construct these plants, it will be able to achieve the required results without any problem.

Therefore SPPL request the authority to modify the existing Generation License (License No: SPGL/18/2017) of 0.0795

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SECTION 2:

AMENDED & RESTATED SCHEDULE I

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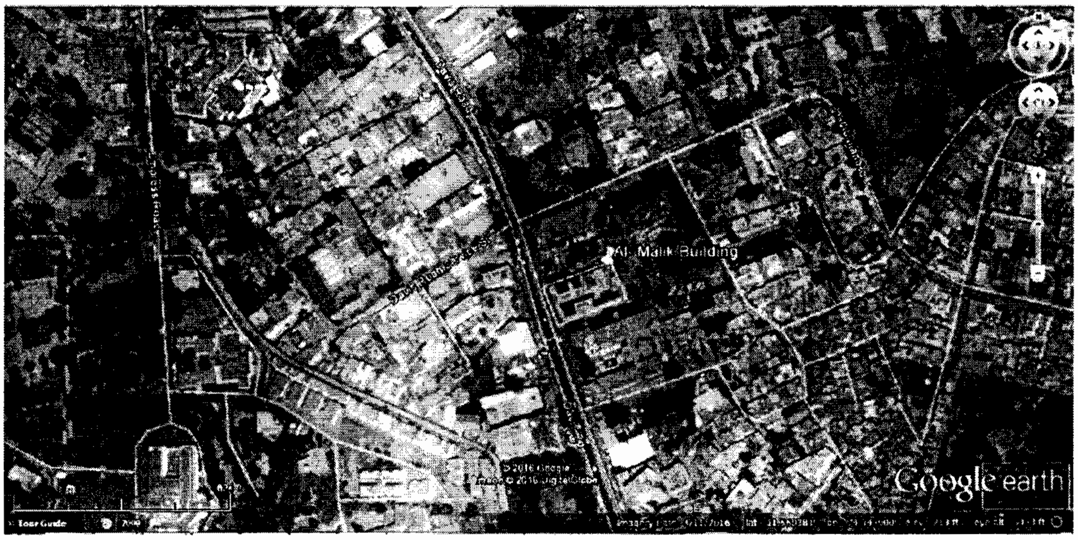
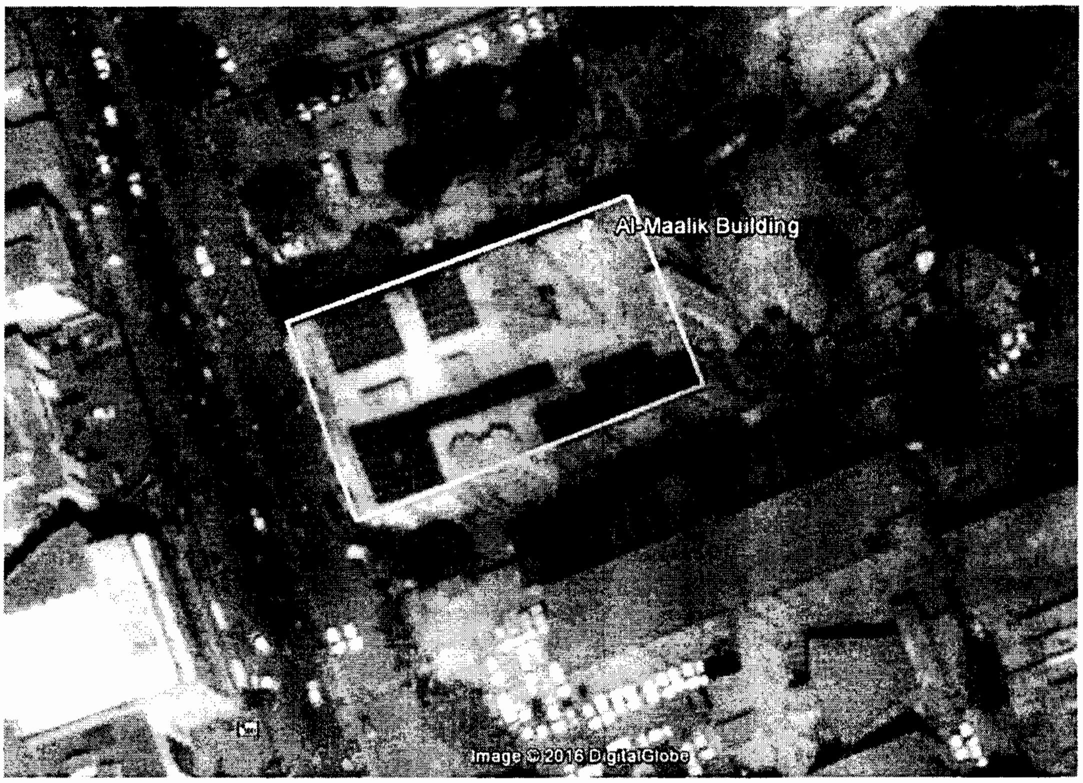
Restated SCHEDULE-I (for Existing Site)

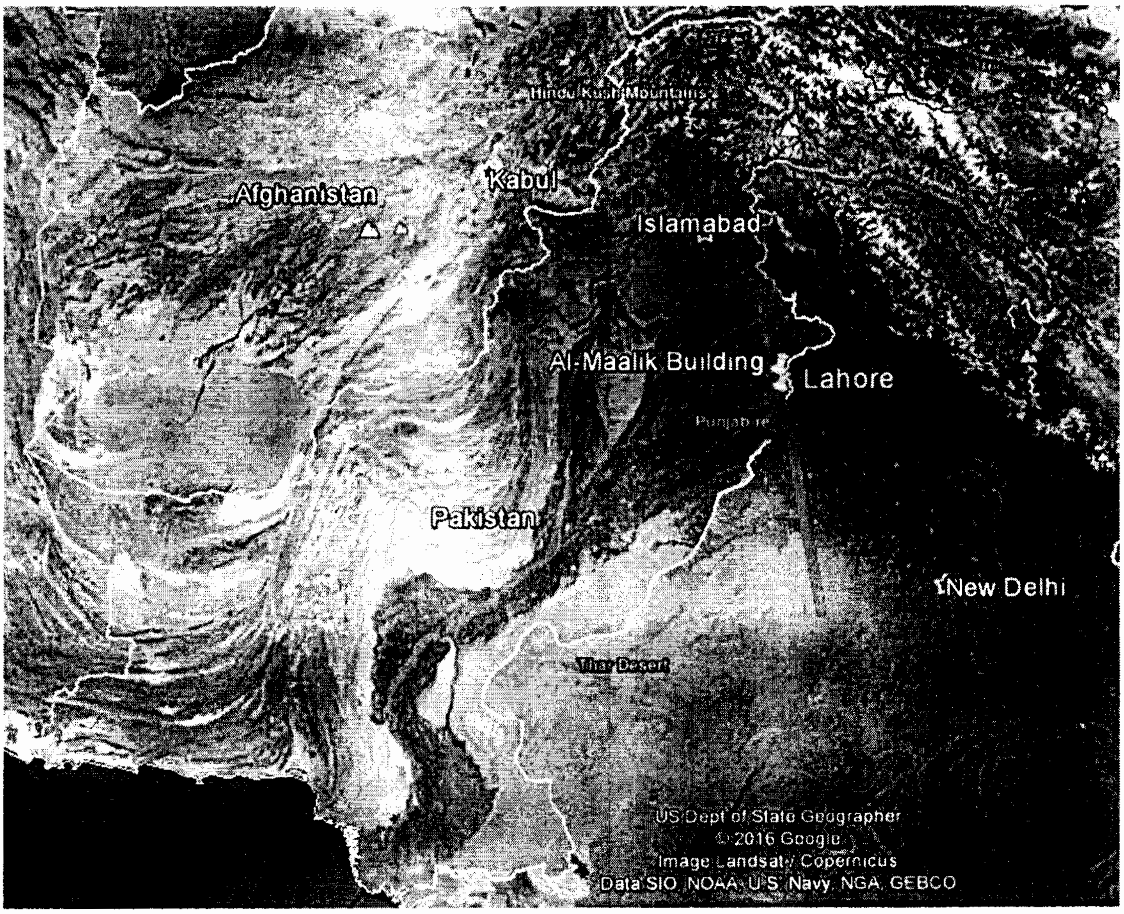
The Location, Size (i.e. Capacity in MW), Type of Technology, Interconnection Arrangements, Technical Limits, Technical/Functional Specifications and other details specific to the Generation Facilities of the Licensee are described in this Schedule.

Location of Existing Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL

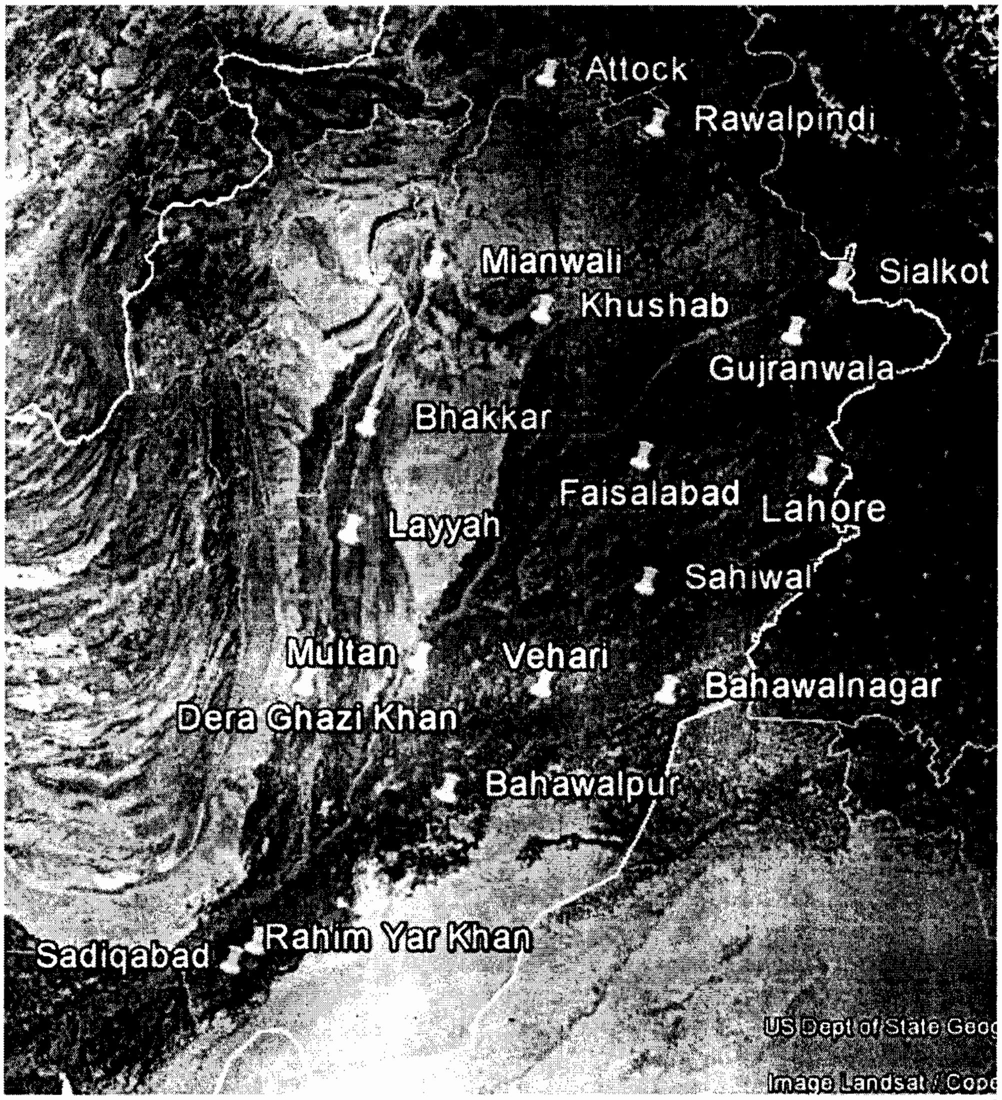




Location of Existing Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of Pakistan

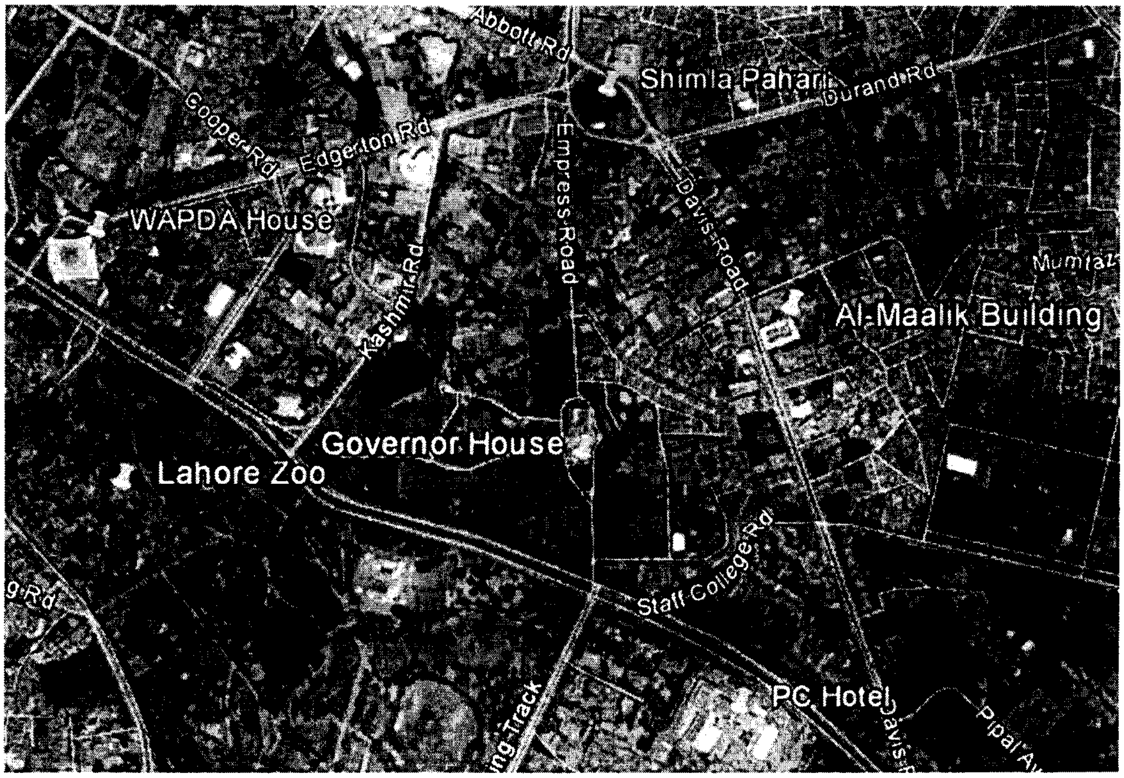


Location of Existing Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of the Province of Punjab

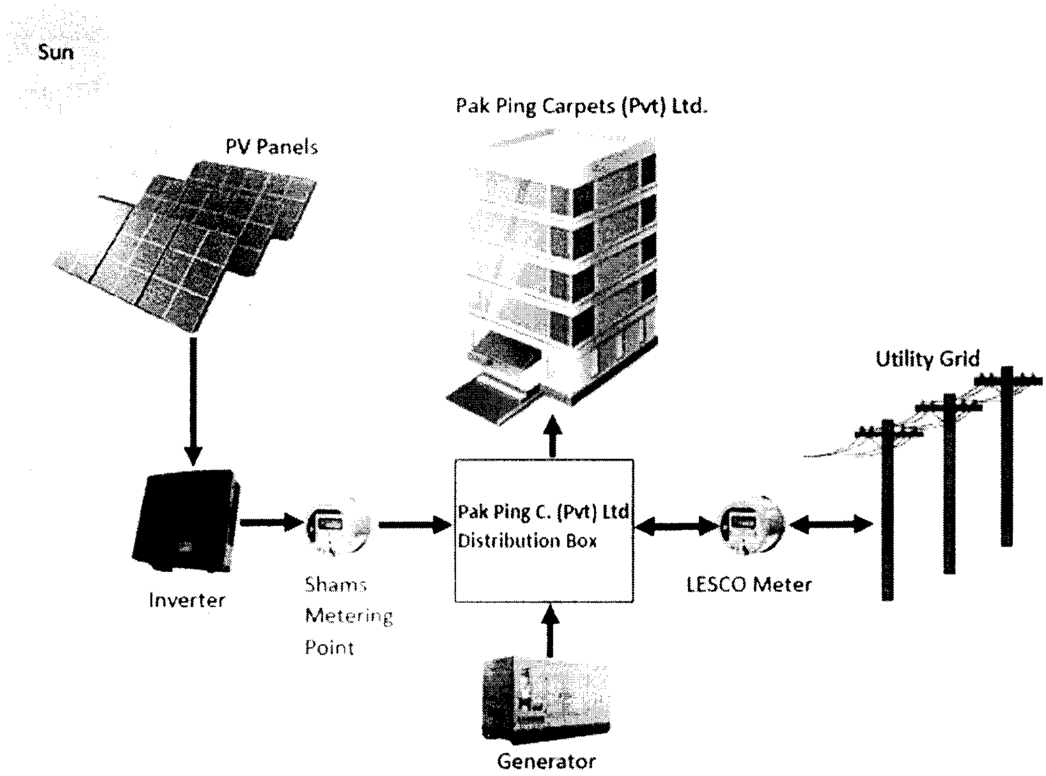


Location of Existing Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of Lahore

Access Road/Link of the Existing Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of Lahore



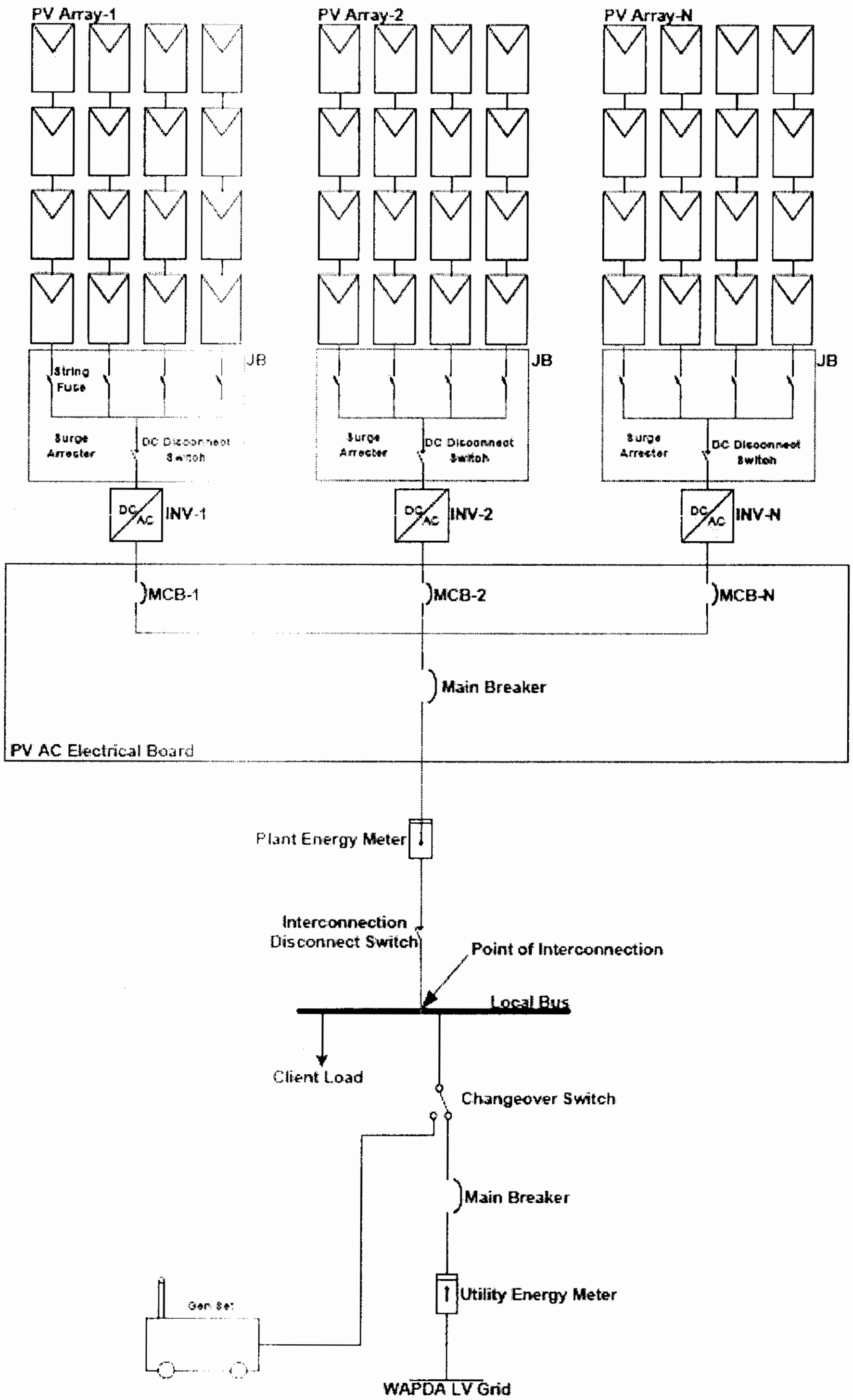
Process Flow Diagram of the Existing Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL



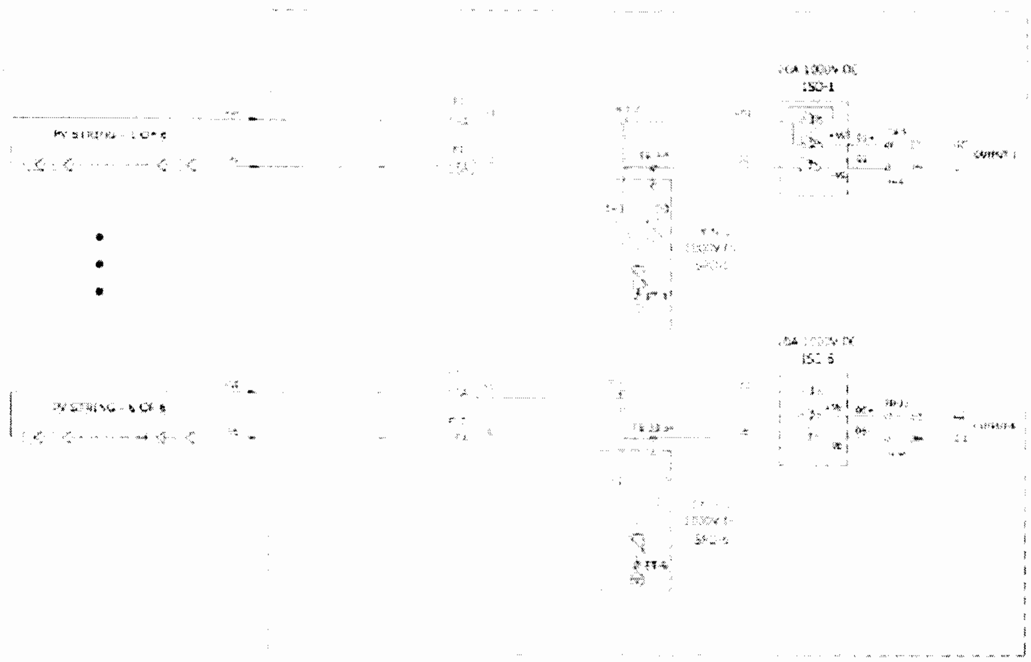
Location Coordinates of the Existing Generation Facility/Solar Farm/Power Plant of the Licensee/SPPL

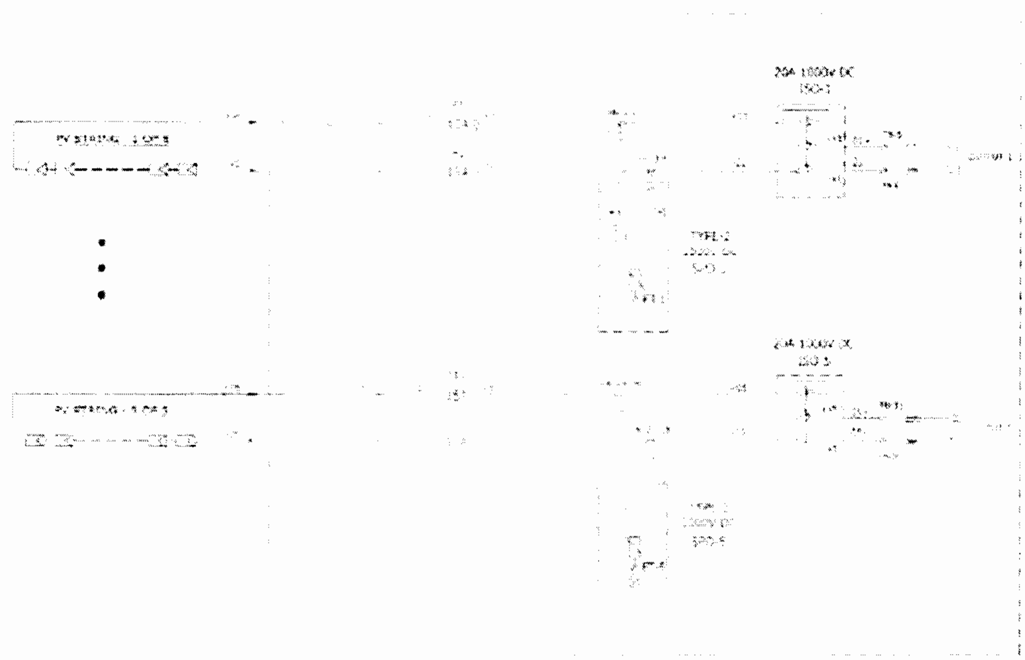
Latitude (North)	Longitude (East)
31° 33' 30.53"	74° 20' 57.99"

Block Diagram of the Existing Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL

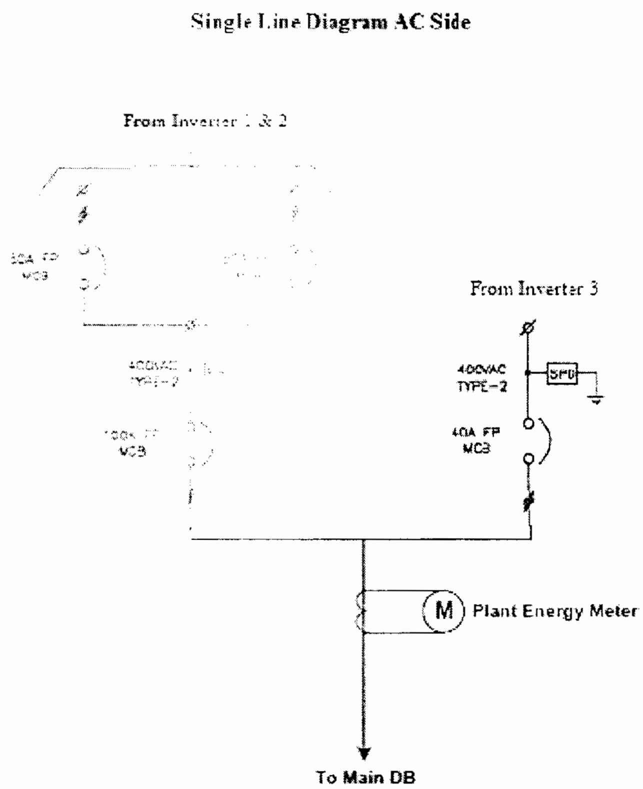


Single Line Diagram of the Existing Generation Facility/Solar Farm/Power Plant of the Licensee/SPPL (DC-Side)





Single Line Diagram of the Existing Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL (AC-Side)



Interconnection

Arrangement for Dispersal of Power from the Existing Generation Facility/Solar Power Plant of Shams Power (Private) Limited

The power generated from the Generation Facility/Power Plant of Shams Power (Private) Limited shall be dispersed at roof top of Al-Maalik Building, 19-Davis Road Lahore for in-house utilization.

(2). The proposed Interconnection Arrangement for dispersal of electric power for the Generation Facility/Solar Power Plant will be as under:-

(a). 230V/400V single circuit on bus bar of existing LT distribution panel of Pak Ping C (Private) Limited/consumer.

(3). Any change in the above Interconnection Arrangement duly agreed by Shams Power (Private) Limited and Pak Ping C (Private) Limited/consumer shall be communicated to the Authority in due course of time.

Detail of Existing

Generation Facility/Solar Power Plant

(A). General Information

(i).	Name of the Company/ Licensee	Shams Power (Private) Limited
(ii).	Registered/Business Office of the Company	2nd Floor, Al-Maalik Building 19-Davis Road Lahore
(iii).	Principal Office	2nd Floor, Al-Maalik Building 19-Davis Road Lahore
(iv).	Plants Location	Al-Maalik building roof top, 19-Davis Road Lahore
(v).	Field Type	Fixed Tilted Plane
(vi)	Field Parameters	Tilt 8° & Azimuth 32°
(vii).	Type of Generation Facility	Solar Photovoltaic (PV)

(B). Solar Power Generation Technology & Capacity

(i).	Type of Technology	Photovoltaic (PV) Cell
(ii).	Type of Cell	Polycrystalline
(ii).	Type of System	Grid Tied
(iii).	Installed Capacity of the Generation Facility (MW)	0.07956 MW_P DC or 0.070 MW inverter's output (AC)

(C). Technical Details of Equipment

(a).	**Solar Panels-PV Modules**		
(i).	Type of Module	Polycrystalline PV Type Module CS6P-260P	
(ii).	Surface Area of Module	1.605240 m^2	
(iii).	Dimension of each Module	1638 mm x 982 mm x 40mm	
(iv)	Total area of roof top for Solar Panels-PV Modules	5565 sq ft	
(v).	No. of Modules	306	
(vi).	Frame of Module	Anodised Aluminium Alloy	
(vii).	Weight of one Module	18.00 kg	
(viii).	Module output warranty	For 1st Year	For 2nd Year to 25th Year
		97.5% or above	Not more than 0.7% output reduction each year
(ix).	Number of Solar Cells in each Module	60 Cells	
(x).	Efficiency of Module	16.16 %	
(xi).	Environment Protection System	Encapsulation and sealing arrangements for protection from environment.	
(xii).	Maximum Power (P_{max})	260 W_P	
(xiii).	Power Tolerance at STC	0 ~ +5W	
(xiv).	Voltage @ (P_{max})	30.4 V	
(xv).	Current @ (P_{max})	8.56 A	
(xvi).	Open circuit voltage (V_{oc})	37.5 V	
(xvii).	Short circuit current (I_{sc})	9.12 A	

(xviii).	Optimum Operating Voltage at NOCT	27.7 V
(xix).	Optimum Operating Current at NOCT	6.80 A
(xx).	Open circuit voltage (Voc) at NOCT	34.5 V
(xxi).	Maximum system open Circuit Voltage	1000V(IEC) or 1000V (UL) or 600V(UL)
(b).	**PV Array**	
(i).	No. of Sub-Arrays	6
(ii).	Modules in a String	18
(iii).	Total No. of Strings	17
(iv).	Modules in Sub-Array	270 Modules (5 Sub Arrays of 54 Modules each) 36 Modules (1 Sub Array of 36 Modules)
(v).	Total Modules	306
(c).	**PV Capacity**	
(i).	Total Capacity	0.07956 MW_P DC or 0.070 MW inverter's output (AC)
(ii).	Net Capacity Factor	16.78%
(d).	**Inverters**	
(i)	Total area of inverter room	170 sqft
(ii).	Maximum DC Power Input	71.54 KW (@50°C)
(iii).	Inverter Model	01 x Sunny Tri power 20000TL (20 KW) 02 x Sunny Tri power 25000TL (25 KW)
(iv).	Manufacturer	SMA Solar Technology, Germany
(v).	Maximum DC Input Voltage	DC 1000 V
(vi).	Start Voltage	DC 150 V

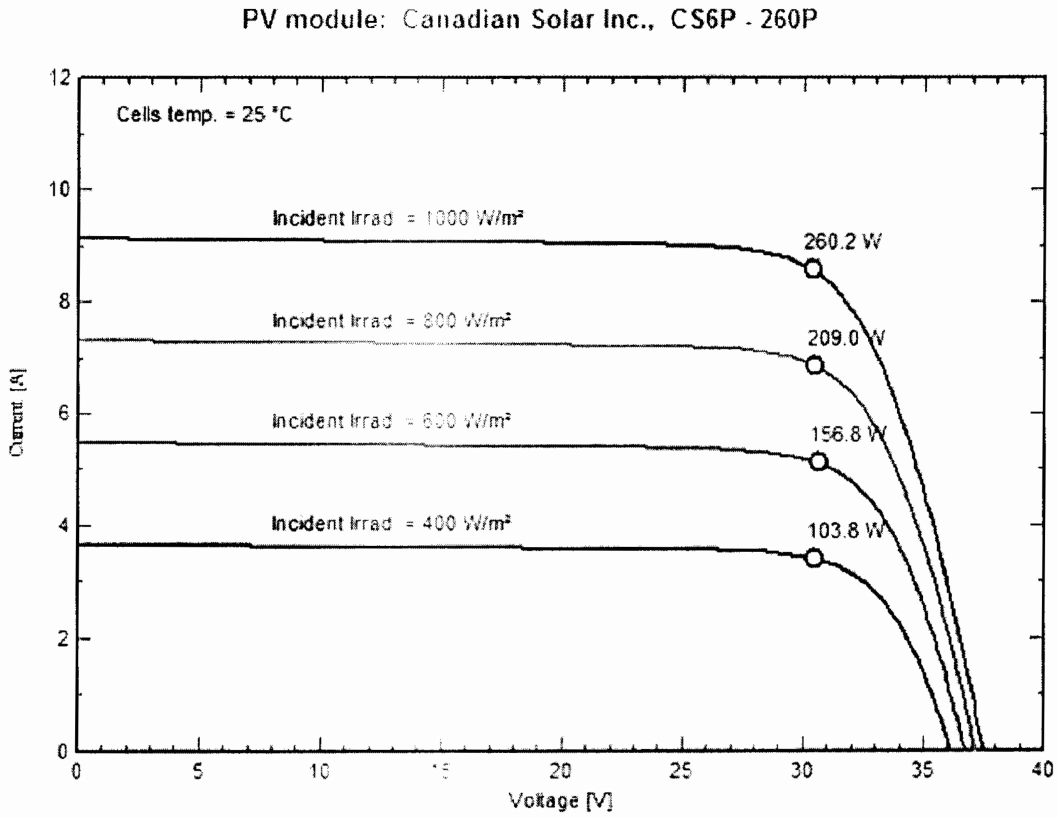
(vii).	Number of Inverters	3	
(viii).	Efficiency	98.4% (Sunny Tri power 20000TL) 98.3% (Sunny Tri power 25000TL	
(x).	Max. Input Current	DC 66 A	
(xi).	MPP Voltage Range	320 V- 800 V DC (@50°C)	
(xii).	Output electrical system	3-Phase, 4-Wire	
(xiii).	Rated Output Voltage	AC 230/400 V	
(xiv).	Rated Frequency	50 Hz	
(xv).	Power Factor	1	
(xvi).	Power Control	MPP Tracker	
(xvii).	Environmental Enclosures	Operating Temperature Range	-25° C to 60° C
		Relative Humidity	100% non-condensing
		Audible Noise	51 dB(A)
		Operating Elevation	<3000m
(e).	**Junction Boxes**		
(i).	Number of Junction Box units	6	
(ii).	Input circuits in each box	1 box with 2 inputs, 5 boxes with 3 inputs	
(iii).	Max. Input current for each circuit	15 A	
(iv).	Max. Input voltage	1000 V	
(v).	Power at each box	$28kW_p$	
(vi).	Protection Level	IP 65	
(vii).	Over-Current protection	Fuse	
(viii).	DC Disconnect switch	6	
(ix).	Surge protection	Yes (1000V)	

(x).	Purpose of Junction Box	(a).	Combining the strings
		(b).	DC Side Protection
(f).	**Data Collecting System**		
(i).	Weather Data	(a).	Irradiance Meter (Survey 100/200R)- 1 Set (to record ambient temp& radiation level)
(ii).	System Data	(a).	DC input voltage (V) & current (A) of each Inverter (Phase, Line)
		(b).	Total DC power (kW) generated by PV array.
		(c).	AC output voltage(V) and current (A) of each Inverter (Phase, Total)
		(d).	AC output power (kW) and energy (kWh) of each Inverter
		(e).	Frequency (Hz)
		(f).	Power Factor (PF)

(D). <u>Other Details</u>

(i).	COD of the Project	Mar 07, 2016
(ii).	Expected Life of the Project from the COD	25 Years

V-I Curve at STC of the Existing Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL

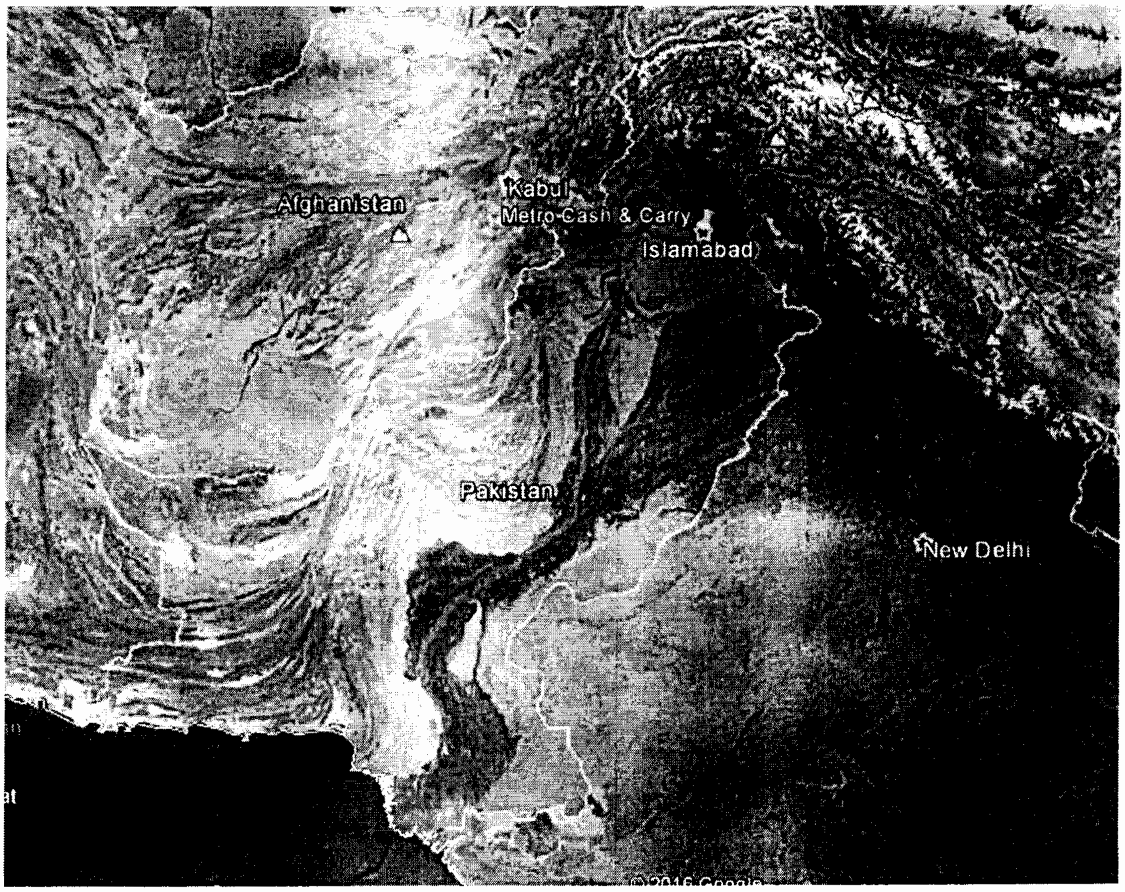


Amended SCHEDULE-I (for 10 New Sites)

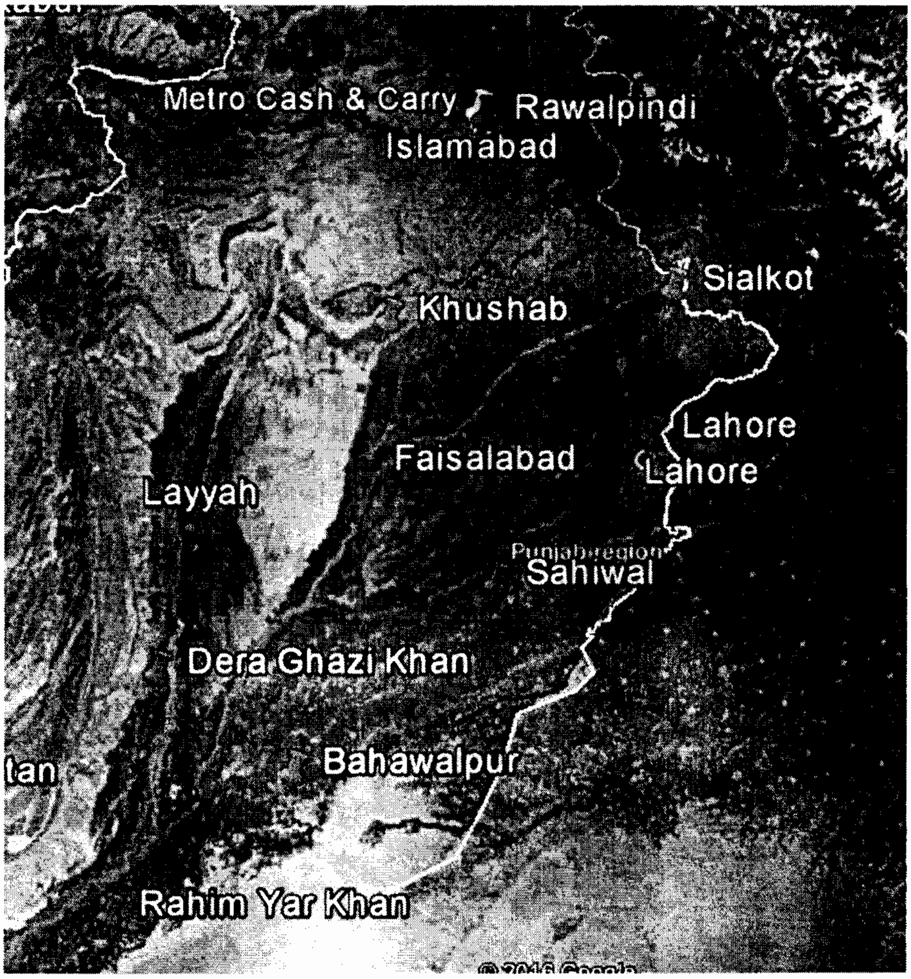
The Location, Size (i.e. Capacity in MW), Type of Technology, Interconnection Arrangements, Technical Limits, Technical/Functional Specifications and other details specific to the Generation Facilities of the Licensee are described in this Schedule.

1. METRO Cash & Carry, Islamabad

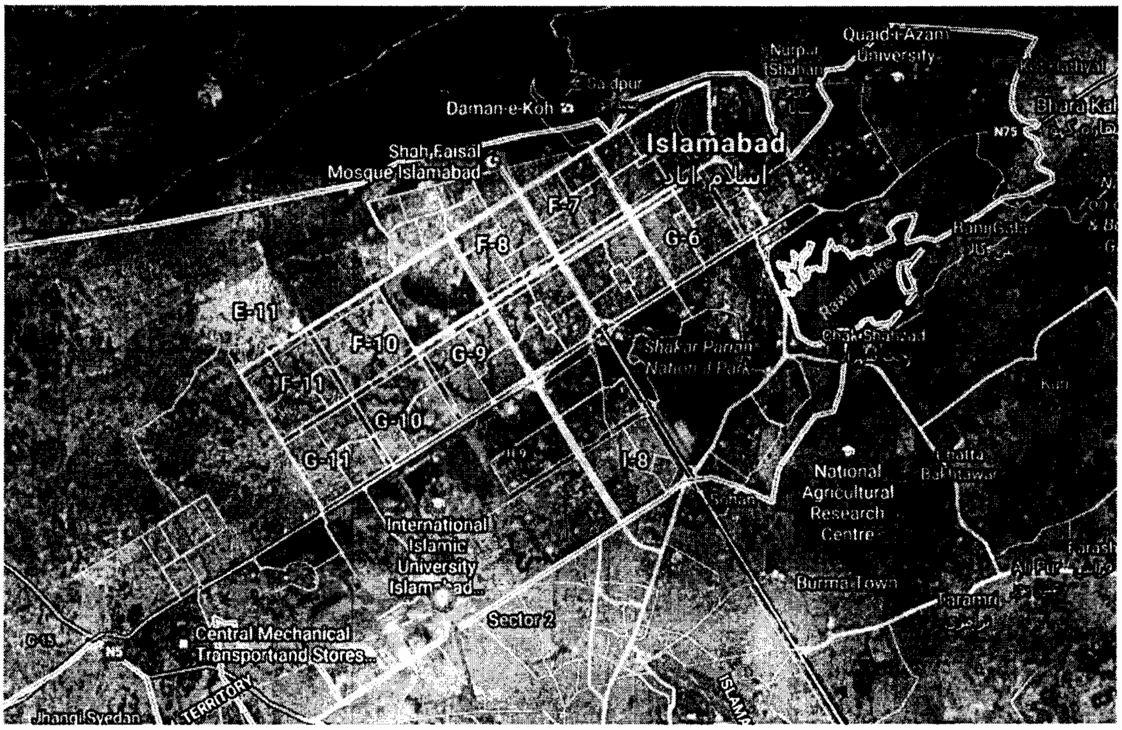
Location of the METRO, Islamabad Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of Pakistan



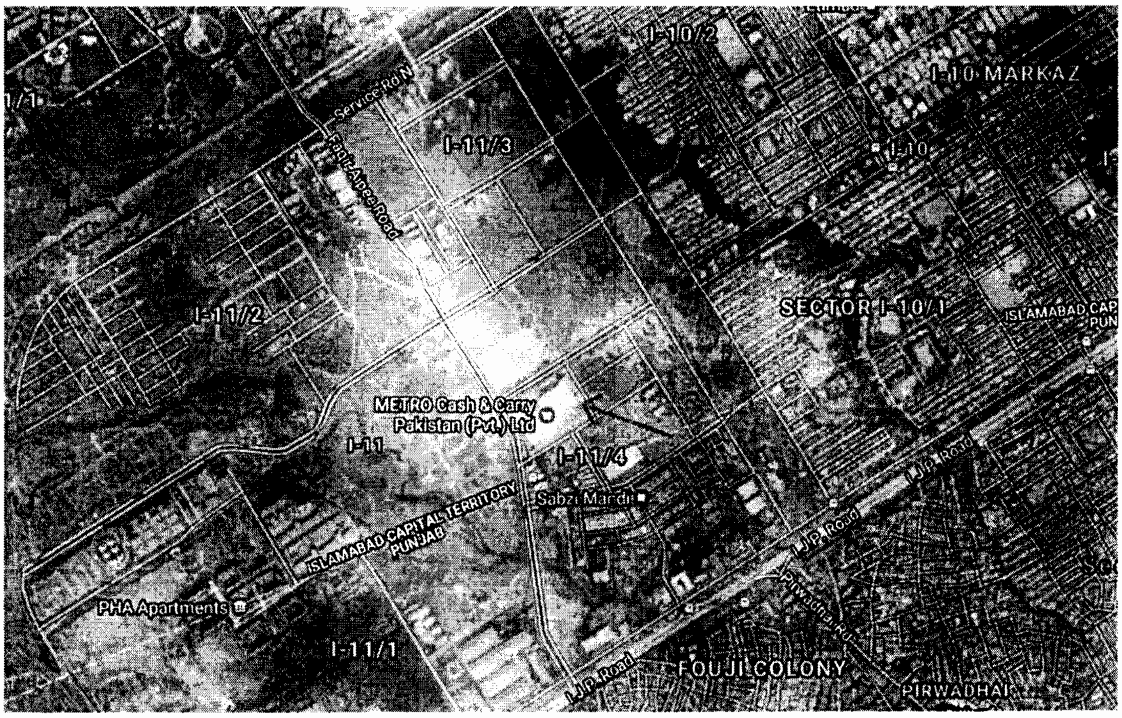
Location of the METRO, Islamabad Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of the Province of Punjab



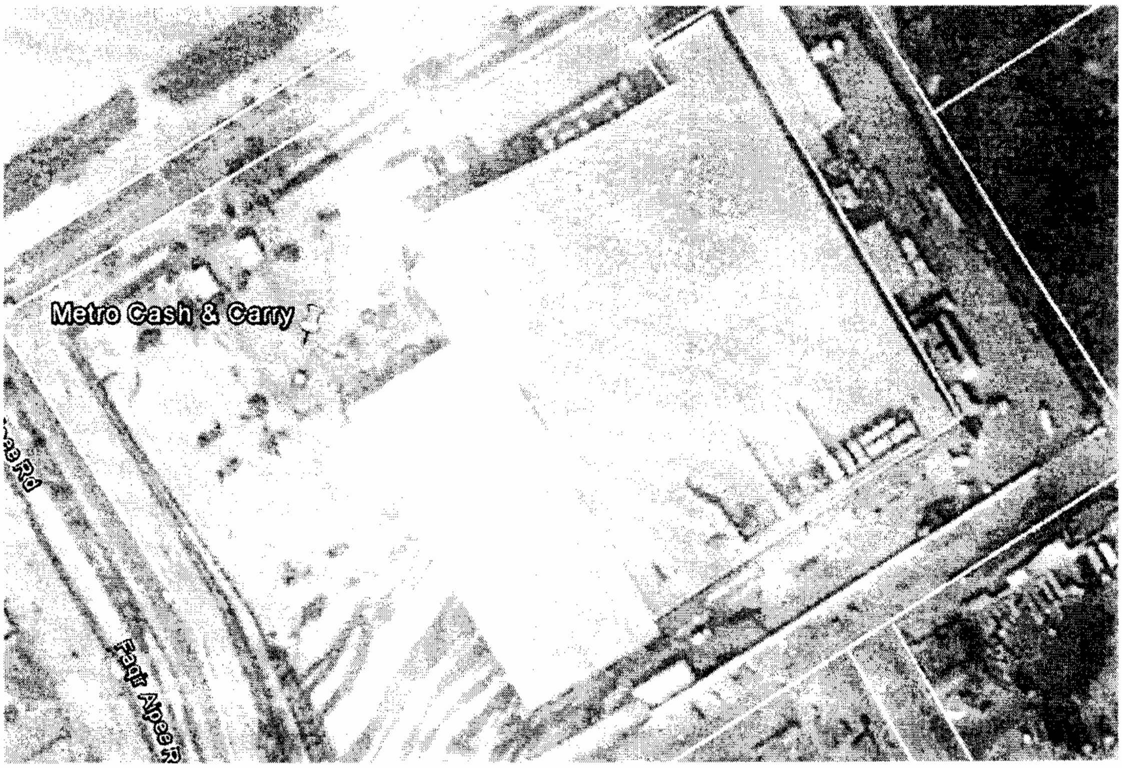
Location of the METRO, Islamabad Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of Islamabad



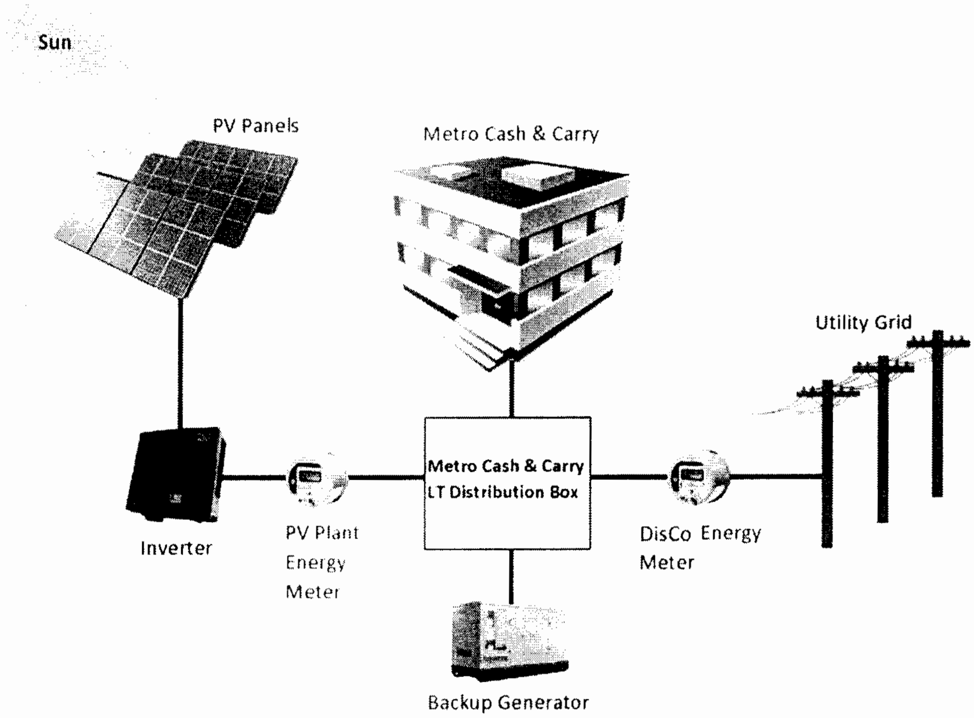
Access Road/Link of the METRO, Islamabad Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of Islamabad



Location of the METRO, Islamabad Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL



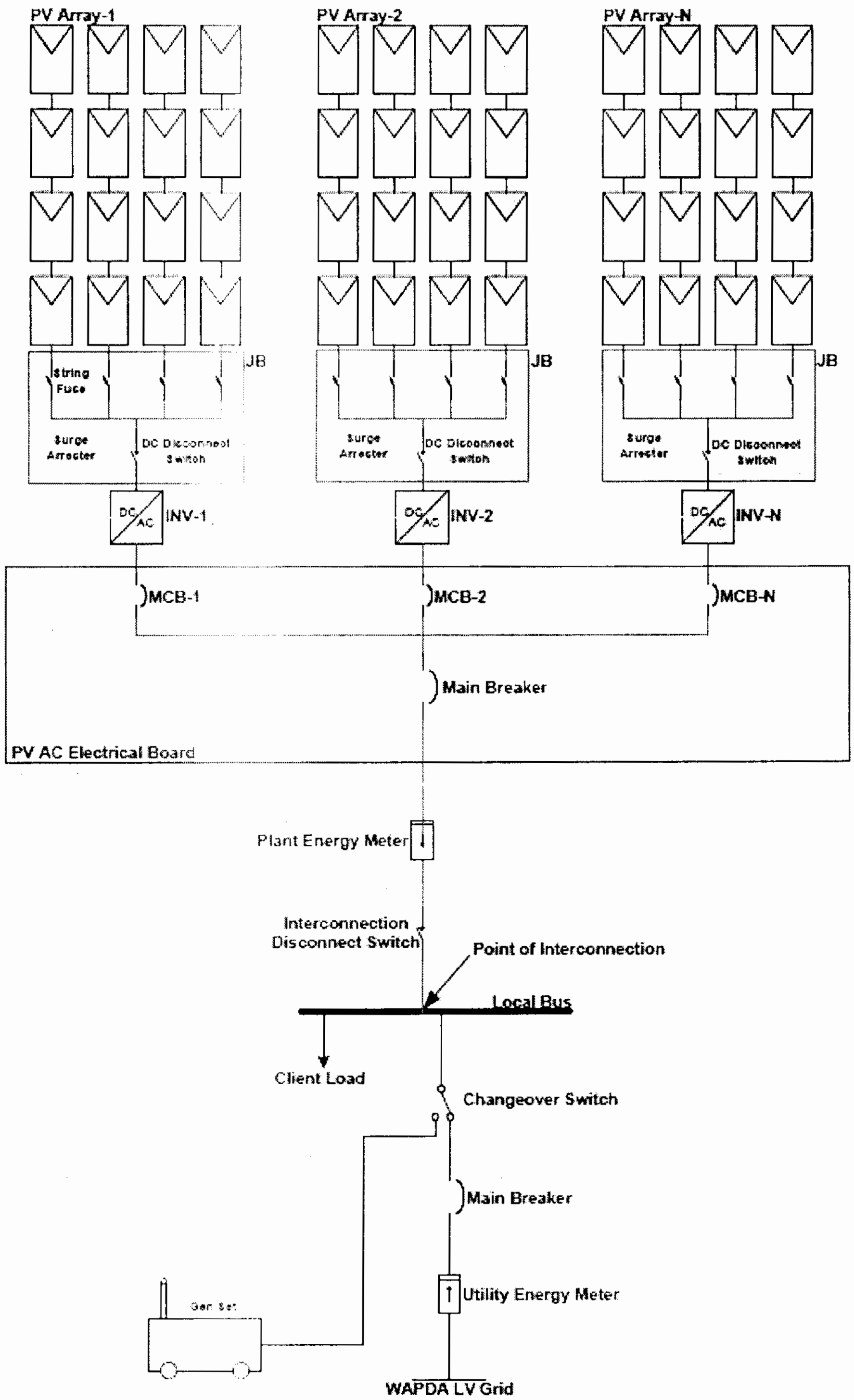
Process Flow Diagram of the Proposed Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL



Location Coordinates of the Generation Facility/Solar Farm/Power Plant of the Licensee/SPPL

Latitude (North)	Longitude (East)
33°38'23.66"	73° 1'30.19"

Single Line Diagram of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL



Interconnection

Arrangement for Dispersal of Power from the Generation Facility/Solar Power Plant of Shams Power (Private) Limited

The power generated from the Generation Facility/Power Plant of Shams Power (Private) Limited shall be dispersed at roof top of METRO Cash & Carry, Plot 1-A, I-11/4, Islamabad for in-house utilization.

(4). The proposed Interconnection Arrangement for dispersal of electric power for the Generation Facility/Solar Power Plant will be as under:-

(b). 230V/400V two single circuits individually on two seperate bus bars of existing LT distribution panel of METRO Cash & Carry/Consumer.

(5). Any change in the above Interconnection Arrangement duly agreed by Shams Power (Private) Limited and METRO Cash & Carry/Consumer shall be communicated to the Authority in due course of time.

Detail of Generation Facility/Solar Power Plant

(A). General Information

(i).	Name of the Company/ Licensee	Shams Power (Private) Limited
(ii).	Registered/Business Office of the Company	2^{nd} Floor, Al-Maalik Building 19-Davis Road Lahore
(iii).	Principal Office	2^{nd} Floor, Al-Maalik Building 19-Davis Road Lahore
(iv).	Plants Location	METRO Cash & Carry Store, Plot 1-A, I-11/4, Islamabad
(v).	Field Type	Fixed Tilted Plane
(vi)	Field Parameters	Tilt 2° & Azimuth 32° 148°
(vii).	Type of Generation Facility	Solar Photovoltaic (PV)

(B). Solar Power Generation Technology & Capacity

(i).	Type of Technology	Photovoltaic (PV) Cell
(ii).	Type of Cell	Polycrystalline
(ii).	Type of System	Grid Tied
(iii).	Installed Capacity of the Generation Facility (MW)	0.3564 MW_P DC

(C). Technical Details of Equipment

(a).	**Solar Panels-PV Modules**		
(i).	Type of Module	Polycrystalline PV Type Module CS6U-330P	
(ii).	Surface Area of Module	1.94432 m^2	
(iii).	Dimension of each Module	1960 mm x 992 mm x 40mm	
(iv)	Total area of roof top for Solar Panels-PV Modules	2100 m^2	
(v).	No. of Modules	1080	
(vi).	Frame of Module	Anodised Aluminium Alloy	
(vii).	Weight of one Module	22.4 kg	
(viii).	Module Output Warranty	For 1st Year	For 2nd Year to 25th Year
		97.5% or above	Not more than 0.7% output reduction each year
(ix).	Number of Solar Cells in each Module	72 Cells	
(x).	Efficiency of Module	16.97 %	
(xi).	Environment Protection System	Encapsulation and sealing arrangements for protection from environment.	
(xii).	Maximum Power (P_{max})	330 W_P	
(xiii).	Power Tolerance at STC	0 ~ +5W	
(xiv).	Operating Voltage @ (P_{max})	37.2 V	
(xv).	Operating Current @ (P_{max})	8.88 A	
(xvi).	Open circuit voltage (V_{oc})	45.6 V	
(xvii).	Short circuit current (I_{sc})	9.45 A	
(xviii).	Optimum Operating Voltage at NOCT	23.9 V	

(xix).	Optimum Operating Current at NOCT	7.05 A
(xx).	Open circuit voltage (Voc) at NOCT	41.9 V
(xxi).	Maximum system open Circuit Voltage	1000V(IEC) or 1000V (UL) or 600V(UL)
(b).	**PV Array**	
(i).	No. of Arrays	12
(ii).	Modules in a String	15
(iii).	Total No. of Strings	72
(iv).	Modules in Array	90 Modules
(v).	Total Modules	1080
(c).	**PV Capacity**	
(i).	Total Capacity	0.3564 MW_P DC
(ii).	Net Capacity Factor	16.30%
(d).	**Inverters**	
(i).	Maximum DC Power Input	0.319 MW (@50°C)
(ii).	Inverter Model	Sunny Tri power 25000TL (25 KW)
(iii).	Manufacturer	SMA Solar Technology, Germany
(iv).	Maximum DC Input Voltage	DC 1000 V
(v).	Start Voltage	DC 150 V
(vi).	Number of Inverters	12
(vii).	Efficiency	98.3% (Sunny Tri power 25000TL)
(viii).	Max. Input Current	DC 66 A
(ix).	MPP Voltage Range	320 V- 800 V DC (@50°C)
(x).	Output electrical system	3-Phase, 4-Wire
(xi).	Rated Output Voltage	AC 230/400 V

(xii).	Rated Frequency	50 Hz		
(xiii).	Power Factor	1		
(xiv).	Power Control	MPP Tracker (2 MPPT/Inverter)		
(xv).	Environmental Enclosures	Operating Temperature Range		-25° C to 60° C
		Relative Humidity		100% non-condensing
		Protection Class		IP65
		Audible Noise		51 dB(A)
		Operating Elevation		<3000m
(xvi)	Protection Devices	(a).	DC Disconnect Switch	
		(b).	Ground Fault Monitoring	
		(c).	Reverse Polarity Protection	
		(d).	Reverse current protection	
		(e).	Over-voltage protection	
(e).	**Junction Boxes**			
(i).	Number of Junction Box units	24		
(ii).	Input circuits in each box	1 box with 3 String inputs and 1 Combined output		
(iii).	Max. Input current for each circuit	15 A		
(iv).	Max. Input voltage	1000 V		
(v).	Power at each box	14.85 kW_p		
(vi).	Protection Level	IP 65		
(vii).	Over-Current protection	Fuse		
(viii).	Surge protection	Yes (>1000V)		
(ix).	Purpose of Junction Box	(a).	Combining the strings	

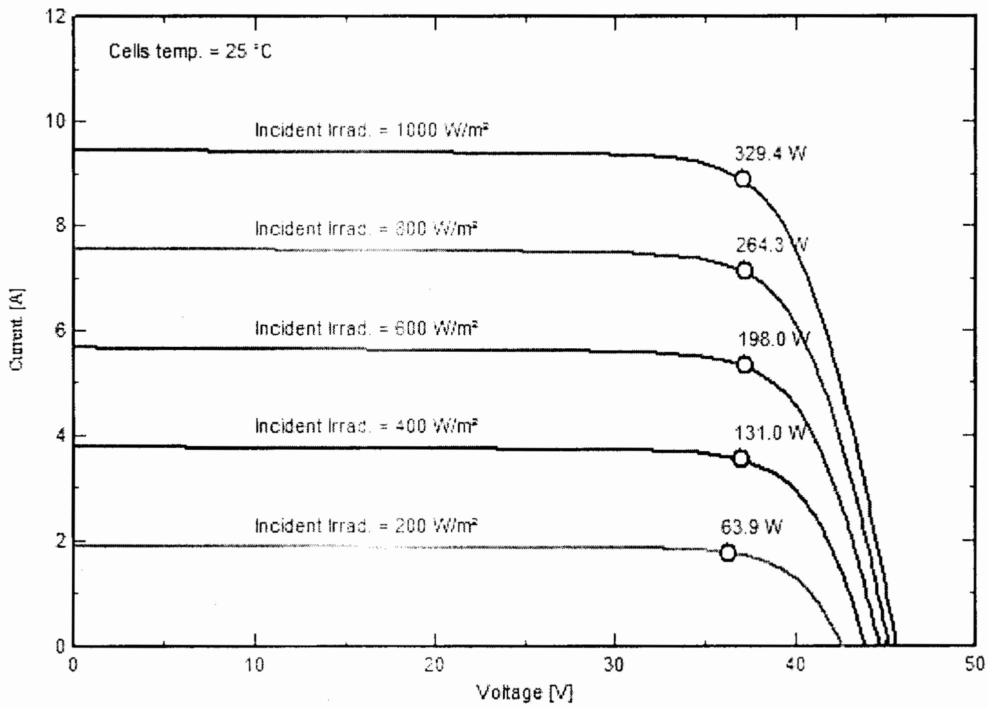
		(b).	Short Circuit Protection
		(c).	DC Surge Protection
(f).	**Data Collecting System**		
(i).	Weather Data	(a).	Irradiance Meter (Survey 100/200R)- 1 Set (to record ambient temp& radiation level)
(ii).	System Data	(a).	DC input voltage (V) & current (A) of each Inverter (Phase, Line)
		(b).	Total DC power (kW) generated by PV array.
		(c).	AC output voltage(V) and current (A) of each Inverter (Phase, Total)
		(d).	AC output power (kW) and energy (kWh) of each Inverter
		(e).	Frequency (Hz)
		(f).	Power Factor (PF)

(D). Other Details

(i).	COD of the Project	July 22, 2018
(ii).	Expected Life of the Project from the COD	25 Years

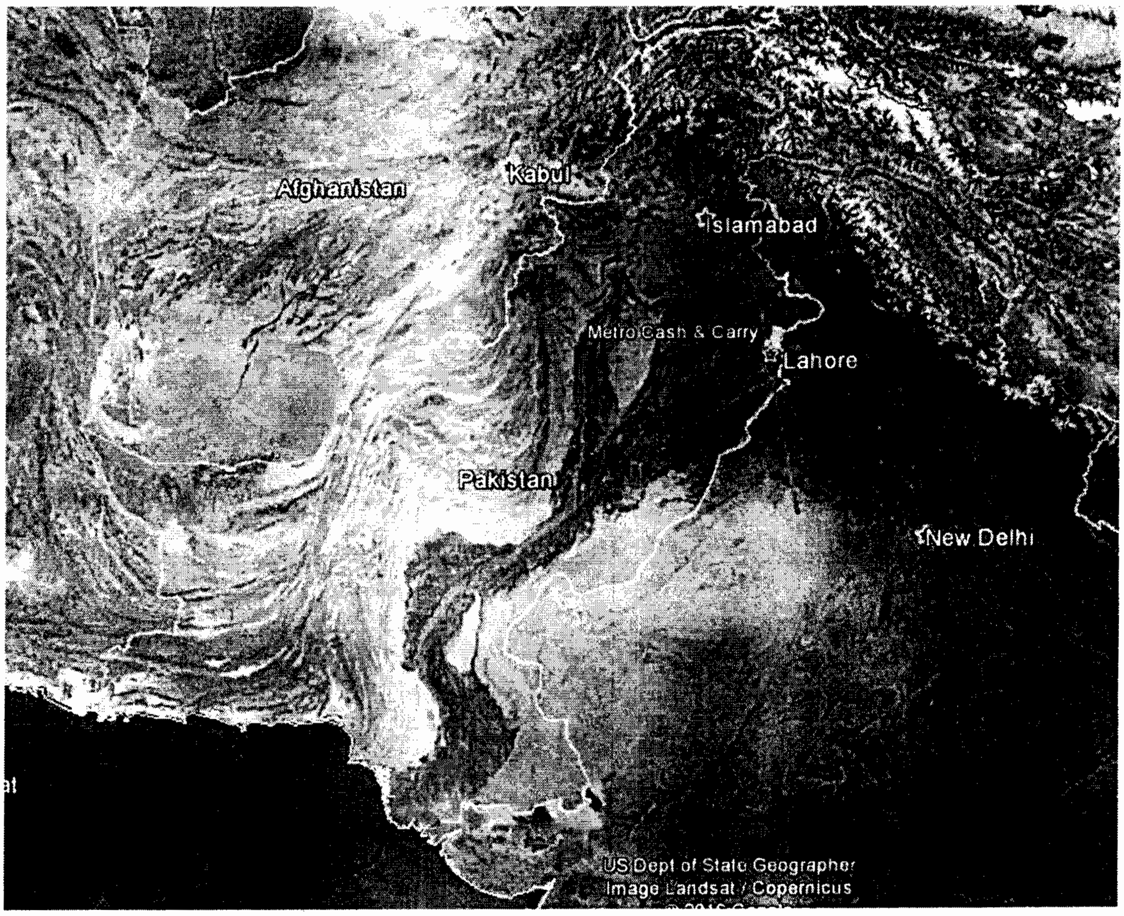
VI Curve of Solar Panel at STC for the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL

PV module: Canadian Solar Inc., CS6U - 330P

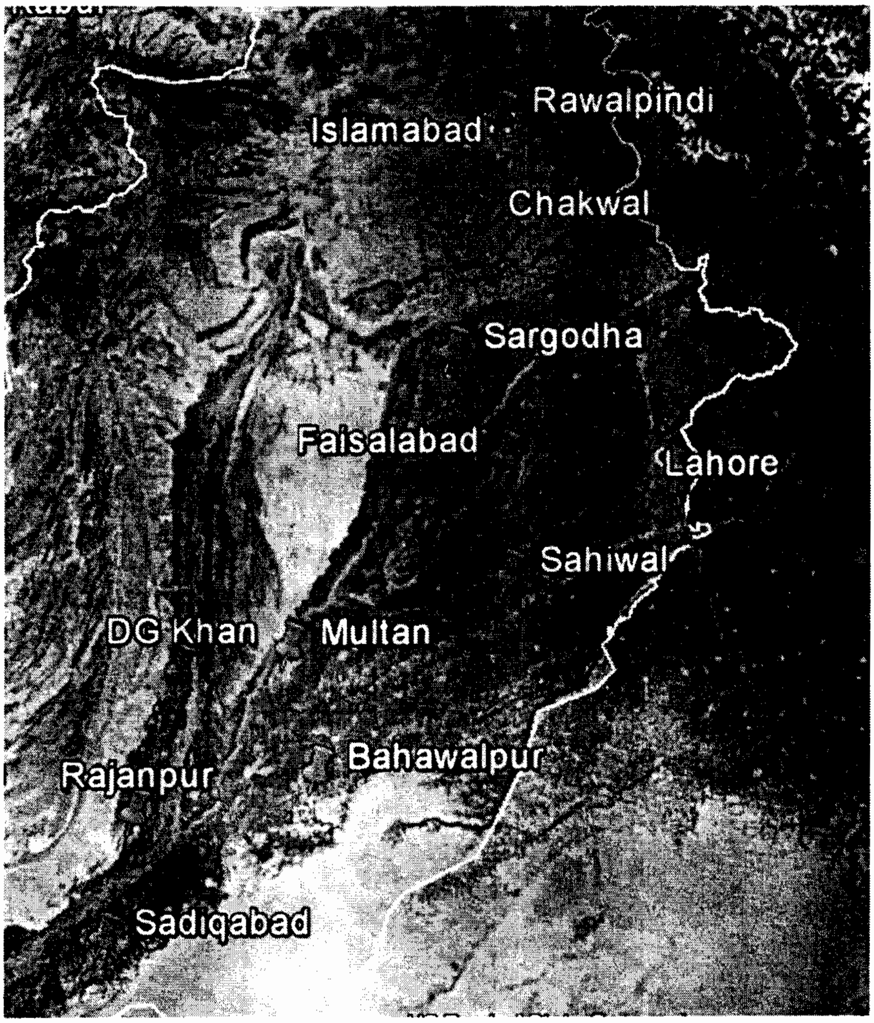


2. METRO Cash & Carry, Thokkar Niaz Baig, Lahore

Location of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of Pakistan

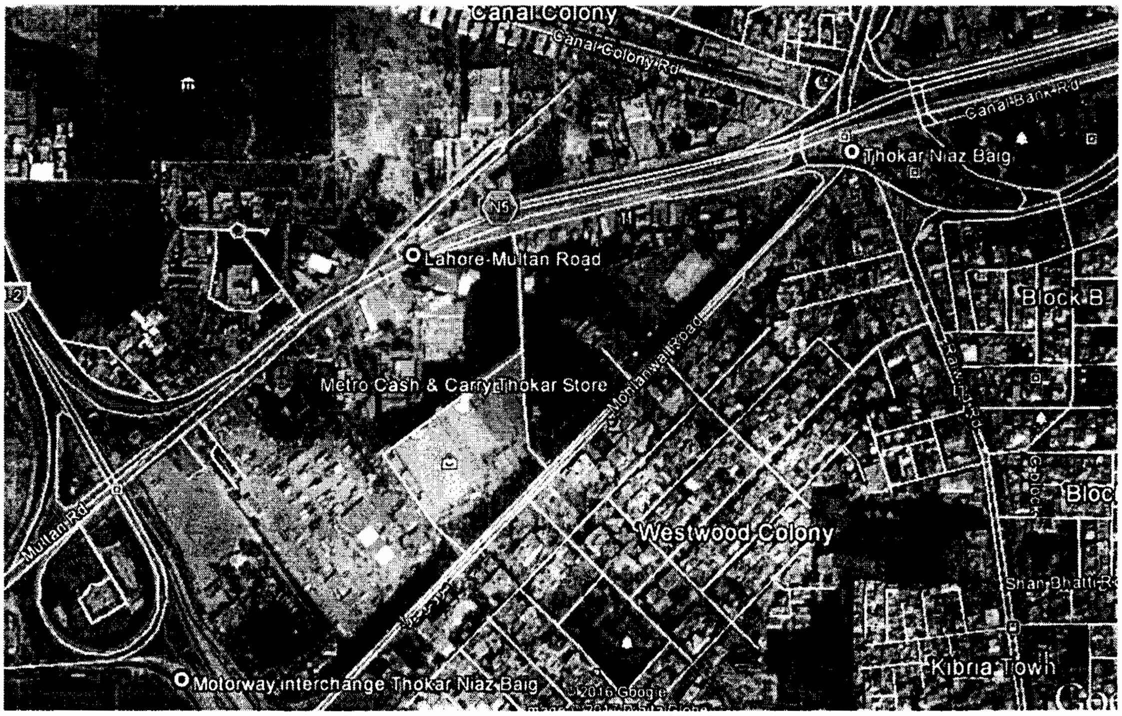


Location of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of the Province of Punjab

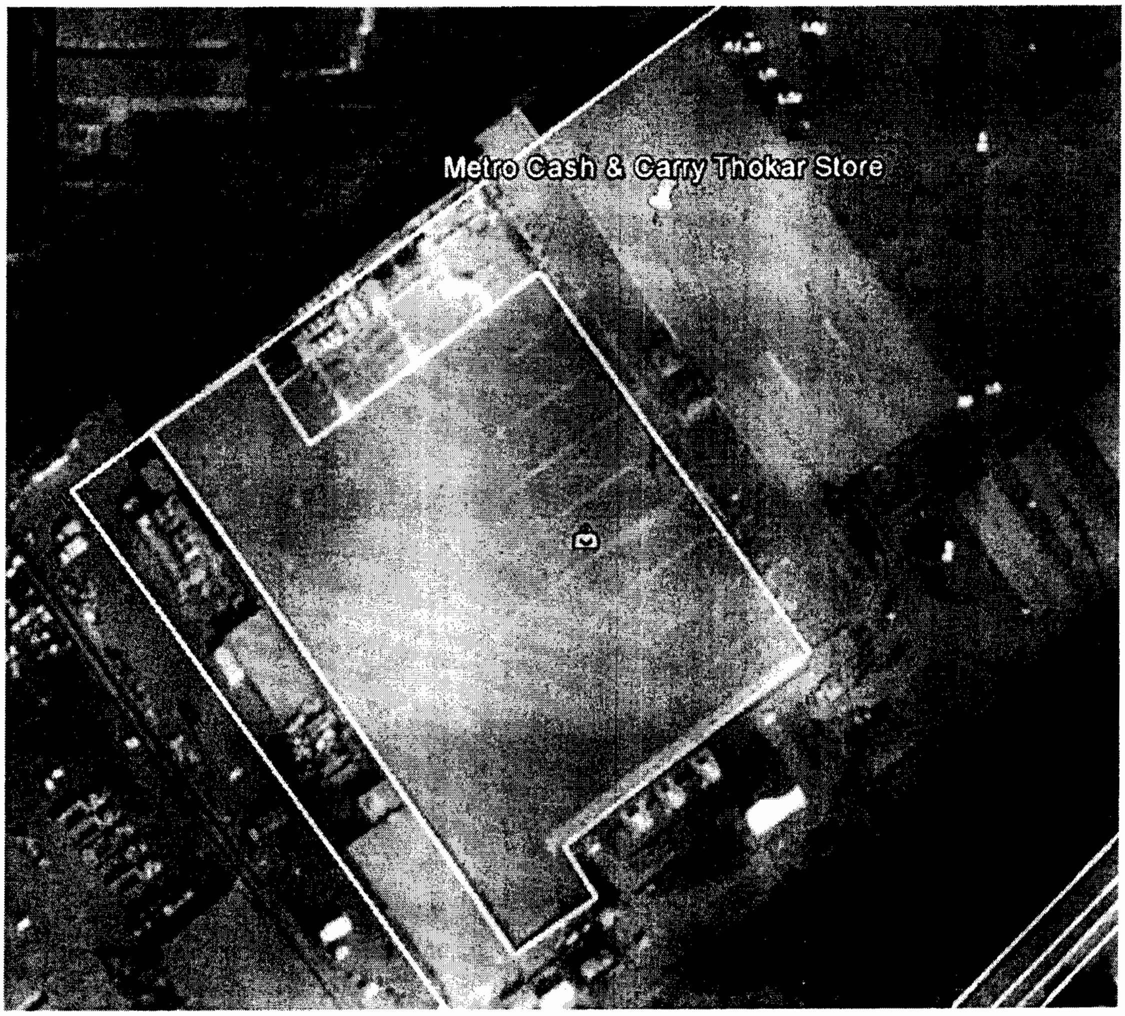


Location of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of Lahore

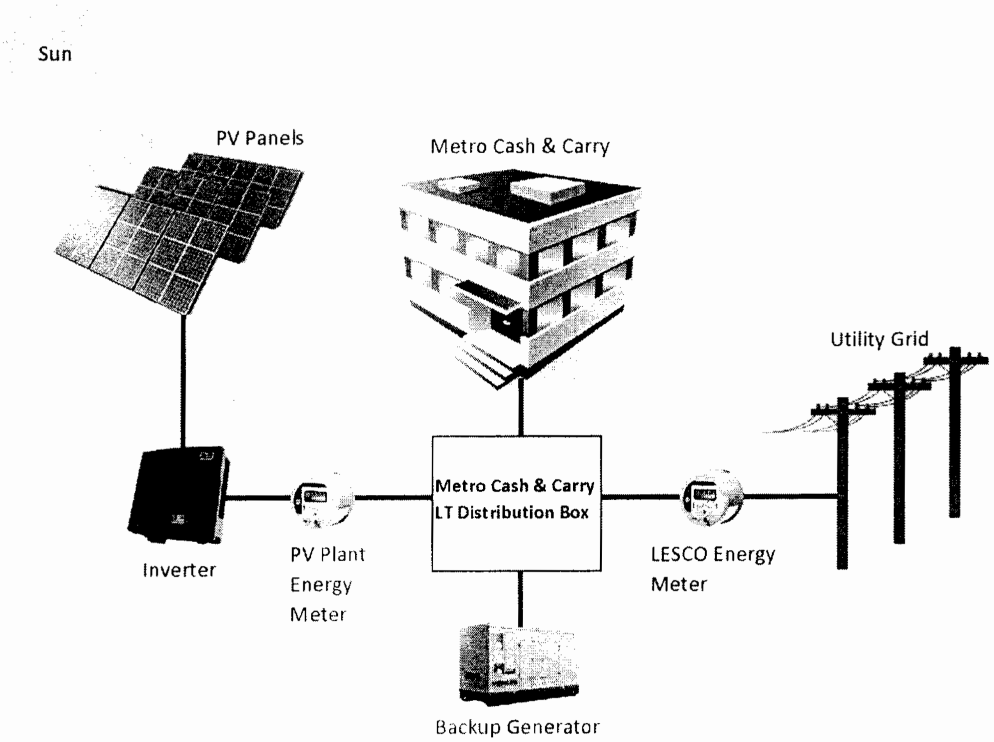
Access Road/Link of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of Lahore



<u>**Location of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL**</u>



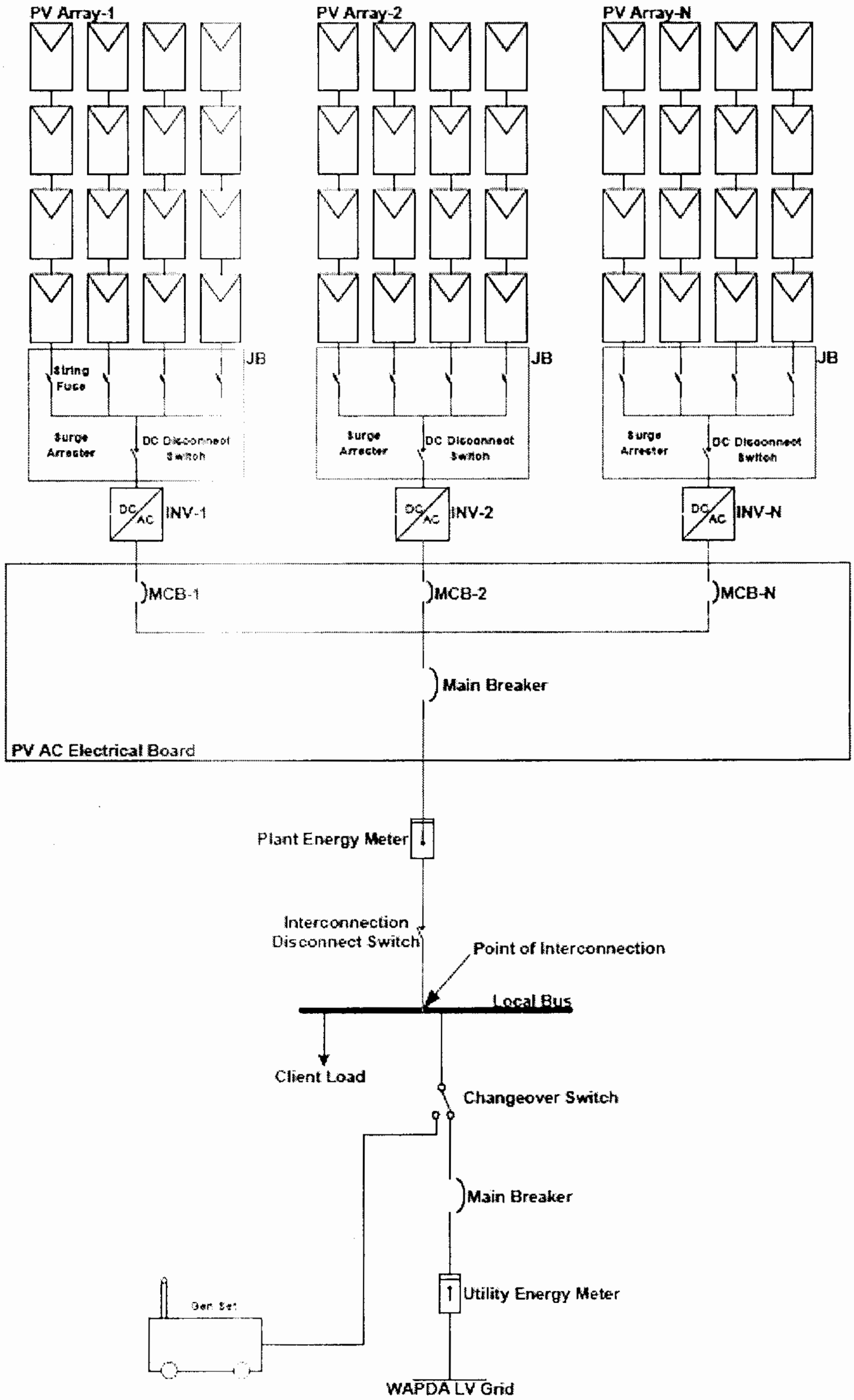
Process Flow Diagram of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL



Location Coordinates of the Generation Facility/Solar Farm/Power Plant of the Licensee/SPPL

Latitude (North)	Longitude (East)
31°28'1.18"	74°14'5.30"

Single Line Diagram of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL



Interconnection

Arrangement for Dispersal of Power from the Generation Facility/Solar Power Plant of Shams Power (Private) Limited

The power generated from the Generation Facility/Power Plant of Shams Power (Private) Limited shall be dispersed at roof top of METRO Cash & Carry, Thokar Niaz Baig Lahore for in-house utilization.

(6). The proposed Interconnection Arrangement for dispersal of electric power for the Generation Facility/Solar Power Plant will be as under:-

(c). 230V/400V two single circuits individually on two separate bus bars of existing LT distribution panel of METRO Cash & Carry/Consumer.

(7). Any change in the above Interconnection Arrangement duly agreed by Shams Power (Private) Limited and METRO Cash & Carry/Consumer shall be communicated to the Authority in due course of time.

Detail of Generation Facility/Solar Power Plant

(A). General Information

(i).	Name of the Company/ Licensee	Shams Power (Private) Limited
(ii).	Registered/Business Office of the Company	2nd Floor, Al-Maalik Building 19-Davis Road Lahore
(iii).	Principal Office	2nd Floor, Al-Maalik Building 19-Davis Road Lahore
(iv).	Plants Location	METRO Cash & Carry Store, Canal Road, Thokar Niaz Baig, Lahore
(v).	Field Type	Fixed Tilted Plane
(vi)	Field Parameters	Tilt 2° & Azimuth 33°
(vii).	Type of Generation Facility	Solar Photovoltaic (PV)

(B). Solar Power Generation Technology & Capacity

(i).	Type of Technology	Photovoltaic (PV) Cell
(ii).	Type of Cell	Polycrystalline
(ii).	Type of System	Grid Tied
(iii).	Installed Capacity of the Generation Facility (MW)	0.38808 MW_P DC

(C). Technical Details of Equipment

(a).	**Solar Panels-PV Modules**		
(i).	Type of Module	Polycrystalline PV Type Module CS6U-330P	
(ii).	Surface Area of Module	1.94432 m^2	
(iii).	Dimension of each Module	1960 mm x 992 mm x 40mm	
(iv)	Total area of roof top for Solar Panels-PV Modules	2287 m^2	
(v).	No. of Modules	1176	
(vi).	Frame of Module	Anodised Aluminium Alloy	
(vii).	Weight of one Module	22.4 kg	
(viii).	Module Output Warranty	For 1st Year	For 2nd Year to 25th Year
		97.5% or above	Not more than 0.7% output reduction each year
(ix).	Number of Solar Cells in each Module	72 Cells	
(x).	Efficiency of Module	16.97 %	
(xi).	Environment Protection System	Encapsulation and sealing arrangements for protection from environment.	
(xii).	Maximum Power (P_{max})	330 W_P	
(xiii).	Power Tolerance at STC	0 ~ +5W	
(xiv).	Operating Voltage @ (P_{max})	37.2 V	
(xv).	Operating Current @ (P_{max})	8.88 A	
(xvi).	Open circuit voltage (V_{oc})	45.6 V	

(xvii).	Short circuit current (I_{sc})	9.45 A
(xviii).	Optimum Operating Voltage at NOCT	33.9 V
(xix).	Optimum Operating Current at NOCT	7.05 A
(xx).	Open circuit voltage (Voc) at NOCT	41.9 V
(xxi).	Maximum system open Circuit Voltage	1000V(IEC) or 1000V (UL) or 600V(UL)
(b).	**PV Array**	
(i).	No. of Arrays	14
(ii).	Modules in a String	14
(iii).	Total No. of Strings	84
(iv).	Modules in Array	84 Modules
(v).	Total Modules	1176
(c).	**PV Capacity**	
(i).	Total Capacity	0.38808 MW_P DC
(ii).	Net Capacity Factor	15.46%
(d).	**Inverters**	
(i).	Maximum DC Power Input	0.347 MW (@50°C)
(ii).	Inverter Model	Sunny Tri power 25000TL (25 KW)
(iii).	Manufacturer	SMA Solar Technology, Germany
(iv).	Maximum DC Input Voltage	DC 1000 V
(v).	Start Voltage	DC 150 V
(vi).	Number of Inverters	14
(vii).	Efficiency	98.3% (Sunny Tri power 25000TL)
(viii).	Max. Input Current	DC 66 A
(ix).	MPP Voltage Range	320 V- 800 V DC (@50°C)

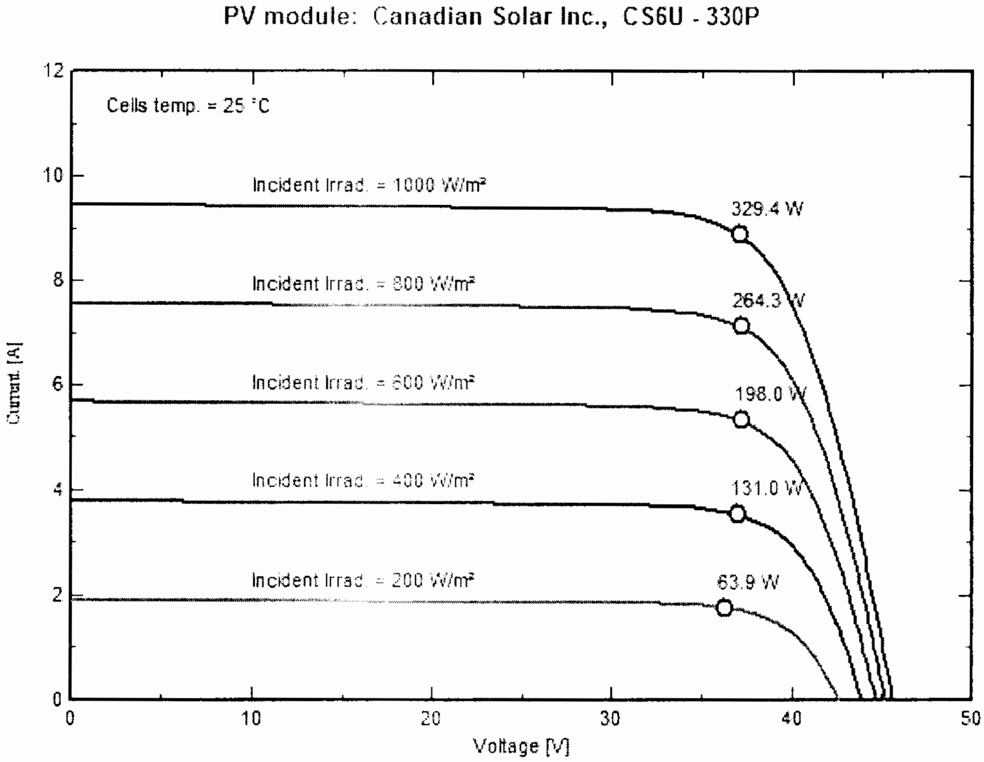
(x).	Output electrical system	3-Phase, 4-Wire	
(xi).	Rated Output Voltage	AC 230/400 V	
(xii).	Rated Frequency	50 Hz	
(xiii).	Power Factor	1	
(xiv).	Power Control	MPP Tracker (2 MPPT/Inverter)	
(xv).	Environmental Enclosures	Operating Temperature Range	-25° C to 60° C
		Relative Humidity	100% non-condensing
		Protection Class	IP65
		Audible Noise	51 dB(A)
		Operating Elevation	<3000m
(xvi)	Protection Devices	(a).	DC Disconnect Switch
		(b).	Ground Fault Monitoring
		(c).	Reverse Polarity Protection
		(d).	Reverse current protection
		(e).	Over-voltage protection
(e).	**Junction Boxes**		
(i).	Number of Junction Box units	28	
(ii).	Input circuits in each box	1 box with 3 String inputs and 1 Combined output	
(iii).	Max. Input current for each circuit	15 A	
(iv).	Max. Input voltage	1000 V	
(v).	Power at each box	13.86kW$_p$	
(vi).	Protection Level	IP 65 & Fire Protection	
(vii).	Over-Current protection	Fuse	

(viii).	Surge protection	Yes (>1000V)	
(ix).	Purpose of Junction Box	(a).	Combining the strings
		(b).	Short Circuit Protection
		(c).	DC Surge Protection
(f).	**Data Collecting System**		
(i).	Weather Data	(a).	Irradiance Meter (Survey 100/200R)- 1 Set (to record ambient temp& radiation level)
(ii).	System Data	(a).	DC input voltage (V) & current (A) of each Inverter (Phase, Line)
		(b).	Total DC power (kW) generated by PV array.
		(c).	AC output voltage(V) and current (A) of each Inverter (Phase, Total)
		(d).	AC output power (kW) and energy (kWh) of each Inverter
		(e).	Frequency (Hz)
		(f).	Power Factor (PF)

(D). Other Details

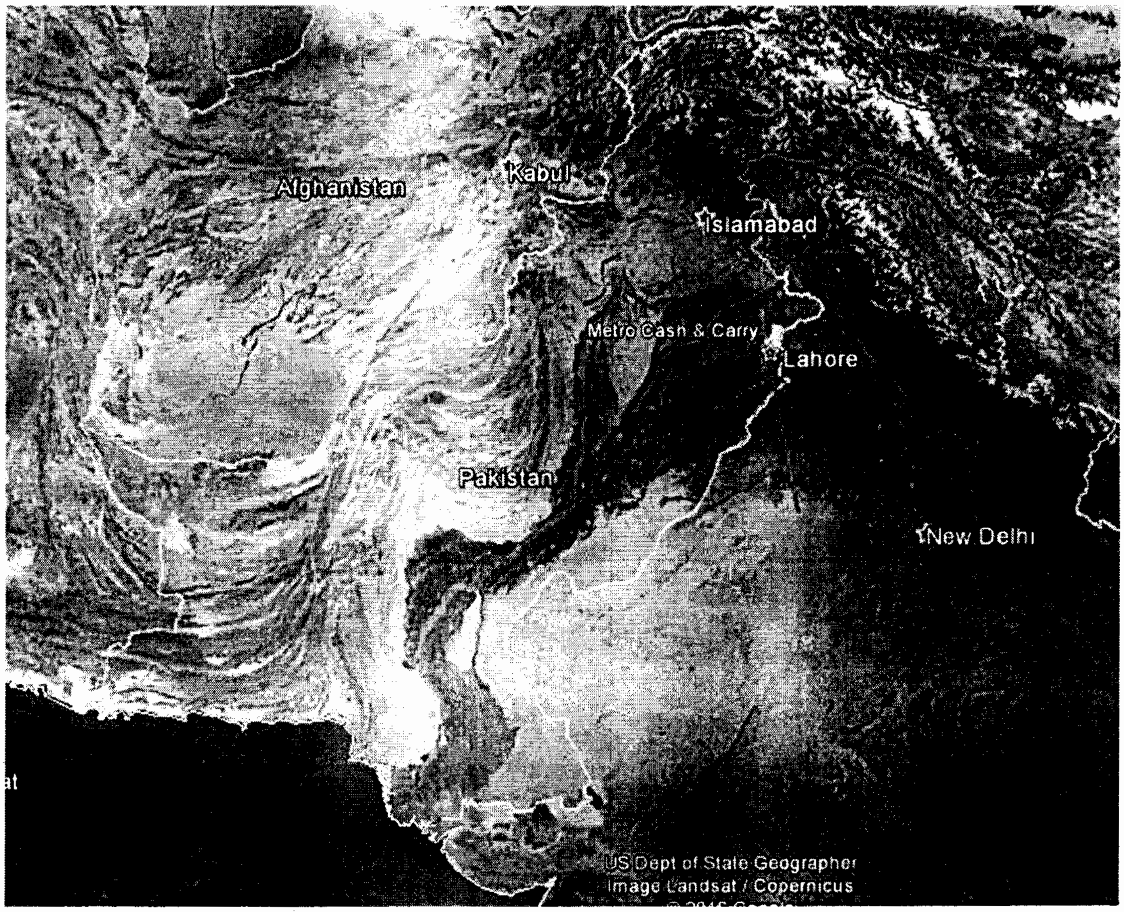
(i).	COD of the Project	January 01, 2018
(ii).	Expected Life of the Project from the COD	25 Years

VI Curve of Solar Panel at STC for the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL

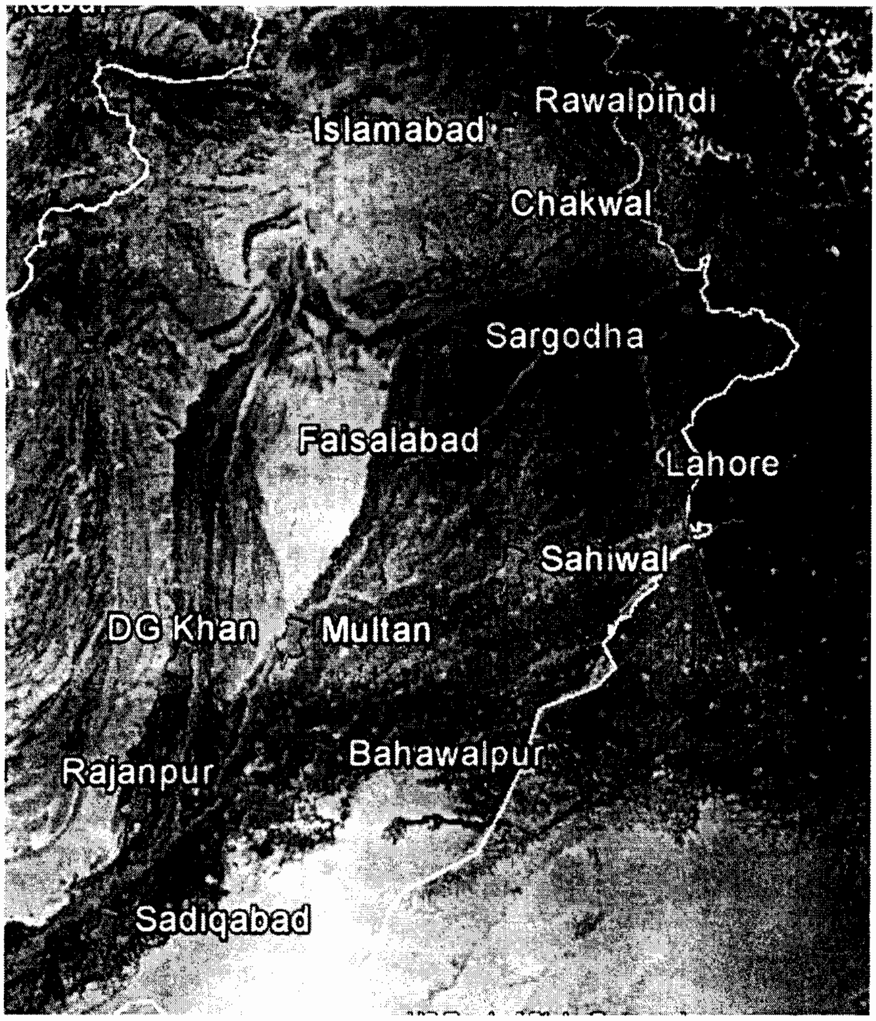


3. METRO Cash & Carry, Airport Road, DHA, Lahore

Location of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of Pakistan

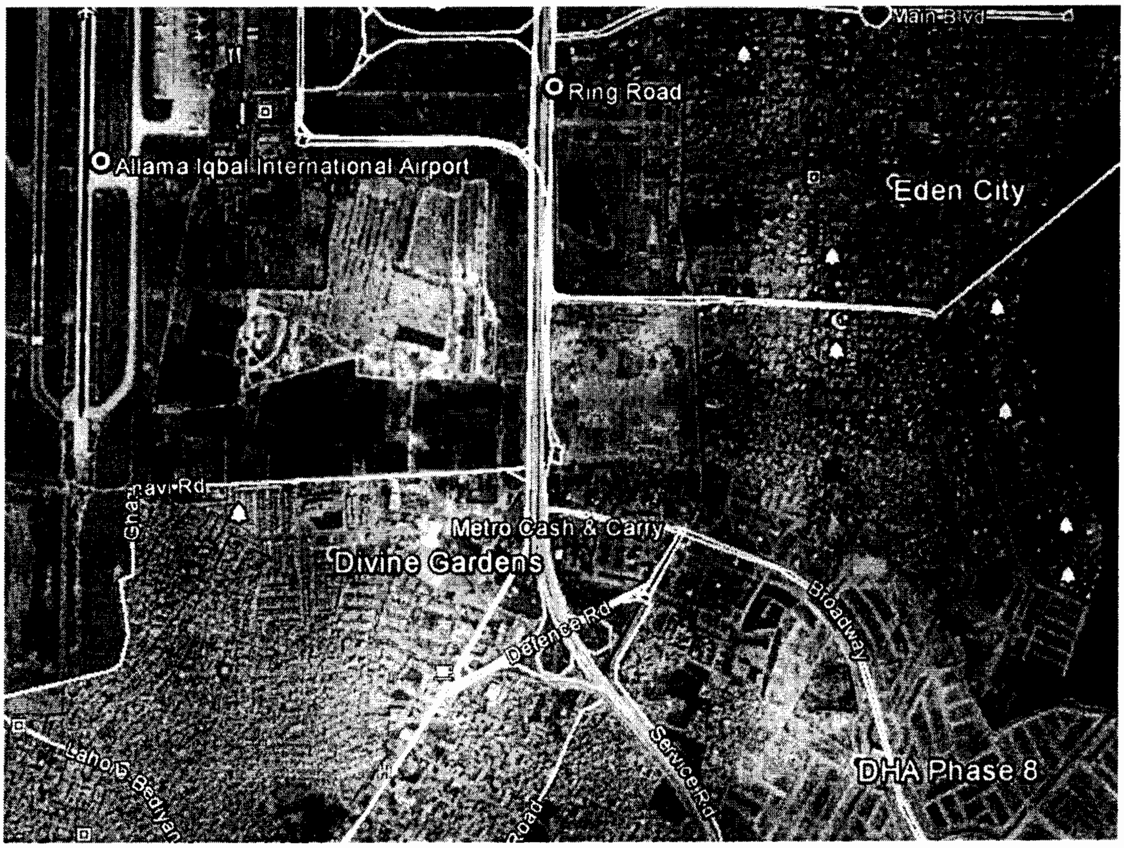


Location of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of the Province of Punjab

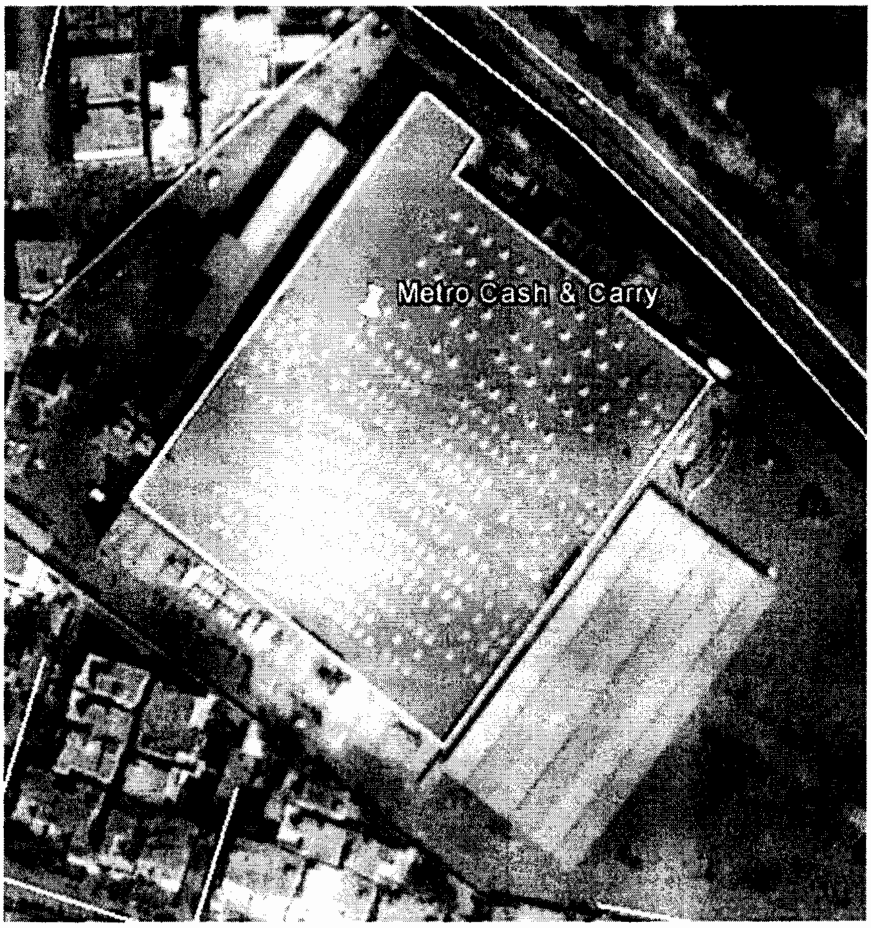


Location of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of Lahore

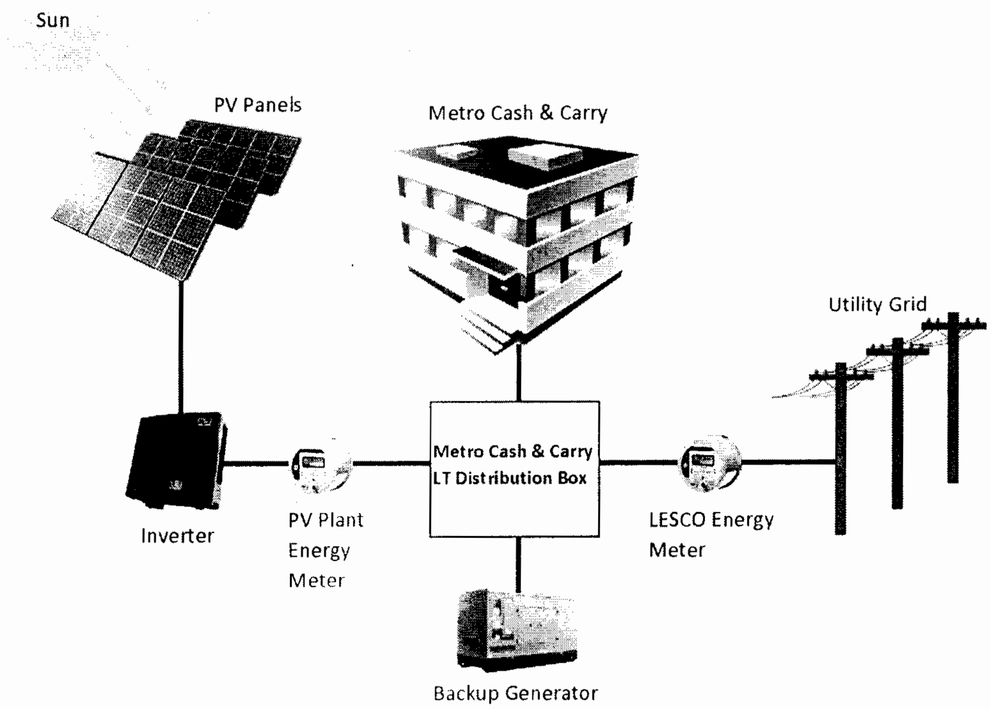
Access Road/Link of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of Lahore



Location of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL



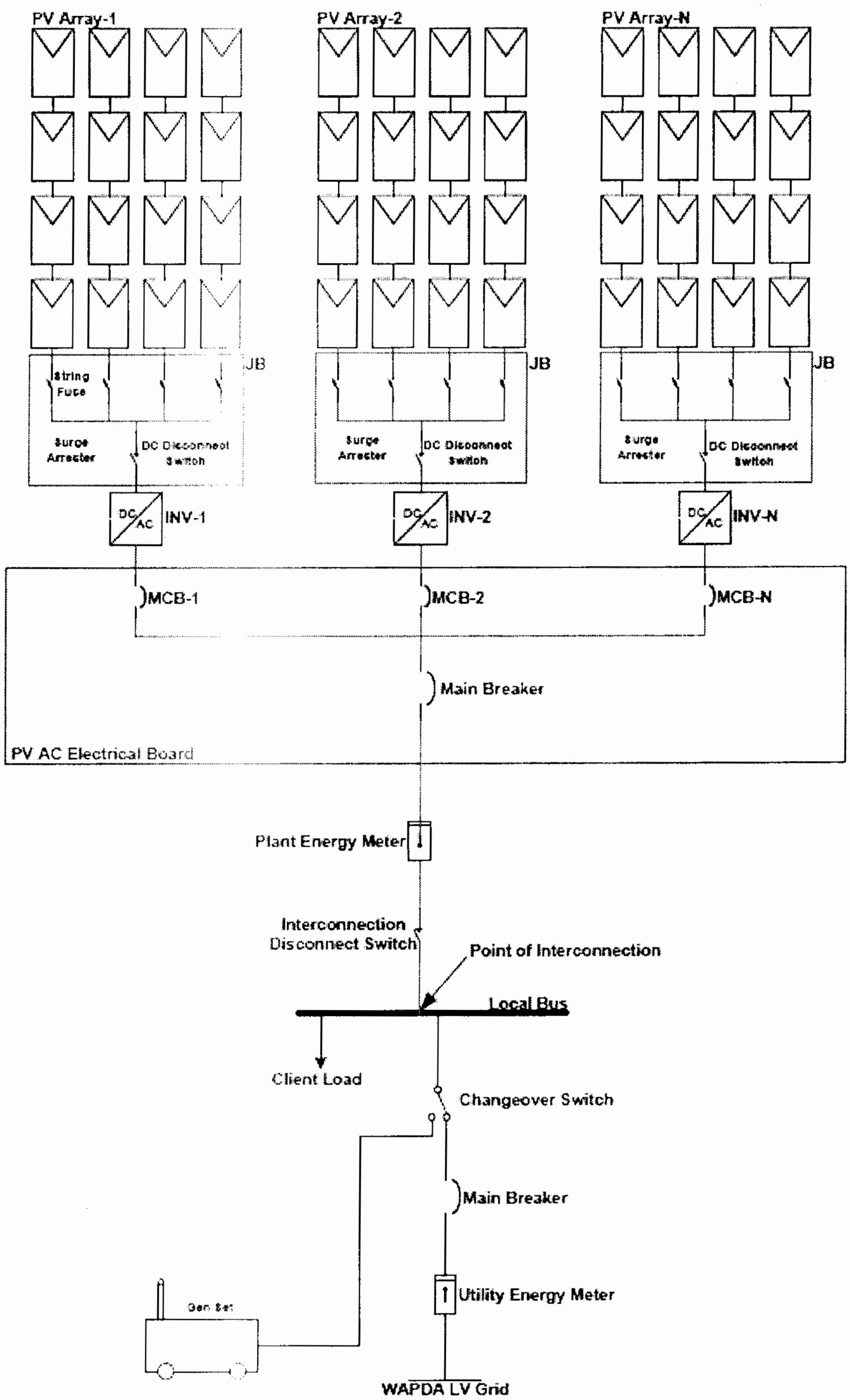
Process Flow Diagram of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL



Location Coordinates of the Generation Facility/Solar Farm/Power Plant of the Licensee/SPPL

Latitude (North)	Longitude (East)
31°30'5.44"	74°25'8.80"

Single Line Diagram of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL



Interconnection

Arrangement for Dispersal of Power from the Generation Facility/Solar Power Plant of Shams Power (Private) Limited

The power generated from the Generation Facility/Power Plant of Shams Power (Private) Limited shall be dispersed at roof top of METRO Cash & Carry, Airport Road Lahore for in-house utilization.

(8). The proposed Interconnection Arrangement for dispersal of electric power for the Generation Facility/Solar Power Plant will be as under:-

(d). 230V/400V two single circuits individually on two separate bus bars of existing LT distribution panel of METRO Cash & Carry/Consumer.

(9). Any change in the above Interconnection Arrangement duly agreed by Shams Power (Private) Limited and METRO Cash & Carry/Consumer shall be communicated to the Authority in due course of time.

Detail of Generation Facility/Solar Power Plant

(A). General Information

(i).	Name of the Company/ Licensee	Shams Power (Private) Limited
(ii).	Registered/Business Office of the Company	2nd Floor, Al-Maalik Building 19-Davis Road Lahore
(iii).	Principal Office	2nd Floor, Al-Maalik Building 19-Davis Road Lahore
(iv).	Plants Location	METRO Cash & Carry Store, Near Airport DHA, Lahore
(v).	Field Type	Fixed Tilted Plane
(vi)	Field Parameters	Tilt 2° & Azimuth 35°,145°
(vii).	Type of Generation Facility	Solar Photovoltaic (PV)

(B). Solar Power Generation Technology & Capacity

(i).	Type of Technology	Photovoltaic (PV) Cell
(ii).	Type of Cell	Polycrystalline
(ii).	Type of System	Grid Tied
(iii).	Installed Capacity of the Generation Facility (MW)	0.3564 MW_P DC

(C). Technical Details of Equipment

(a).	Solar Panels-PV Modules		
(i).	Type of Module	Polycrystalline PV Type Module CS6U-330P	
(ii).	Surface Area of Module	1.94432 m^2	
(iii).	Dimension of each Module	1960 mm x 992 mm x 40mm	
(iv)	Total area of roof top for Solar Panels-PV Modules	2100 m^2	
(v).	No. of Modules	1080	
(vi).	Frame of Module	Anodised Aluminium Alloy	
(vii).	Weight of one Module	22.1 kg	
(viii).	Module Output Warranty	For 1^{st} Year	For 2^{nd} Year to 25^{th} Year
		97.5% or above	Not more than 0.7% output reduction each year
(ix).	Number of Solar Cells in each Module	72 Cells	
(x).	Efficiency of Module	16.97 %	
(xi).	Environment Protection System	Encapsulation and sealing arrangements for protection from environment.	
(xii).	Maximum Power (P_{max})	330 W_P	
(xiii).	Power Tolerance at STC	0 ~ +5W	
(xiv).	Operating Voltage @ (P_{max})	37.2 V	
(xv).	Operating Current @ (P_{max})	8.88 A	
(xvi).	Open circuit voltage (V_{oc})	45.6 V	
(xvii).	Short circuit current (I_{sc})	9.45 A	

(xviii).	Optimum Operating Voltage at NOCT	33.9 V
(xix).	Optimum Operating Current at NOCT	7.05 A
(xx).	Open circuit voltage (Voc) at NOCT	41.9 V
(xxi).	Maximum system open Circuit Voltage	1000V(IEC) or 1000V (UL) or 600V(UL)
(b).	**PV Array**	
(i).	No. of Arrays	12
(ii).	Modules in a String	15
(iii).	Total No. of Strings	72
(iv).	Modules in Array	90 Modules
(v).	Total Modules	1080
(c).	**PV Capacity**	
(i).	Total Capacity	0.3564 MW_P DC
(ii).	Net Capacity Factor	16.10%
(d).	**Inverters**	
(i).	Maximum DC Power Input	0.318 MW (@50°C)
(ii).	Inverter Model	Sunny Tri power 25000TL (25 KW)
(iii).	Manufacturer	SMA Solar Technology, Germany
(iv).	Maximum DC Input Voltage	DC 1000 V
(v).	Start Voltage	DC 150 V
(vi).	Number of Inverters	12
(vii).	Efficiency	98.3% (Sunny Tri power 25000TL)
(viii).	Max. Input Current	DC 66 A
(ix).	MPP Voltage Range	320 V- 800 V DC (@50°C)
(x).	Output electrical system	3-Phase, 4-Wire

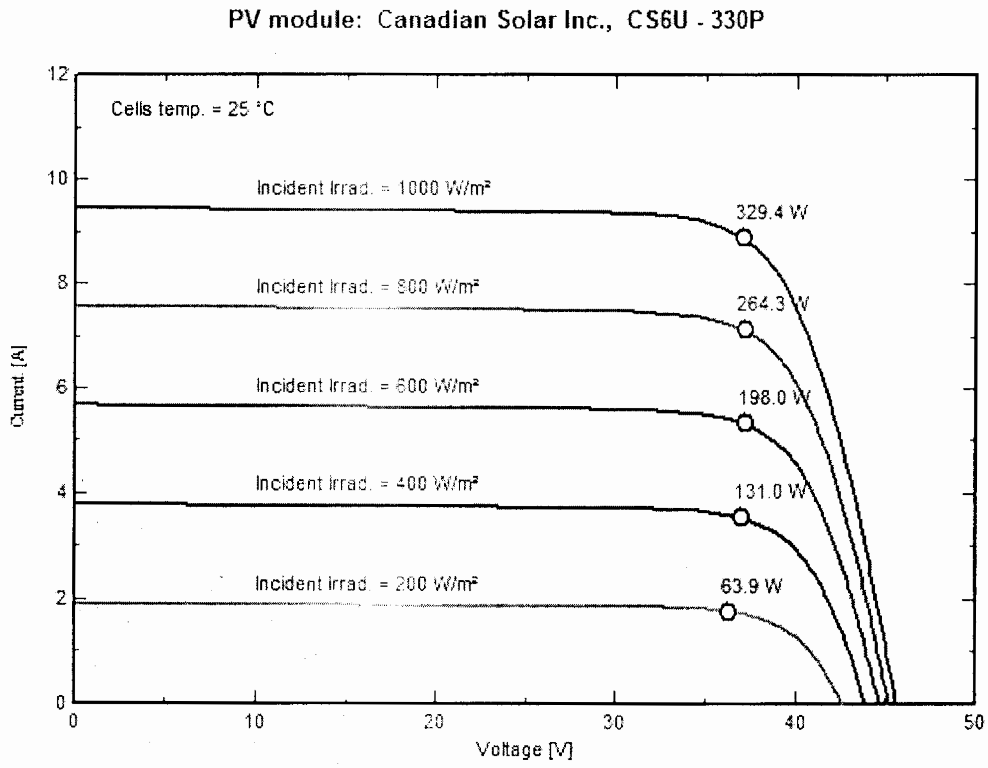
(xi).	Rated Output Voltage	AC 230/400 V	
(xii).	Rated Frequency	50 Hz	
(xiii).	Power Factor	1	
(xiv).	Power Control	MPP Tracker (2 MPPT/Inverter)	
(xv).	Environmental Enclosures	Operating Temperature Range	-25° C to 60° C
		Relative Humidity	100% non-condensing
		Protection Class	IP65
		Audible Noise	51 dB(A)
		Operating Elevation	<3000m
(xvi)	Protection Devices	(a).	DC Disconnect Switch
		(b).	Ground Fault Monitoring
		(c).	Reverse Polarity Protection
		(d).	Reverse current protection
		(e).	Over-voltage protection
(e).	**Junction Boxes**		
(i).	Number of Junction Box units	24	
(ii).	Input circuits in each box	1 box with 3 String inputs and 1 Combined output	
(iii).	Max. Input current for each circuit	15 A	
(iv).	Max. Input voltage	1000 V	
(v).	Power at each box	14.85 kW_p	
(vi).	Protection Level	IP 65	
(vii).	Over-Current protection	Fuse	
(viii).	Surge protection	Yes (>1000V)	

(ix).	Purpose of Junction Box	(a).	Combining the strings
		(b).	Short Circuit Protection
		(c).	DC Surge Protection
(f).	**Data Collecting System**		
(i).	Weather Data	(a).	Irradiance Meter (Survey 100/200R)- 1 Set (to record ambient temp& radiation level)
(ii).	System Data	(a).	DC input voltage (V) & current (A) of each Inverter (Phase, Line)
		(b).	Total DC power (kW) generated by PV array.
		(c).	AC output voltage(V) and current (A) of each Inverter (Phase, Total)
		(d).	AC output power (kW) and energy (kWh) of each Inverter
		(e).	Frequency (Hz)
		(f).	Power Factor (PF)

(D). Other Details

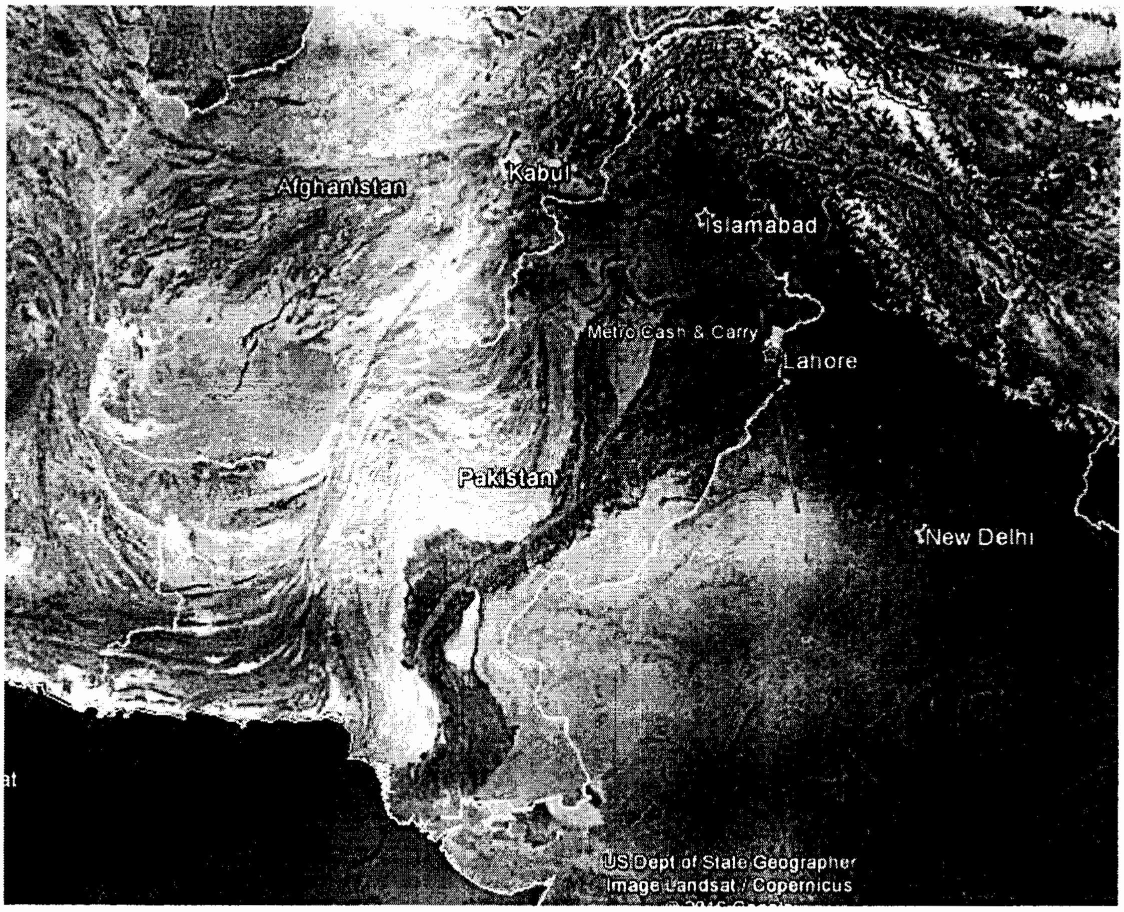
(i).	COD of the Project	Mar 12, 2018
(ii).	Expected Life of the Project from the COD	25 Years

VI Curve of Solar Panel at STC for the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL

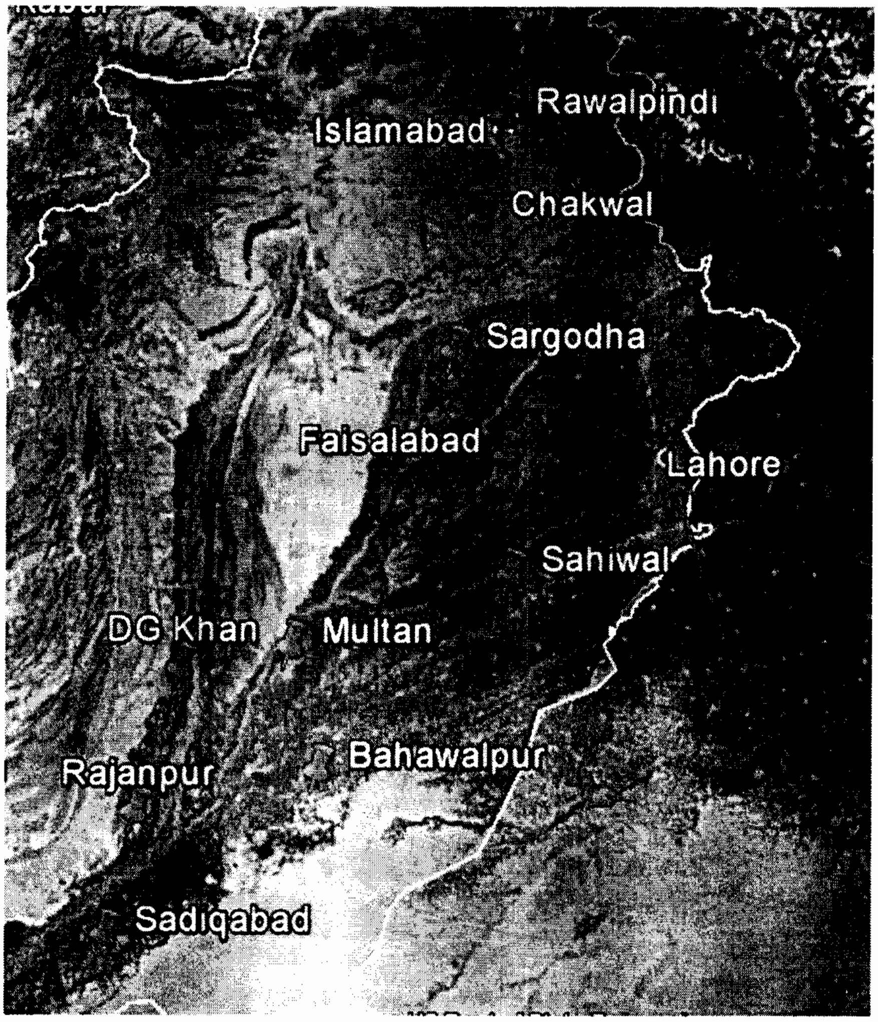


4. METRO Cash & Carry, Ravi Road, Lahore

Location of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of Pakistan



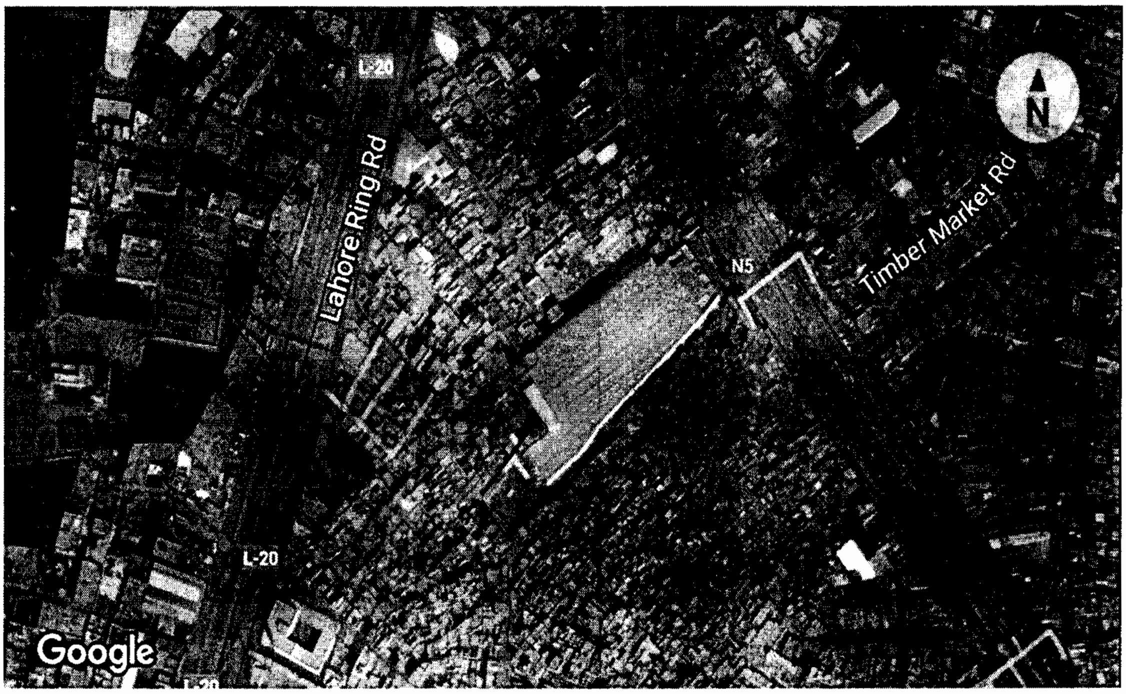
Location of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of the Province of Punjab

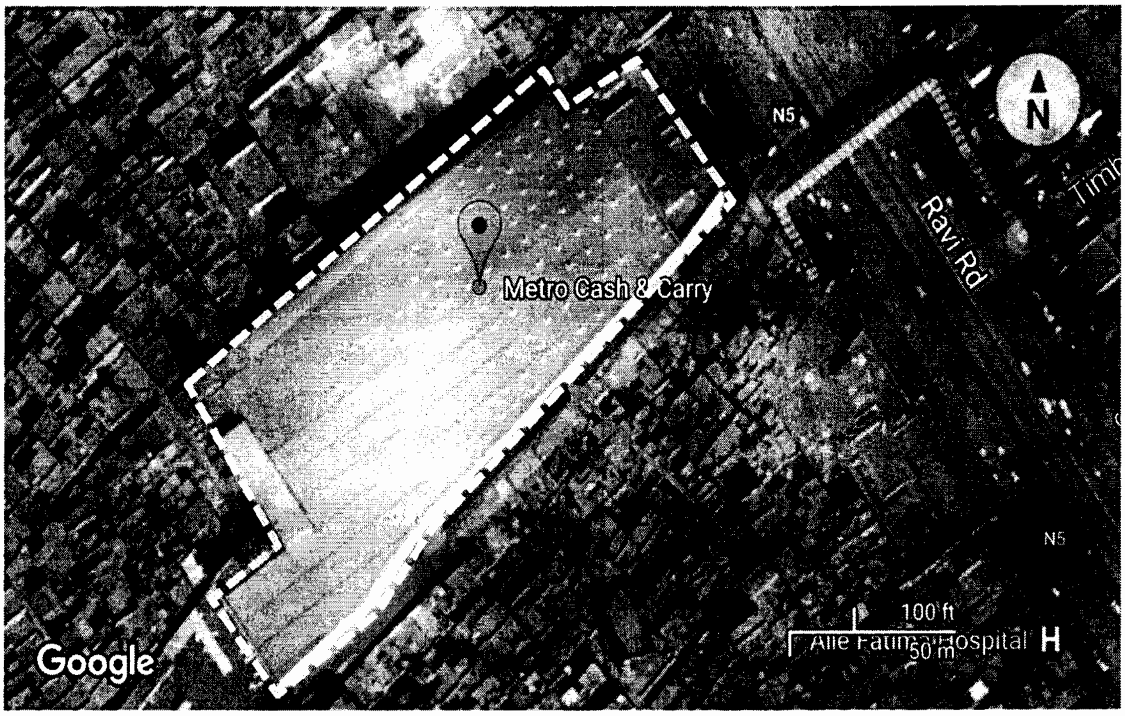


Location of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of Lahore

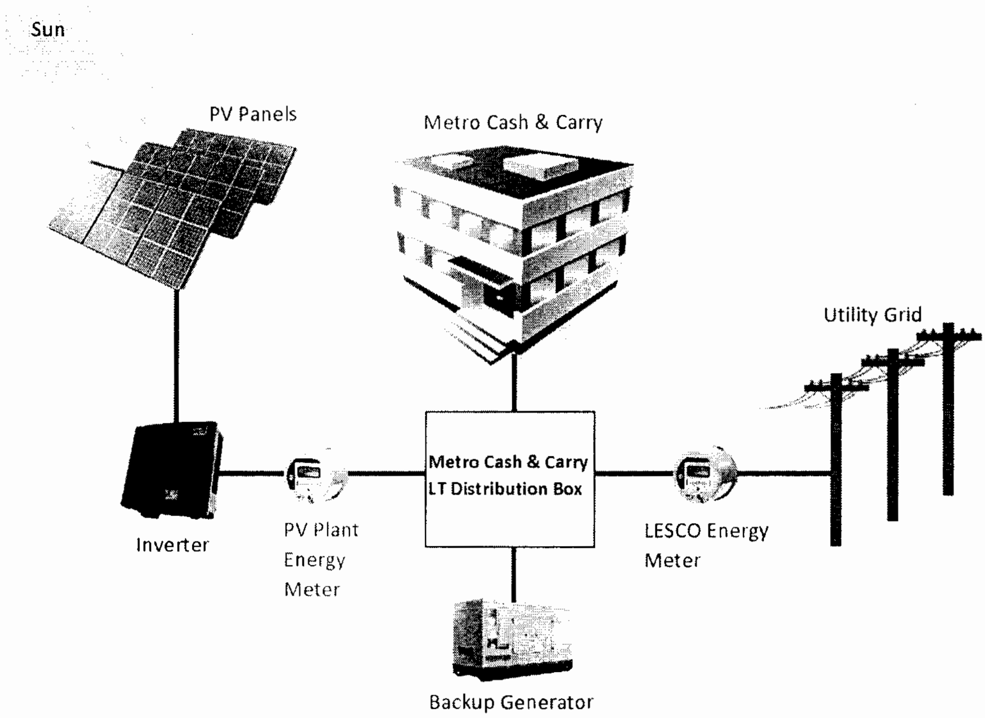
Access Road/Link of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of Lahore

Location of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL





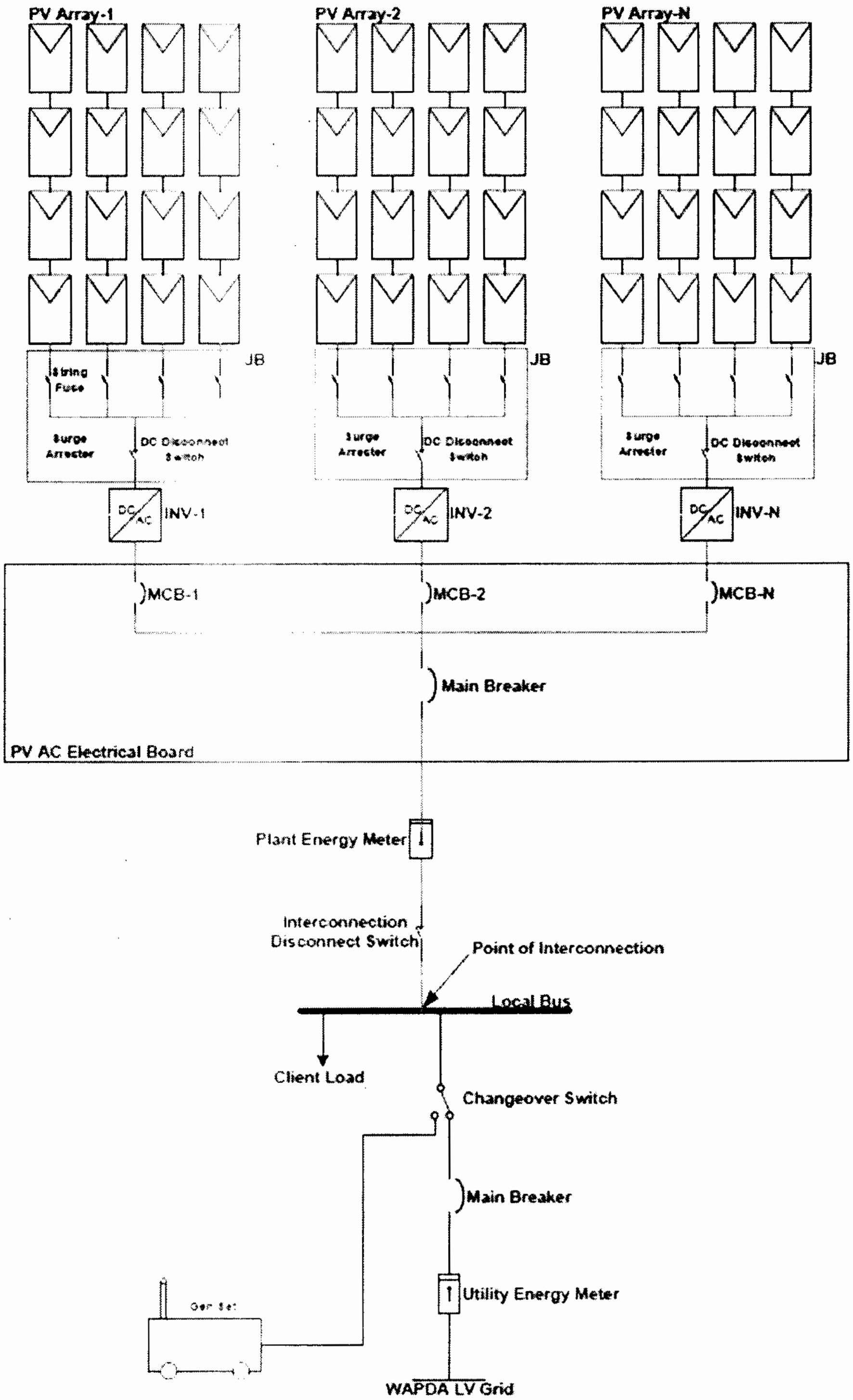
Process Flow Diagram of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL



Location Coordinates of the Generation Facility/Solar Farm/Power Plant of the Licensee/SPPL

Latitude (North)	Longitude (East)
31°35'48.92"N	74°17'53.48"E

Single Line Diagram of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL



Interconnection

Arrangement for Dispersal of Power from the Generation Facility/Solar Power Plant of Shams Power (Private) Limited

The power generated from the Generation Facility/Power Plant of Shams Power (Private) Limited shall be dispersed at roof top of METRO Cash & Carry, Ravi Road, Lahore, for in-house utilization.

(10). The proposed Interconnection Arrangement for dispersal of electric power for the Generation Facility/Solar Power Plant will be as under:-

(e). 230V/400V two single circuits individually on two separate bus bars of existing LT distribution panel of METRO Cash & Carry/Consumer.

(11). Any change in the above Interconnection Arrangement duly agreed by Shams Power (Private) Limited and METRO Cash & Carry/Consumer shall be communicated to the Authority in due course of time.

Detail of Generation Facility/Solar Power Plant

(A). General Information

(i).	Name of the Company/ Licensee	Shams Power (Private) Limited
(ii).	Registered/Business Office of the Company	2nd Floor, Al-Maalik Building 19-Davis Road Lahore
(iii).	Principal Office	2nd Floor, Al-Maalik Building 19-Davis Road Lahore
(iv).	Plants Location	METRO Cash & Carry Store, Ravi Road, Lahore
(v).	Field Type	Fixed Tilted Plane
(vi)	Field Parameters	Tilt 3° & Azimuth -38°
(vii).	Type of Generation Facility	Solar Photovoltaic (PV)

(B). Solar Power Generation Technology & Capacity

(i).	Type of Technology	Photovoltaic (PV) Cell
(ii).	Type of Cell	Polycrystalline
(ii).	Type of System	Grid Tied
(iii).	Installed Capacity of the Generation Facility (MW)	0.33264 MW_P DC

(C). Technical Details of Equipment

(a).	**Solar Panels-PV Modules**		
(i).	Type of Module	Polycrystalline PV Type Module CS6U-330P	
(ii).	Surface Area of Module	1.94432 m^2	
(iii).	Dimension of each Module	1960 mm x 992 mm x 40mm	
(iv)	Total area of roof top for Solar Panels-PV Modules	1960 m^2	
(v).	No. of Modules	1008	
(vi).	Frame of Module	Anodised Aluminium Alloy	
(vii).	Weight of one Module	22.4 kg	
(viii).	Module Output Warranty	For 1st Year	For 2nd Year to 25th Year
		97.5% or above	Not more than 0.7% output reduction each year
(ix).	Number of Solar Cells in each Module	72 Cells	
(x).	Efficiency of Module	16.97 %	
(xi).	Environment Protection System	Encapsulation and sealing arrangements for protection from environment.	
(xii).	Maximum Power (P_{max})	330 W_P	
(xiii).	Power Tolerance at STC	0 ~ +5W	
(xiv).	Operating Voltage @ (P_{max})	37.2 V	
(xv).	Operating Current @ (P_{max})	8.88 A	
(xvi).	Open circuit voltage (V_{oc})	45.6 V	
(xvii).	Short circuit current (I_{sc})	9.45 A	

(xviii).	Optimum Operating Voltage at NOCT	33.9 V
(xix).	Optimum Operating Current at NOCT	7.05 A
(xx).	Open circuit voltage (Voc) at NOCT	41.9 V
(xxi).	Maximum system open Circuit Voltage	1000V(IEC) or 1000V (UL) or 600V(UL)
(b).	**PV Array**	
(i).	No. of Arrays	12
(ii).	Modules in a String	14
(iii).	Total No. of Strings	72
(iv).	Modules in Array	84 Modules
(v).	Total Modules	1008
(c).	**PV Capacity**	
(i).	Total Capacity	0.33264 MW_P DC
(ii).	Net Capacity Factor	15.20%
(d).	**Inverters**	
(i).	Maximum DC Power Input	0.299 MW (@50°C)
(ii).	Inverter Model	Sunny Tri power 25000TL (25 KW)
(iii).	Manufacturer	SMA Solar Technology, Germany
(iv).	Maximum DC Input Voltage	DC 1000 V
(v).	Start Voltage	DC 150 V
(vi).	Number of Inverters	12
(vii).	Efficiency	98.3% (Sunny Tri power 25000TL
(viii).	Max. Input Current	DC 66 A
(ix).	MPP Voltage Range	320 V- 800 V DC (@50°C)
(x).	Output electrical system	3-Phase, 4-Wire

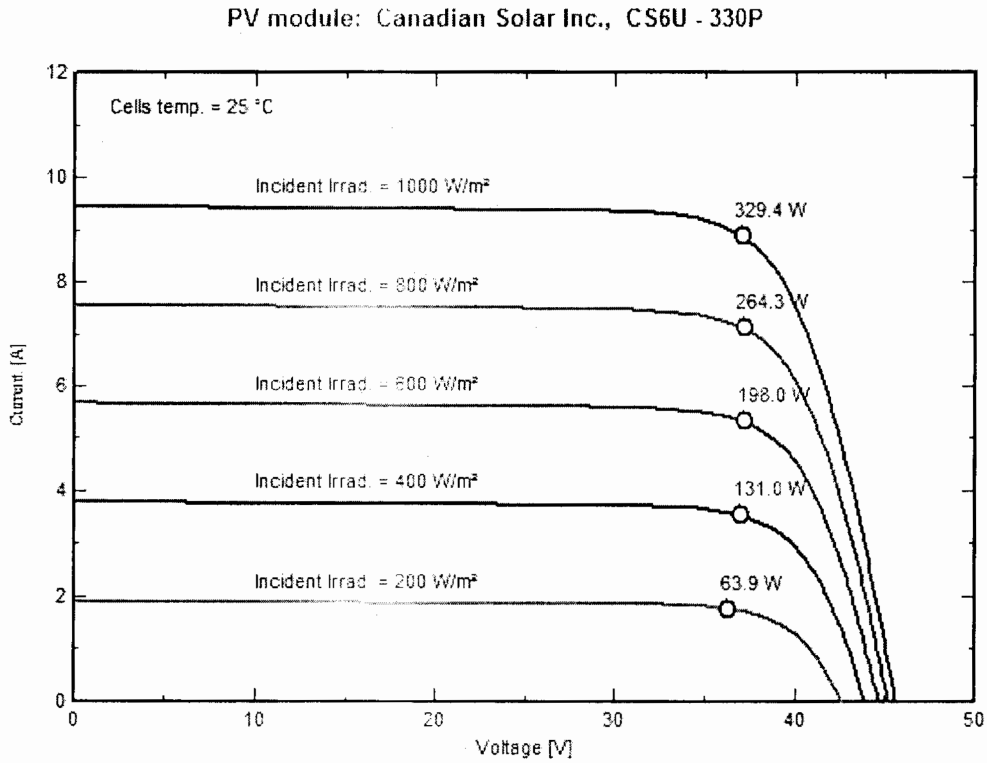
(xi).	Rated Output Voltage	AC 230/400 V	
(xii).	Rated Frequency	50 Hz	
(xiii).	Power Factor	1	
(xiv).	Power Control	MPP Tracker (2 MPPT/Inverter)	
(xv).	Environmental Enclosures	Operating Temperature Range	-25° C to 60° C
		Relative Humidity	100% non-condensing
		Protection Class	IP65
		Audible Noise	51 dB(A)
		Operating Elevation	<3000m
(xvi)	Protection Devices	(a).	DC Disconnect Switch
		(b).	Ground Fault Monitoring
		(c).	Reverse Polarity Protection
		(d).	Reverse current protection
		(e).	Over-voltage protection
(e).	**Junction Boxes**		
(i).	Number of Junction Box units	24	
(ii).	Input circuits in each box	1 box with 3 String inputs and 1 Combined output	
(iii).	Max. Input current for each circuit	15 A	
(iv).	Max. Input voltage	1000 V	
(v).	Power at each box	13.86kW$_p$	
(vi).	Protection Level	IP 65	
(vii).	Over-Current protection	Fuse	
(viii).	DC Disconnect switch	3 per DC Box (on +ve side only)	

(ix).	Surge protection	Yes (>1000V)	
(x).	Purpose of Junction Box	(a).	Combining the strings
		(b).	Short Circuit Protection
		(c).	DC Surge Protection
(f).	**Data Collecting System**		
(i).	Weather Data	(a).	Irradiance Meter (Survey 100/200R)- 1 Set (to record ambient temp& radiation level)
(ii).	System Data	(a).	DC input voltage (V) & current (A) of each Inverter (Phase, Line)
		(b).	Total DC power (kW) generated by PV array.
		(c).	AC output voltage(V) and current (A) of each Inverter (Phase, Total)
		(d).	AC output power (kW) and energy (kWh) of each Inverter
		(e).	Frequency (Hz)
		(f).	Power Factor (PF)

(D). Other Details

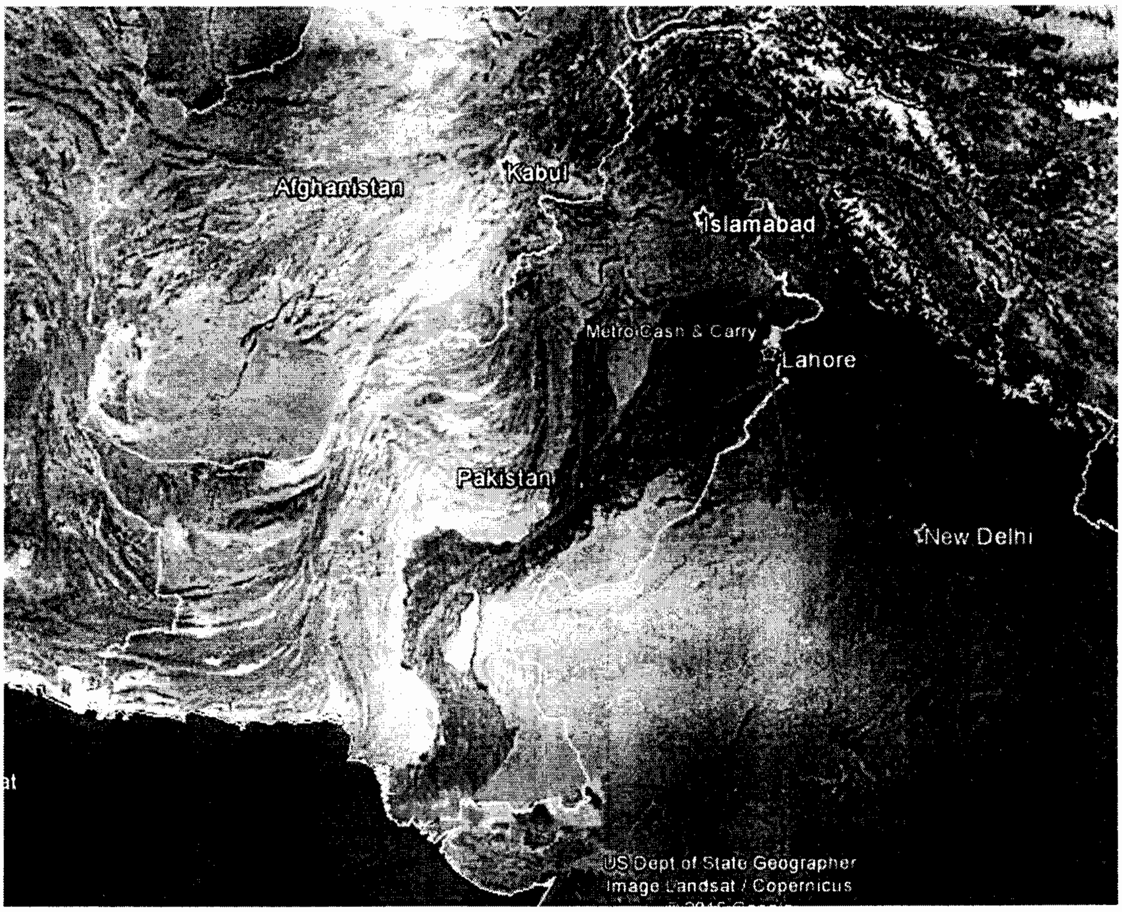
(i).	COD of the Project	Nov 12, 2017
(ii).	Expected Life of the Project from the COD	25 Years

VI Curve of Solar Panel at STC for the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL

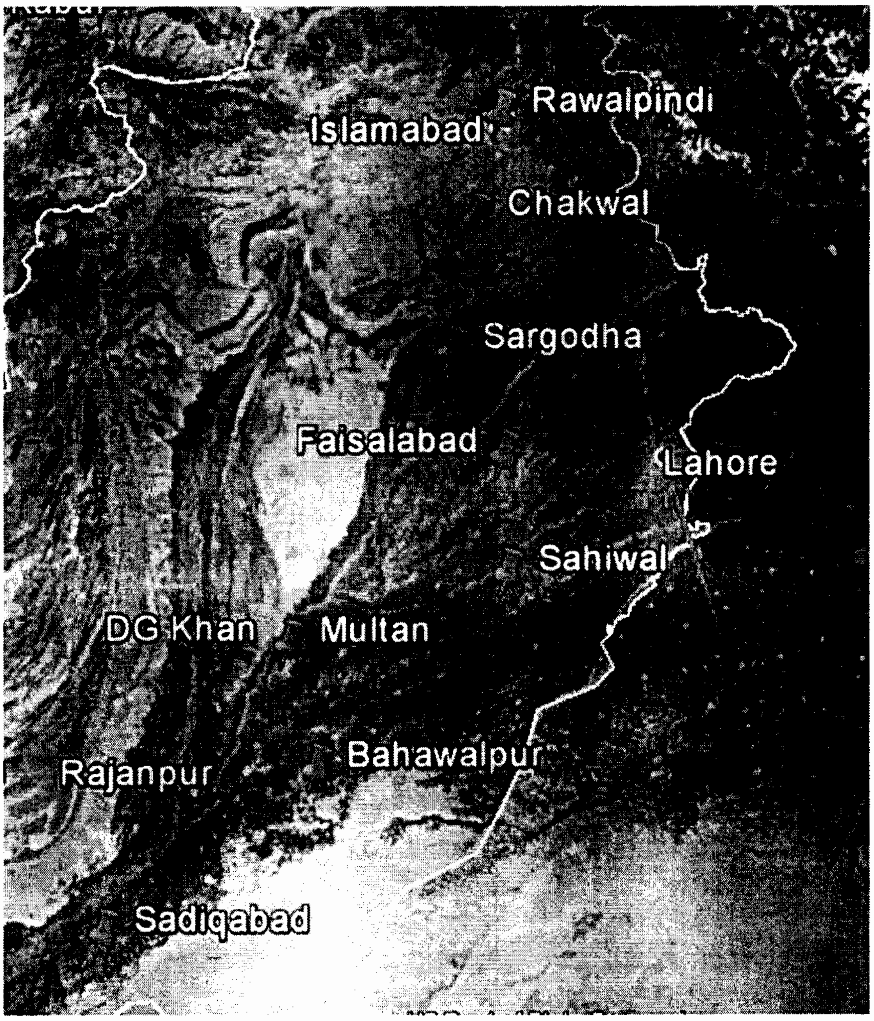


5. METRO Cash & Carry, Model Town, Lahore

Location of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of Pakistan



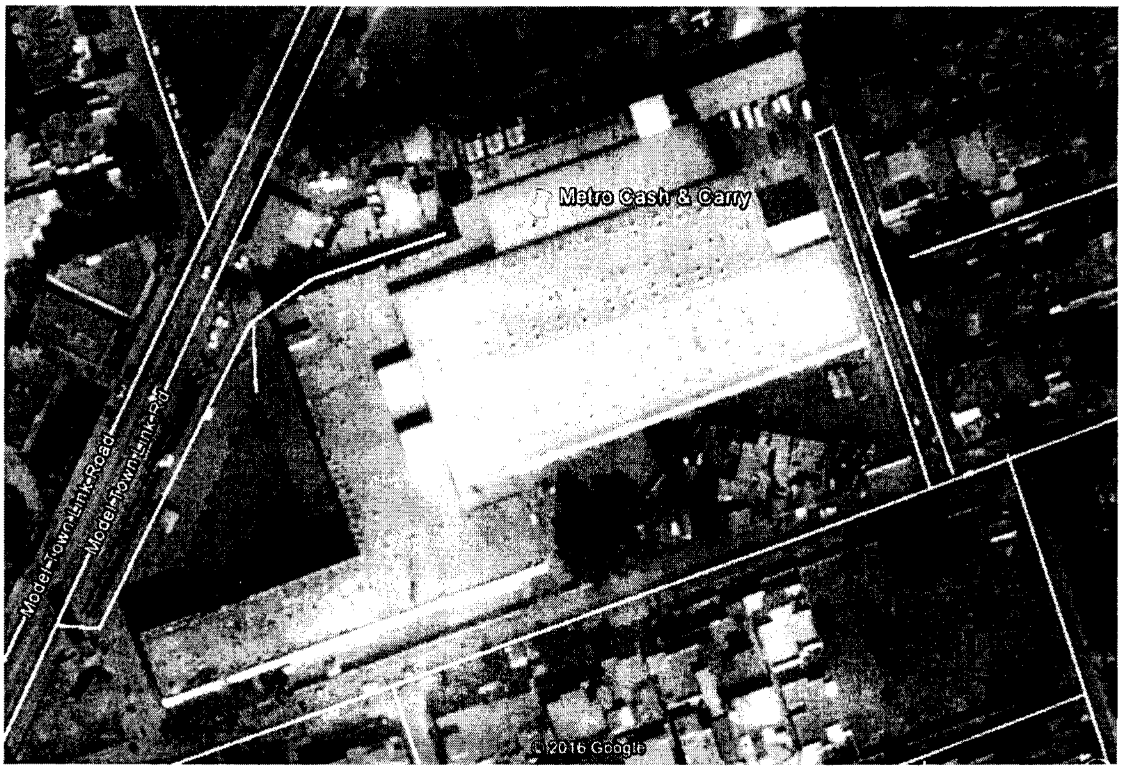
Location of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of the Province of Punjab



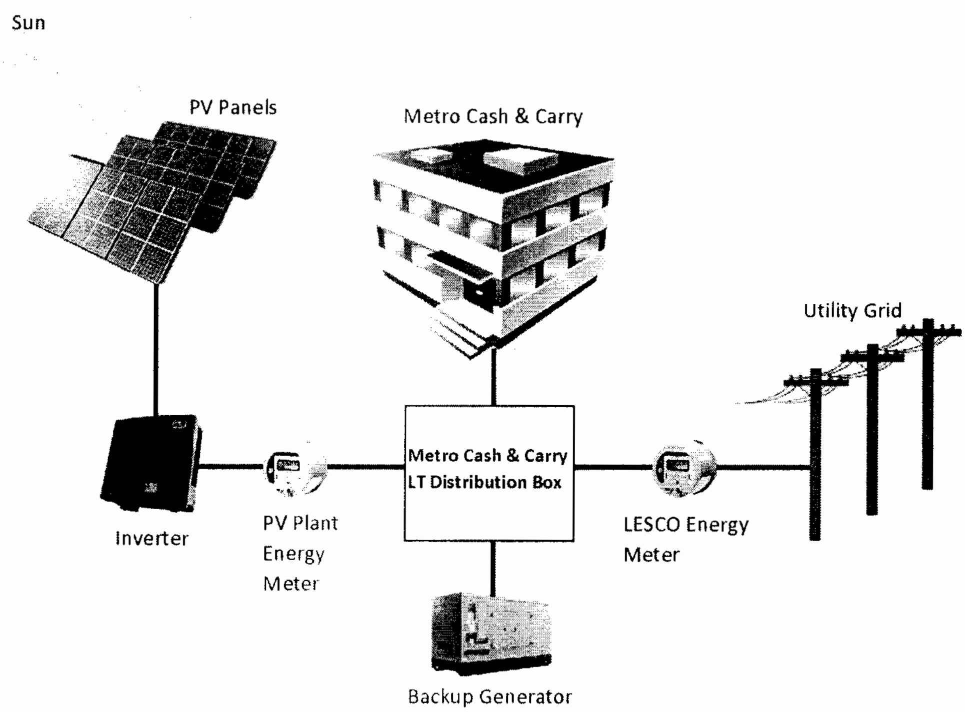
Location of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of Lahore

Access Road/Link of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of Lahore

Location of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL



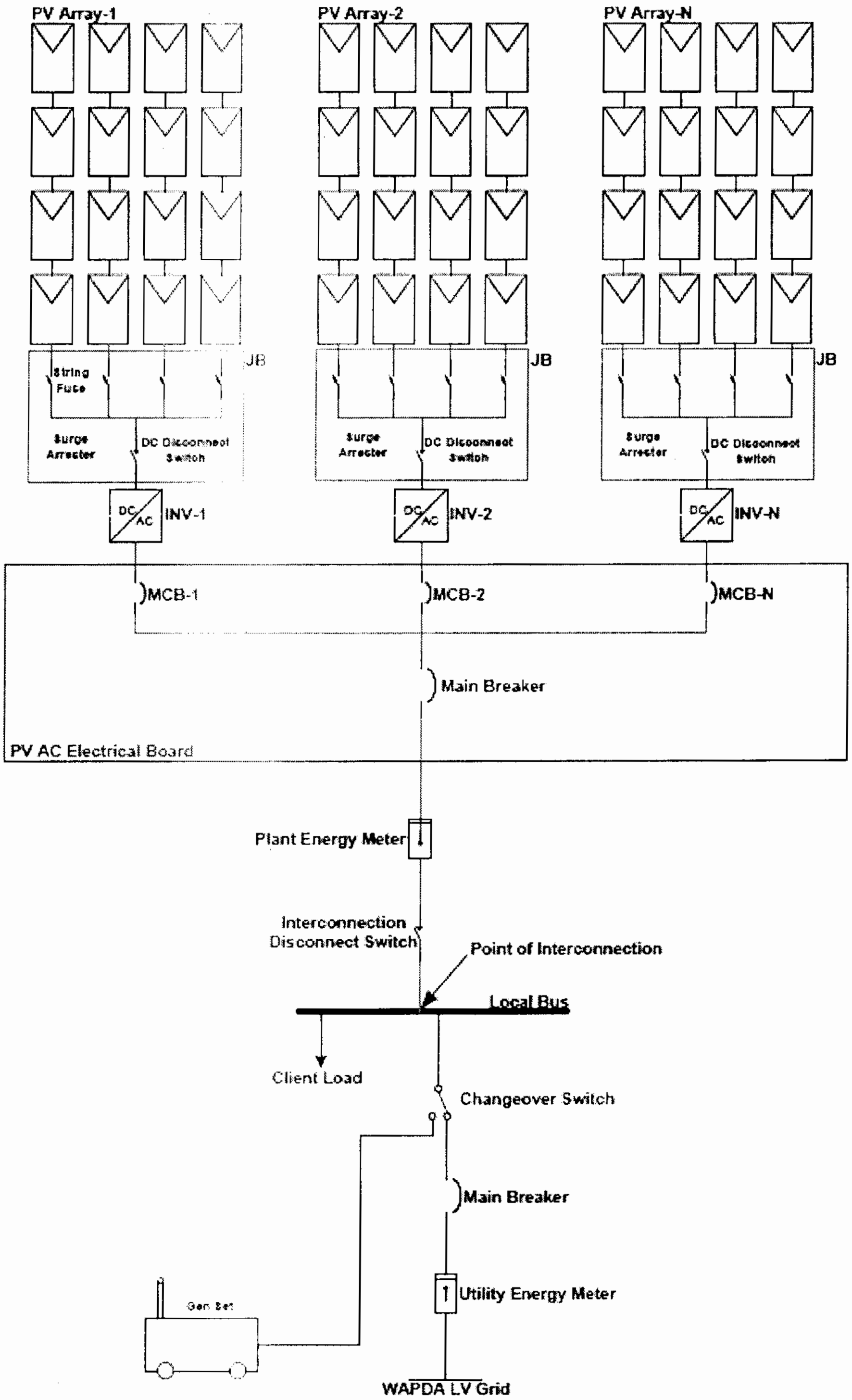
Process Flow Diagram of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL



Location Coordinates of the Generation Facility/Solar Farm/Power Plant of the Licensee/SPPL

Latitude (North)	Longitude (East)
31°28'20.92"	74°19'13.48"

Single Line Diagram of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL



Interconnection

Arrangement for Dispersal of Power from the Generation Facility/Solar Power Plant of Shams Power (Private) Limited

The power generated from the Generation Facility/Power Plant of Shams Power (Private) Limited shall be dispersed at roof top of METRO Cash & Carry, Link Road Model Town Lahore for in-house utilization

(12). The proposed Interconnection Arrangement for dispersal of electric power for the Generation Facility/Solar Power Plant will be as under:-

(f). 230V/400V two single circuits individually on two separate bus bars of existing LT distribution panel of METRO Cash & Carry/Consumer.

(13). Any change in the above Interconnection Arrangement duly agreed by Shams Power (Private) Limited and METRO Cash & Carry/Consumer shall be communicated to the Authority in due course of time.

Detail of Generation Facility/Solar Power Plant

(A). General Information

(i).	Name of the Company/ Licensee	Shams Power (Private) Limited
(ii).	Registered/Business Office of the Company	2nd Floor, Al-Maalik Building 19-Davis Road Lahore
(iii).	Principal Office	2nd Floor, Al-Maalik Building 19-Davis Road Lahore
(iv).	Plants Location	METRO Cash & Carry Store, Link Road Model Town Lahore
(v).	Field Type	Fixed Tilted Plane
(vi)	Field Parameters	Tilt 8° & Azimuth 20°
(vii).	Type of Generation Facility	Solar Photovoltaic (PV)

(B). Solar Power Generation Technology & Capacity

(i).	Type of Technology	Photovoltaic (PV) Cell
(ii).	Type of Cell	Polycrystalline
(ii).	Type of System	Grid Tied
(iii).	Installed Capacity of the Generation Facility (MW)	0.24948 MW_P DC

(C). Technical Details of Equipment

(a).	Solar Panels-PV Modules		
(i).	Type of Module	Polycrystalline PV Type Module CS6U-330P	
(ii).	Surface Area of Module	1.94432 m^2	
(iii).	Dimension of each Module	1960 mm x 992 mm x 40mm	
(iv)	Total area of roof top for Solar Panels-PV Modules	1470 m^2	
(v).	No. of Modules	756	
(vi).	Frame of Module	Anodised Aluminium Alloy	
(vii).	Weight of one Module	22.4 kg	
(viii).	Module Output Warranty	For 1st Year	For 2nd Year to 25th Year
		97.5% or above	Not more than 0.7% output reduction each year
(ix).	Number of Solar Cells in each Module	72 Cells	
(x).	Efficiency of Module	16.97 %	
(xi).	Environment Protection System	Encapsulation and sealing arrangements for protection from environment.	
(xii).	Maximum Power (P_{max})	330 W_P	
(xiii).	Power Tolerance at STC	0 ~ +5W	
(xiv).	Operating Voltage @ (P_{max})	37.2 V	
(xv).	Operating Current @ (P_{max})	8.88 A	
(xvi).	Open circuit voltage (V_{oc})	45.6 V	
(xvii).	Short circuit current (I_{sc})	9.45 A	

(xviii).	Optimum Operating Voltage at NOCT	33.9 V
(xix).	Optimum Operating Current at NOCT	7.05 A
(xx).	Open circuit voltage (Voc) at NOCT	41.9 V
(xxi).	Maximum system open Circuit Voltage	1000V(IEC) or 1000V (UL) or 600V(UL)
(b).	**PV Array**	
(i).	No. of Arrays	9
(ii).	Modules in a String	14
(iii).	Total No. of Strings	54
(iv).	Modules in Array	84 Modules
(v).	Total Modules	756
(c).	**PV Capacity**	
(i).	Total Capacity	0.249480 MW_P DC
(ii).	Net Capacity Factor	15.68%
(d).	**Inverters**	
(i).	Maximum DC Power Input	0.223 MW (@50°C)
(ii).	Inverter Model	Sunny Tri power 25000TL (25 KW)
(iii).	Manufacturer	SMA Solar Technology, Germany
(iv).	Maximum DC Input Voltage	DC 1000 V
(v).	Start Voltage	DC 150 V
(vi).	Number of Inverters	9
(vii).	Efficiency	98.3% (Sunny Tri power 25000TL)
(viii).	Max. Input Current	DC 66 A
(ix).	MPP Voltage Range	320 V- 800 V DC (@50°C)
(x).	Output electrical system	3-Phase, 4-Wire

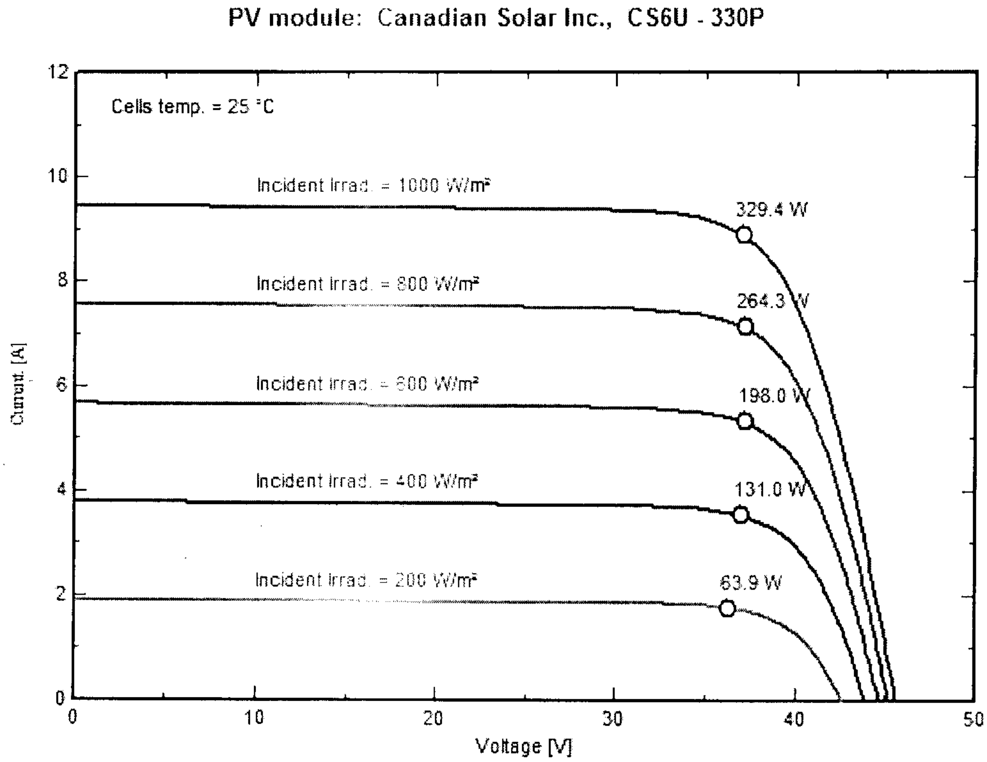
(xi).	Rated Output Voltage	AC 230/400 V	
(xii).	Rated Frequency	50 Hz	
(xiii).	Power Factor	1	
(xiv).	Power Control	MPP Tracker (2 MPPT/Inverter)	
(xv).	Environmental Enclosures	Operating Temperature Range	-25° C to 60° C
		Relative Humidity	100% non-condensing
		Protection Class	IP65
		Audible Noise	51 dB(A)
		Operating Elevation	<3000m
(xvi)	Protection Devices	(a).	DC Disconnect Switch
		(b).	Ground Fault Monitoring
		(c).	Reverse Polarity Protection
		(d).	Reverse current protection
		(e).	Over-voltage protection
(e).	**Junction Boxes**		
(i).	Number of Junction Box units	18	
(ii).	Input circuits in each box	1 box with 3 String inputs and 1 Combined output	
(iii).	Max. Input current for each circuit	15 A	
(iv).	Max. Input voltage	1000 V	
(v).	Power at each box	13.86kW$_p$	
(vi).	Protection Level	IP 65	
(vii).	Over-Current protection	Fuse	
(viii).	Surge protection	Yes (>1000V)	

(ix).	Purpose of Junction Box	(a).	Combining the strings
		(b).	Short Circuit Protection
		(c).	DC Surge Protection
(f).	**Data Collecting System**		
(i).	Weather Data	(a).	Irradiance Meter (Survey 100/200R)- 1 Set (to record ambient temp& radiation level)
(ii).	System Data	(a).	DC input voltage (V) & current (A) of each Inverter (Phase, Line)
		(b).	Total DC power (kW) generated by PV array.
		(c).	AC output voltage(V) and current (A) of each Inverter (Phase, Total)
		(d).	AC output power (kW) and energy (kWh) of each Inverter
		(e).	Frequency (Hz)
		(f).	Power Factor (PF)

(D). Other Details

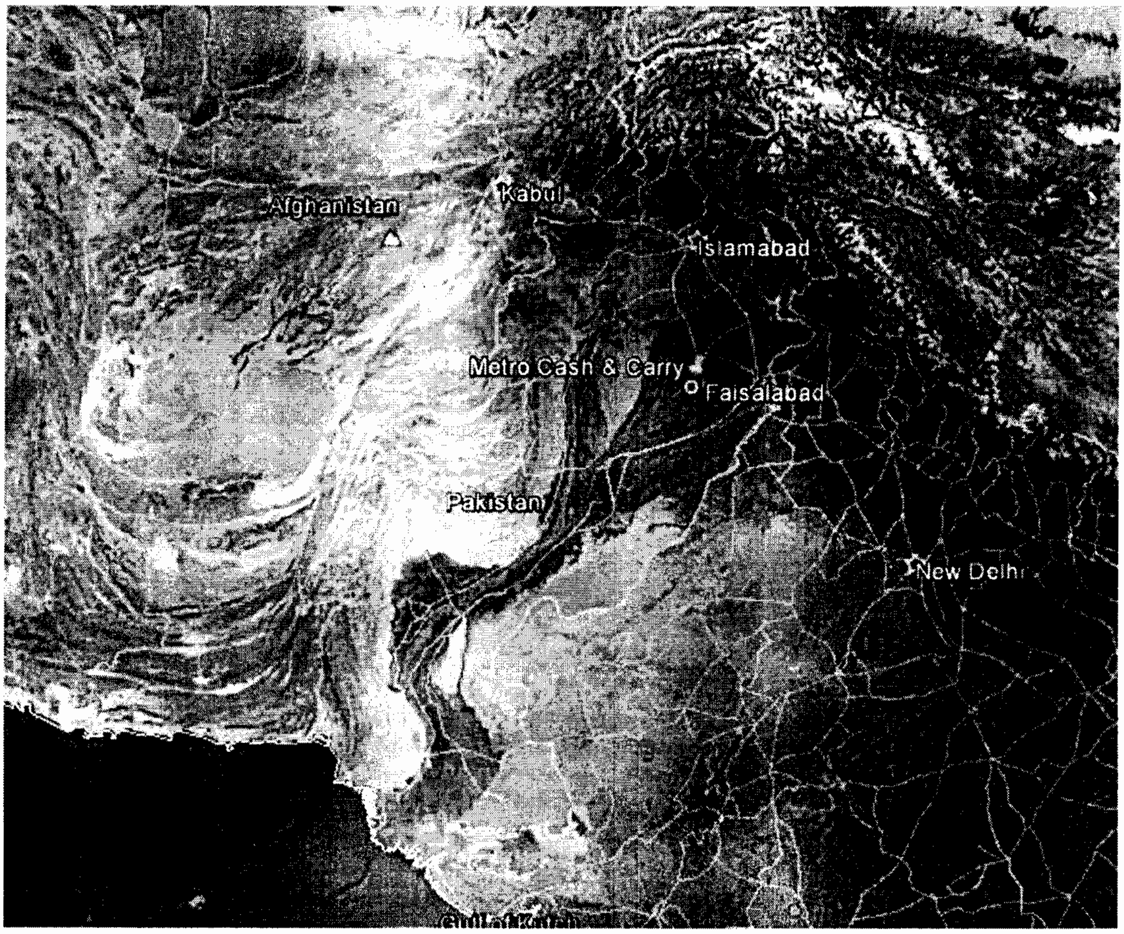
(i).	COD of the Project	September 15, 2017
(ii).	Expected Life of the Project from the COD	25 Years

VI Curve of Solar Panel at STC for the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL

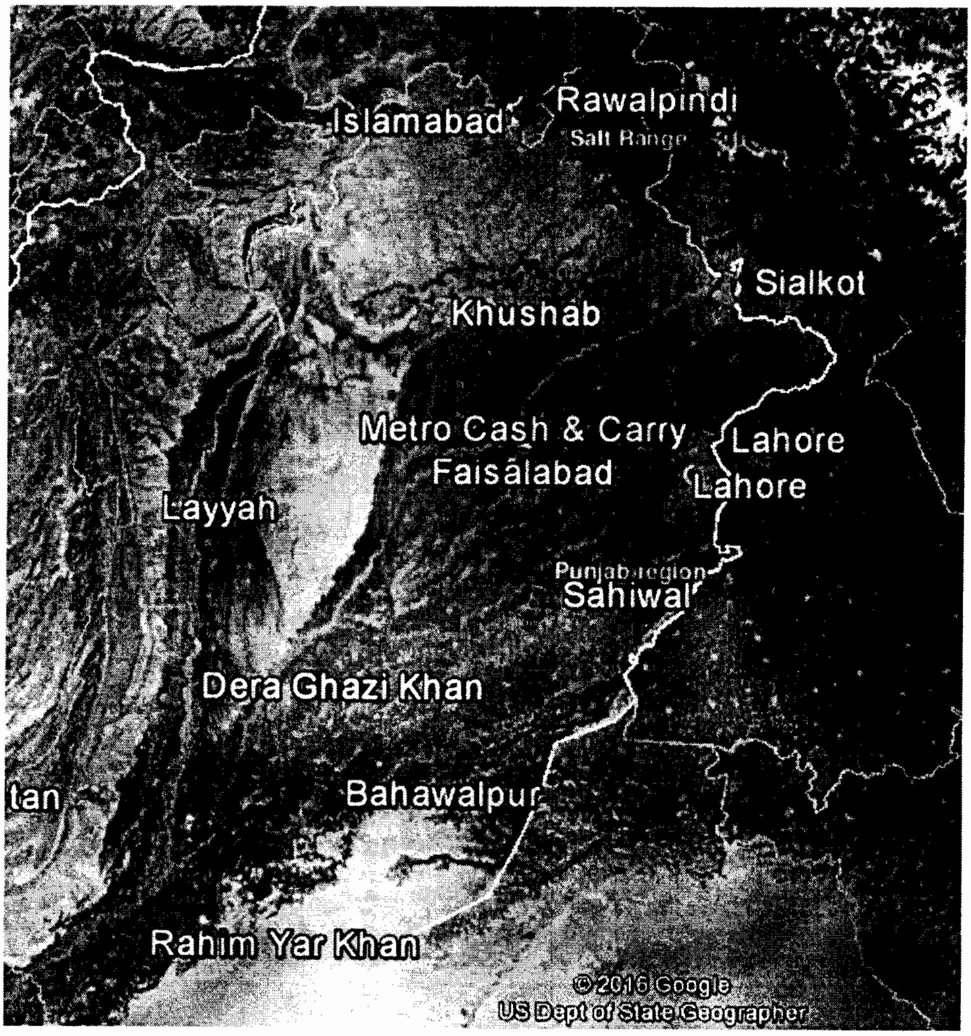


6. METRO Cash & Carry, Sargodha Road, Faisalabad

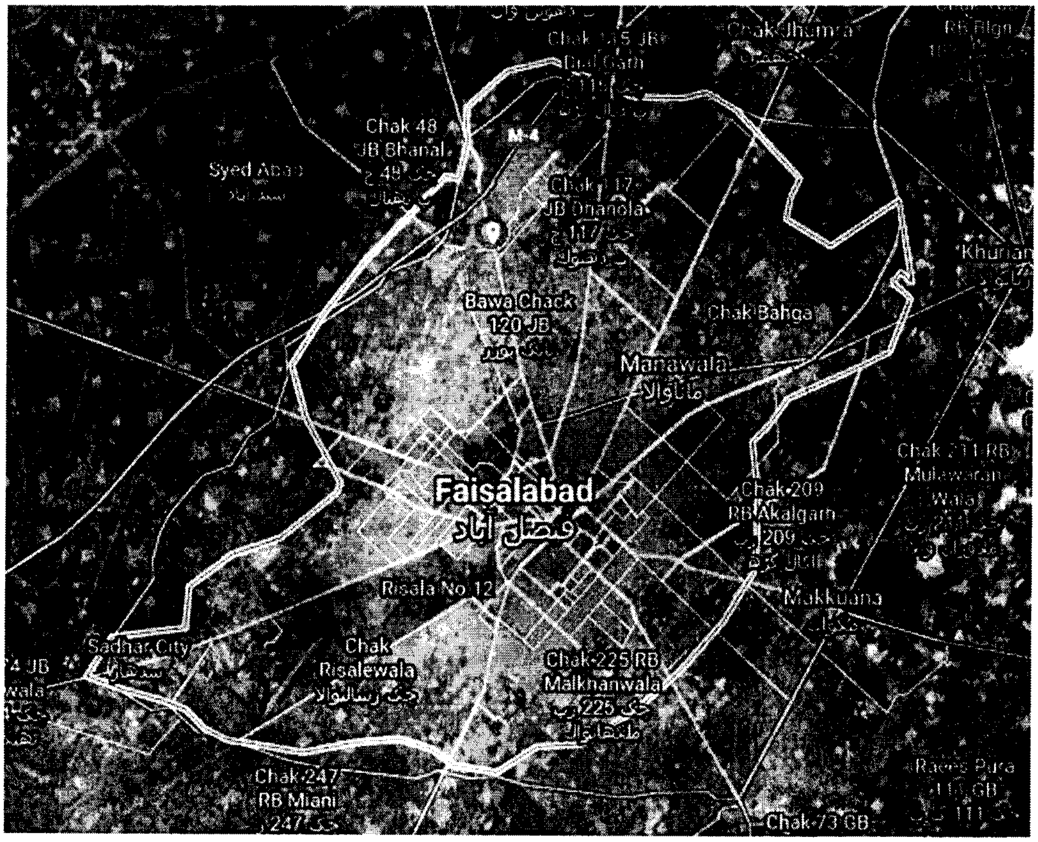
Location of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of Pakistan



Location of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of the Province of Punjab

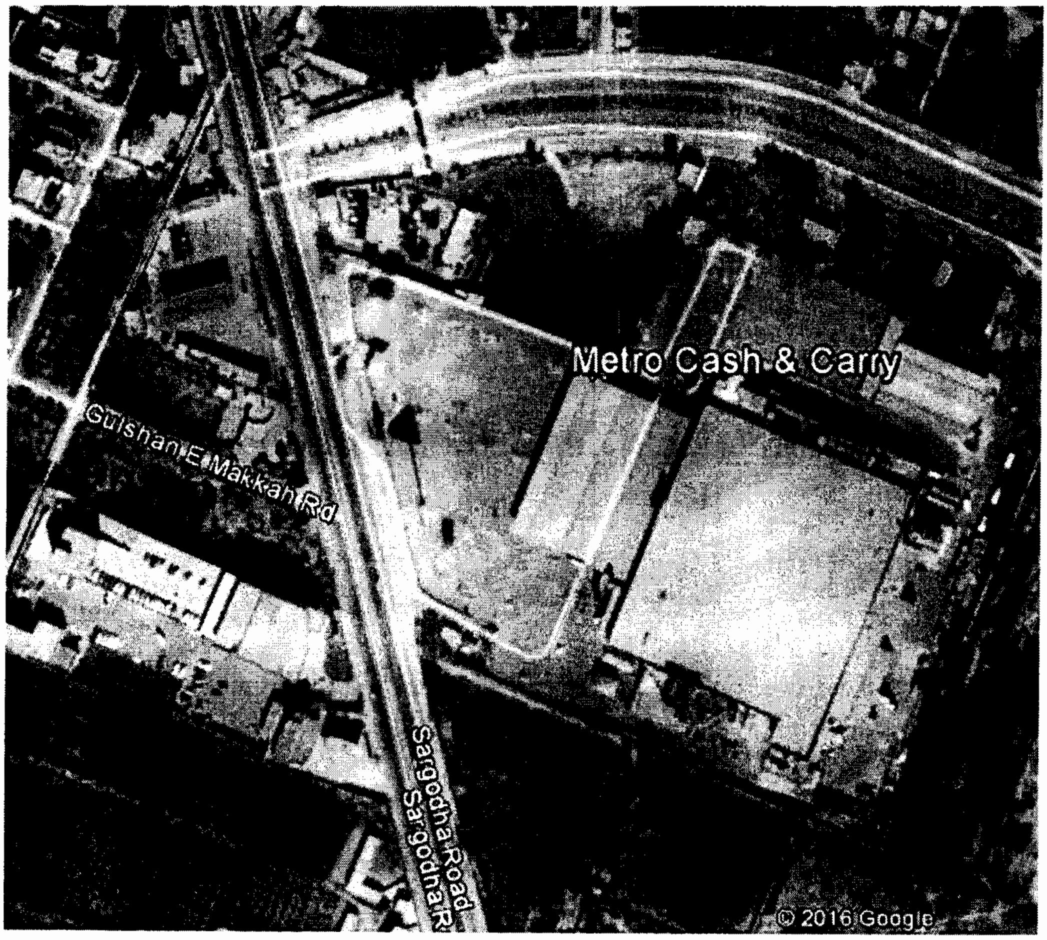


Location of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of Faisalabad

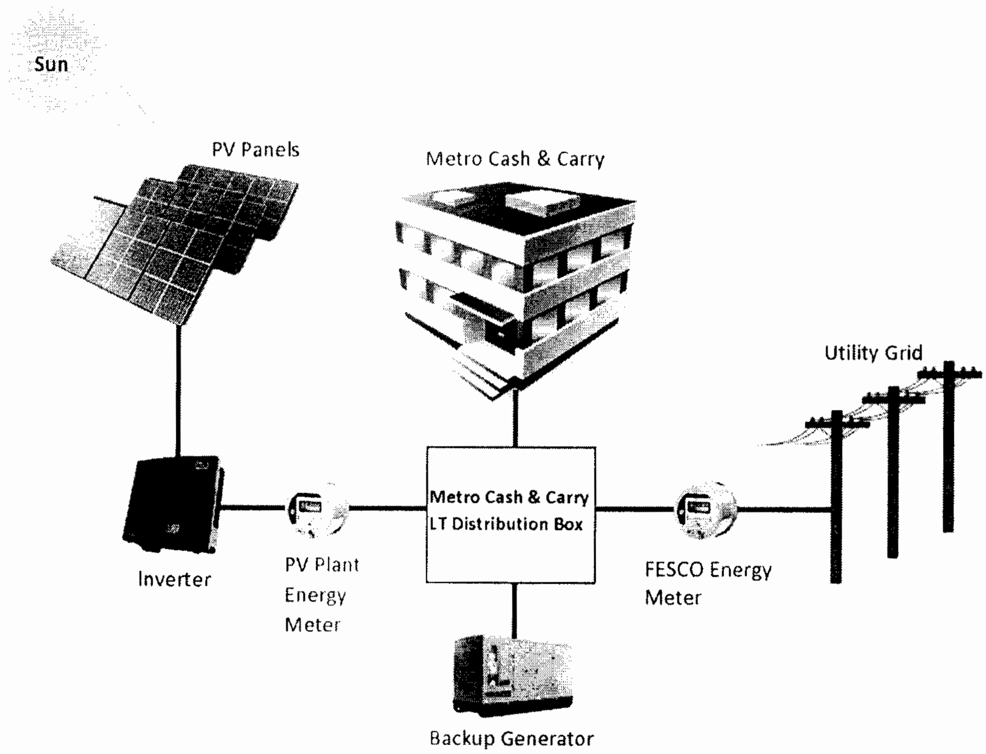


Access Road/Link of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of Faisalabad

<u>**Location of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL**</u>



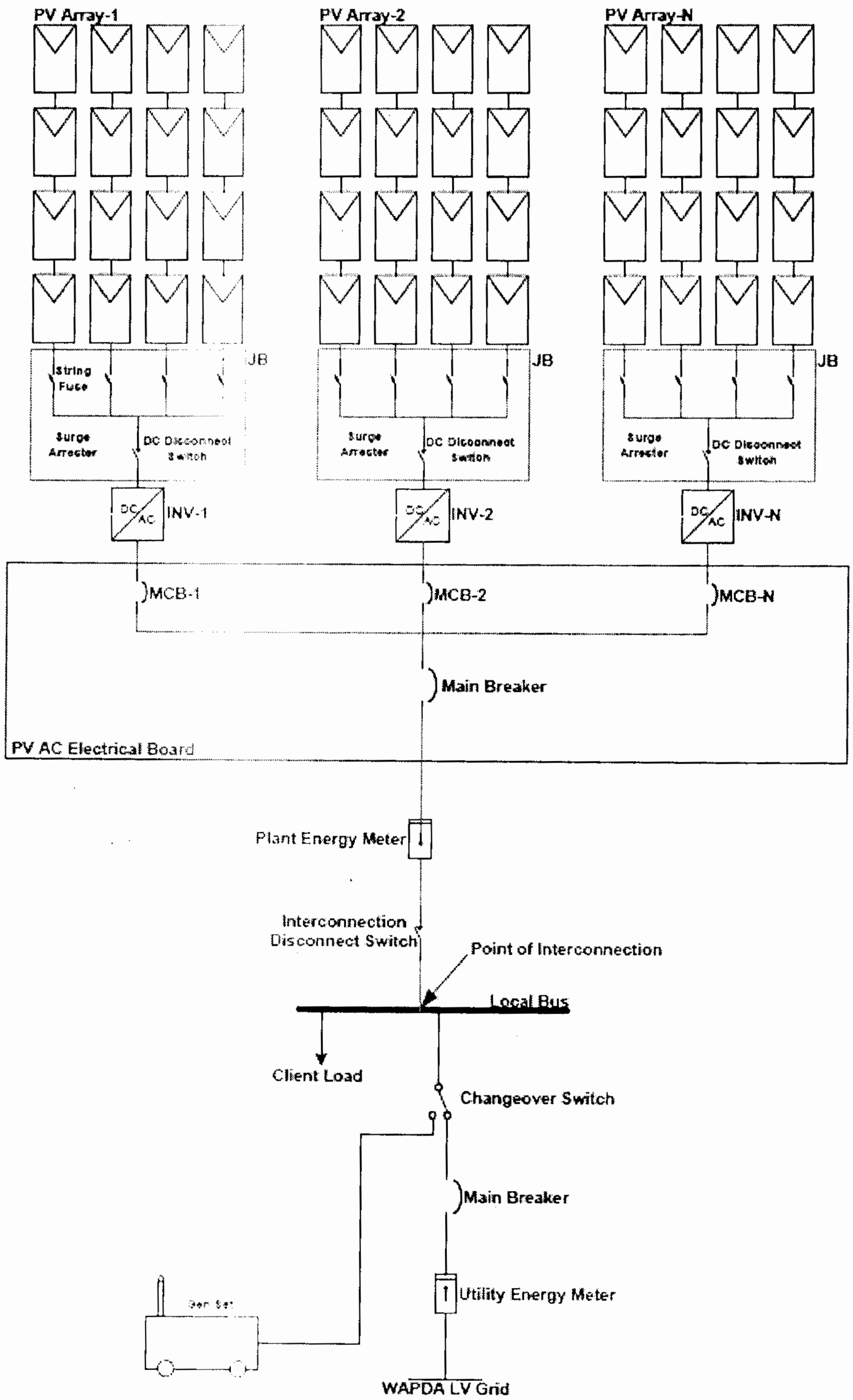
Process Flow Diagram of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL



<u>**Location Coordinates of the Generation Facility/Solar Farm/Power Plant of the Licensee/SPPL**</u>

Latitude (North)	Longitude (East)
31°30'29.87"	73° 4'14.46"

Single Line Diagram of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL



Interconnection

Arrangement for Dispersal of Power from the Generation Facility/Solar Power Plant of Shams Power (Private) Limited

The power generated from the Generation Facility/Power Plant of Shams Power (Private) Limited shall be dispersed at roof top of METRO Cash & Carry, Sargodha Road, Faisalabad for in-house utilization.

(14). The proposed Interconnection Arrangement for dispersal of electric power for the Generation Facility/Solar Power Plant will be as under:-

(g). 230V/400V two single circuits individually on two seperate bus bars of existing LT distribution panel of METRO Cash & Carry/Consumer.

(15). Any change in the above Interconnection Arrangement duly agreed by Shams Power (Private) Limited and METRO Cash & Carry/Consumer shall be communicated to the Authority in due course of time.

Detail of Generation Facility/Solar Power Plant

(A). General Information

(i).	Name of the Company/ Licensee	Shams Power (Private) Limited
(ii).	Registered/Business Office of the Company	2nd Floor, Al-Maalik Building 19-Davis Road Lahore
(iii).	Principal Office	2nd Floor, Al-Maalik Building 19-Davis Road Lahore
(iv).	Plants Location	METRO Cash & Carry Store, Sargodha Road, Faisalabad
(v).	Field Type	Fixed Tilted Plane
(vi)	Field Parameters	Tilt 2° & Azimuth 22°
(vii).	Type of Generation Facility	Solar Photovoltaic (PV)

(B). Solar Power Generation Technology & Capacity

(i).	Type of Technology	Photovoltaic (PV) Cell
(ii).	Type of Cell	Polycrystalline
(ii).	Type of System	Grid Tied
(iii).	Installed Capacity of the Generation Facility (MW)	0.297 MW_P DC

(C). Technical Details of Equipment

(a).	Solar Panels-PV Modules		
(i).	Type of Module	Polycrystalline PV Type Module CS6U-330P	
(ii).	Surface Area of Module	1.94432 m^2	
(iii).	Dimension of each Module	1960 mm x 992 mm x 40mm	
(iv)	Total area of roof top for Solar Panels-PV Modules	1750 m^2	
(v).	No. of Modules	900	
(vi).	Frame of Module	Anodised Aluminium Alloy	
(vii).	Weight of one Module	22.4 kg	
(viii).	Module Output Warranty	For 1st Year	For 2nd Year to 25th Year
		97.5% or above	Not more than 0.7% output reduction each year
(ix).	Number of Solar Cells in each Module	72 Cells	
(x).	Efficiency of Module	16.97 %	
(xi).	Environment Protection System	Encapsulation and sealing arrangements for protection from environment.	
(xii).	Maximum Power (P_{max})	330 W_P	
(xiii).	Power Tolerance at STC	0 ~ +5W	
(xiv).	Operating Voltage @ (P_{max})	37.2 V	
(xv).	Operating Current @ (P_{max})	8.88 A	
(xvi).	Open circuit voltage (V_{oc})	45.6 V	
(xvii).	Short circuit current (I_{sc})	9.45 A	

(xviii).	Optimum Operating Voltage at NOCT	33.9 V
(xix).	Optimum Operating Current at NOCT	7.05 A
(xx).	Open circuit voltage (Voc) at NOCT	41.9 V
(xxi).	Maximum system open Circuit Voltage	1000V(IEC) or 1000V (UL) or 600V(UL)
(b).	**PV Array**	
(i).	No. of Arrays	10
(ii).	Modules in a String	15
(iii).	Total No. of Strings	60
(iv).	Modules in Array	90 Modules
(v).	Total Modules	900
(c).	**PV Capacity**	
(i).	Total Capacity	0.297 MW_P DC
(ii).	Net Capacity Factor	15.91%
(d).	**Inverters**	
(i).	Maximum DC Power Input	0.266 MW (@50°C)
(ii).	Inverter Model	Sunny Tri power 25000TL (25 KW)
(iii).	Manufacturer	SMA Solar Technology, Germany
(iv).	Maximum DC Input Voltage	DC 1000 V
(v).	Start Voltage	DC 150 V
(vi).	Number of Inverters	10
(vii).	Efficiency	98.3% (Sunny Tri power 25000TL)
(viii).	Max. Input Current	DC 66 A
(ix).	MPP Voltage Range	320 V- 800 V DC (@50°C)
(x).	Output electrical system	3-Phase, 4-Wire

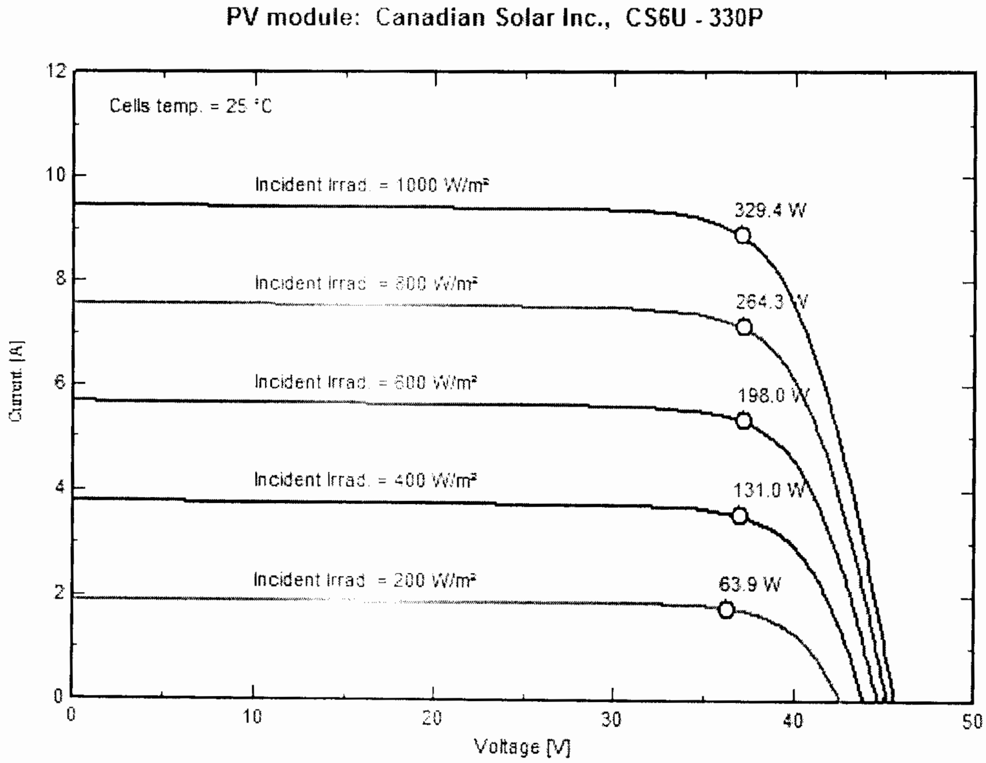
(xi).	Rated Output Voltage	AC 230/400 V	
(xii).	Rated Frequency	50 Hz	
(xiii).	Power Factor	1	
(xiv).	Power Control	MPP Tracker (2 MPPT/Inverter)	
(xv).	Environmental Enclosures	Operating Temperature Range	-25° C to 60° C
		Relative Humidity	100% non-condensing
		Protection Class	IP65
		Audible Noise	51 dB(A)
		Operating Elevation	<3000m
(xvi)	Protection Devices	(a).	DC Disconnect Switch
		(b).	Ground Fault Monitoring
		(c).	Reverse Polarity Protection
		(d).	Reverse current protection
		(e).	Over-voltage protection
(e).	**Junction Boxes**		
(i).	Number of Junction Box units	20	
(ii).	Input circuits in each box	1 box with 3 String inputs and 1 Combined output	
(iii).	Max. Input current for each circuit	15 A	
(iv).	Max. Input voltage	1000 V	
(v).	Power at each box	$14.85kW_p$	
(vi).	Protection Level	IP 65	
(vii).	Over-Current protection	Fuse	
(viii).	Surge protection	Yes (>1000V)	

(ix).	Purpose of Junction Box	(a).	Combining the strings
		(b).	Short Circuit Protection
		(c).	DC Surge Protection
(f).	**Data Collecting System**		
(i).	Weather Data	(a).	Irradiance Meter (Survey 100/200R)- 1 Set (to record ambient temp& radiation level)
(ii).	System Data	(a).	DC input voltage (V) & current (A) of each Inverter (Phase, Line)
		(b).	Total DC power (kW) generated by PV array.
		(c).	AC output voltage(V) and current (A) of each Inverter (Phase, Total)
		(d).	AC output power (kW) and energy (kWh) of each Inverter
		(e).	Frequency (Hz)
		(f).	Power Factor (PF)

(D). Other Details

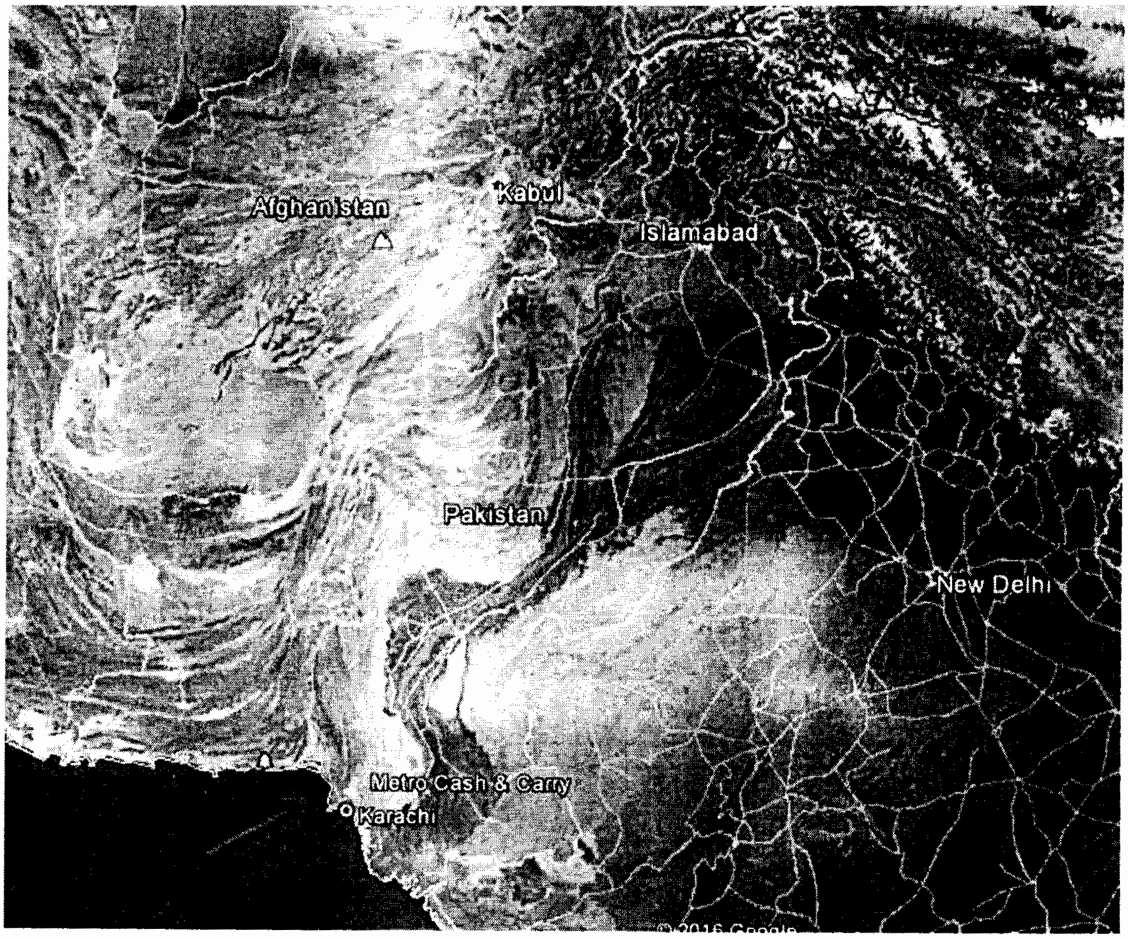
(i).	COD of the Project	May 17, 2018
(ii).	Expected Life of the Project from the COD	25 Years

VI Curve of Solar Panel at STC for the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL

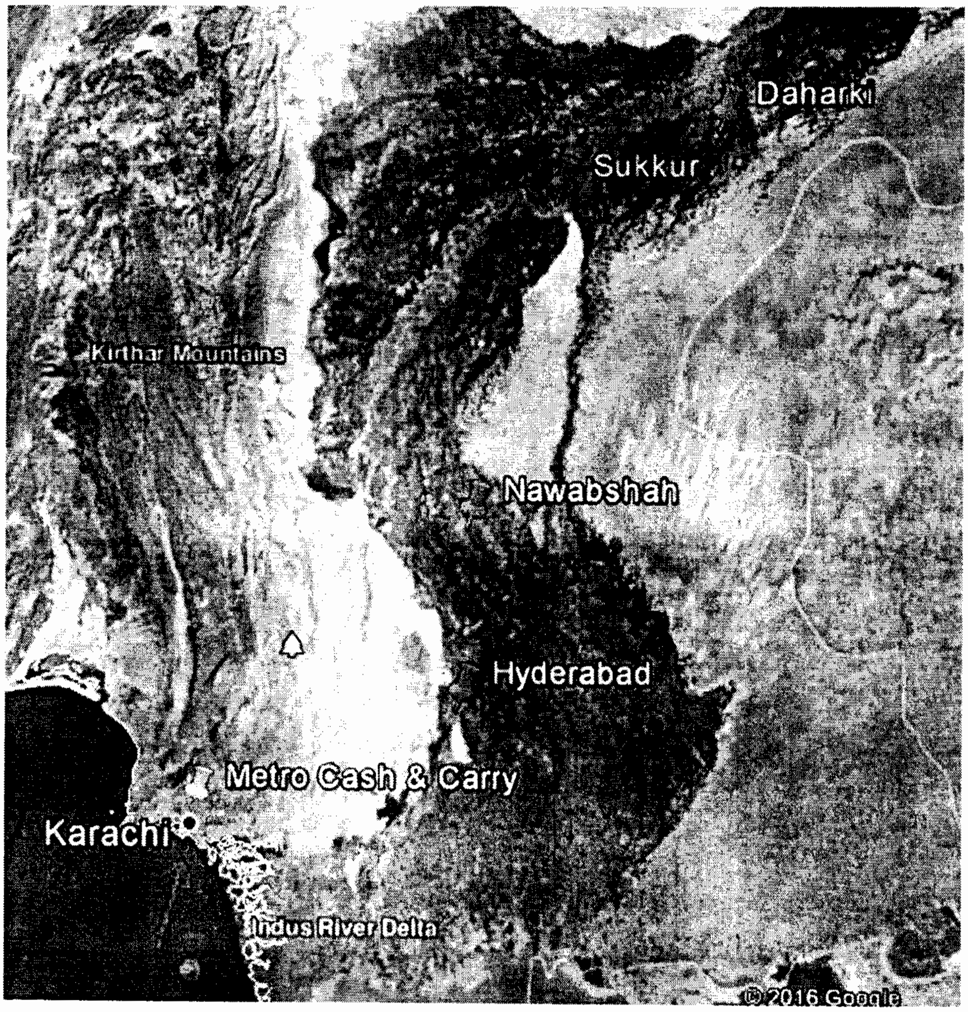


7. METRO Cash & Carry, Manghopir Road, Karachi

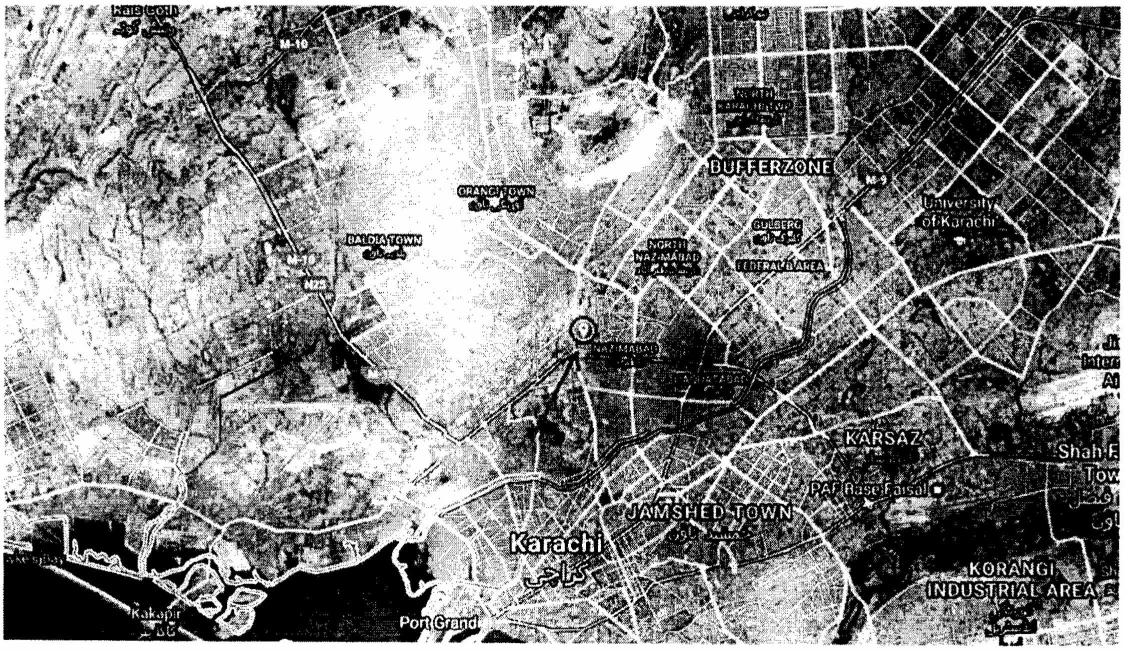
Location of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of Pakistan



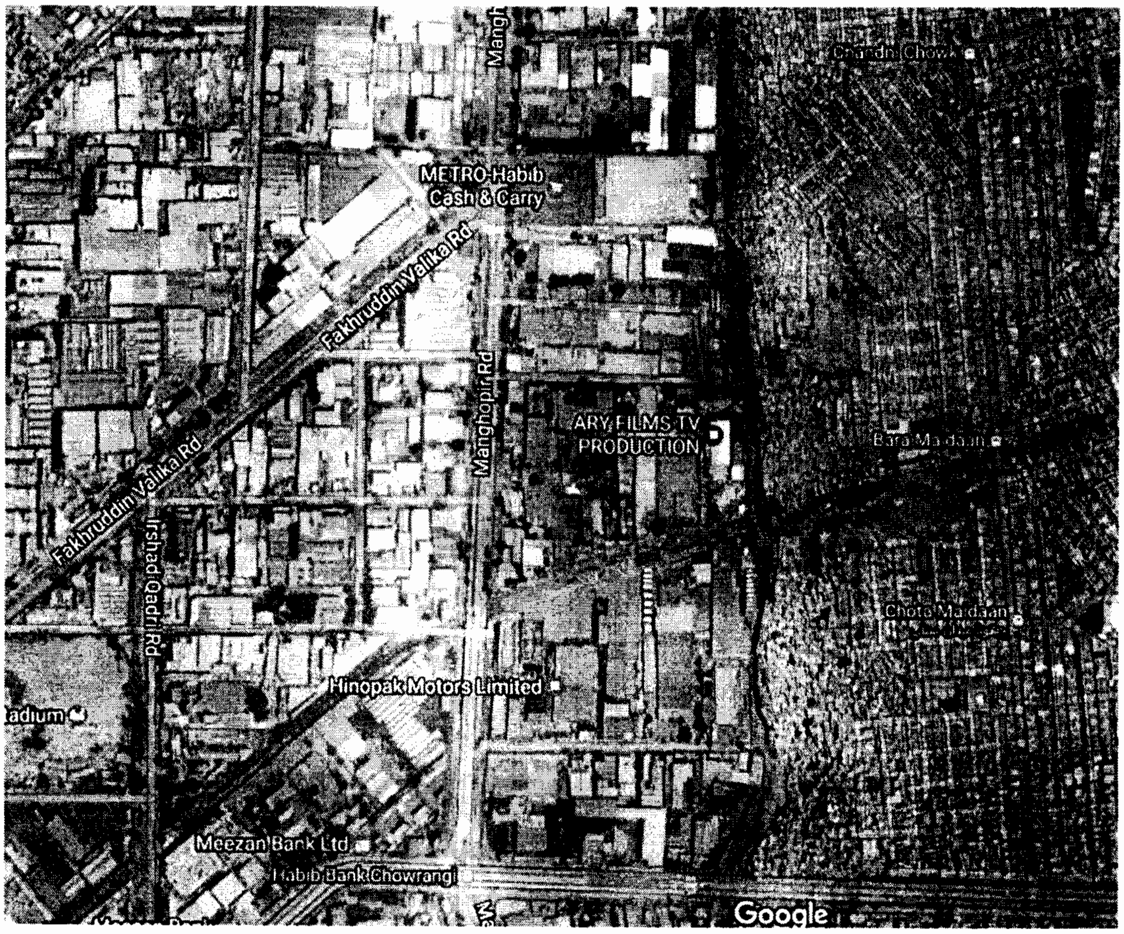
Location of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of the Province of Sindh



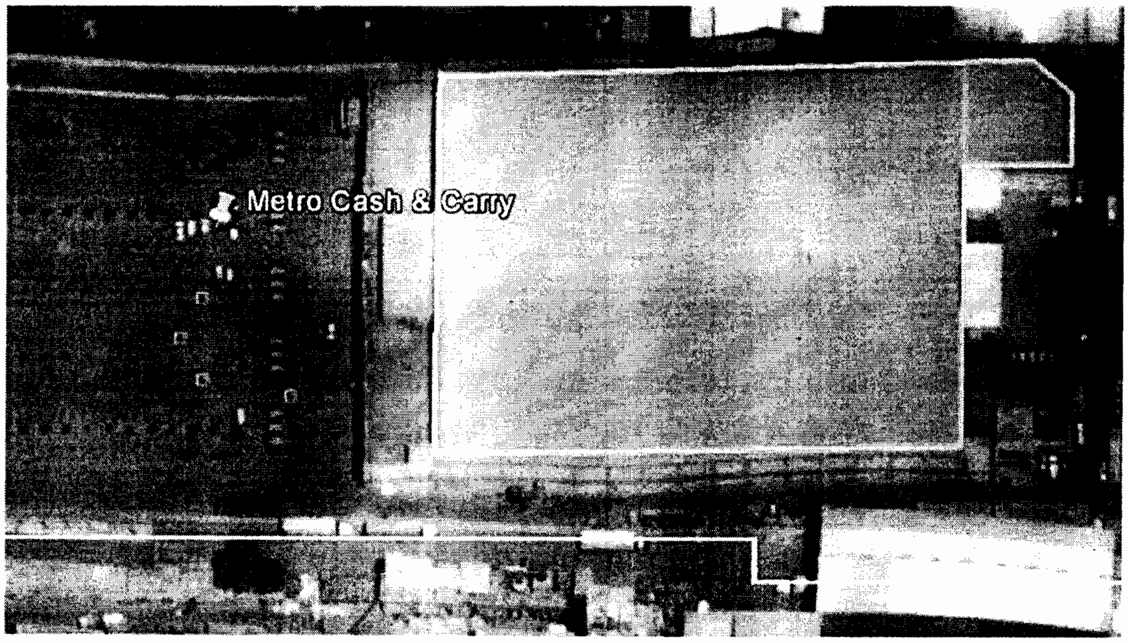
Location of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of Karachi



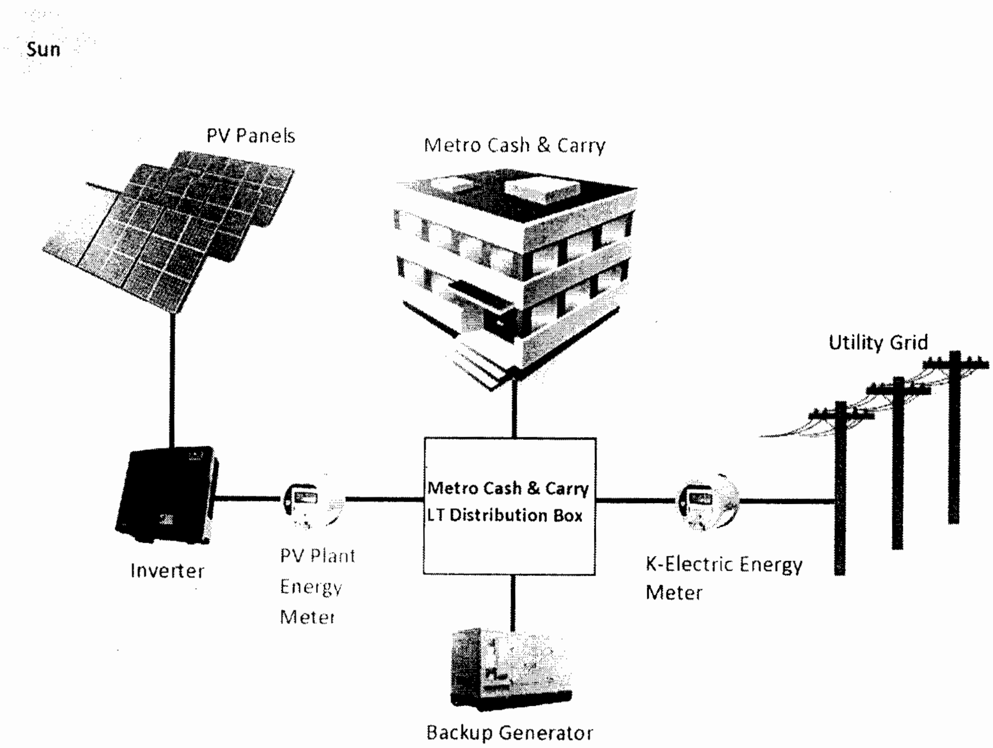
Access Road/Link of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of Karachi



Location of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL



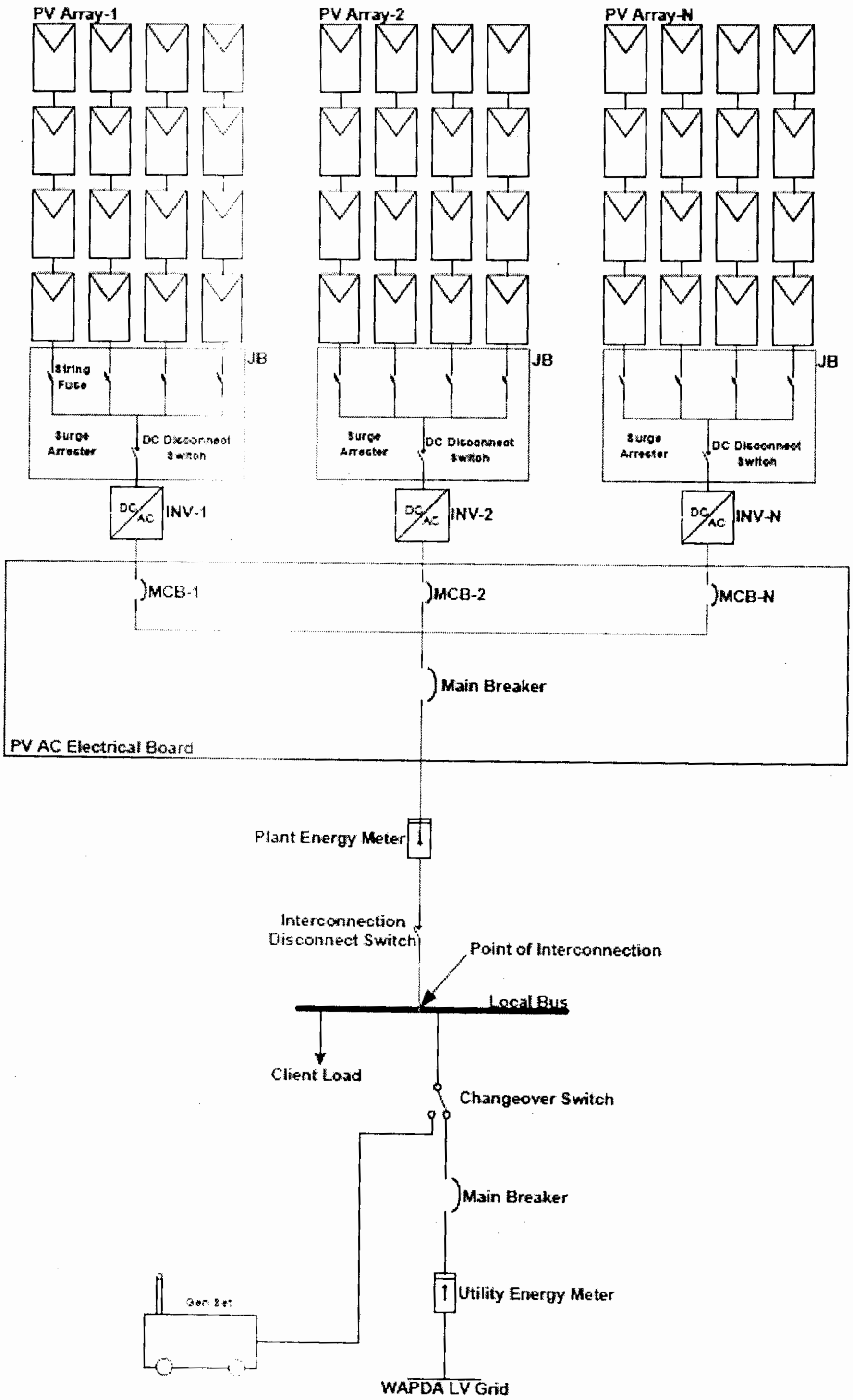
Process Flow Diagram of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL



Location Coordinates of the Generation Facility/Solar Farm/Power Plant of the Licensee/SPPL

Latitude (North)	Longitude (East)
24°55'11.57"	67° 0'56.73"

Single Line Diagram of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL



Interconnection

Arrangement for Dispersal of Power from the Generation Facility/Solar Power Plant of Shams Power (Private) Limited

The power generated from the Generation Facility/Power Plant of Shams Power (Private) Limited shall be dispersed at roof top of METRO Cash & Carry, D-22, Manghopir Road, Karachi for in-house utilization.

(16). The proposed Interconnection Arrangement for dispersal of electric power for the Generation Facility/Solar Power Plant will be as under:-

(h). 230V/400V two single circuits individually on two separate bus bars of existing LT distribution panel of METRO Cash & Carry/Consumer.

(17). Any change in the above Interconnection Arrangement duly agreed by Shams Power (Private) Limited and METRO Cash & Carry/Consumer shall be communicated to the Authority in due course of time.

Detail of Generation Facility/Solar Power Plant

(A). General Information

(i).	Name of the Company/ Licensee	Shams Power (Private) Limited
(ii).	Registered/Business Office of the Company	2nd Floor, Al-Maalik Building 19-Davis Road Lahore
(iii).	Principal Office	2nd Floor, Al-Maalik Building 19-Davis Road Lahore
(iv).	Plants Location	METRO Cash & Carry Store, D-22, Manghopir Road, Karachi
(v).	Field Type	Fixed Tilted Plane
(vi)	Field Parameters	Tilt 2° & Azimuth 0°
(vii).	Type of Generation Facility	Solar Photovoltaic (PV)

(B). Solar Power Generation Technology & Capacity

(i).	Type of Technology	Photovoltaic (PV) Cell
(ii).	Type of Cell	Polycrystalline
(ii).	Type of System	Grid Tied
(iii).	Installed Capacity of the Generation Facility (MW)	0.2376 MW_P DC

(C). Technical Details of Equipment

(a).	Solar Panels-PV Modules		
(i).	Type of Module	Polycrystalline PV Type Module CS6U-330P	
(ii).	Surface Area of Module	1.94432 m^2	
(iii).	Dimension of each Module	1960 mm x 992 mm x 40mm	
(iv)	Total area of roof top for Solar Panels-PV Modules	1400 m^2	
(v).	No. of Modules	720	
(vi).	Frame of Module	Anodised Aluminium Alloy	
(vii).	Weight of one Module	22.4 kg	
(viii).	Module Output Warranty	For 1^{st} Year	For 2^{nd} Year to 25^{th} Year
		97.5% or above	Not more than 0.7% output reduction each year
(ix).	Number of Solar Cells in each Module	72 Cells	
(x).	Efficiency of Module	16.97 %	
(xi).	Environment Protection System	Encapsulation and sealing arrangements for protection from environment.	
(xii).	Maximum Power (P_{max})	330 W_P	
(xiii).	Power Tolerance at STC	0 ~ +5W	
(xiv).	Operating Voltage @ (P_{max})	37.2 V	
(xv).	Operating Current @ (P_{max})	8.88 A	
(xvi).	Open circuit voltage (V_{oc})	45.6 V	
(xvii).	Short circuit current (I_{sc})	9.45 A	

(xviii).	Optimum Operating Voltage at NOCT	33.9 V
(xix).	Optimum Operating Current at NOCT	7.05 A
(xx).	Open circuit voltage (Voc) at NOCT	41.9 V
(xxi).	Maximum system open Circuit Voltage	1000V(IEC) or 1000V (UL) or 600V(UL)
(b).	**PV Array**	
(i).	No. of Arrays	8
(ii).	Modules in a String	15
(iii).	Total No. of Strings	48
(iv).	Modules in Array	90 Modules
(v).	Total Modules	720
(c).	**PV Capacity**	
(i).	Total Capacity	0.2376 MW_P DC
(ii).	Net Capacity Factor	18.02%
(d).	**Inverters**	
(i).	Maximum DC Power Input	0.213 MW (@50°C)
(ii).	Inverter Model	Sunny Tri power 25000TL (25 KW)
(iii).	Manufacturer	SMA Solar Technology, Germany
(iv).	Maximum DC Input Voltage	DC 1000 V
(v).	Start Voltage	DC 150 V
(vi).	Number of Inverters	8
(vii).	Efficiency	98.3% (Sunny Tri power 25000TL)
(viii).	Max. Input Current	DC 66 A
(ix).	MPP Voltage Range	320 V- 800 V DC (@50°C)
(x).	Output electrical system	3-Phase, 4-Wire

(xi).	Rated Output Voltage	AC 230/400 V	
(xii).	Rated Frequency	50 Hz	
(xiii).	Power Factor	1	
(xiv).	Power Control	MPP Tracker (2 MPPT/Inverter)	
(xv).	Environmental Enclosures	Operating Temperature Range	-25° C to 60° C
		Relative Humidity	100% non-condensing
		Protection Class	IP65
		Audible Noise	51 dB(A)
		Operating Elevation	<3000m
(xvi)	Protection Devices	(a).	DC Disconnect Switch
		(b).	Ground Fault Monitoring
		(c).	Reverse Polarity Protection
		(d).	Reverse current protection
		(e).	Over-voltage protection
(e).	**Junction Boxes**		
(i).	Number of Junction Box units	16	
(ii).	Input circuits in each box	1 box with 3 String inputs and 1 Combined output	
(iii).	Max. Input current for each circuit	15 A	
(iv).	Max. Input voltage	1000 V	
(v).	Power at each box	14.85 kW_p	
(vi).	Protection Level	IP 65	
(vii).	Over-Current protection	Fuse	
(viii).	Surge protection	Yes (>1000V)	

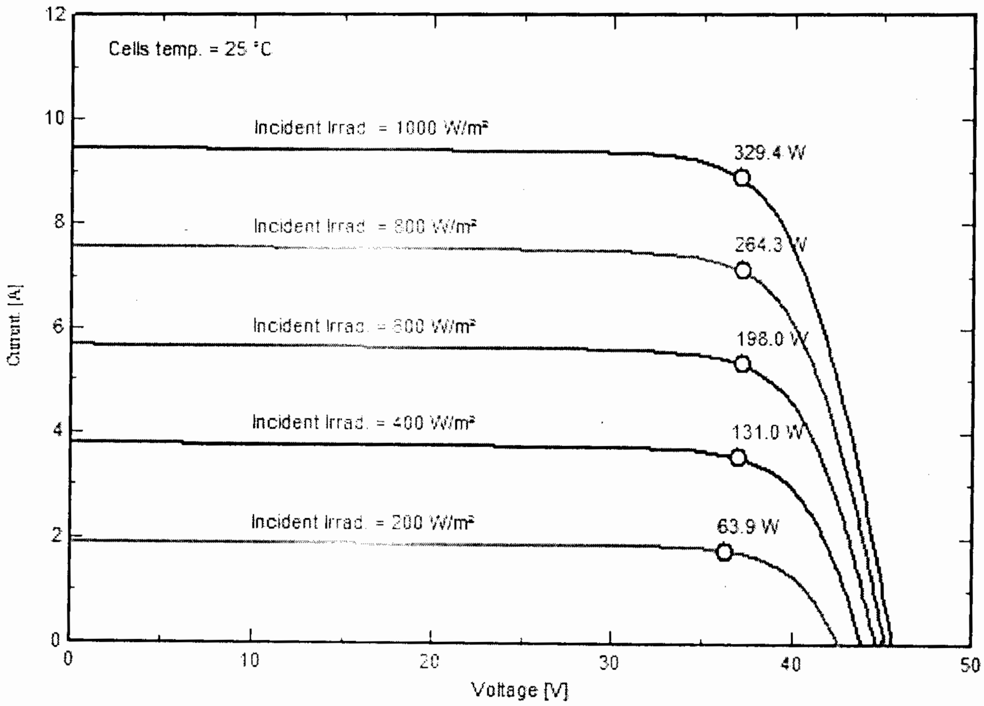
(ix).	Purpose of Junction Box	(a).	Combining the strings
		(b).	Short Circuit Protection
		(c).	DC Surge Protection
(f).	**Data Collecting System**		
(i).	Weather Data	(a).	Irradiance Meter (Survey 100/200R)- 1 Set (to record ambient temp& radiation level)
(ii).	System Data	(a).	DC input voltage (V) & current (A) of each Inverter (Phase, Line)
		(b).	Total DC power (kW) generated by PV array.
		(c).	AC output voltage(V) and current (A) of each Inverter (Phase, Total)
		(d).	AC output power (kW) and energy (kWh) of each Inverter
		(e).	Frequency (Hz)
		(f).	Power Factor (PF)

(D). <u>Other Details</u>

(i).	COD of the Project	August 25, 2018
(ii).	Expected Life of the Project from the COD	25 Years

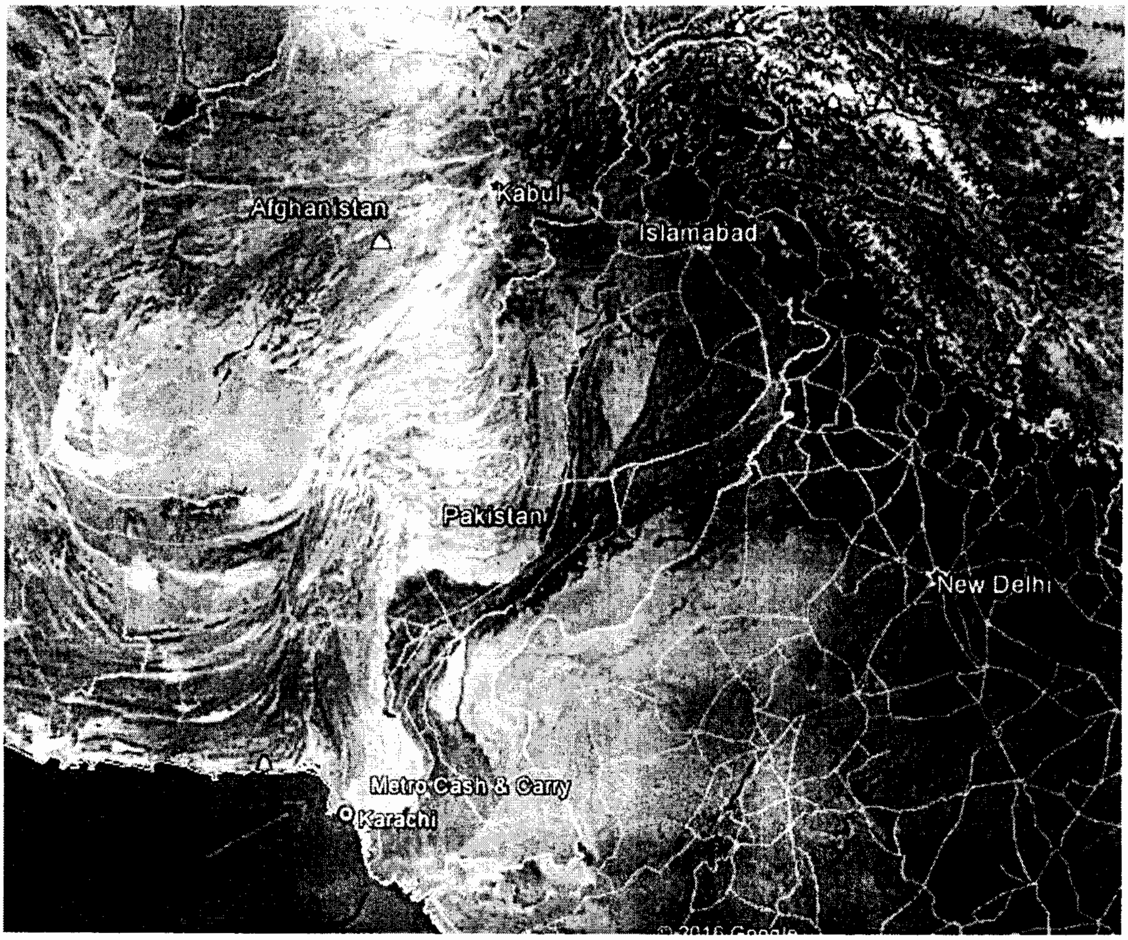
VI Curve of Solar Panel at STC for the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL

PV module: Canadian Solar Inc., CS6U - 330P

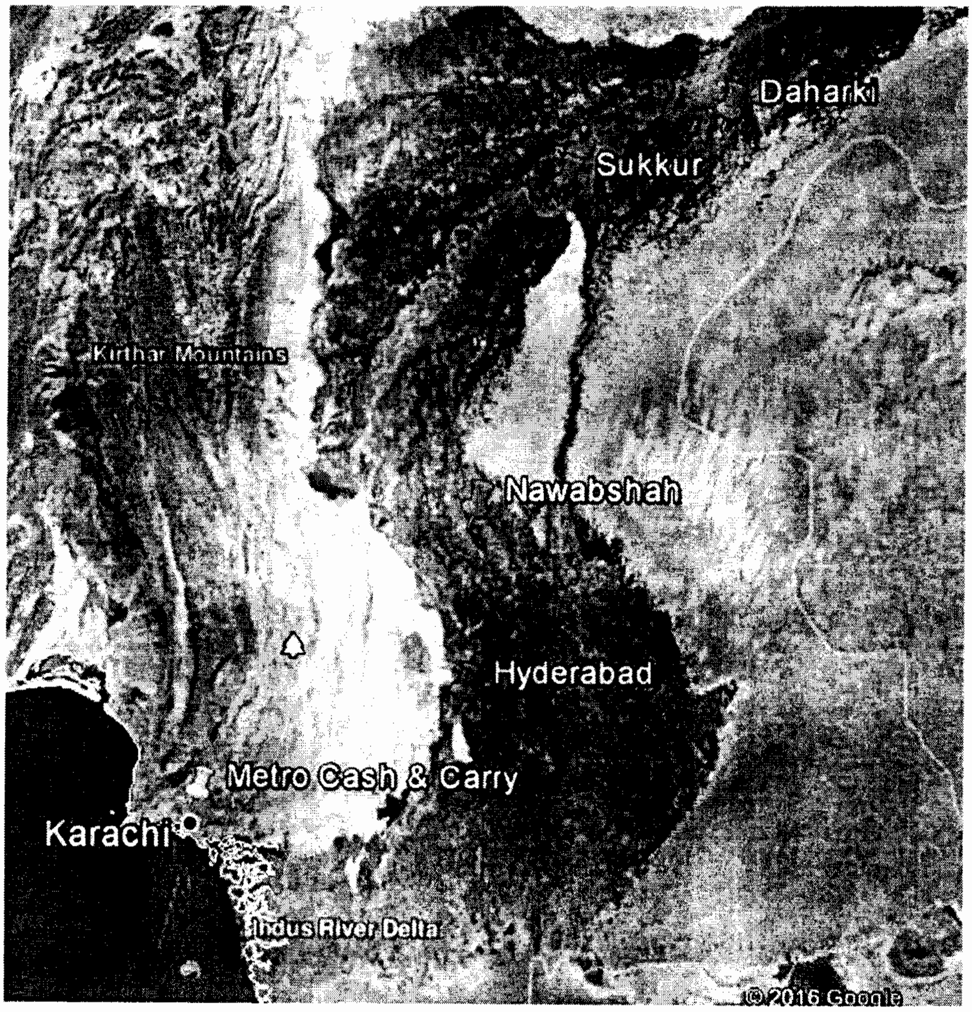


8. METRO Cash & Carry, Near Stargate, Karachi

Location of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of Pakistan

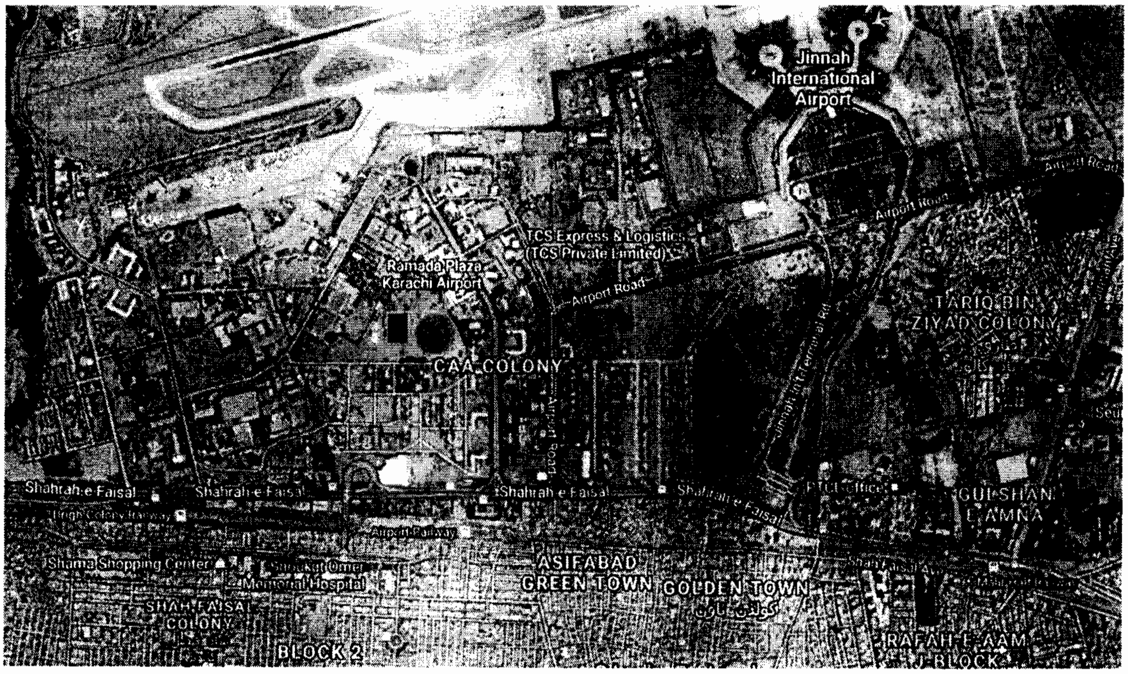


Location of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of the Province of Sindh

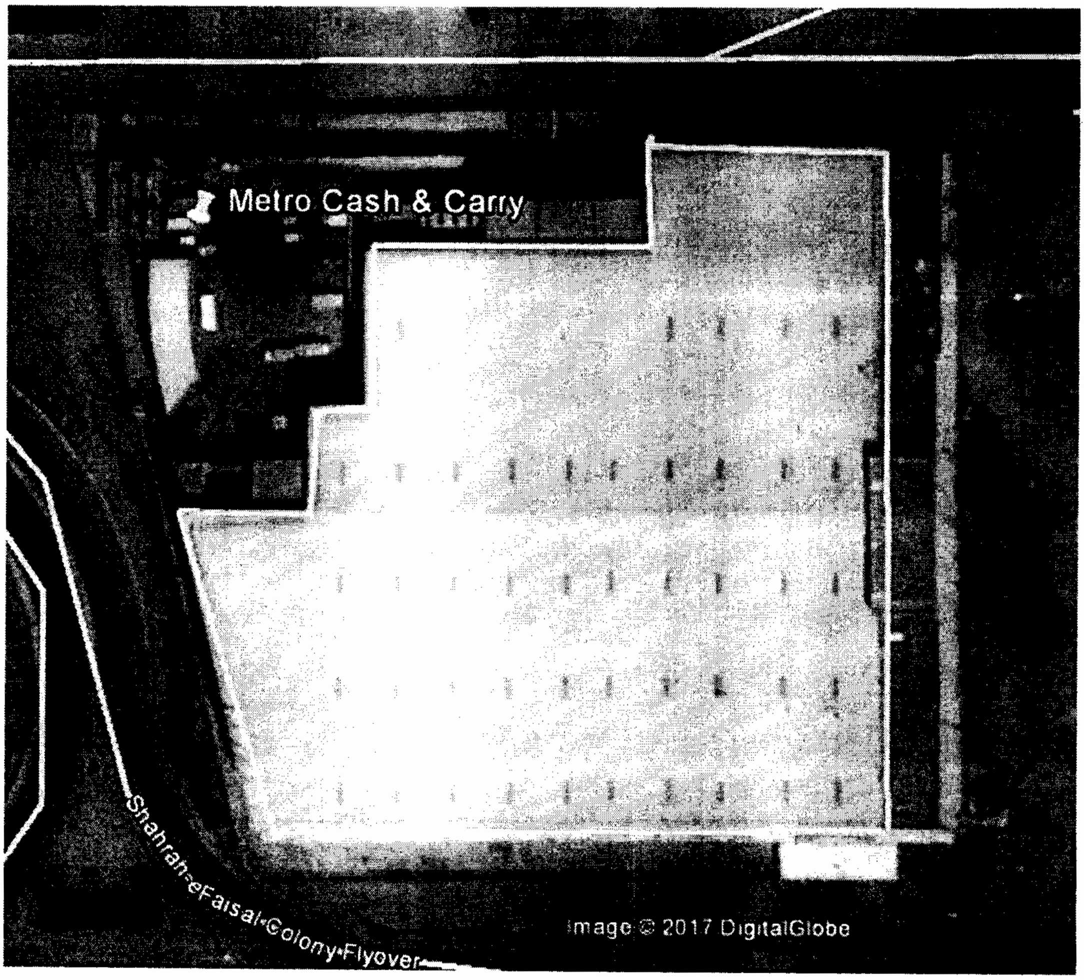


Location of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of Karachi

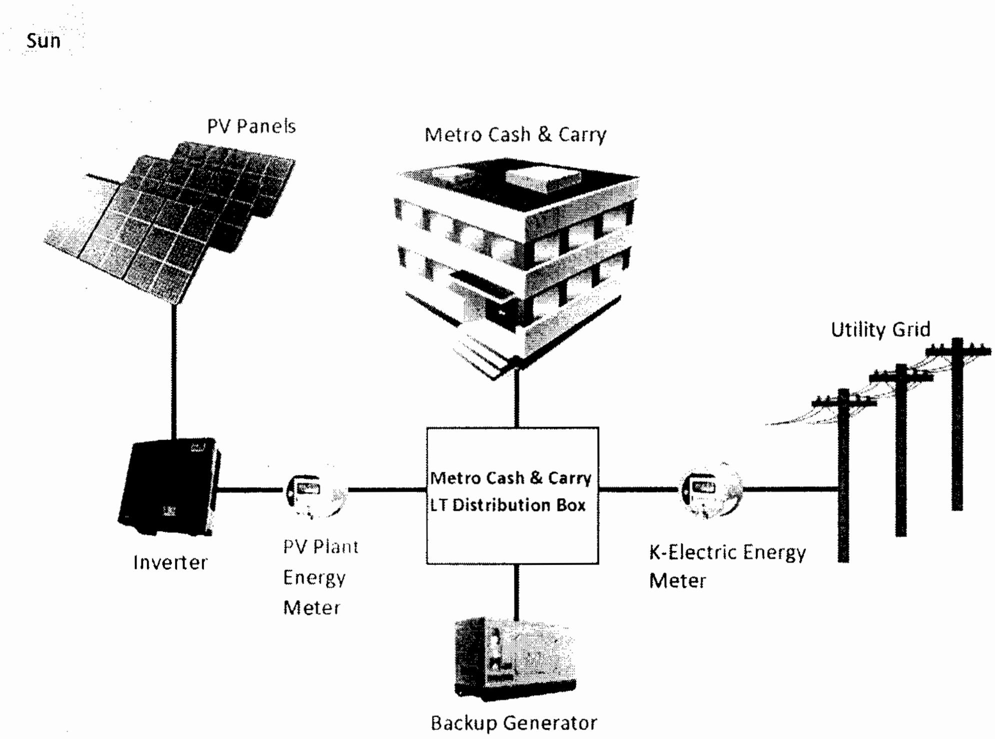
Access Road/Link of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of Karachi



Location of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL



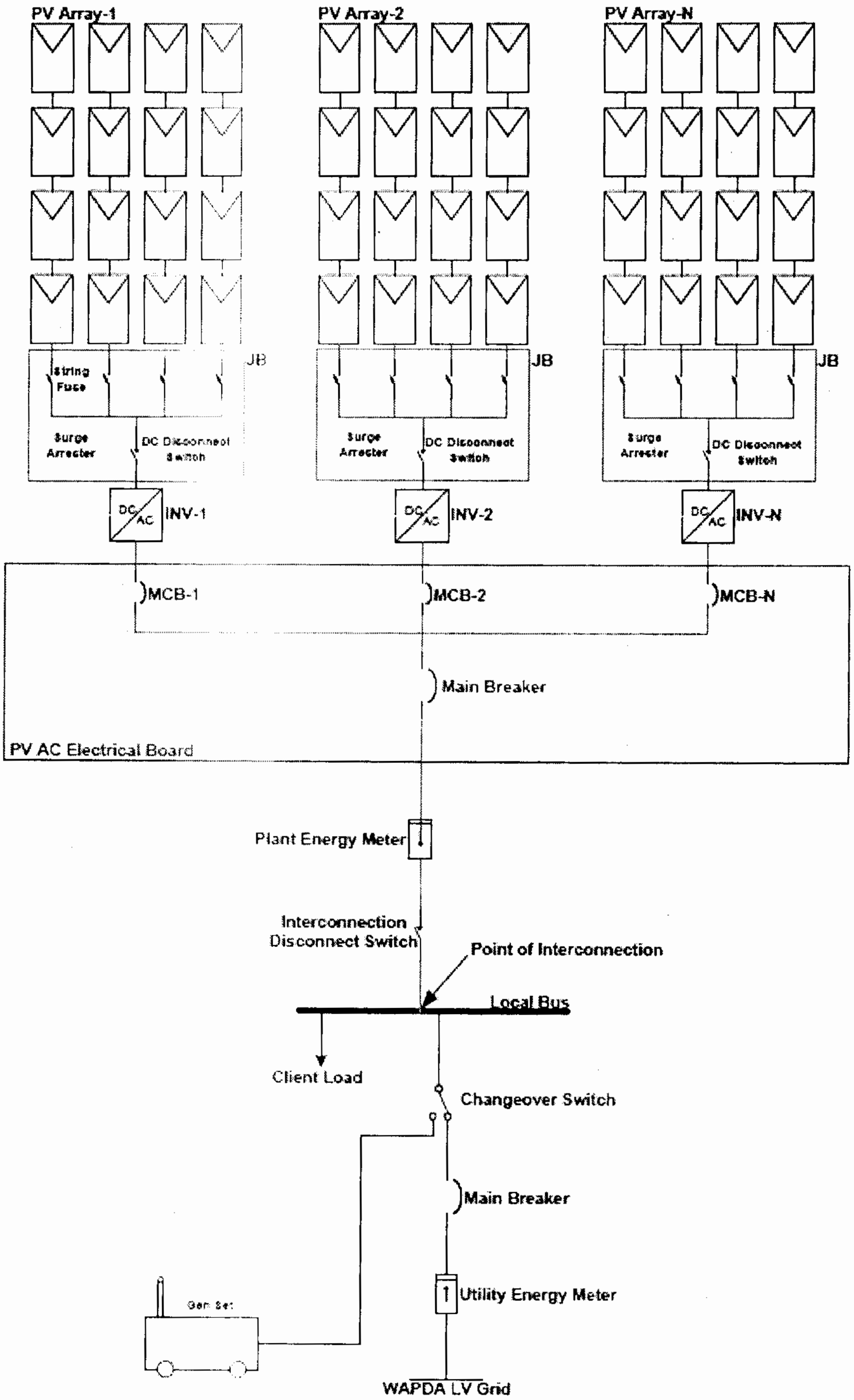
Process Flow Diagram of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL



Location Coordinates of the Generation Facility/Solar Farm/Power Plant of the Licensee/SPPL

Latitude (North)	Longitude (East)
24°53'17.05"	67° 9'5.08"

Single Line Diagram of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL



Interconnection

Arrangement for Dispersal of Power from the Generation Facility/Solar Power Plant of Shams Power (Private) Limited

The power generated from the Generation Facility/Power Plant of Shams Power (Private) Limited shall be dispersed at roof top of METRO Cash & Carry, Near Stargate, Karachi for in-house utilization.

(18). The proposed Interconnection Arrangement for dispersal of electric power for the Generation Facility/Solar Power Plant will be as under:-

(i). 230V/400V two single circuits individually on two separate bus bars of existing LT distribution panel of METRO Cash & Carry/Consumer.

(19). Any change in the above Interconnection Arrangement duly agreed by Shams Power (Private) Limited and METRO Cash & Carry/Consumer shall be communicated to the Authority in due course of time.

Detail of Generation Facility/Solar Power Plant

(A). General Information

(i).	Name of the Company/ Licensee	Shams Power (Private) Limited
(ii).	Registered/Business Office of the Company	2nd Floor, Al-Maalik Building 19-Davis Road Lahore
(iii).	Principal Office	2nd Floor, Al-Maalik Building 19-Davis Road Lahore
(iv).	Plants Location	METRO Cash & Carry Store, Near Stargate, Karachi
(v).	Field Type	Fixed Tilted Plane
(vi)	Field Parameters	Tilt 2° & Azimuth 0°
(vii).	Type of Generation Facility	Solar Photovoltaic (PV)

(B). Solar Power Generation Technology & Capacity

(i).	Type of Technology	Photovoltaic (PV) Cell
(ii).	Type of Cell	Polycrystalline
(ii).	Type of System	Grid Tied
(iii).	Installed Capacity of the Generation Facility (MW)	0.3564 MW_P DC

(C). Technical Details of Equipment

(a).	**Solar Panels-PV Modules**		
(i).	Type of Module	Polycrystalline PV Type Module CS6U-330P	
(ii).	Surface Area of Module	1.94432 m^2	
(iii).	Dimension of each Module	1960 mm x 992 mm x 40mm	
(iv)	Total area of roof top for Solar Panels-PV Modules	2100 m^2	
(v).	No. of Modules	1080	
(vi).	Frame of Module	Anodised Aluminium Alloy	
(vii).	Weight of one Module	22.4 kg	
(viii).	Module Output Warranty	For 1^{st} Year	For 2^{nd} Year to 25^{th} Year
		97.5% or above	Not more than 0.7% output reduction each year
(ix).	Number of Solar Cells in each Module	72 Cells	
(x).	Efficiency of Module	16.97 %	
(xi).	Environment Protection System	Encapsulation and sealing arrangements for protection from environment.	
(xii).	Maximum Power (P_{max})	330 W_P	
(xiii).	Power Tolerance at STC	0 ~ +5W	
(xiv).	Operating Voltage @ (P_{max})	37.2 V	
(xv).	Operating Current @ (P_{max})	8.88 A	
(xvi).	Open circuit voltage (V_{oc})	45.6 V	
(xvii).	Short circuit current (I_{sc})	9.45 A	

(xviii).	Optimum Operating Voltage at NOCT	33.9 V
(xix).	Optimum Operating Current at NOCT	7.05 A
(xx).	Open circuit voltage (Voc) at NOCT	41.9 V
(xxi).	Maximum system open Circuit Voltage	1000V(IEC) or 1000V (UL) or 600V(UL)
(b).	**PV Array**	
(i).	No. of Arrays	12
(ii).	Modules in a String	15
(iii).	Total No. of Strings	72
(iv).	Modules in Array	90 Modules
(v).	Total Modules	1080
(c).	**PV Capacity**	
(i).	Total Capacity	0.3564 MW_P DC
(ii).	Net Capacity Factor	18.21%
(d).	**Inverters**	
(i).	Maximum DC Power Input	0.319 MW (@50°C)
(ii).	Inverter Model	Sunny Tri power 25000TL (25 KW)
(iii).	Manufacturer	SMA Solar Technology, Germany
(iv).	Maximum DC Input Voltage	DC 1000 V
(v).	Start Voltage	DC 150 V
(vi).	Number of Inverters	12
(vii).	Efficiency	98.3% (Sunny Tri power 25000TL)
(viii).	Max. Input Current	DC 66 A
(ix).	MPP Voltage Range	320 V- 800 V DC (@50°C)
(x).	Output electrical system	3-Phase, 4-Wire

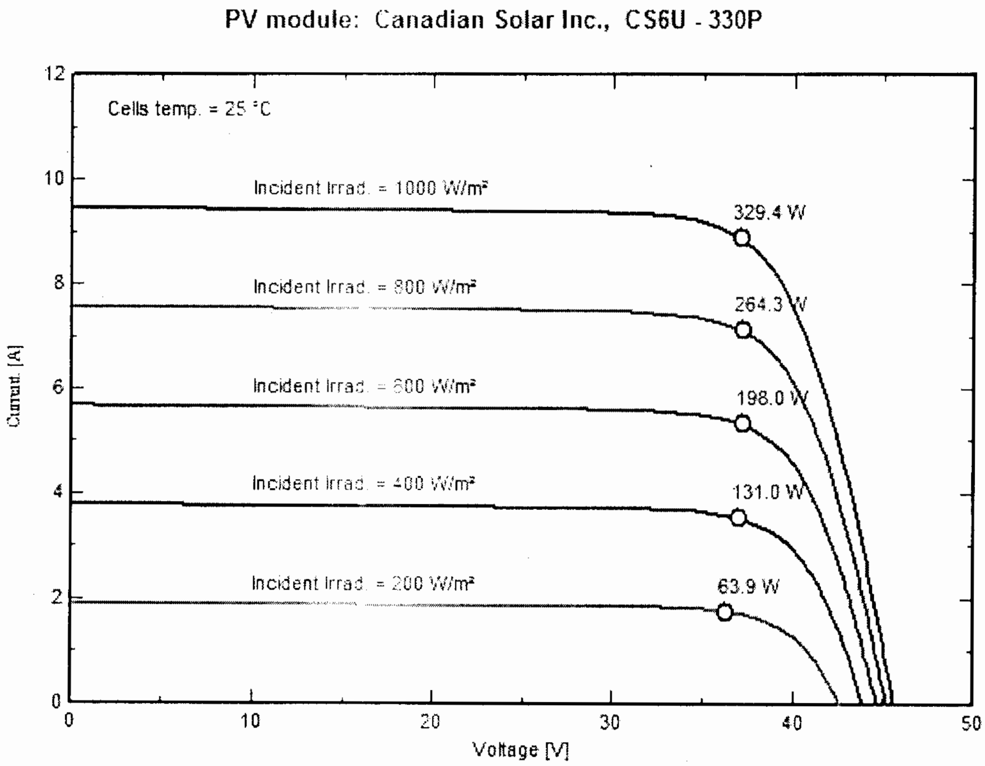
(xi).	Rated Output Voltage	AC 230/400 V		
(xii).	Rated Frequency	50 Hz		
(xiii).	Power Factor	1		
(xiv).	Power Control	MPP Tracker (2 MPPT/Inverter)		
(xv).	Environmental Enclosures	Operating Temperature Range		-25° C to 60° C
		Relative Humidity		100% non-condensing
		Protection Class		IP65
		Audible Noise		51 dB(A)
		Operating Elevation		<3000m
(xvi)	Protection Devices	(a).	DC Disconnect Switch	
		(b).	Ground Fault Monitoring	
		(c).	Reverse Polarity Protection	
		(d).	Reverse current protection	
		(e).	Over-voltage protection	
(e).	**Junction Boxes**			
(i).	Number of Junction Box units	24		
(ii).	Input circuits in each box	1 box with 3 String inputs and 1 Combined output		
(iii).	Max. Input current for each circuit	15 A		
(iv).	Max. Input voltage	1000 V		
(v).	Power at each box	14.85 kW_p		
(vi).	Protection Level	IP 65		
(vii).	Over-Current protection	Fuse		
(viii).	Surge protection	Yes (>1000V)		

(ix).	Purpose of Junction Box	(a).	Combining the strings
		(b).	Short Circuit Protection
		(c).	DC Surge Protection
(f).	**Data Collecting System**		
(i).	Weather Data	(a).	Irradiance Meter (Survey 100/200R)- 1 Set (to record ambient temp& radiation level)
(ii).	System Data	(a).	DC input voltage (V) & current (A) of each Inverter (Phase, Line)
		(b).	Total DC power (kW) generated by PV array.
		(c).	AC output voltage(V) and current (A) of each Inverter (Phase, Total)
		(d).	AC output power (kW) and energy (kWh) of each Inverter
		(e).	Frequency (Hz)
		(f).	Power Factor (PF)

(D). Other Details

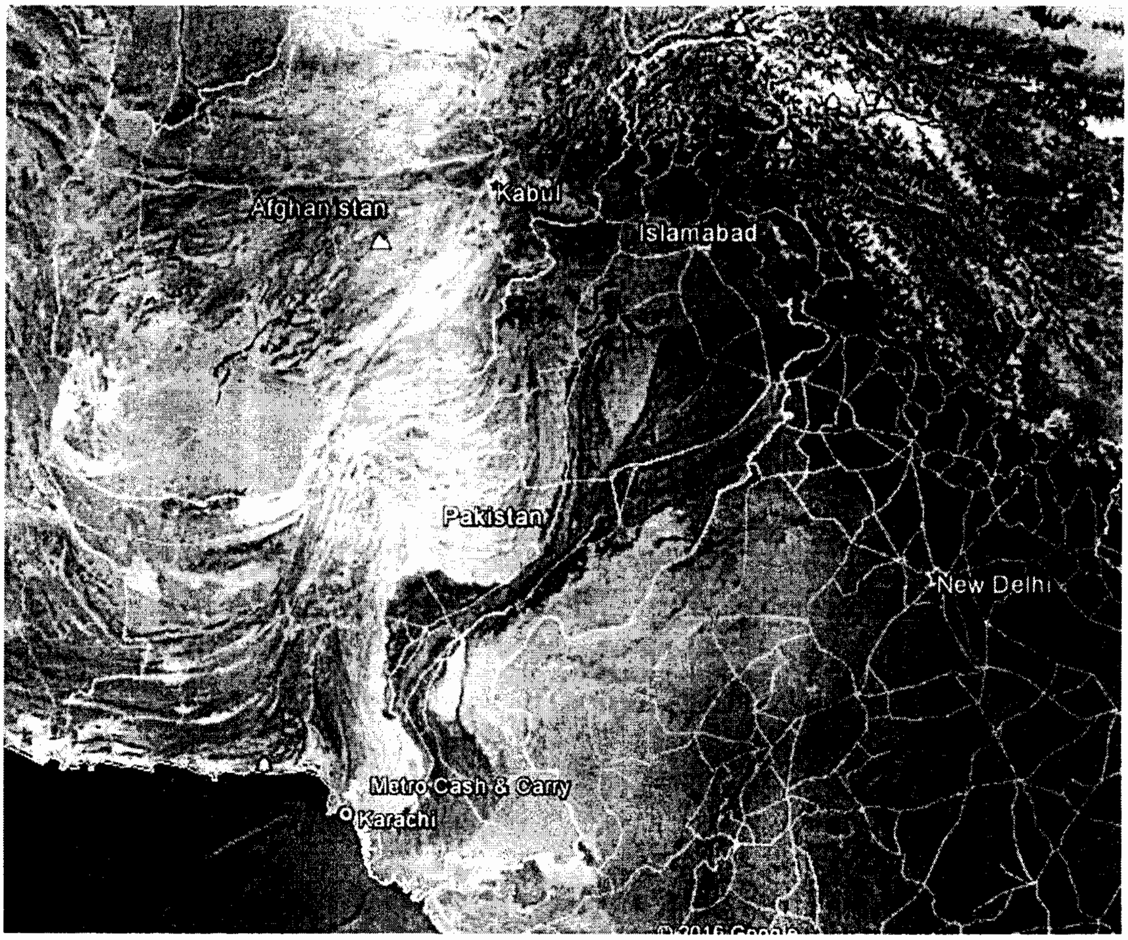
(i).	COD of the Project	December 23, 2018
(ii).	Expected Life of the Project from the COD	25 Years

VI Curve of Solar Panel at STC for the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL

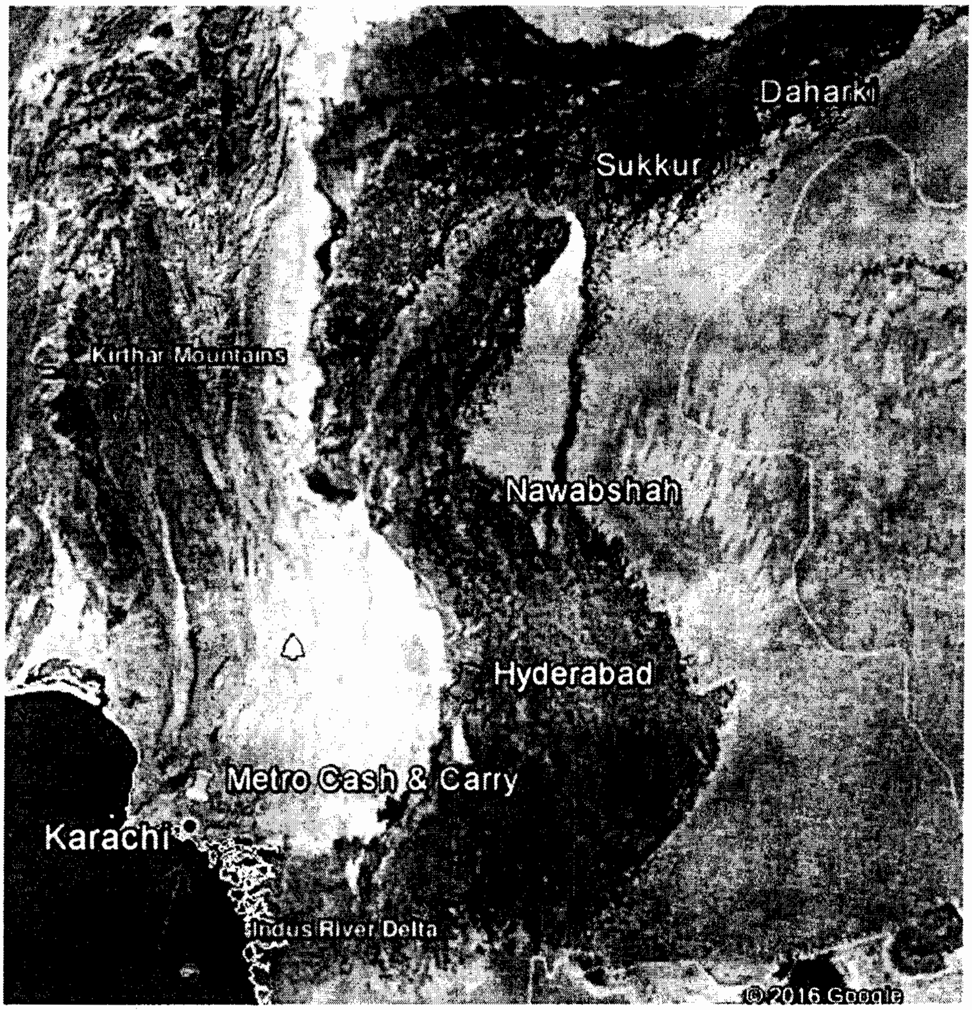


9. METRO Cash & Carry, Near Safari Park, Karachi

Location of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of Pakistan



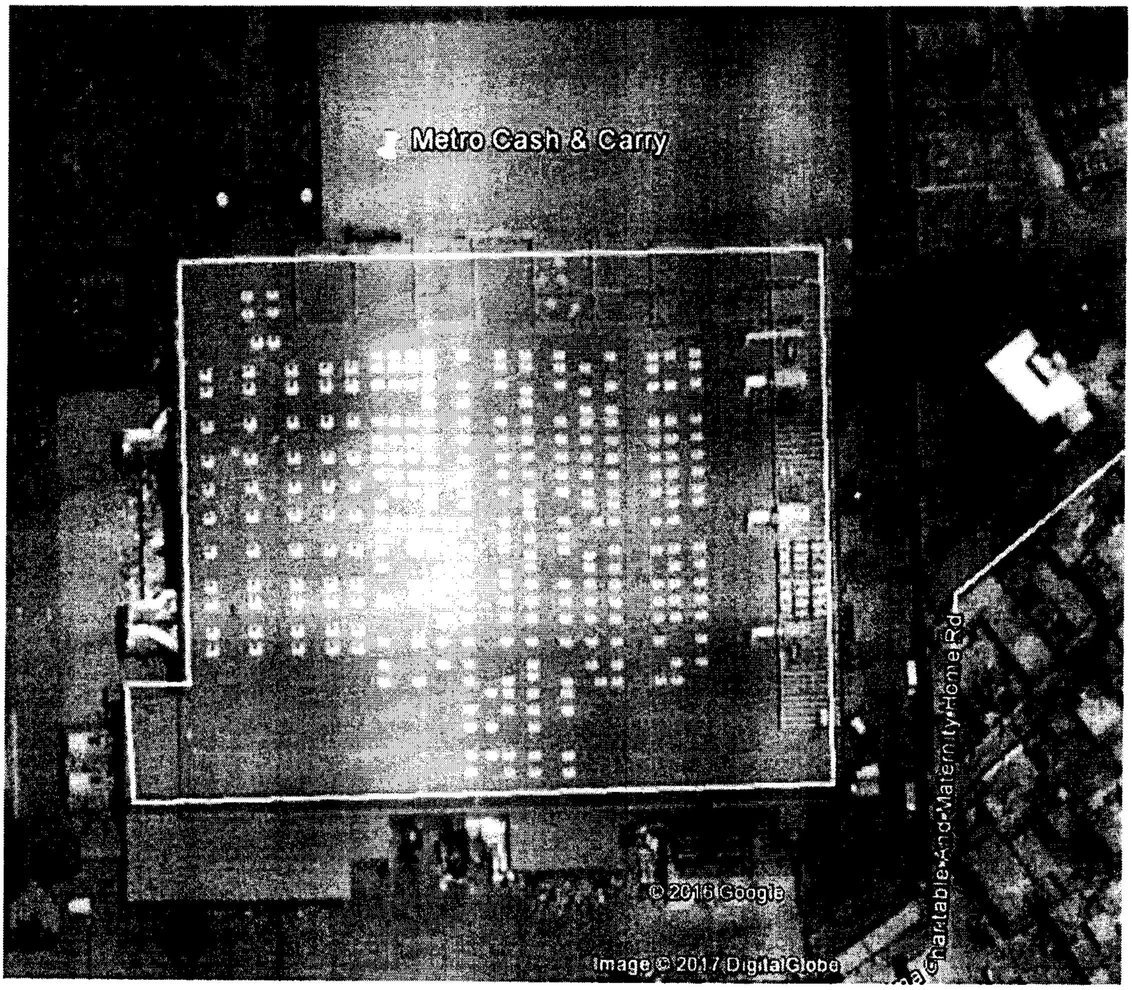
Location of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of the Province of Sindh



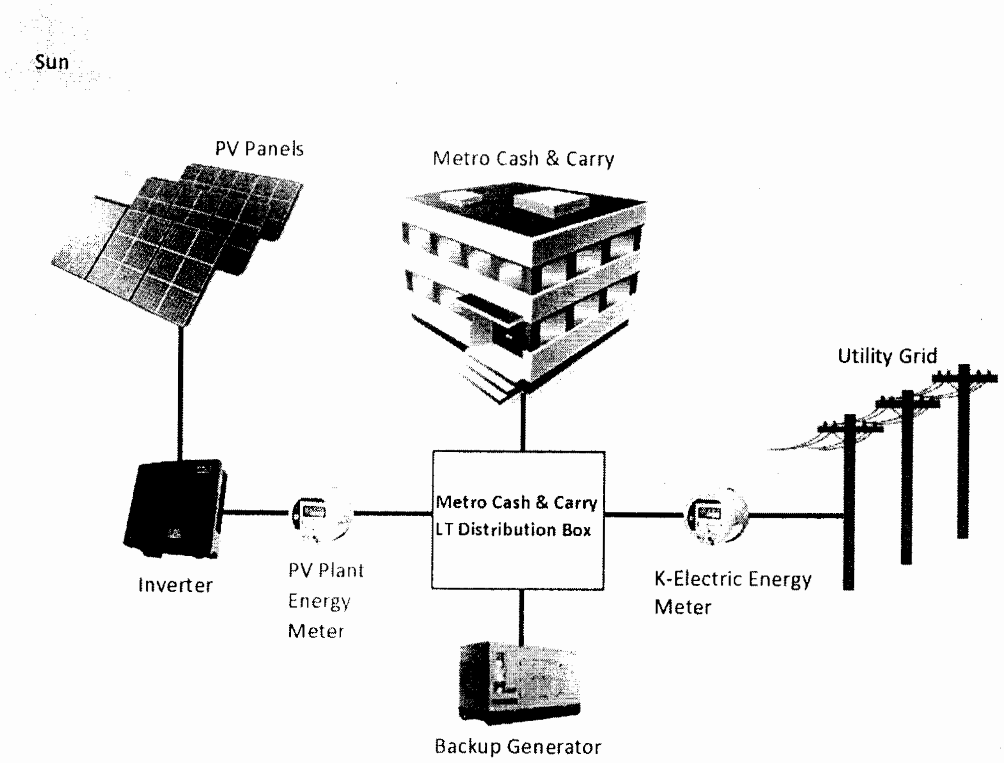
Location of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of Karachi

Access Road/Link of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of Karachi

Location of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL



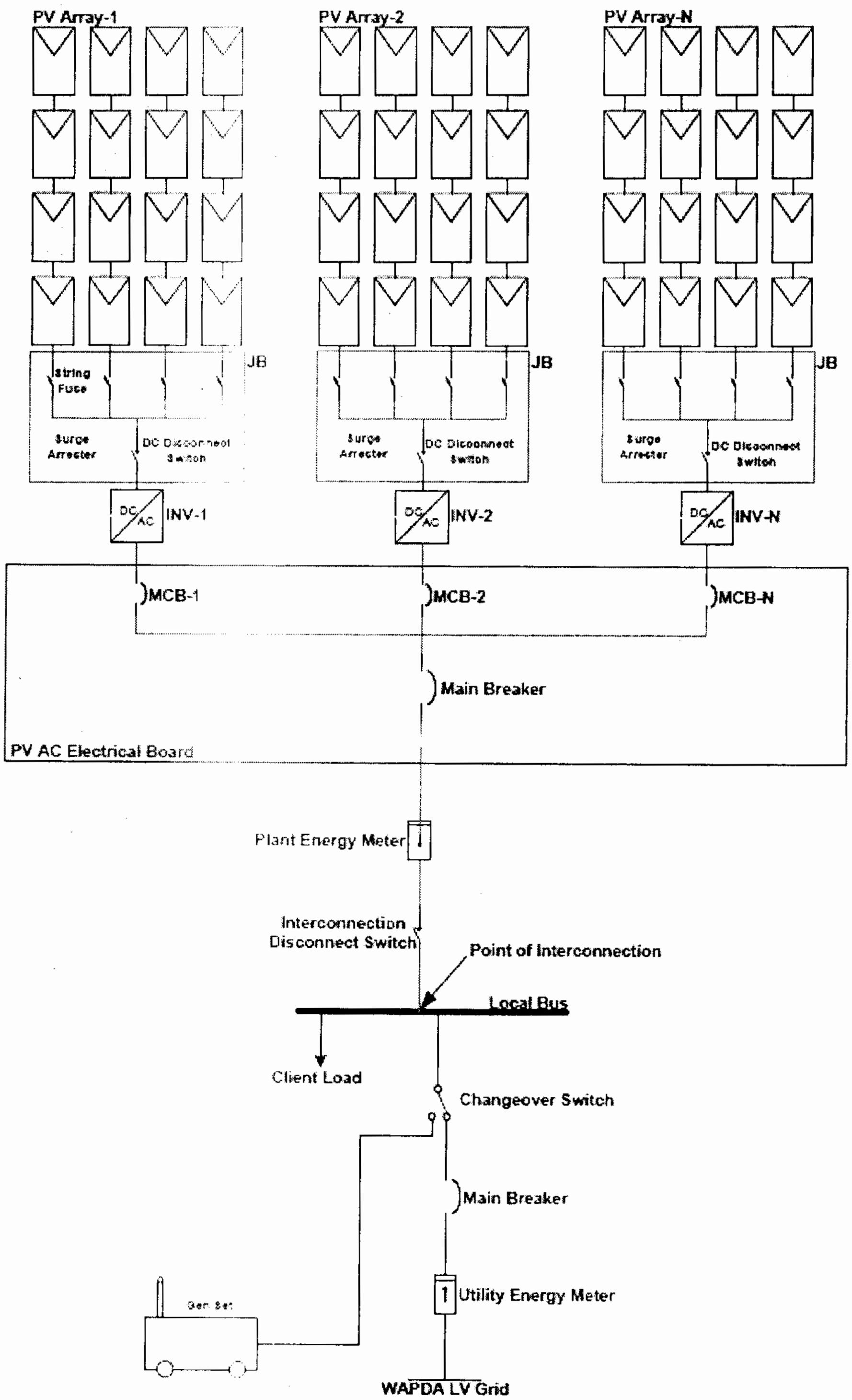
Process Flow Diagram of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL



Location Coordinates of the Generation Facility/Solar Farm/Power Plant of the Licensee/SPPL

Latitude (North)	Longitude (East)
24°55'17.60"	67° 6'19.45"

Single Line Diagram of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL



Interconnection

Arrangement for Dispersal of Power from the Generation Facility/Solar Power Plant of Shams Power (Private) Limited

The power generated from the Generation Facility/Power Plant of Shams Power (Private) Limited shall be dispersed at roof top of METRO Cash & Carry, Near Safari Park, Karachi for in-house utilization.

(20). The proposed Interconnection Arrangement for dispersal of electric power for the Generation Facility/Solar Power Plant will be as under:-

(j). 230V/400V two single circuits individually on two separate bus bars of existing LT distribution panel of METRO Cash & Carry/Consumer.

(21). Any change in the above Interconnection Arrangement duly agreed by Shams Power (Private) Limited and METRO Cash & Carry/Consumer shall be communicated to the Authority in due course of time.

Detail of Generation Facility/Solar Power Plant

(A). General Information

(i).	Name of the Company/ Licensee	Shams Power (Private) Limited
(ii).	Registered/Business Office of the Company	2nd Floor, Al-Maalik Building 19-Davis Road Lahore
(iii).	Principal Office	2nd Floor, Al-Maalik Building 19-Davis Road Lahore
(iv).	Plants Location	METRO Cash & Carry Store, Near Safari Park, University Road, Gulshan Iqbal, Karachi
(v).	Field Type	Fixed Tilted Plane
(vi)	Field Parameters	Tilt 2° & Azimuth 90° -90°
(vii).	Type of Generation Facility	Solar Photovoltaic (PV)

(B). Solar Power Generation Technology & Capacity

(i).	Type of Technology	Photovoltaic (PV) Cell
(ii).	Type of Cell	Polycrystalline
(ii).	Type of System	Grid Tied
(iii).	Installed Capacity of the Generation Facility (MW)	0.4455 MW_P DC

(C). Technical Details of Equipment

(a).	**Solar Panels-PV Modules**		
(i).	Type of Module	Polycrystalline PV Type Module CS6U-330P	
(ii).	Surface Area of Module	1.94432 m^2	
(iii).	Dimension of each Module	1960 mm x 992 mm x 40mm	
(iv)	Total area of roof top for Solar Panels-PV Modules	2624 m^2	
(v).	No. of Modules	1350	
(vi).	Frame of Module	Anodised Aluminium Alloy	
(vii).	Weight of one Module	22.4 kg	
(viii).	Module Output Warranty	For 1st Year	For 2nd Year to 25th Year
		97.5% or above	Not more than 0.7% output reduction each year
(ix).	Number of Solar Cells in each Module	72 Cells	
(x).	Efficiency of Module	16.97 %	
(xi).	Environment Protection System	Encapsulation and sealing arrangements for protection from environment.	
(xii).	Maximum Power (P_{max})	330 W_P	
(xiii).	Power Tolerance at STC	0 ~ +5W	
(xiv).	Operating Voltage @ (P_{max})	37.2 V	
(xv).	Operating Current @ (P_{max})	8.88 A	
(xvi).	Open circuit voltage (V_{oc})	45.6 V	
(xvii).	Short circuit current (I_{sc})	9.45 A	

(xviii).	Optimum Operating Voltage at NOCT	33.9 V
(xix).	Optimum Operating Current at NOCT	7.05 A
(xx).	Open circuit voltage (Voc) at NOCT	41.9 V
(xxi).	Maximum system open Circuit Voltage	1000V(IEC) or 1000V (UL) or 600V(UL)
(b).	**PV Array**	
(i).	No. of Arrays	15
(ii).	Modules in a String	15
(iii).	Total No. of Strings	90
(iv).	Modules in Array	90 Modules
(v).	Total Modules	1350
(c).	**PV Capacity**	
(i).	Total Capacity	0.4455 MW_P DC
(ii).	Net Capacity Factor	18.1%
(d).	**Inverters**	
(i).	Maximum DC Power Input	0.399 MW (@50°C)
(ii).	Inverter Model	Sunny Tri power 25000TL (25 KW)
(iii).	Manufacturer	SMA Solar Technology, Germany
(iv).	Maximum DC Input Voltage	DC 1000 V
(v).	Start Voltage	DC 150 V
(vi).	Number of Inverters	15
(vii).	Efficiency	98.3% (Sunny Tri power 25000TL)
(viii).	Max. Input Current	DC 66 A
(ix).	MPP Voltage Range	320 V- 800 V DC (@50°C)
(x).	Output electrical system	3-Phase, 4-Wire

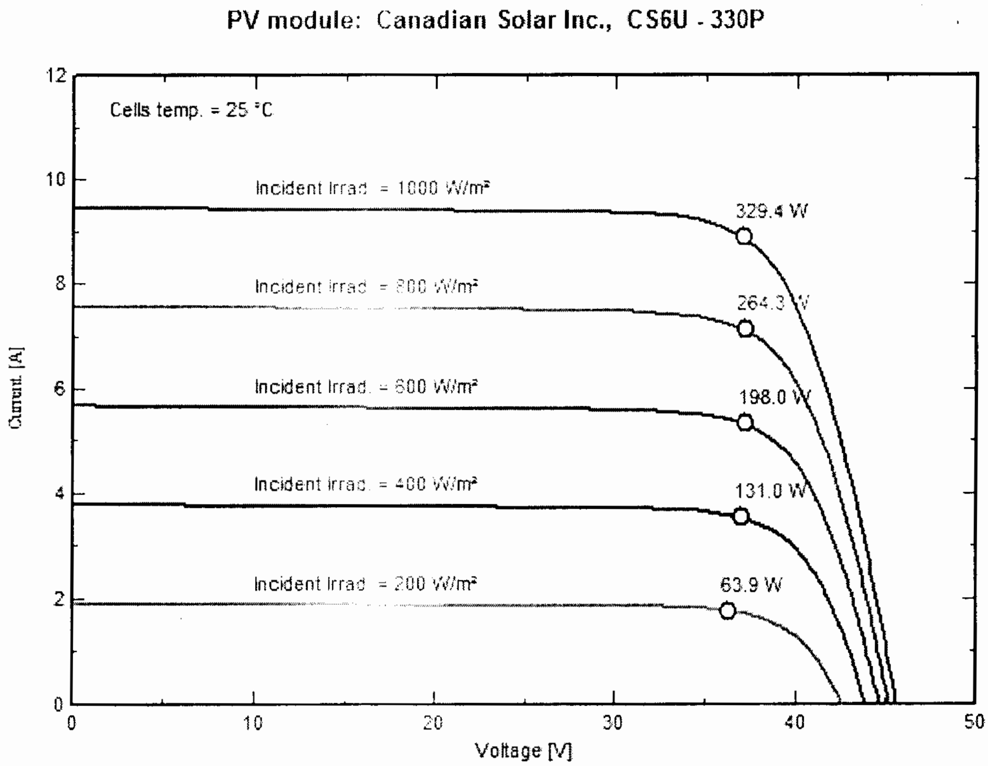
(xi).	Rated Output Voltage	AC 230/400 V	
(xii).	Rated Frequency	50 Hz	
(xiii).	Power Factor	1	
(xiv).	Power Control	MPP Tracker (2 MPPT/Inverter)	
(xv).	Environmental Enclosures	Operating Temperature Range	-25° C to 60° C
		Relative Humidity	100% non-condensing
		Protection Class	IP65
		Audible Noise	51 dB(A)
		Operating Elevation	<3000m
(xvi)	Protection Devices	(a).	DC Disconnect Switch
		(b).	Ground Fault Monitoring
		(c).	Reverse Polarity Protection
		(d).	Reverse current protection
		(e).	Over-voltage protection
(e).	**Junction Boxes**		
(i).	Number of Junction Box units	30	
(ii).	Input circuits in each box	1 box with 3 String inputs and 1 Combined output	
(iii).	Max. Input current for each circuit	15 A	
(iv).	Max. Input voltage	1000 V	
(v).	Power at each box	14.85 kW_p	
(vi).	Protection Level	IP 65	
(vii).	Over-Current protection	Fuse	
(viii).	Surge protection	Yes (>1000V)	

(ix).	Purpose of Junction Box	(a).	Combining the strings
		(b).	Short Circuit Protection
		(c).	DC Surge Protection
(f).	**Data Collecting System**		
(i).	Weather Data	(a).	Irradiance Meter (Survey 100/200R)- 1 Set (to record ambient temp& radiation level)
(ii).	System Data	(a).	DC input voltage (V) & current (A) of each Inverter (Phase, Line)
		(b).	Total DC power (kW) generated by PV array.
		(c).	AC output voltage(V) and current (A) of each Inverter (Phase, Total)
		(d).	AC output power (kW) and energy (kWh) of each Inverter
		(e).	Frequency (Hz)
		(f).	Power Factor (PF)

(D). Other Details

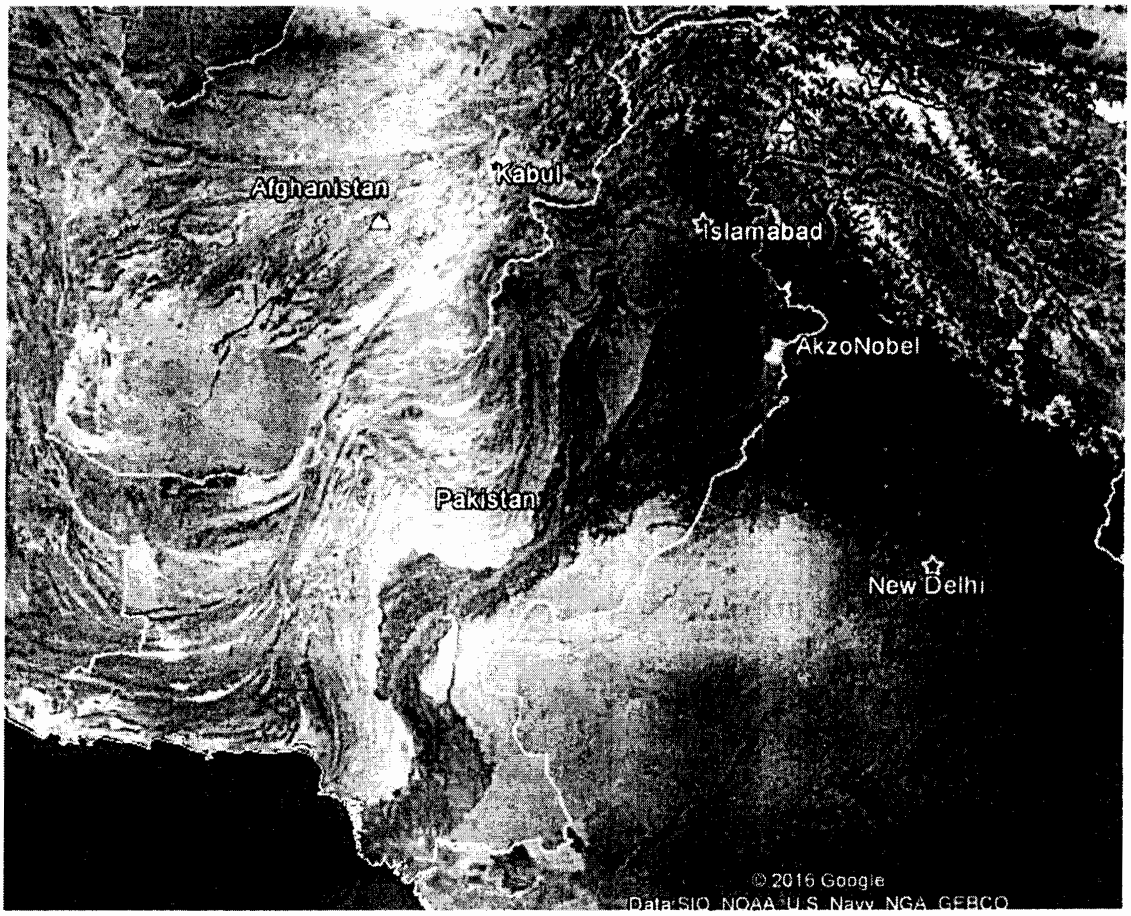
(i).	COD of the Project	October 14, 2018
(ii).	Expected Life of the Project from the COD	25 Years

VI Curve of Solar Panel at STC for the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL

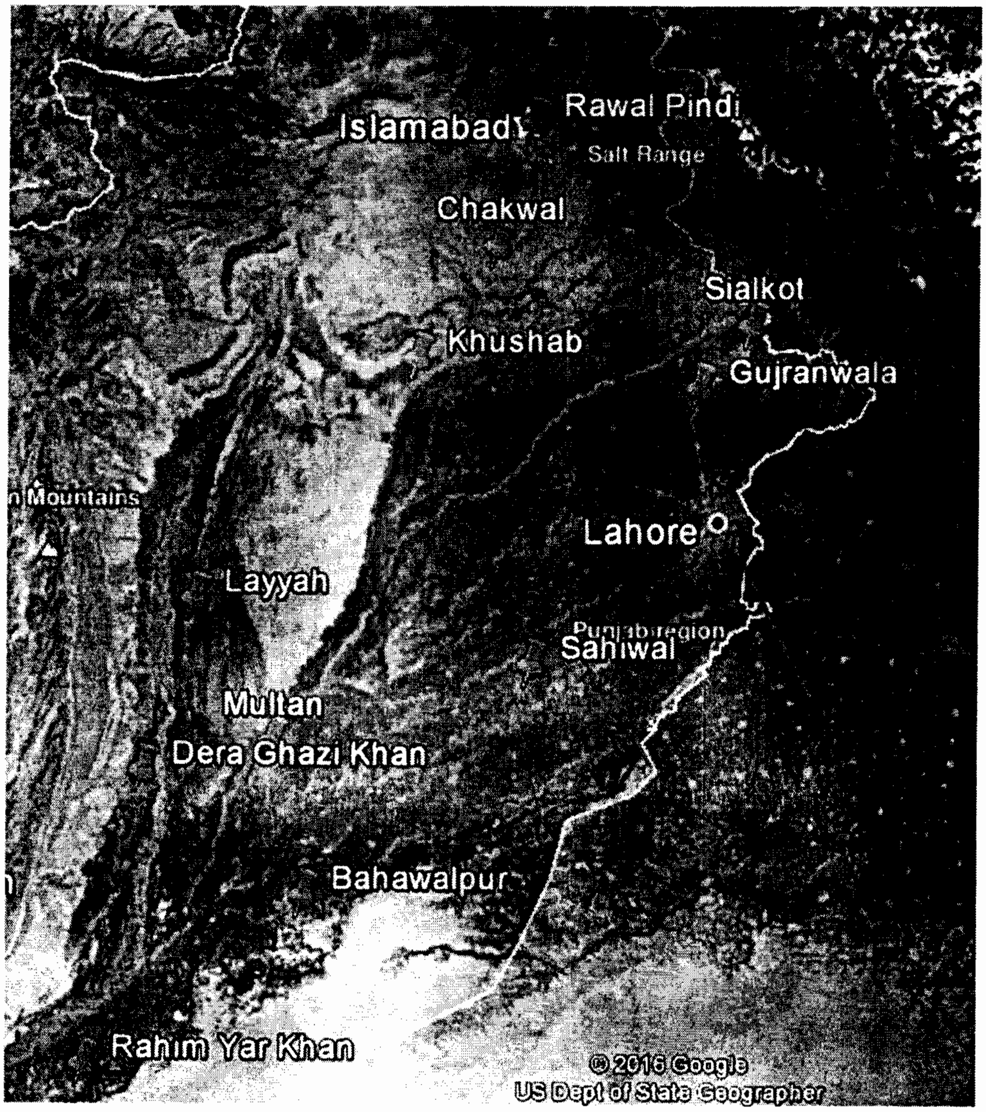


10. AkzoNobel, Head Office, Lahore

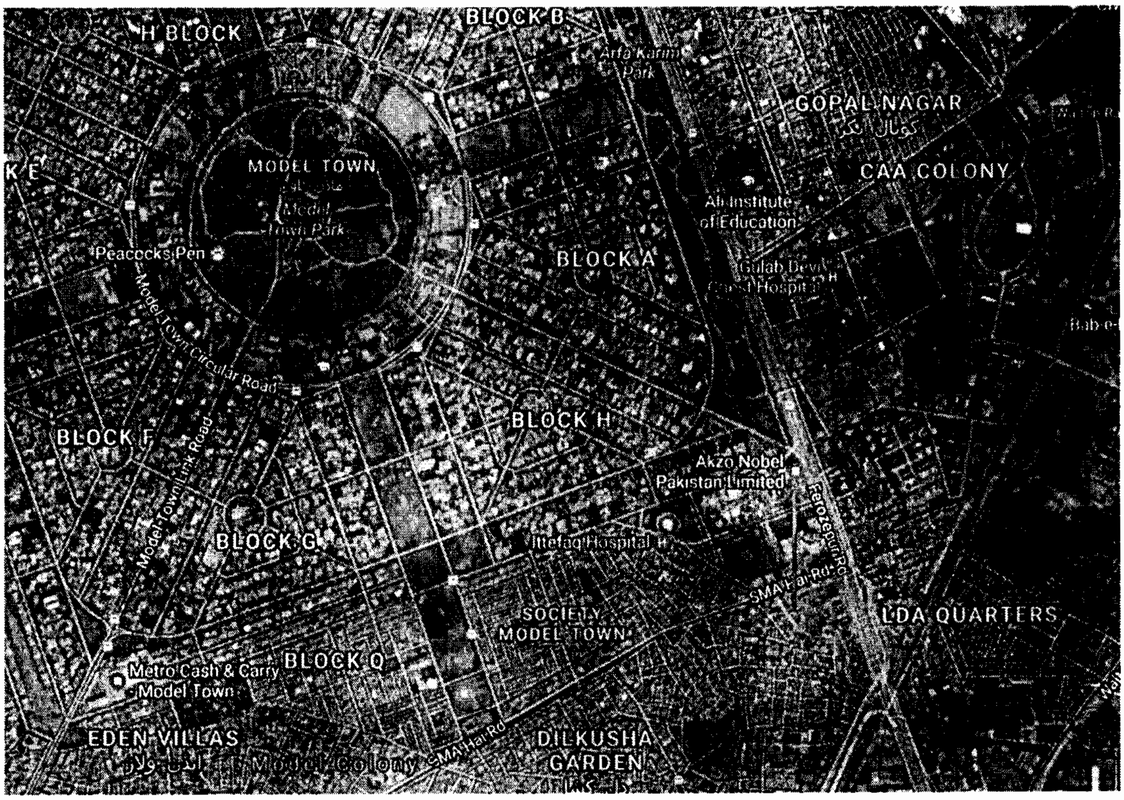
Location of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of Pakistan



Location of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of the Province of Punjab

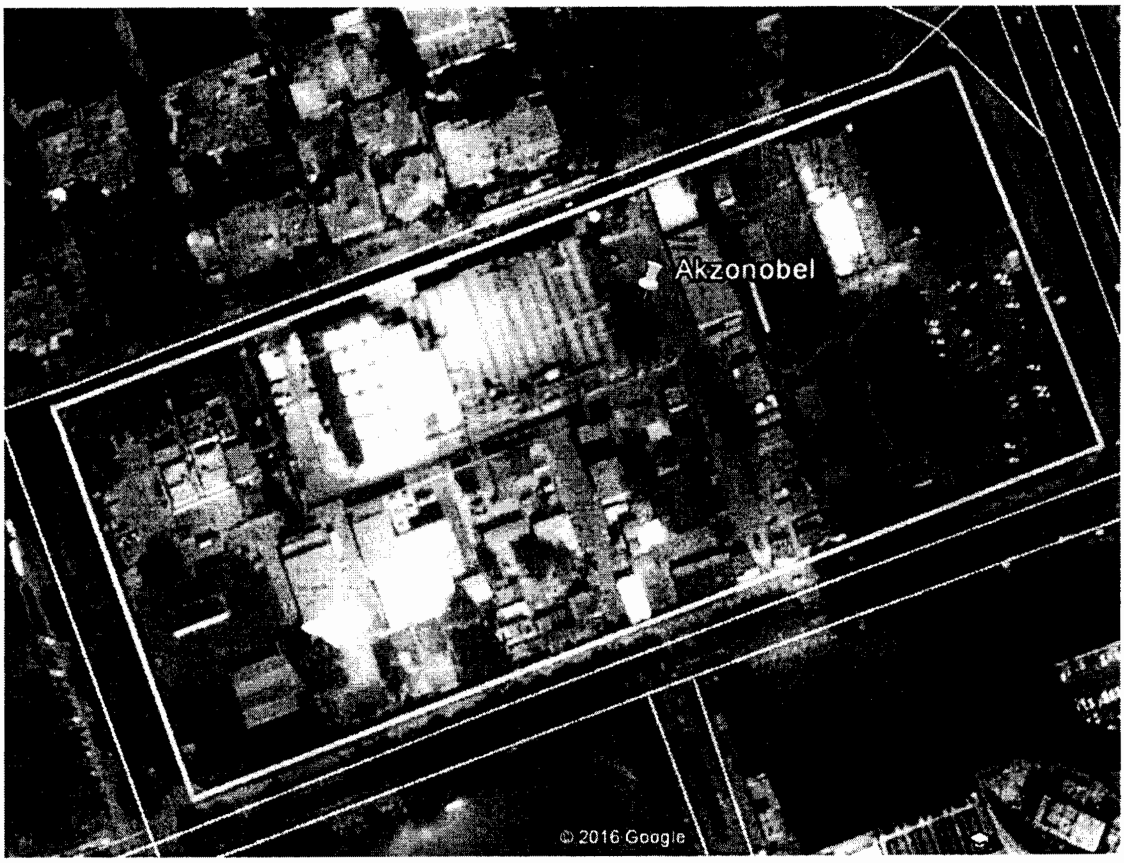


Location of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of Lahore

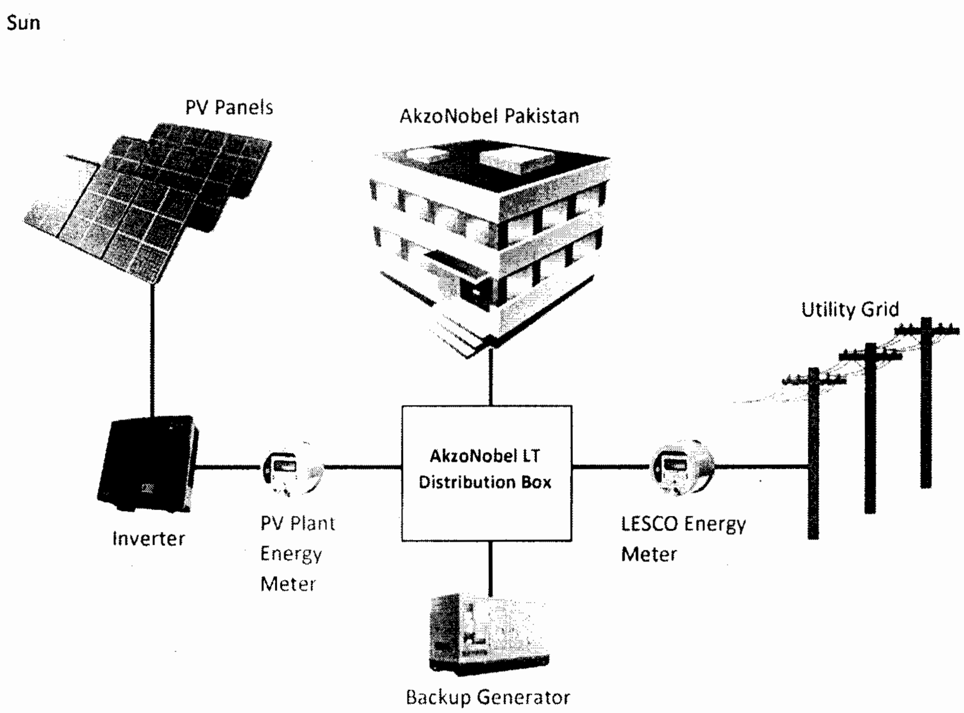


Access Road/Link of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL on Map of Lahore

Location of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL



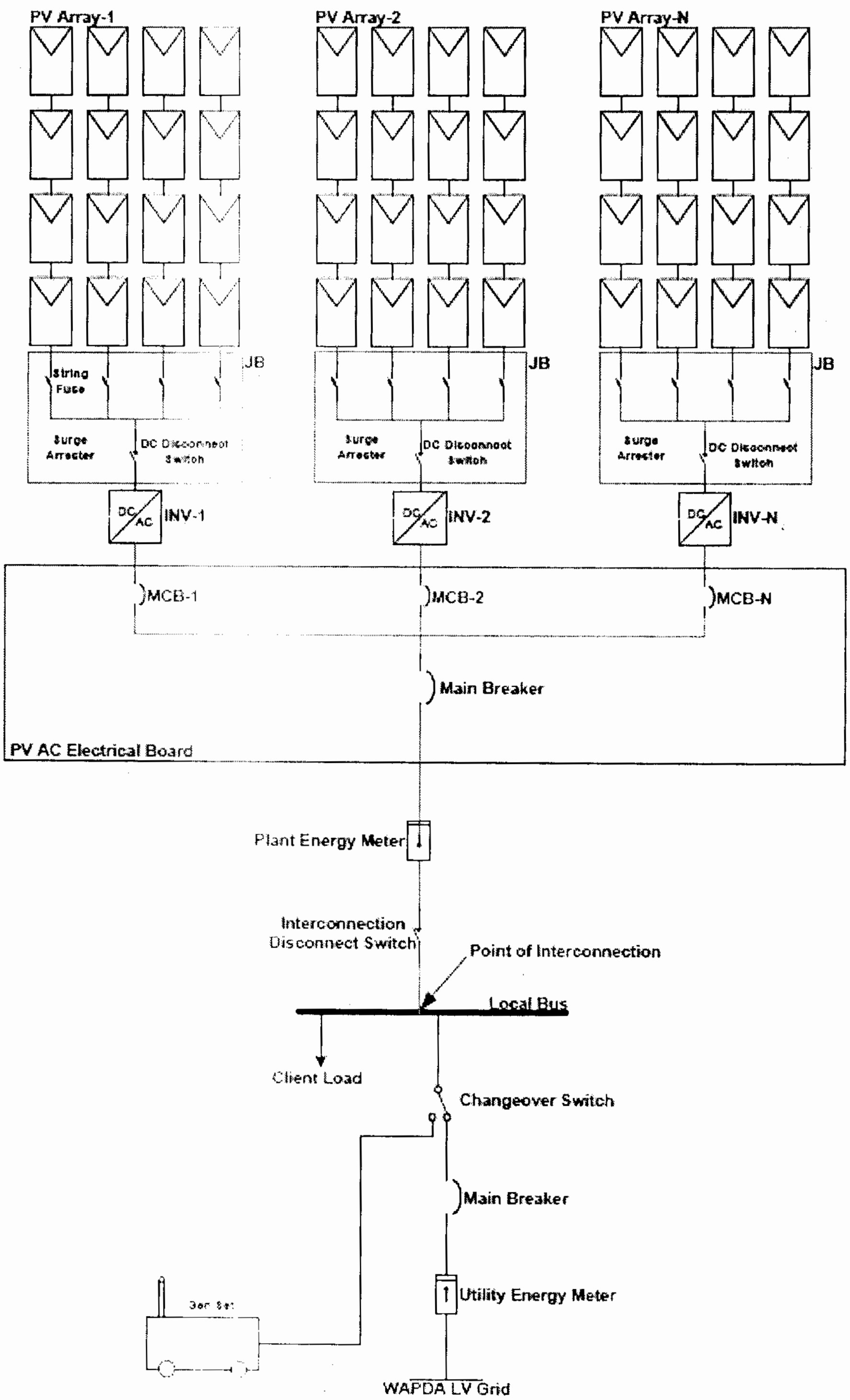
Process Flow Diagram of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL



Location Coordinates of the Generation Facility/Solar Farm/Power Plant of the Licensee/SPPL

Latitude (North)	Longitude (East)
31°28'38.70"	74°20'27.63"

Single Line Diagram of the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL



Interconnection

Arrangement for Dispersal of Power from the Generation Facility/Solar Power Plant of Shams Power (Private) Limited

The power generated from the Generation Facility/Power Plant of Shams Power (Private) Limited shall be dispersed at roof tops and car parking of AkzoNobel Lahore for in-house utilization.

(22). The proposed Interconnection Arrangement for dispersal of electric power for the Generation Facility/Solar Power Plant will be as under:-

(k). 230V/400V single circuit on bus bars of existing LT distribution panel of AkzoNobel/Consumer.

(l). If cable lengths exceed the estimated limit, then Parking area will be synced in Office building and other three locations (Production Hall, FG & New FG Shed and Area 31) will be combined and synced in main distribution LT panel of AkzoNobel/Consumer.

(23). Any change in the above Interconnection Arrangement duly agreed by Shams Power (Private) Limited and AkzoNobel/Consumer shall be communicated to the Authority in due course of time.

Detail of Generation Facility/Solar Power Plant

(A). General Information

(i).	Name of the Company/ Licensee	Shams Power (Private) Limited
(ii).	Registered/Business Office of the Company	2nd Floor, Al-Maalik Building 19-Davis Road Lahore
(iii).	Principal Office	2nd Floor, Al-Maalik Building 19-Davis Road Lahore
(iv).	Plants Location	Akzonobel (ICI) Pakistan, 346 Ferozepur Road, Lahore
(v).	Field Type	Fixed Tilted Plane
(vi)	Field Parameters	Tilt 8° & Azimuth 20°,70°,-110°
(vii).	Type of Generation Facility	Solar Photovoltaic (PV)

(B). Solar Power Generation Technology & Capacity

(i).	Type of Technology	Photovoltaic (PV) Cell
(ii).	Type of Cell	Polycrystalline
(ii).	Type of System	Grid Tied
(iii).	Installed Capacity of the Generation Facility (MW)	0.458 MW_P DC

(C). Technical Details of Equipment

(a).	**Solar Panels-PV Modules**		
(i).	Type of Module	Polycrystalline PV Type Module CS6U-330P	
(ii).	Surface Area of Module	1.94432 m^2	
(iii).	Dimension of each Module	1960 mm x 992 mm x 40mm	
(iv)	Total area of roof top & Ground for Solar Panels-PV Modules	2698 m^2	
(v).	No. of Modules	1388	
(vi).	Frame of Module	Anodised Aluminium Alloy	
(vii).	Weight of one Module	22.4 kg	
(viii).	Module Output Warranty	For 1st Year	For 2nd Year to 25th Year
		97.5% or above	Not more than 0.7% output reduction each year
(ix).	Number of Solar Cells in each Module	72 Cells	
(x).	Efficiency of Module	16.97 %	
(xi).	Environment Protection System	Encapsulation and sealing arrangements for protection from environment.	
(xii).	Maximum Power (P_{max})	330 W_P	
(xiii).	Power Tolerance at STC	0 ~ +5W	
(xiv).	Operating Voltage @ (P_{max})	37.2V	
(xv).	Operating Current @ (P_{max})	8.88 A	
(xvi).	Open circuit voltage (V_{oc})	45.6 V	
(xvii).	Short circuit current (I_{sc})	9.45 A	

(xviii).	Optimum Operating Voltage at NOCT	33.9 V
(xix).	Optimum Operating Current at NOCT	7.05 A
(xx).	Open circuit voltage (Voc) at NOCT	41.9 V
(xxi).	Maximum system open Circuit Voltage	1000V(IEC) or 1000V (UL) or 600V(UL)
(b).	**PV Array**	
(i).	No. of Arrays	16
(ii).	Modules in a String	15
(iii).	Total No. of Strings	92
(iv).	Modules in Array	90
(v).	Total Modules	1380
(c).	**PV Capacity**	
(i).	Total Capacity	0.458 MW_P DC (0.400 MW_P AC)
(ii).	Net Capacity Factor	15.95%
(d).	**Inverters**	
(i).	Maximum DC Power Input	0.411 MW (@50°C)
(ii).	Inverter Model	Sunny Tri power 25000TL (25 KW)
(iii).	Manufacturer	SMA Solar Technology, Germany
(iv).	Maximum DC Input Voltage	DC 1000 V
(v).	Start Voltage	DC 150 V
(vi).	Number of Inverters	16
(vii).	Efficiency	98.3% (Sunny Tri power 25000TL)
(viii).	Max. Input Current	DC 66 A
(ix).	MPP Voltage Range	320 V- 800 V DC (@50°C)
(x).	Output electrical system	3-Phase, 4-Wire

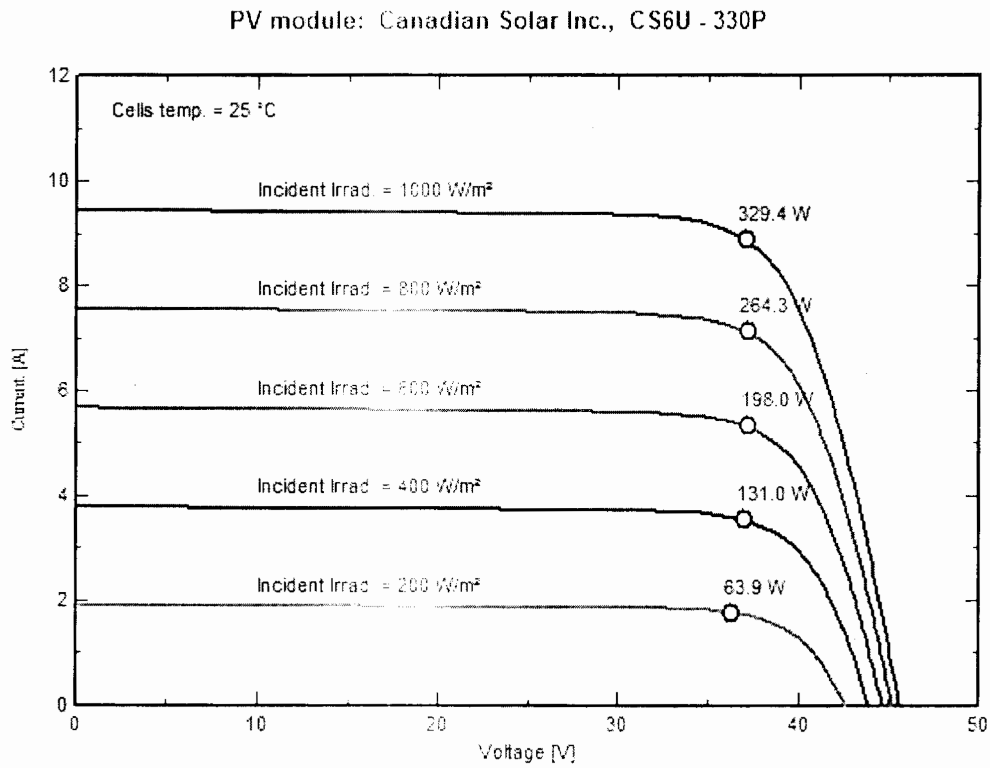
(xi).	Rated Output Voltage	AC 230/400 V	
(xii).	Rated Frequency	50 Hz	
(xiii).	Power Factor	1	
(xiv).	Power Control	MPP Tracker (2 MPPT/Inverter)	
(xv).	Environmental Enclosures	Operating Temperature Range	-25° C to 60° C
		Relative Humidity	100% non-condensing
		Protection Class	IP65
		Audible Noise	51 dB(A)
		Operating Elevation	<3000m
(xvi)	Protection Devices	(a).	DC Disconnect Switch
		(b).	Ground Fault Monitoring
		(c).	Reverse Polarity Protection
		(d).	Reverse current protection
		(e).	Over-voltage protection
(e).	**DC Side Protection**		
(i).	Number of Fuses/Inverter	6	
(ii).	Input circuits in each Inverter	6	
(iii).	Max. Input current for each circuit/string	15 A	
(iv).	Max. Input voltage	1000 V	
(v).	Power at each MPPT	14.85 kW_p	
(vi).	Over-Current protection	Fuse (SMA Inline Fuses)	
(vii).	Surge protection	Yes (>1000V) Integrated DC SPD (SMA)	
(viii).	DC Protection	(a).	Reverse Polarity

		(b).	Short Circuit Protection
		(c).	DC Surge Protection
(f).	**Data Collecting System**		
(i).	Weather Data	(a).	Irradiance Meter (Survey 100/200R)- 1 Set (to record ambient temp& radiation level)
(ii).	System Data	(a).	DC input voltage (V) & current (A) of each Inverter (Phase, Line)
		(b).	Total DC power (kW) generated by PV array.
		(c).	AC output voltage(V) and current (A) of each Inverter (Phase, Total)
		(d).	AC output power (kW) and energy (kWh) of each Inverter
		(e).	Frequency (Hz)
		(f).	Power Factor (PF)

(D). <u>Other Details</u>

(i).	COD of the Project	Feb 20, 2018
(ii).	Expected Life of the Project from the COD	25 Years

VI Curve of Solar Panel at STC for the Generation Facility/Solar Farm/Solar Power Plant of the Licensee/SPPL



SECTION 3:

AMENDED & RESTATED SCHEDULE II

Index

Restated SCHEDULE-II (For Existing Facility)

The Total Installed Gross ISO Capacity of the Generation Facility/Power Plant/Solar Plant (MW), Total Annual Full Load (Hours), Average Sun Availability, Total Gross Generation of the Generation Facility/Solar Farm (in kWh), Annual Energy Generation (25 years Equivalent Net Annual Production-AEP) KWh and Net Capacity Factor of the Generation Facility/Power Plant/Solar Farm of Licensee is given in this Schedule.

SCHEDULE-II

Existing Generation Facility/Solar Farm/Solar Power Plant

(1).	Total PV Installed Capacity of Generation Facility	70 KWp (Inverters' Output)
(2).	Average Sun Hour Availability/Day (Irradiation on Inclined Surface)	5.06 Hrs
(3).	Days per Year	365
(4).	PV Plant Generating Capacity Annually (As Per Simulation)	97986 KWh
(5).	Expected Total Generation in 25 years Life Span	2449650 KWh
(6).	Generation per Year from plant keeping 24 Hours Working	70 x 24 x 365 = 613200 KWh
(7).	Net Capacity Factor (4/6)	16.00%

Note

All the above figures are indicative as provided by the Licensee. The Net energy available to the Power Purchaser for dispatch will be determined through procedures contained in the Energy Purchase Agreement.

Amended SCHEDULE-II (For 10 Proposed Facilities)

The Total Installed Gross ISO Capacity of the Generation Facility/Power Plant/Solar Plant (MW), Total Annual Full Load (Hours), Average Sun Availability, Total Gross Generation of the Generation Facility/Solar Farm (in kWh), Annual Energy Generation (25 years Equivalent Net Annual Production-AEP) KWh and Net Capacity Factor of the Generation Facility/Power Plant/Solar Farm of Licensee is given in this Schedule.

SCHEDULE-II

Proposed 10 Generation Facilities/Solar Farms/Solar Power Plants

1. METRO Cash & Carry, Islamabad

(1).	Total PV Installed Capacity of Generation Facility	0.300 MWp (AC)
(2).	Average Sun Hour Availability/Day (Irradiation on Inclined Surface)	5.06 Hrs
(3).	Days per Year	365
(4).	PV Plant Generating Capacity Annually (As Per Simulation)	428361 KWh
(5).	Expected Total Generation in 25 years Life Span	9786401 KWh
(6).	Generation per Year from plant keeping 24 Hours Working	300 x 24 x 365 = 2628000 KWh
(7).	Net Capacity Factor (4/6)	16.30%

Note

All the above figures are indicative as provided by the Licensee. The Net energy available to the Power Purchaser for dispatch will be determined through procedures contained in the Energy Purchase Agreement.

2. METRO Cash & Carry, Thokkar Niaz Baig, Lahore

(1).	Total PV Installed Capacity of Generation Facility	0.350 MWp (AC)
(2).	Average Sun Hour Availability/Day (Irradiation on Inclined Surface)	5.06 Hrs
(3).	Days per Year	365
(4).	PV Plant Generating Capacity Annually (As Per Simulation)	474170 KWh
(5).	Expected Total Generation in 25 years Life Span	10832961 KWh
(6).	Generation per Year from plant keeping 24 Hours Working	350 x 24 x 365 = 3066000 KWh
(7).	Net Capacity Factor (4/6)	15.46%

Note

All the above figures are indicative as provided by the Licensee. The Net energy available to the Power Purchaser for dispatch will be determined through procedures contained in the Energy Purchase Agreement.

3. METRO Cash & Carry, Airport Road, DHA, Lahore

(1).	Total PV Installed Capacity of Generation Facility	0.300 MWp (AC)
(2).	Average Sun Hour Availability/Day (Irradiation on Inclined Surface)	5.06 Hrs
(3).	Days per Year	365
(4).	PV Plant Generating Capacity Annually (As Per Simulation)	423195 KWh
(5).	Expected Total Generation in 25 years Life Span	9667555 KWh
(6).	Generation per Year from plant keeping 24 Hours Working	300 x 24 x 365 = 2628000 KWh
(7).	Net Capacity Factor (4/6)	16.10%

Note

All the above figures are indicative as provided by the Licensee. The Net energy available to the Power Purchaser for dispatch will be determined through procedures contained in the Energy Purchase Agreement.

4. METRO Cash & Carry, Ravi Road, Lahore

(1).	Total PV Installed Capacity of Generation Facility	0.300 MWp (AC)
(2).	Average Sun Hour Availability/Day (Irradiation on Inclined Surface)	5.06 Hrs
(3).	Days per Year	365
(4).	PV Plant Generating Capacity Annually (As Per Simulation)	399522 KWh
(5).	Expected Total Generation in 25 years Life Span	9127541 KWh
(6).	Generation per Year from plant keeping 24 Hours Working	300 KW x 24 x 365 = 2628000 KWh
(7).	Net Capacity Factor (4/6)	15.20%

Note

All the above figures are indicative as provided by the Licensee. The Net energy available to the Power Purchaser for dispatch will be determined through procedures contained in the Energy Purchase Agreement.

5. METRO Cash & Carry, Model Town, Lahore

(1).	Total PV Installed Capacity of Generation Facility	0.225 MWp (AC)
(2).	Average Sun Hour Availability/Day (Irradiation on Inclined Surface)	5.06 Hrs
(3).	Days per Year	365
(4).	PV Plant Generating Capacity Annually (As Per Simulation)	309084 KWh
(5).	Expected Total Generation in 25 years Life Span	7061381 KWh
(6).	Generation per Year from plant keeping 24 Hours Working	225 x 24 x 365 = 2190000 KWh
(7).	Net Capacity Factor (4/6)	15.68%

Note

All the above figures are indicative as provided by the Licensee. The Net energy available to the Power Purchaser for dispatch will be determined through procedures contained in the Energy Purchase Agreement.

6. METRO Cash & Carry, Sargodha Road, Faisalabad

(1).	Total PV Installed Capacity of Generation Facility	0.250 MWp (AC)
(2).	Average Sun Hour Availability/Day (Irradiation on Inclined Surface)	5.06 Hrs
(3).	Days per Year	365
(4).	PV Plant Generating Capacity Annually (As Per Simulation)	348433 KWh
(5).	Expected Total Generation in 25 years Life Span	7960354 KWh
(6).	Generation per Year from plant keeping 24 Hours Working	250 x 24 x 365 = 2190000 KWh
(7).	Net Capacity Factor (4/6)	15.91%

Note

All the above figures are indicative as provided by the Licensee. The Net energy available to the Power Purchaser for dispatch will be determined through procedures contained in the Energy Purchase Agreement.

7. METRO Cash & Carry, Manghopir Road, Karachi

(1).	Total PV Installed Capacity of Generation Facility	0.200 MWp (AC)
(2).	Average Sun Hour Availability/Day (Irradiation on Inclined Surface)	5.10 Hrs
(3).	Days per Year	365
(4).	PV Plant Generating Capacity Annually (As Per Simulation)	315797 KWh
(5).	Expected Total Generation in 25 years Life Span	7214747 KWh
(6).	Generation per Year from plant keeping 24 Hours Working	200 x 24 x 365 = 1752000 KWh
(7).	Net Capacity Factor (4/6)	18.02%

Note

All the above figures are indicative as provided by the Licensee. The Net energy available to the Power Purchaser for dispatch will be determined through procedures contained in the Energy Purchase Agreement.

8. METRO Cash & Carry, Near Stargate, Karachi

(1).	Total PV Installed Capacity of Generation Facility	0.300 MWp (AC)
(2).	Average Sun Hour Availability/Day (Irradiation on Inclined Surface)	5.10 Hrs
(3).	Days per Year	365
(4).	PV Plant Generating Capacity Annually (As Per Simulation)	478607 KWh
(5).	Expected Total Generation in 25 years Life Span	10934329 KWh
(6).	Generation per Year from plant keeping 24 Hours Working	300 x 24 x 365 = 2628000 KWh
(7).	Net Capacity Factor (4/6)	18.21%

Note

All the above figures are indicative as provided by the Licensee. The Net energy available to the Power Purchaser for dispatch will be determined through procedures contained in the Energy Purchase Agreement.

9. METRO Cash & Carry, Near Safari Park, Karachi

(1).	Total PV Installed Capacity of Generation Facility	0.375 MWp (AC)
(2).	Average Sun Hour Availability/Day (Irradiation on Inclined Surface)	5.10 Hrs
(3).	Days per Year	365
(4).	PV Plant Generating Capacity Annually (As Per Simulation)	593365 KWh
(5).	Expected Total Generation in 25 years Life Span	13556108 KWh
(6).	Generation per Year from plant keeping 24 Hours Working	375 x 24 x 365 = 3285000 KWh
(7).	Net Capacity Factor (4/6)	18.10%

Note

All the above figures are indicative as provided by the Licensee. The Net energy available to the Power Purchaser for dispatch will be determined through procedures contained in the Energy Purchase Agreement.

10. AkzoNobel, Head Office, Lahore

(1).	Total PV Installed Capacity of Generation Facility	0.400 MWp (AC)
(2).	Average Sun Hour Availability/Day (Irradiation on Inclined Surface)	5.06 Hrs
(3).	Days per Year	365
(4).	PV Plant Generating Capacity Annually (As Per Simulation)	559040 KWh
(5).	Expected Total Generation in 25 years Life Span	12771913 KWh
(6).	Generation per Year from plant keeping 24 Hours Working	400 x 24 x 365 = 3504000 KWh
(7).	Net Capacity Factor (4/6)	15.95%

Note

All the above figures are indicative as provided by the Licensee. The Net energy available to the Power Purchaser for dispatch will be determined through procedures contained in the Energy Purchase Agreement.

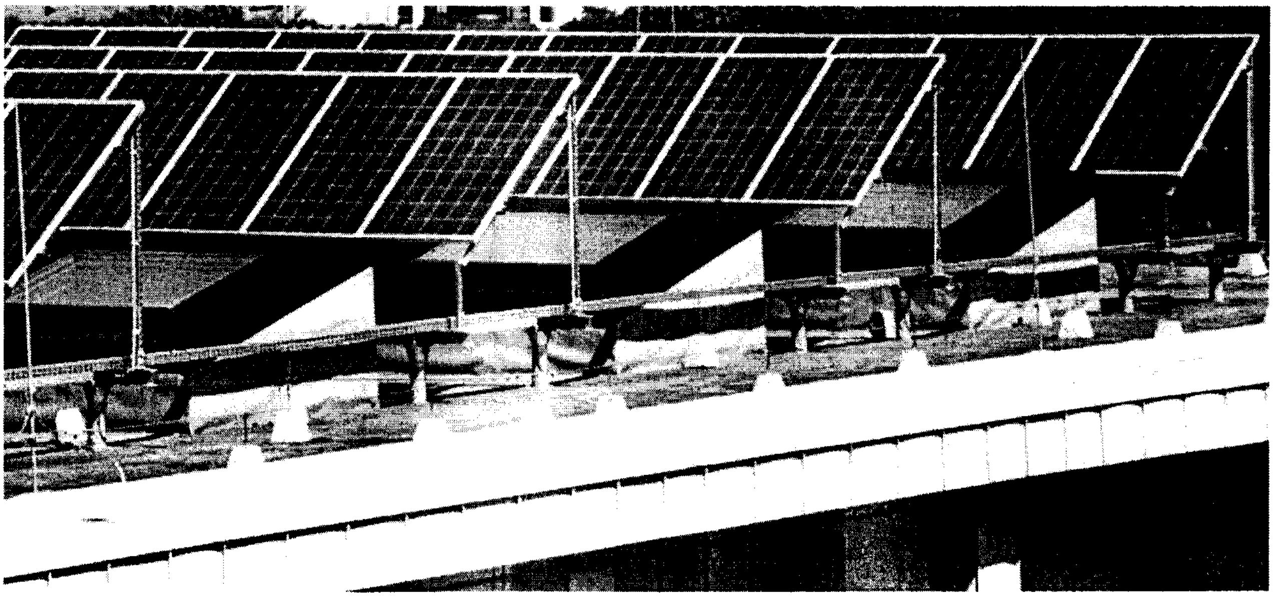
SECTION 4:

Feasibility Studies for the Proposed Facilities

ShamsPower

Index

ShamsPower



1. FEASIBILITY STUDY FOR ROOFTOP SOLAR INSTALLATION AT METRO CASH & CARRY STORE I-11/4 ISLAMABAD

SHAMS POWER (PVT) LIMITED

EXECUTIVE SUMMARY

The feasibility study examines the costs, practicality, and likely outcome of a solar photovoltaic (PV) installation on the rooftop of Metro Cash & Carry Store I-11/4, Islamabad.

The main outcomes of the feasibility report are given below:

Technical Site Analysis: The project site is suitable for a solar PV energy system. For the purpose of estimation of power generation potential, solar insolation is assumed to be "good" (1,720 kWh/ square meter/ year). Panel azimuth (32,148 degree), panel tilt (2 degrees) and satisfactory roof condition and structure are also assumed.

Anticipated System Information: The project will accommodate a 300 kW (AC) solar PV system with a projected annual production of 428,361 kWh/ year. Use of a Canadian Solar Inc. CS6U – 330P (330 watt) PV panel as a basis for design will result in an acceptable system weight density of 2.36 lbs/sqft. The system will offset approximately 149 tons of carbon dioxide annually.

Financial Analysis: The project will be financed on a 100% equity model. The total estimated project cost is USD 427,680.

Based on the technical and financial analysis, the installation of a 300 kW Solar PV System on the rooftop of Metro Cash & Carry Store is deemed to be feasible.

Introduction

The project site is the rooftop of Metro Cash & Carry Store I-11/4, Islamabad, Pakistan. Metro Cash & Carry Store is a single storied commercial building/retail store. The exact coordinates of the project site are:

Latitude: 33°38'23.66" North

Longitude: 73° 1'30.19" East

A bird's eye view of the project site is given in the figure below:

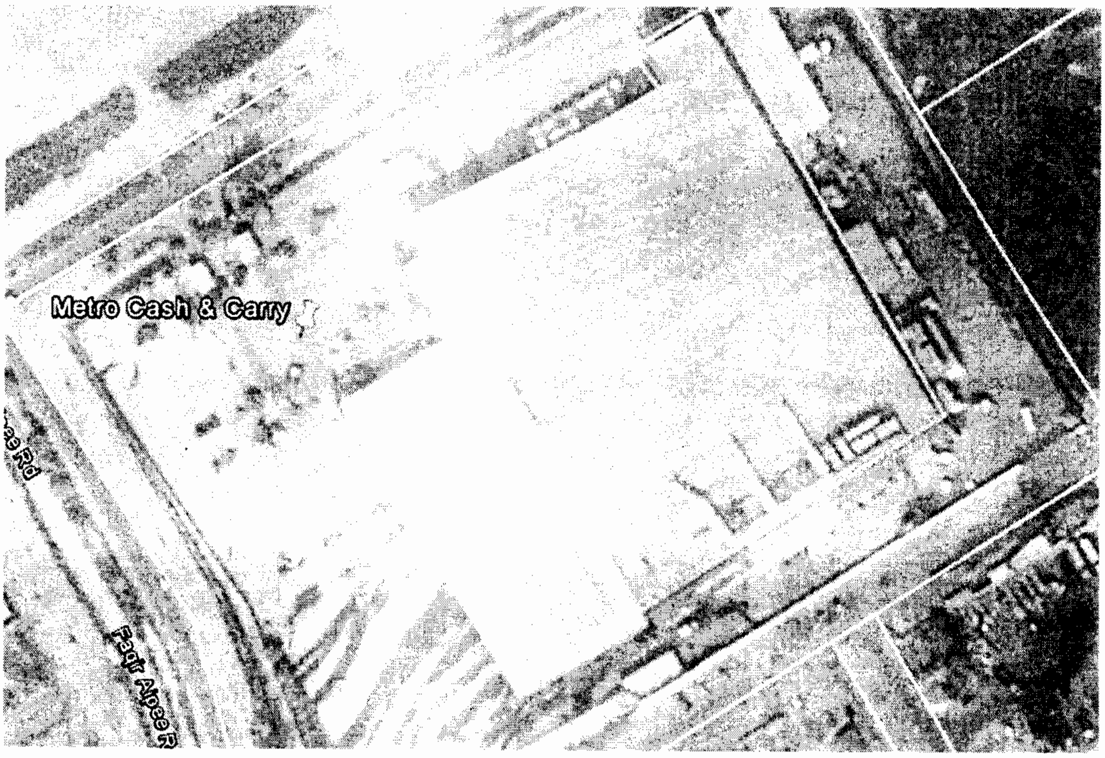


Figure 1: Overview of Project Site

Current Energy Demand and Supply Situation

As per the historical consumption data, the total electricity consumption during 2016 was 2,675,077 kWh.

Details of electricity generation/supply sources during this period are given below:

- Electricity imported from the national grid is 2,178,000 kWh
- In-house power generation from Diesel Generators is 497,077 kWh

Technical Analysis

Site Conditions

The following tasks were carried out:

- Global Horizontal Irradiation, annual and inter-annual variation was assessed.
- Near shading objects were taken into account for placement of PV modules.
- Area required for selected module technology was calculated. Keeping in view available area and minimum inter row shading, tilt angle and appropriate spacing was calculated from near shading objects.

Details of the finalized parameters are given under section 3.5.1

Technology Review and Selection

Technology Selection

PV Modules:

S. No	Specification	Data
1	Type of Module	CS6U-330P
2	Type of Cell	Polycrystalline
3	Dimensions of each module	1960*992*40 mm
4	Weight	22.4 Kg
5	No of Modules	1080
6	Module Area	1.94432 m^2
7	Total Land Area Used	Roof Top
8	Module Frame	Anodized aluminum alloy
9	Nominal Max. Power (Pmax)	330 W
10	Opt. Operating Voltage (Vmp)	37.2 V
11	Opt. Operating Current (Imp)	8.88 A
12	Open Circuit Voltage (Voc)	45.6 V
13	Short Circuit Current (Isc)	9.45 A
14	Module Efficiency	16.97%
15	Operating Temperature	-40°C ~ +85°C
16	Max. System Voltage	1000 V (IEC) or 1000 V (UL) or 600 V (UL)

17	Module Fire Performance	TYPE 1 (UL 1703) or CLASS C (IEC 61730)

PV Array

S. No	Specification	Data
1	No of Strings	72
2	Modules in String	15

PV Capacity

S. No	Specification	Data
1	Total Site	356.4 KW Peak
2	Net Capacity Factor	16.3%

Inverters

S. No	Specification	
1	Manufacturer	SMA
2	Capacity of each Unit	25 KW
3	No of Inverters	12
4	MPP Input Voltage Range	390 V to 800 V
5	Rated Input Voltage	600 V
6	Max Input Voltage	1000 V
7	Total Power (AC)	300 KW
8	Max Input Current Input A/Input B	33A/33A
9	Max Output Current	36.1 A
10	Output Electrical System	3 Phase AC (4 Wire)
11	AC Nominal Voltage	230/400 V
12	Rated Power Frequency	50 Hz
13	Efficiency	98.3%
14	Relative Humidity (Non-Condensing)	100%
15	Noise Emission	51 dB(A)
16	Degree of Protection	IP65

Junction Boxes

S. No	Specification	Data
1	Number of J/Box units	24
2	Input circuits in each box	3

3	Max. input current for each circuit	15A
4	Protection Level	IP 65
5	Over current protection	Fuse
6	Surge protection	>1000V

PV Mounting Structure

S. No	Specification	Data
1	Structure	Aluminum
2	Tilt of Array Frame	2° (In line with shed rooftop)

Data Collecting System

S. No	Specification	Data
1	System Data	Continuous on-line logging and monitoring over web portal

Solar PV Yield Estimation and Simulation

The aim of yield estimation is to predict the average annual energy output of the site. PvSyst software is used for simulation and near shading analysis.

Working Conditions: Zero Export

The solar system will have automatic mechanism to ensure that PV power currently generated by the inverters always matches the current power consumption of the site load. A closed loop control system of inverter AC output is implemented in reference to energy flow at grid connection point which will reduce inverter AC output of the inverter if site load will be less than the solar production.

Plant Characteristics
Generation Voltage: 230/400 V three phase four wire system
Power Factor at rated power: 1
Frequency: 50 Hz
Generation characteristic: Inverter has built-in features of controllable active power ramp following grid disturbance or normal connection, voltage regulation and frequency response. There are no additional control metering and instrumentations.

Design Parameters

The following tasks were carried out for PV layout and shading.

- Assessment of shading (horizon and nearby building)
- Outline layout of area suitable for PV development
- Designing row spacing to reduce inter-row shading and associated shading losses.
- Designing the layout to minimize cable runs and associated electrical losses
- Creating access routes and sufficient space to allow movement for maintenance purposes
- Choosing a tilt angle that optimizes the annual energy yield according to the latitude of the site and the annual distribution of solar resource
- Module cleaning strategy
- Simulating the annual energy losses associated with various configurations of tilt angle, orientation and row spacing. The optimized configuration and simulation results are given in section "Energy Yield Prediction"
- PV layouts of the site are given in 3D and 2D view in the following section.

Layout

The detailed layout (2D and 3D) of the solar panels is given below. PV layout may change depending upon site constraints before or during installation. PvSyst simulation is also performed as per following layout:

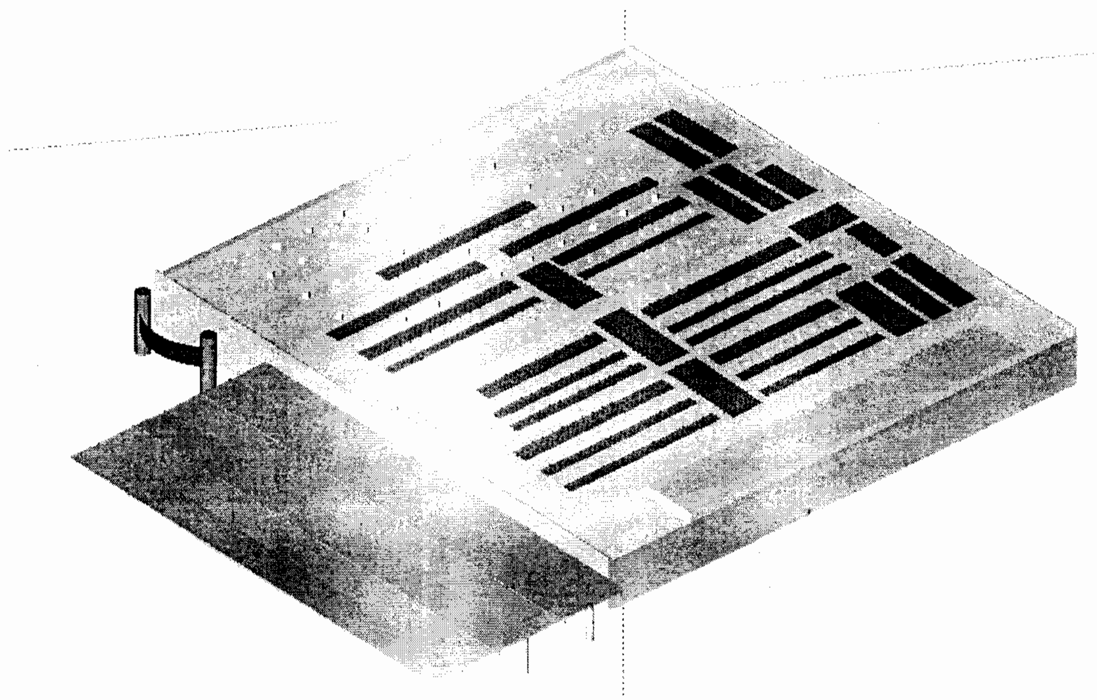


Figure 2: 3D Layout of rooftop of Metro Cash & Carry Islamabad

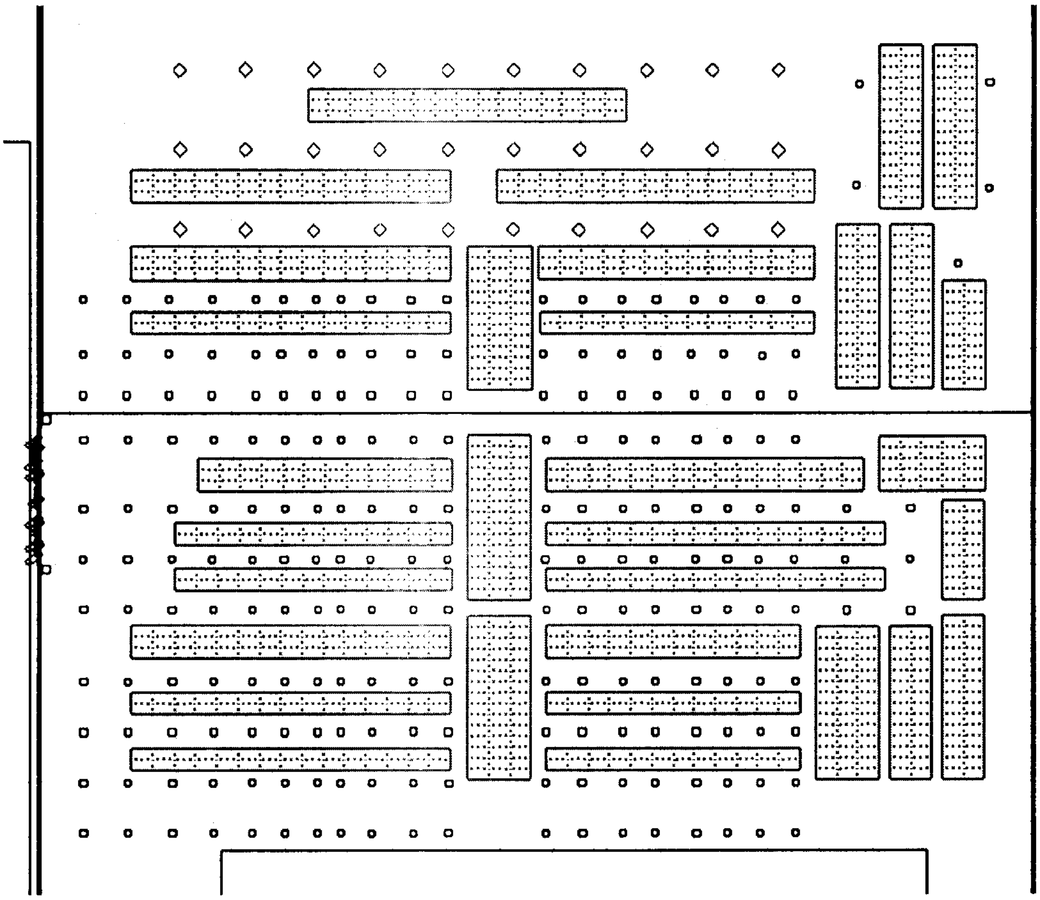


Figure 3: 2D Layout of rooftop of Metro Cash & Carry Islamabad showing solar panel locations

Electrical Design

The electrical system comprises the following components:

- Array(s) of PV modules
- DC/AC cabling (module, string and main cable)
- DC connectors (plugs and sockets)
- Junction boxes
- Disconnects/switches
- Protection devices e.g. fuses, surge protective devices, beakers
- Energy Metering
- Earthing

The single line diagram is given below. The single line diagram includes the protection devices that will be used for safe and smooth operation of the system.

Protections DC Side: String Fuses, Surge Protective Device and DC Disconnect Switches

Protections AC Side: MCBs, Main Breaker and Surge Protective Device

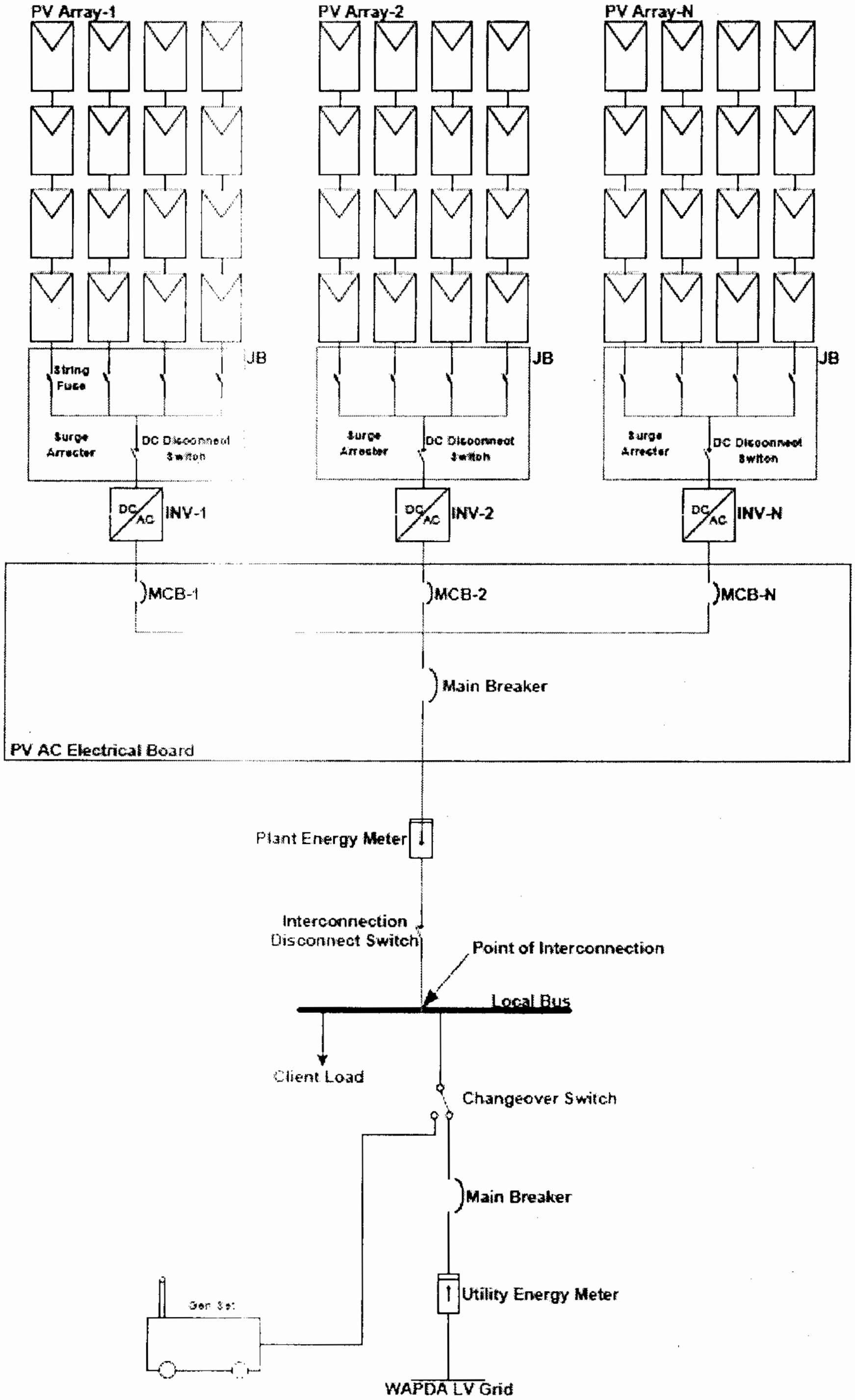


Figure 4: Single Line Diagram of PV Plant

Energy Yield Estimation

The energy yield prediction provides the basis for calculating project revenues. The aim is to predict the average annual energy output for the lifetime of the proposed power plant.

To estimate accurately the energy produced from a PV power plant, information is needed on the solar resource and temperature conditions of the site. Also required are the layout and technical specifications of the plant components.

A number of solar energy yield prediction software packages are available in the market. These packages use time step simulation to model the performance of a project over the course of a year. PvSyst software has been used for energy yield prediction for this site and its results are given below.

Details of the simulation steps are presented in the following sections:

ShamsPower

Simulation Parameters

PVSYST V6.40	Shams Power (Pvt) Ltd.	05/06/17	Page 1/5

Grid-Connected System: Simulation parameters

Project :	**Metro Cash & Carry Store, Islamabad**			
Geographical Site	Metro Islamabad		Country	**Pakistan**
Situation	Latitude	33.63° N	Longitude	73.02° E
Time defined as	Legal Time	Time zone UT+5	Altitude	511 m
	Albedo	0.20		
Meteo data:	Metro Islamabad	Meteonorm 7.1 - Synthetic		

Simulation variant :	**metro isb**			
	Simulation date	05/06/17 12h47		

Simulation parameters				
2 orientations	Tilts/Azimuths	2°/-32° and 2°/148°		
Models used	Transposition	Perez	Diffuse	Perez, Meteonorm
Horizon	Free Horizon			
Near Shadings	According to strings		Electrical effect	100 %
PV Arrays Characteristics (2 kinds of array defined)				
PV module Si-poly	Model	**CS6U - 330P**		
Custom parameters definition	Manufacturer	Canadian Solar Inc.		
Sub-array "Sub-array #1"	Orientation	#1	Tilt/Azimuth	2°/-32°
Number of PV modules	In series	15 modules	In parallel	42 strings
Total number of PV modules	Nb. modules	630	Unit Nom. Power	330 Wp
Array global power	Nominal (STC)	**208 kWp**	At operating cond.	186 kWp (50°C)
Array operating characteristics (50°C)	U mpp	497 V	I mpp	374 A
Sub-array "Sub-array #2"	Orientation	#2	Tilt/Azimuth	2°/148°
Number of PV modules	In series	15 modules	In parallel	30 strings
Total number of PV modules	Nb. modules	450	Unit Nom. Power	330 Wp
Array global power	Nominal (STC)	**149 kWp**	At operating cond.	133 kWp (50°C)
Array operating characteristics (50°C)	U mpp	497 V	I mpp	267 A
Total Arrays global power	Nominal (STC)	**356 kWp**	Total	1080 modules
	Module area	**2100 m²**	Cell area	1893 m²
Inverter	Model	**Sunny Tripower 25000TL-30**		
Original PVsyst database	Manufacturer	SMA		
Characteristics	Operating Voltage	390-800 V	Unit Nom. Power	25.0 kWac
Sub-array "Sub-array #1"	Nb. of inverters	7 units	Total Power	175 kWac
Sub-array "Sub-array #2"	Nb. of inverters	5 units	Total Power	125 kWac
Total	Nb. of inverters	12	Total Power	300 kWac
PV Array loss factors				
Array Soiling Losses			Loss Fraction	2.0 %
Thermal Loss factor	Uc (const)	20.0 W/m²K	Uv (wind)	0.0 W/m²K / m/s
Wiring Ohmic Loss	Array#1	29 mOhm	Loss Fraction	1.9 % at STC
	Array#2	31 mOhm	Loss Fraction	1.5 % at STC
	Global		Loss Fraction	1.7 % at STC

Grid-Connected System: Simulation parameters (continued)

LID - Light Induced Degradation		Loss Fraction	2.5 %
Module Quality Loss		Loss Fraction	2.0 %
Module Mismatch Losses		Loss Fraction	1.0 % at MPP

Incidence effect (IAM): User defined IAM profile

10°	20°	30°	40°	50°	60°	70°	80°	90°
0.998	0.998	0.995	0.992	0.986	0.970	0.917	0.763	0.000

System loss factors

Wiring Ohmic Loss	Wires 3x500.0 mm² 367 m	Loss Fraction	3.0 % at STC
Unavailability of the system	34.0 days, 4 periods	Time fraction	9.3 %

User's needs : Unlimited load (grid)

ShamsPower

Near Shading Definition

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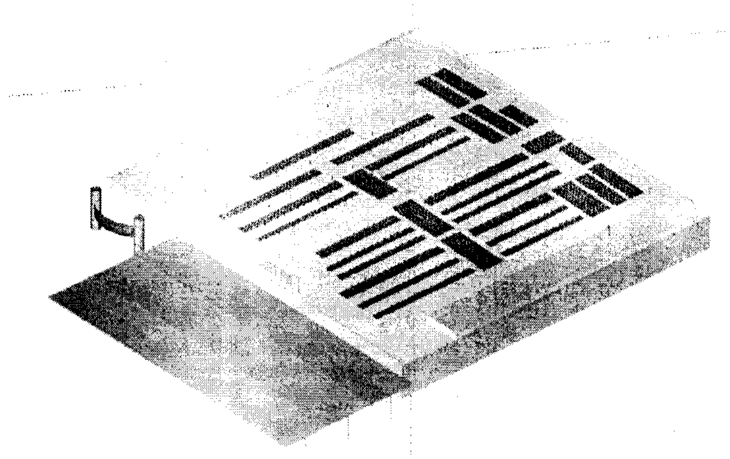
Grid-Connected System: Near shading definition

Project : Metro Cash & Carry Store, Islamabad

Simulation variant : metro isb

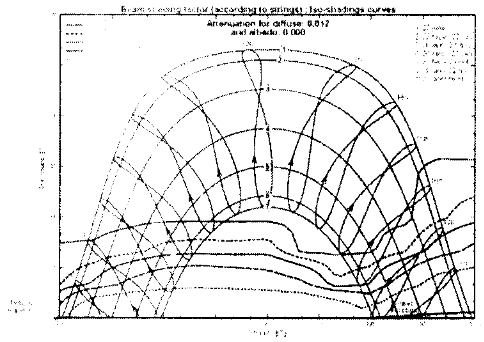
Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	2 orientations	Tilt/Azimuth = 2°/-32° and 2°/148°		
PV modules	Model	CS6U - 330P	Pnom	330 Wp
PV Array	Nb. of modules	1080	Pnom total	**356 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
Inverter pack	Nb. of units	12.0	Pnom total	**300 kW ac**
User's needs	Unlimited load (grid)			

Perspective of the PV-field and surrounding shading scene



Iso-shadings diagram

Metro Cash & Carry Store, Islamabad



Losses

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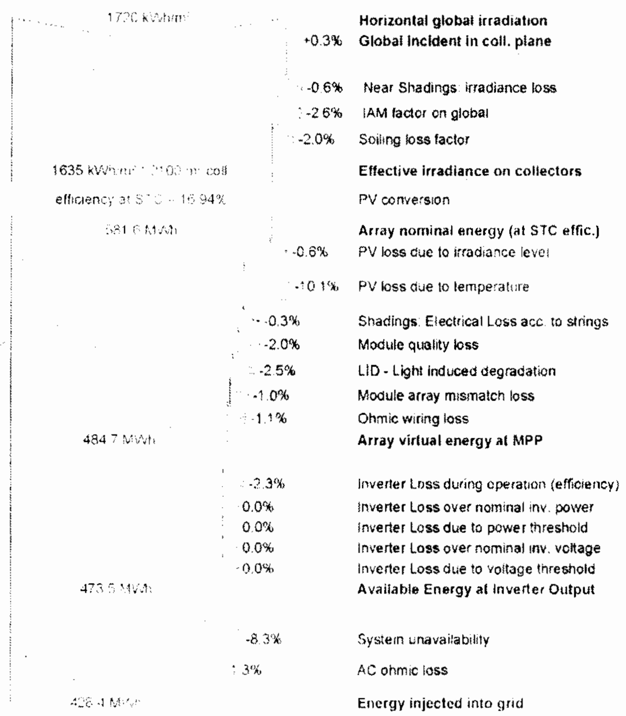
Grid-Connected System: Loss diagram

Project : Metro Cash & Carry Store, Islamabad

Simulation variant : metro isb

Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	2 orientations	Tilt/Azimuth = 2°/-32° and 2°/148°		
PV modules	Model	CS6U - 330P	Pnom	330 Wp
PV Array	Nb. of modules	1080	Pnom total	**356 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
Inverter pack	Nb. of units	12.0	Pnom total	**300 kW ac**
User's needs	Unlimited load (grid)			

Loss diagram over the whole year



Simulation Results

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Grid-Connected System: Main results

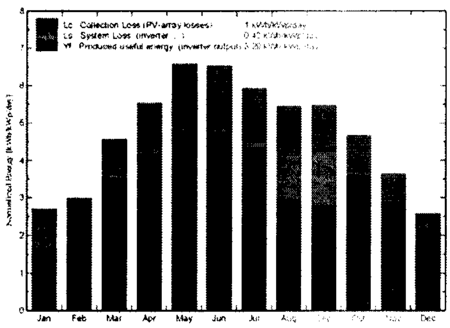
Project : Metro Cash & Carry Store, Islamabad

Simulation variant : metro isb

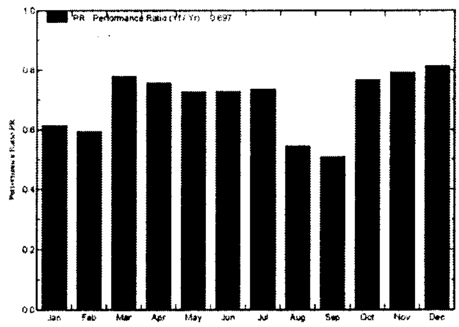
Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	2 orientations	Tilt/Azimuth = 2°/-32° and 2°/148°		
PV modules	Model	CS6U - 330P	Pnom	330 Wp
PV Array	Nb. of modules	1080	Pnom total	**356 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
Inverter pack	Nb. of units	12.0	Pnom total	**300 kW ac**
User's needs	Unlimited load (grid)			

Main simulation results				
System Production	Produced Energy	**428.4 MWh/year**	Specific prod.	1202 kWh/kWp/year
	Performance Ratio PR	69.68 %		

Normalized productions (per installed kWp): Nominal power 356 kWp



Performance Ratio PR



metro isb

Balances and main results

	GlobHor	DiffHor	T Amb	GlobInc	GlobEff	EArray	E_Grid	PR
	kWh/m²	kWh/m²	°C	kWh/m²	kWh/m²	MWh	MWh	
January	[illegible]	[illegible]	10.25	83.5	78.1	25.14	18.30	0.615
February	83.5	[illegible]	13.42	83.7	78.7	25.07	17.74	0.594
March	140.7	[illegible]	19.04	141.1	133.7	40.58	39.15	0.779
April	[illegible]	[illegible]	24.02	165.7	157.4	46.50	44.80	0.758
May	[illegible]	[illegible]	29.71	204.1	194.7	55.10	52.92	0.728
June	[illegible]	[illegible]	30.89	196.0	186.8	52.97	50.91	0.729
July	[illegible]	[illegible]	30.19	183.5	174.4	50.04	48.15	0.736
August	[illegible]	[illegible]	28.97	168.7	160.2	48.63	32.61	0.548
September	[illegible]	[illegible]	26.74	164.4	156.2	45.67	29.83	0.509
October	[illegible]	[illegible]	22.54	145.0	137.5	41.16	39.71	0.768
November	[illegible]	[illegible]	15.87	109.4	102.4	31.88	30.84	0.791
December	79.5	[illegible]	11.71	80.0	74.7	23.95	23.21	0.814
Year	[illegible]	[illegible]	21.99	1725.0	1634.7	484.66	428.36	0.697

Legends			
GlobHor	[illegible]	GlobEff	Effective Global, corr. for IAM and shadings
DiffHor	[illegible]	EArray	Effective energy at the output of the array
T Amb	[illegible]	E_Grid	Energy injected into grid
GlobInc	[illegible]	PR	Performance Ratio

Financial Analysis

Cost/watt: **USD 1.2**

Total Project Cost for 356.4 KWp (DC) Solar PV System: **USD 427,680**

Equity: **100%**

Debt: **0%**

Safety and Emergency Plans

- Only qualified and authorized electricians will be allowed to undertake servicing or maintenance tasks.
- The authorized personnel will wear appropriate equipment, including a safety harness to restrain from falling off the roof, sturdy shoes that will have thick rubber soles to provide electrical insulation and good grip and appropriate clothing for personal protection, including a hat, sunglasses, gloves and long pants and sleeves
- Lock out and tag out procedures will be used before commencement of maintenance tasks.
- On-going operation and maintenance concerns for solar power systems will be addressed properly. These systems are exposed to outdoor weather conditions that enhance the aging process, and the infrastructure needs to be in place for the on-going maintenance of these systems to assure their safe operation.
- Properly grounded or double insulated power tools will be used for maintenance tasks. Tools will be maintained in good condition.
- Working on electrical equipment and circuits will be carried out in de energized state.
- Proper pathways will be available for operation, maintenance and firefighting.
- Fire protection and suppression will be placed at site

Training and Capacity Development

Trained and qualified personnel will be available at site 24/7 with proper safety and firefighting training. Training program will focus on but not limited to Solar Resource Assessment, Site Survey, Technology, Engineering Design, Regulation, Policy, Metering & Billing, and Project Management of Rooftop Solar System. The following components will include in training and development program.

a. Collection of Resource Data
b. Variability and uncertainty of resource data
c. Site evaluation
d. Crystalline and Thin film technology comparison
e. Rooftop solar system components
f. Module mounting structure selection
g. Inverter selection
h. Design of PV Array
i. Shadow Analysis
j. DC cable sizing
k. DC cable layout
l. Protection and Metering
m. Installation and testing standards for solar PV plants
n. Solar Module testing standards
o. Economy of Roof top Solar System
p. Detailed Project Report
q. Operation and maintenance of rooftop solar system
r. Safety and firefighting training

Environmental Aspects

Every energy generation and transmission method affects the environment. Conventional generating options can damage air, climate, water, land and wildlife, landscape as well as raise the levels of harmful radiation. PV technology is substantially safer offering a solution to many environmental and social problems associated with fossil and nuclear fuels. Solar PV energy technology provides obvious environmental advantages in comparison to the conventional energy sources thus contributing to the sustainable development of human activities. Not counting the depletion of the exhausted natural resources, their main advantage is related to the reduced CO2 emissions and normally absence of any air emissions or waste products during their operation.

The use of solar power has additional positive implications such as:

- Reduction of the emissions of the greenhouse gases (mainly CO2, NOx) and prevention of toxic gas emissions (SO2,particulates)
- Reduction of the required transmission lines of the electricity grids

Socio-Economic Aspects

In regard to the socio-economic viewpoint, the benefits of exploitation of solar PV system comprise of:

- Increase of the regional/national energy independency
- Provision of significant work opportunities
- Diversification and security of energy supply
- Support of the deregulation of energy markets

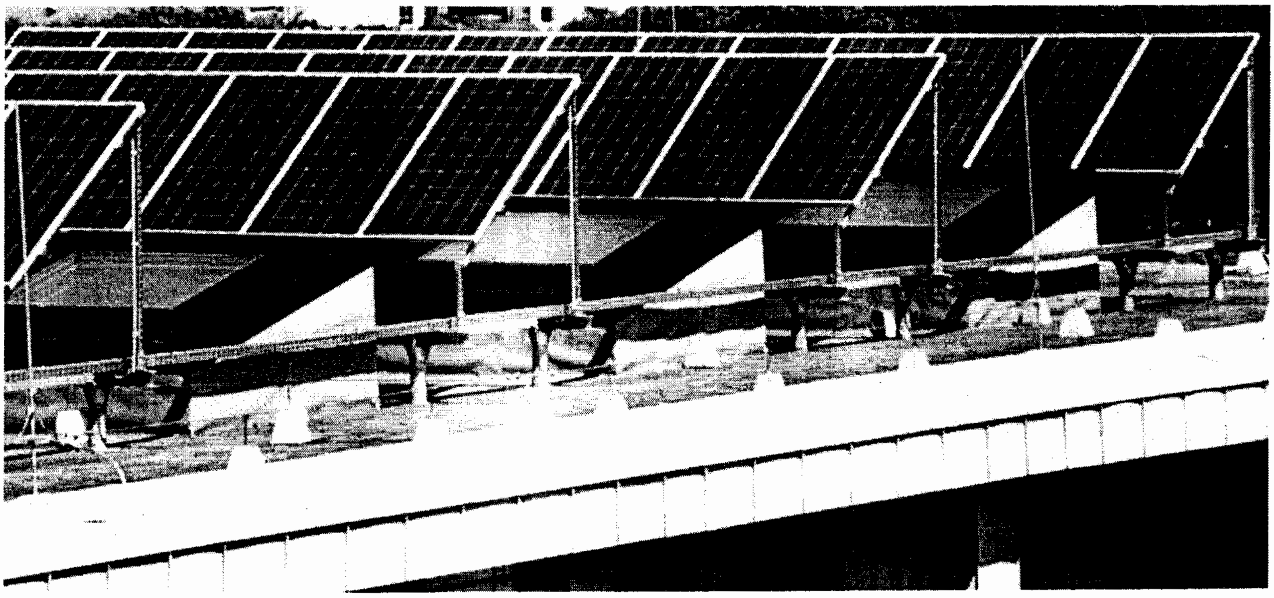
Conclusion

This feasibility study is conducted to ascertain the technical feasibility and commercial viability of installation of 300kW rooftop PV system installation at Metro Cash & Carry I-11/4, Islamabad.

Installation of the PV system will result in annual power generation of 428,361 kWh.

The results of the financial analysis indicate that the project is feasible.

Based on the outcomes of both the technical and financial analysis, the project is deemed to be viable.



2. FEASIBILITY STUDY FOR ROOFTOP SOLAR INSTALLATION AT METRO CASH & CARRY STORE THOKAR NIAZ BAIG LAHORE

SHAMS POWER (PVT) LIMITED

EXECUTIVE SUMMARY

The feasibility study examines the costs, practicality, and likely outcome of a solar photovoltaic (PV) installation on the rooftop of Metro Cash & Carry Store Thokar Niaz Baig, Lahore.

The main outcomes of the feasibility report are given below:

Technical Site Analysis: The project site is suitable for a solar PV energy system. For the purpose of estimation of power generation potential, solar insolation is assumed to be "good" (1,719 kWh/ square meter/ year). Panel azimuth (33 degree), panel tilt (2 degrees) and satisfactory roof condition and structure are also assumed.

Anticipated System Information: The project will accommodate a 350 kW (AC) solar PV system with a projected annual production of 474,170 kWh/ year. Use of a Canadian Solar Inc. CS6U – 330P (330 watt) PV panel as a basis for design will result in an acceptable system weight density of 2.36 lbs/sqft. The system will offset approximately 166 tons of carbon dioxide annually.

Financial Analysis: The project will be financed on a 100% equity model. The total estimated project cost is USD 465,696.

Based on the technical and financial analysis, the installation of a 350 kW Solar PV System on the rooftop of Metro Cash & Carry Store Thokar Niaz Baig Store is deemed to be feasible.

Introduction

The project site is the rooftop of Metro Cash & Carry Store Thokar Niaz Baig, Lahore. Pakistan. Metro Cash & Carry Store is a 2 storied commercial building/retail store and Head Office of Metro Cash & Carry Pakistan. The exact coordinates of the project site are:

Latitude:	31°28'1.18" North
Longitude:	74°14'5.30" East

A bird's eye view of the project site is given in the figure below:

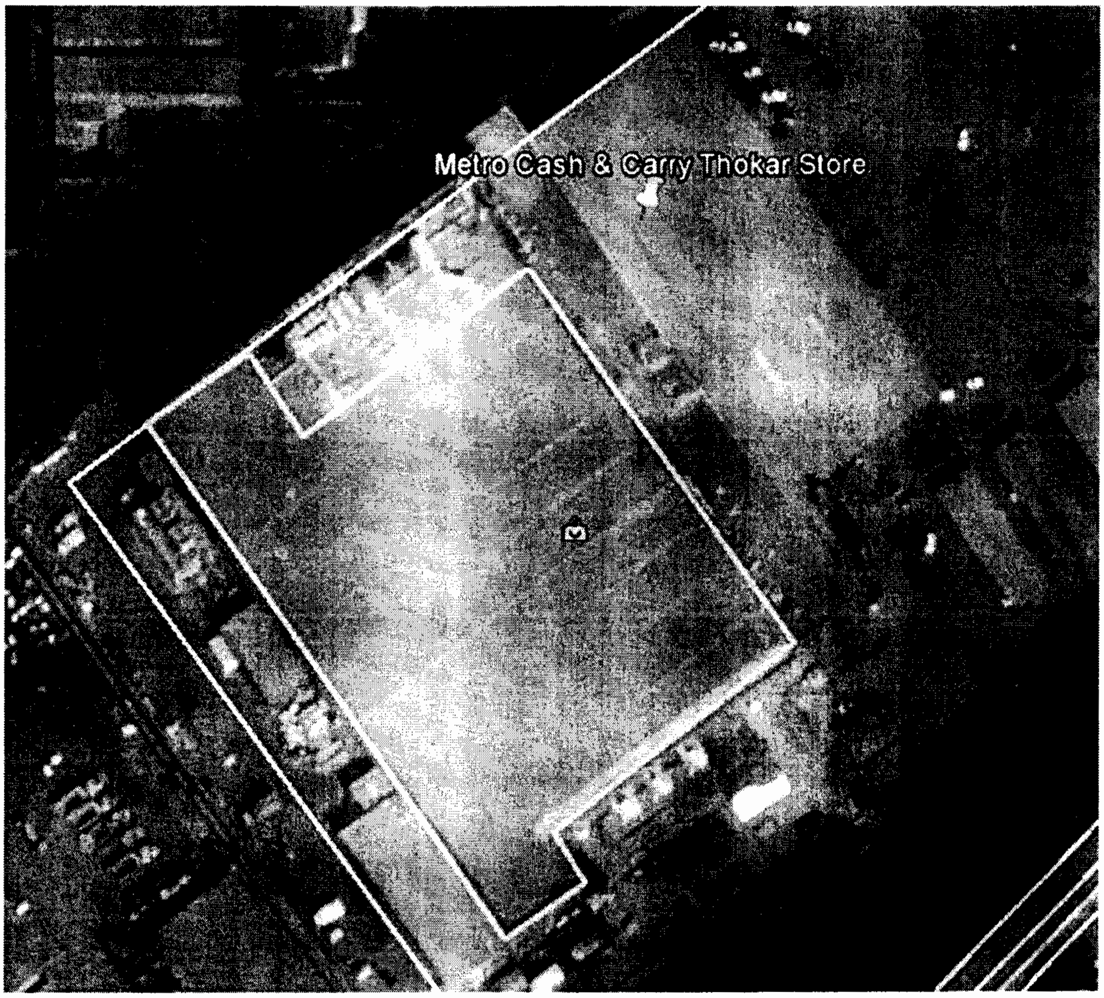


Figure 5: Overview of Project Site

Current Energy Demand and Supply Situation

As per the historical consumption data, the total electricity consumption during 2016 was 3,295,264 kWh.

Details of electricity generation/supply sources during this period are given below:

- Electricity imported from the national grid is 2,510,140 kWh
- In-house power generation from Diesel Generators is 785,124 kWh

Technical Analysis

Site Conditions

The following tasks were carried out:

- Global Horizontal Irradiation, annual and inter-annual variation was assessed.
- Near shading objects were taken into account for placement of PV modules.
- Area required for selected module technology was calculated. Keeping in view available area, tilt angle and appropriate spacing was calculated from near shading objects.

Details of the finalized parameters are given under section 3.5.1

Technology Review and Selection

Technology Selection

PV Modules:

S. No	Specification	Data
1	Type of Module	CS6U-330P
2	Type of Cell	Polycrystalline
3	Dimensions of each module	1960*992*40 mm
4	Weight	22.4 Kg
5	No of Modules	1176
6	Module Area	1.94432 m^2
7	Total Land Area Used	Roof Top
8	Module Frame	Anodized aluminum alloy
9	Nominal Max. Power (Pmax)	330 W
10	Opt. Operating Voltage (Vmp)	37.2 V
11	Opt. Operating Current (Imp)	8.88 A
12	Open Circuit Voltage (Voc)	45.6 V
13	Short Circuit Current (Isc)	9.45 A
14	Module Efficiency	16.97%
15	Operating Temperature	-40°C ~ +85°C
16	Max. System Voltage	1000 V (IEC) or 1000 V (UL) or 600 V (UL)
17	Module Fire Performance	TYPE 1 (UL 1703) or CLASS C (IEC 61730)

PV Array

S. No	Specification	Data
1	No of Strings	84
2	Modules in String	14

PV Capacity

S. No	Specification	Data
1	Total Site	388.08 KW Peak
2	Net Capacity Factor	15.46%

Inverters

S. No	Specification	
1	Manufacturer	SMA
2	Capacity of each Unit	25 KW
3	No of Inverters	14
4	MPP Input Voltage Range	390 V to 800 V
5	Rated Input Voltage	600 V
6	Max Input Voltage	1000 V
7	Total Power (AC)	350 KW
8	Max Input Current Input A/Input B	33A/33A
9	Max Output Current	36.1 A
10	Output Electrical System	3 Phase AC (4 Wire)
11	AC Nominal Voltage	230/400 V
12	Rated Power Frequency	50 Hz
13	Efficiency	98.3%
14	Relative Humidity (Non-Condensing)	100%
15	Noise Emission	51 dB(A)
16	Degree of Protection	IP65

Junction Boxes

S. No	Specification	Data
1	Number of J/Box units	28
2	Input circuits in each box	3
3	Max. input current for each circuit	15A
4	Protection Level	IP 65
5	Over current protection	Fuse
6	Surge protection	>1000V

PV Mounting Structure

S. No	Specification	Data
1	Structure	Aluminum
2	Tilt of Array Frame	2°

Data Collecting System

S. No	Specification	Data
1	System Data	Continuous on-line logging and monitoring over web portal

Solar PV Yield Estimation and Simulation

The aim of yield estimation is to predict the average annual energy output of the site. PvSyst software is used for simulation and near shading analysis.

Working Conditions

The solar system will have automatic mechanism to ensure that PV power currently generated by the inverters always matches the current power consumption of the site load. A closed loop control system of inverter AC output is implemented in reference to energy flow at grid connection point which will reduce inverter AC output of the inverter if site load will be less than the solar production in case of Load shedding.

Plant Characteristics
Generation Voltage: 230/400 V three phase four wire system
Power Factor at rated power: 1
Frequency: 50 Hz
Generation characteristic: Inverter has built-in features of controllable active power ramp following grid disturbance or normal connection, voltage regulation and frequency response. There are no additional control metering and instrumentations.

Design Parameters
The following tasks were carried out for PV layout and shading.

- Assessment of shading (horizon and nearby building)
- Outline layout of area suitable for PV development
- Designing row spacing to reduce inter-row shading and associated shading losses.
- Designing the layout to minimize cable runs and associated electrical losses
- Creating access routes and sufficient space to allow movement for maintenance purposes
- Choosing a tilt angle that optimizes the annual energy yield according to the latitude of the site and the annual distribution of solar resource

- Module cleaning strategy
- Simulating the annual energy losses associated with various configurations of tilt angle, orientation and row spacing. The optimized configuration and simulation results are given in section "Energy Yield Prediction"
- PV layouts of the site are given in 3D and 2D view in the following section.

Layout

The detailed layout (2D and 3D) of the solar panels is given below, PV layout may change depending upon site constraints before or during installation. PvSyst simulation is also performed as per following layout:

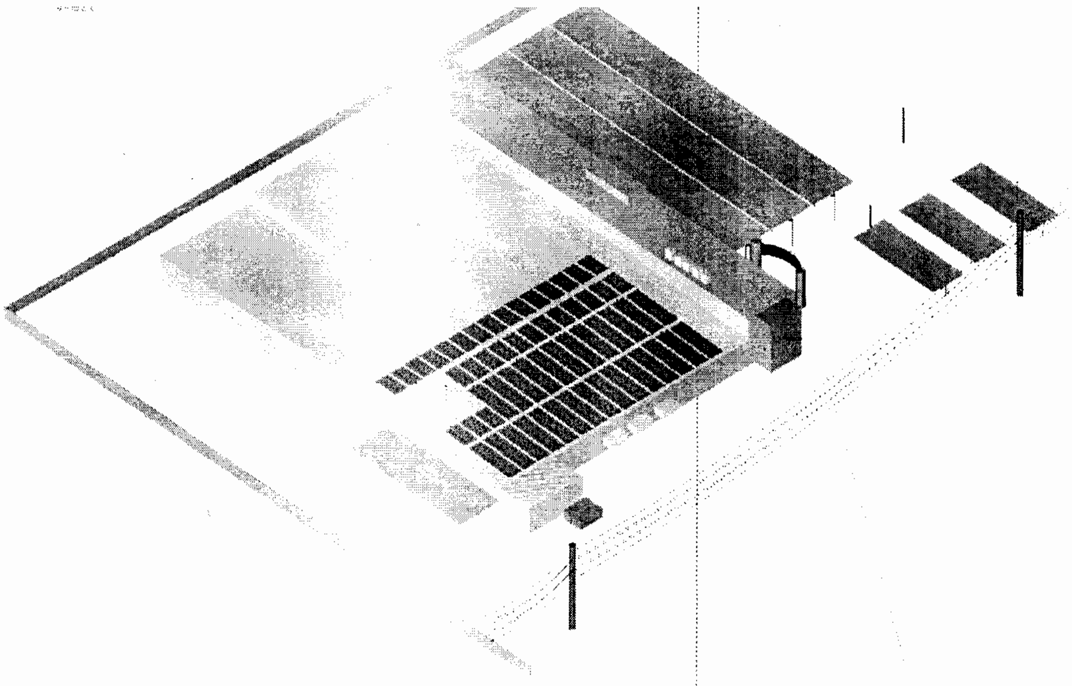


Figure 6: 3D Layout of rooftop of Metro Cash & Carry Thokar Niaz Baig

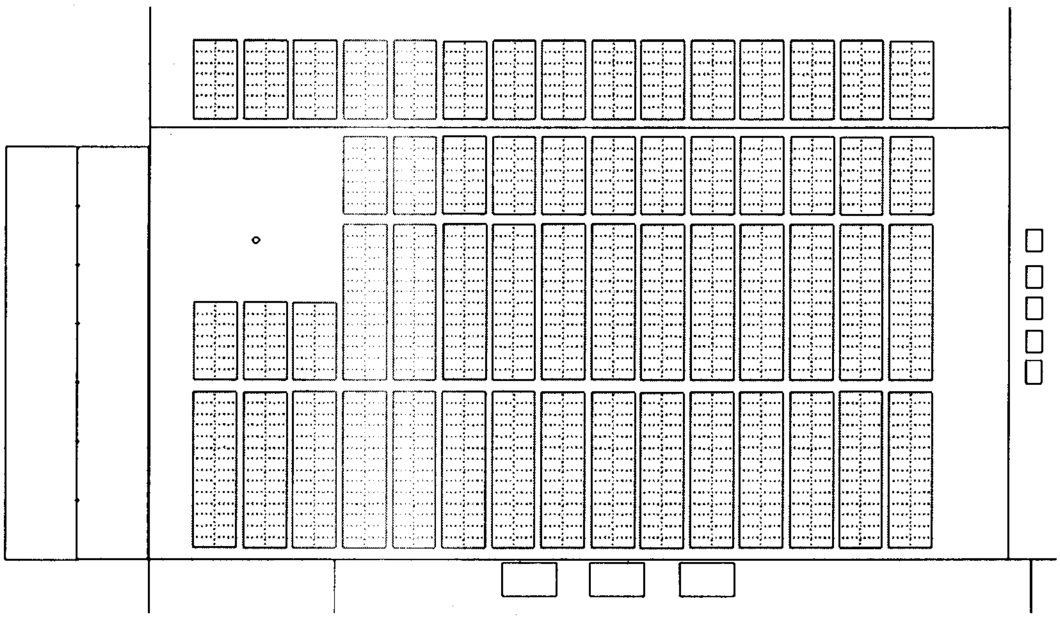


Figure 7: 2D Layout of rooftop of Metro Cash & Carry Thokar Niaz Baig showing solar panel lacations

Electrical Design

The electrical system comprises the following components:

- Array(s) of PV modules
- DC/AC cabling (module, string and main cable)
- DC connectors (plugs and sockets)
- Junction boxes
- Disconnects/switches
- Protection devices e.g. fuses, surge protective devices, beakers
- Energy Metering
- Earthing

The single line diagram is given below. The single line diagram includes the protection devices that will be used for safe and smooth operation of the system.

Protections DC Side: String Fuses, Surge Protective Device and DC Disconnect Switches

Protections AC Side: MCBs, Main Breaker and Surge Protective Device

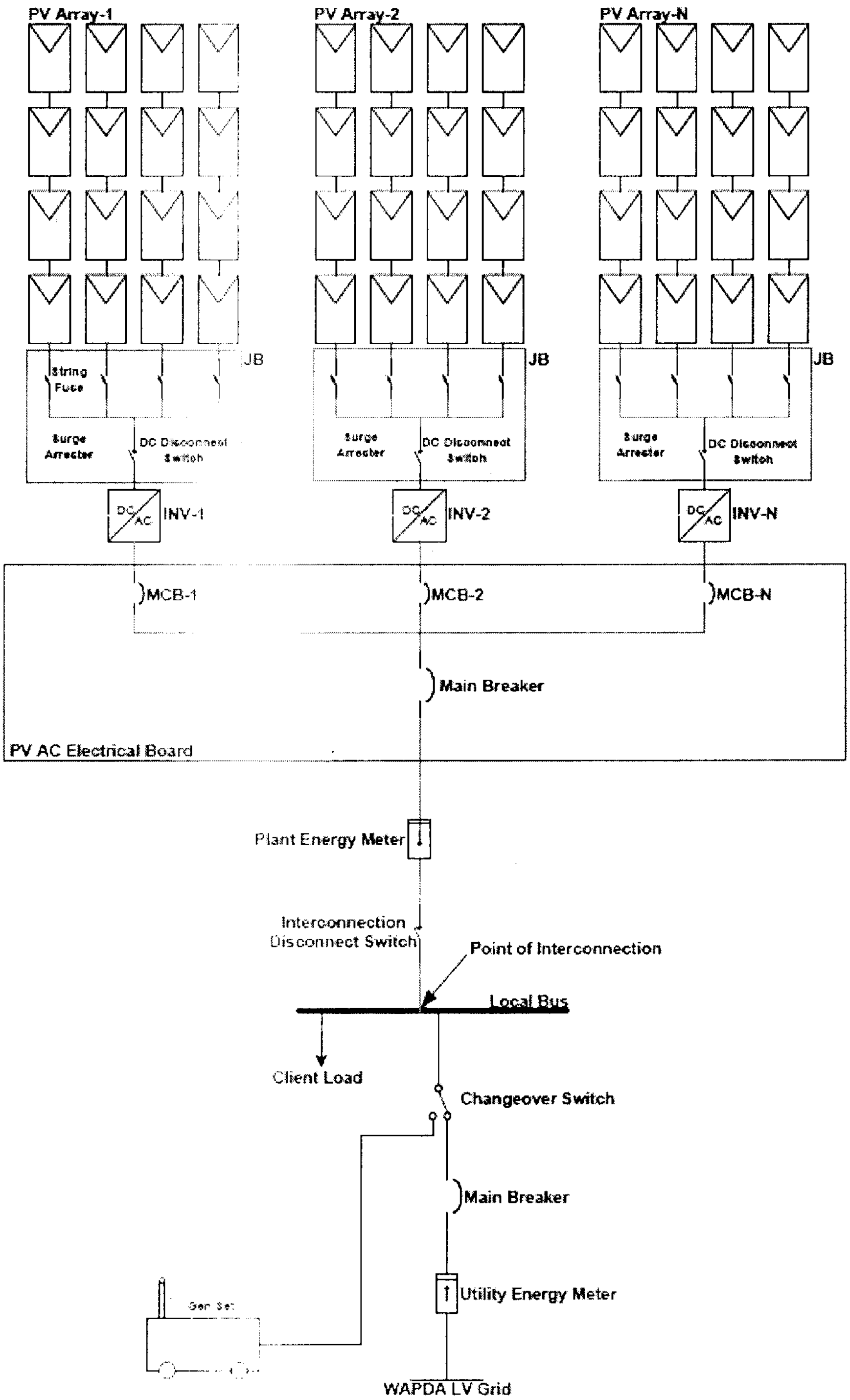


Figure 8: Single Line Diagram of PV Plant

Energy Yield Estimation

The energy yield prediction provides the basis for calculating project revenues. The aim is to predict the average annual energy output for the lifetime of the proposed power plant.

To estimate accurately the energy produced from a PV power plant, information is needed on the solar resource and temperature conditions of the site. Also required are the layout and technical specifications of the plant components.

A number of solar energy yield prediction software packages are available in the market. These packages use time step simulation to model the performance of a project over the course of a year. PvSyst software has been used for energy yield prediction for this site and its results are given below.

Details of the simulation steps are presented in the following sections:

Simulation Parameters

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Grid-Connected System: Simulation parameters

Project :	**Metro Cash & Carry, Thokar Niaz Baig, Lahore**				
Geographical Site	**Metro Cash & Carry, Thokar Niaz Baig, Lahore**			Country	**Pakistan**
Situation		Latitude	31.45° N	Longitude	74.23° E
Time defined as		Legal Time	Time zone UT+5	Altitude	209 m
		Albedo	0.20		
Meteo data	**Metro Cash & Carry, Thokar Niaz Baig, Lahore**		Meteonorm 7.1- Synthetic		

Simulation variant :	metro 2-33 330cs				
		Simulation date	30/05/17 13h32		

Simulation parameters

2 orientations		Tilts/Azimuths	2°/-33° and 2°/147°		
Models used		Transposition	Perez	Diffuse	Perez, Meteonorm
Horizon		Free Horizon			
Near Shadings		According to strings		Electrical effect	100 %

PV Arrays Characteristics (3 kinds of array defined)

PV module	Si-poly	Model	**CS6U - 330P**		
Custom parameters definition		Manufacturer	Canadian Solar Inc.		
Sub-array "Sub-array #1"		Orientation	#1	Tilt/Azimuth	2°/-33°
Number of PV modules		In series	14 modules	In parallel	66 strings
Total number of PV modules		Nb. modules	924	Unit Nom. Power	330 Wp
Array global power		Nominal (STC)	**305 kWp**	At operating cond.	273 kWp (50°C)
Array operating characteristics (50°C)		U mpp	464 V	I mpp	588 A
Sub-array "Sub-array #2"		Orientation	#2	Tilt/Azimuth	2°/147°
Number of PV modules		In series	14 modules	In parallel	12 strings
Total number of PV modules		Nb. modules	168	Unit Nom. Power	330 Wp
Array global power		Nominal (STC)	**55.4 kWp**	At operating cond.	49.7 kWp (50°C)
Array operating characteristics (50°C)		U mpp	464 V	I mpp	107 A
Sub-array "Sub-array #3"		Mixed orient.	#1/2: 3/3 strings	Tilt/Azimuth	2°/-33°, 2°/147°
Number of PV modules		In series	14 modules	In parallel	6 strings
Total number of PV modules		Nb. modules	84	Unit Nom. Power	330 Wp
Array global power		Nominal (STC)	**27.72 kWp**	At operating cond.	24.83 kWp (50°C)
Array operating characteristics (50°C)		U mpp	464 V	I mpp	53 A
Total	Arrays global power	Nominal (STC)	**388 kWp**	Total	1176 modules
		Module area	**2287 m²**	Cell area	2061 m²

Inverter	Model	**Sunny Tripower 25000TL-30**		
Original PVsyst database	Manufacturer	SMA		
Characteristics	Operating Voltage	390-800 V	Unit Nom. Power	25.0 kWac
Sub-array "Sub-array #1"	Nb. of inverters	11 units	Total Power	275 kWac
Sub-array "Sub-array #2"	Nb. of inverters	2 units	Total Power	50 kWac
Sub-array "Sub-array #3"	Nb. of inverters	1 units	Total Power	25 kWac
Total	Nb. of inverters	14	Total Power	350 kWac

PV Array loss factors

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Grid-Connected System: Simulation parameters (continued)

Array Soiling Losses			Loss Fraction	3.0 %
Thermal Loss factor	Uc (const)	29.0 W/m²K	Uv (wind)	0.0 W/m²K / m/s
Wiring Ohmic Loss	Array#1	10 mOhm	Loss Fraction	1.1 % at STC
	Array#2	29 mOhm	Loss Fraction	0.6 % at STC
	Array#3	29 mOhm	Loss Fraction	0.3 % at STC
	Global		Loss Fraction	0.9 % at STC
LID - Light Induced Degradation			Loss Fraction	2.5 %
Module Quality Loss			Loss Fraction	2.0 %
Module Mismatch Losses			Loss Fraction	1.0 % at MPP

Incidence effect (IAM): User defined IAM profile

10°	20°	30°	40°	50°	60°	70°	80°	90°
0.998	0.998	0.995	0.992	0.986	0.970	0.917	0.763	0.000

System loss factors

	Wires: 3x300.0 mm² 203 m	Loss Fraction	3.0 % at STC
Unavailability of the system	34.0 days, 4 periods	Time fraction	9.3 %

User's needs : Unlimited load (grid)

Near Shading Definition

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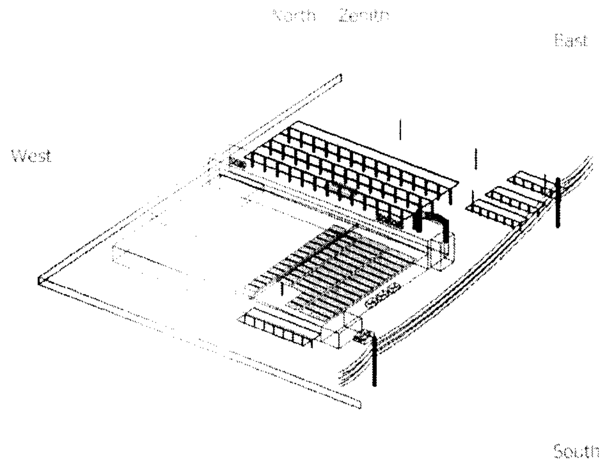
Grid-Connected System: Near shading definition

Project : Metro Cash & Carry, Thokar Niaz Baig, Lahore

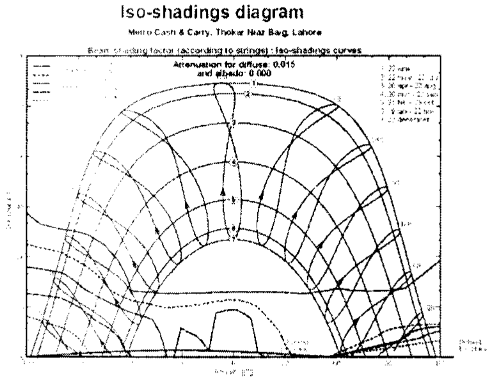
Simulation variant : metro 2-33 330cs

Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	2 orientations	Tilt/Azimuth = 2°/-33° and 2°/147°		
PV modules	Model	CS6U - 330P	Pnom	330 Wp
PV Array	Nb. of modules	1176	Pnom total	**388 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
Inverter pack	Nb. of units	14.0	Pnom total	**350 kW ac**
User's needs	Unlimited load (grid)			

Perspective of the PV-field and surrounding shading scene



Iso-shadings diagram



Losses

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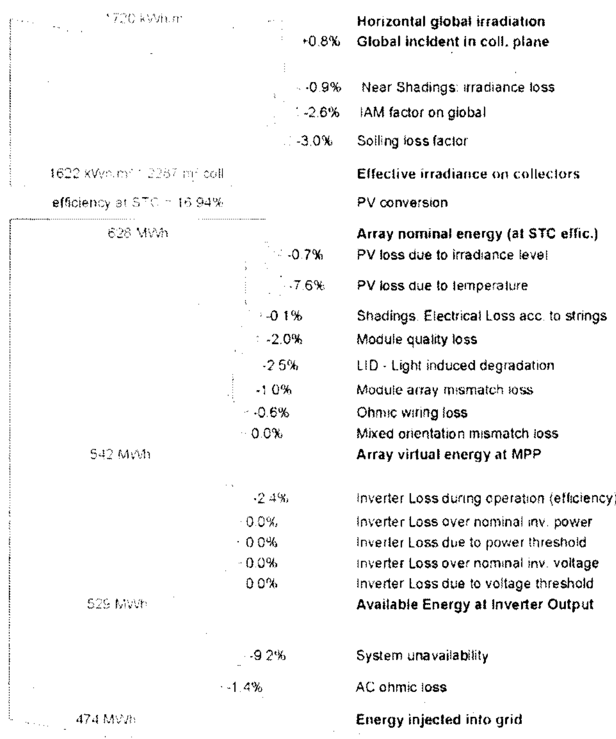
Grid-Connected System: Loss diagram

Project : Metro Cash & Carry, Thokar Niaz Baig, Lahore

Simulation variant : metro 2-33 330cs

Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	2 orientations	Tilt/Azimuth = 2°/-33° and 2°/147°		
PV modules	Model	CS6U - 330P	Pnom	330 Wp
PV Array	Nb. of modules	1176	Pnom total	**388 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
Inverter pack	Nb. of units	14.0	Pnom total	**350 kW ac**
User's needs	Unlimited load (grid)			

Loss diagram over the whole year



Simulation Results

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Grid-Connected System: Main results

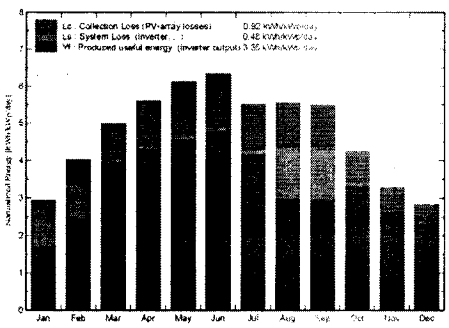
Project : **Metro Cash & Carry, Thokar Niaz Baig, Lahore**

Simulation variant : **metro 2-33 330cs**

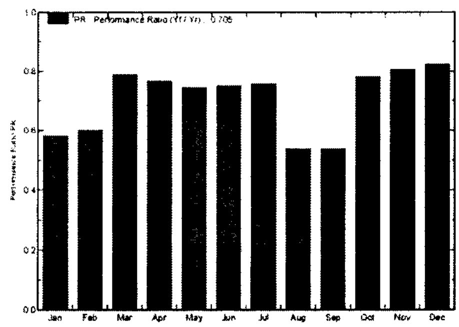
Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	**100 %**
PV Field Orientation	2 orientations	Tilt/Azimuth = 2°/-33° and 2°/147°		
PV modules	Model	CS6U - 330P	Pnom	330 Wp
PV Array	Nb. of modules	1176	Pnom total	**388 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
Inverter pack	Nb. of units	14.0	Pnom total	**350 kW ac**
User's needs	Unlimited load (grid)			

Main simulation results				
System Production	Produced Energy	**474.2 MWh/year**	Specific prod.	1222 kWh/kWp/year
	Performance Ratio PR	70.48 %		

Normalized productions (per installed kWp): Nominal power 388 kWp



Performance Ratio PR



metro 2-33 330cs

Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_Grid MWh	PR
January	89.5	[illegible]	11.38	91.1	84.7	30.40	20.80	0.582
February	[illegible]	[illegible]	15.61	112.9	105.5	37.01	26.30	0.600
March	[illegible]	[illegible]	21.38	154.8	145.0	49.22	47.33	0.769
April	[illegible]	[illegible]	26.71	167.9	157.3	51.94	49.94	0.766
May	[illegible]	[illegible]	30.35	189.9	178.2	57.14	54.88	0.744
June	[illegible]	[illegible]	32.14	190.4	178.7	57.71	55.41	0.750
July	[illegible]	[illegible]	30.90	170.9	159.9	52.25	50.22	0.757
August	[illegible]	[illegible]	[illegible]	172.5	161.6	53.05	36.07	0.539
September	[illegible]	[illegible]	28.12	164.7	154.4	51.08	34.45	0.509
October	[illegible]	[illegible]	24.66	131.5	123.2	41.47	39.99	0.782
November	[illegible]	[illegible]	17.89	98.7	91.8	31.94	30.83	0.806
December	[illegible]	[illegible]	13.28	87.9	81.5	29.00	28.07	0.823
Year	[illegible]	[illegible]	23.77	1733.6	1621.8	542.20	474.17	0.705

Legends			
GlobHor	Horizontal global irradiation	GlobEff	Effective Global, corr. for IAM and shadings
DiffHor	Horizontal diffuse irradiation	EArray	Effective energy at the output of the array
T Amb	Ambient temperature	E_Grid	Energy injected into grid
GlobInc	Global incident in coll. plane	PR	Performance Ratio

Financial Analysis

Cost/watt: **USD 1.2**

Total Project Cost for 388.08 KWp (DC) Solar PV System: **USD 465,696**

Equity: **100%**

Debt: **0%**

Safety and Emergency Plans

- Only qualified and authorized electricians will be allowed to undertake servicing or maintenance tasks.
- The authorized personnel will wear appropriate equipment, including a safety harness to restrain from falling off the roof, sturdy shoes that will have thick rubber soles to provide electrical insulation and good grip and appropriate clothing for personal protection, including a hat, sunglasses, gloves and long pants and sleeves
- Lock out and tag out procedures will be used before commencement of maintenance tasks.
- On-going operation and maintenance concerns for solar power systems will be addressed properly. These systems are exposed to outdoor weather conditions that enhance the aging process, and the infrastructure needs to be in place for the on-going maintenance of these systems to assure their safe operation.
- Properly grounded or double insulated power tools will be used for maintenance tasks. Tools will be maintained in good condition.
- Working on electrical equipment and circuits will be carried out in de energized state.
- Proper pathways will be available for operation, maintenance and firefighting.
- Fire protection and suppression will be placed at site

Training and Capacity Development

Trained and qualified personnel will be available at site 24/7 with proper safety and firefighting training. Training program will focus on but not limited to Solar Resource Assessment, Site Survey, Technology, Engineering Design, Regulation, Policy, Metering & Billing, and Project Management of Rooftop Solar System. The following components will include in training and development program.

a. Collection of Resource Data
b. Variability and uncertainty of resource data
c. Site evaluation
d. Crystalline and Thin film technology comparison
e. Rooftop solar system components
f. Module mounting structure selection
g. Inverter selection
h. Design of PV Array
i. Shadow Analysis
j. DC cable sizing
k. DC cable layout
l. Protection and Metering
m. Installation and testing standards for solar PV plants
n. Solar Module testing standards
o. Economy of Roof top Solar System
p. Detailed Project Report
q. Operation and maintenance of rooftop solar system
r. Safety and firefighting training

Environmental Aspects

Every energy generation and transmission method affects the environment. Conventional generating options can damage air, climate, water, land and wildlife, landscape as well as raise the levels of harmful radiation. PV technology is substantially safer offering a solution to many environmental and social problems associated with fossil and nuclear fuels. Solar PV energy technology provides obvious environmental advantages in comparison to the conventional energy sources thus contributing to the sustainable development of human activities. Not counting the depletion of the exhausted natural resources, their main advantage is related to the reduced CO2 emissions and normally absence of any air emissions or waste products during their operation.

The use of solar power has additional positive implications such as:

- Reduction of the emissions of the greenhouse gases (mainly CO2, NOx) and prevention of toxic gas emissions (SO2,particulates)
- Reduction of the required transmission lines of the electricity grids

Socio-Economic Aspects

In regard to the socio-economic viewpoint, the benefits of exploitation of solar PV system comprise of:

- Increase of the regional/national energy independency
- Provision of significant work opportunities
- Diversification and security of energy supply
- Support of the deregulation of energy markets

Conclusion

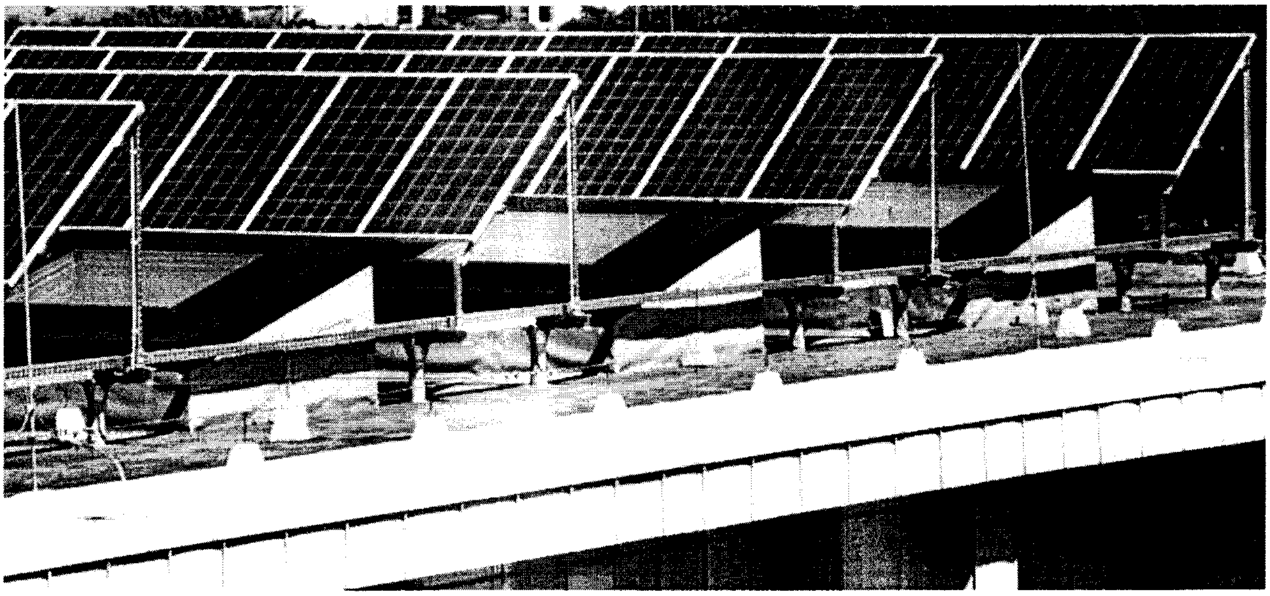
This feasibility study is conducted to ascertain the technical feasibility and commercial viability of installation of 350kW rooftop PV system installation at Metro Cash & Carry Thokar Niaz Baig, Lahore.

Installation of the PV system will result in annual power generation of 474,170 kWh.

The results of the financial analysis indicate that the project is feasible.

Based on the outcomes of both the technical and financial analysis, the project is deemed to be viable.

ShamsPower



3. FEASIBILITY STUDY FOR ROOFTOP SOLAR INSTALLATION AT METRO CASH & CARRY STORE NEAR DHA AIRPORT LAHORE

SHAMS POWER (PVT) LIMITED

ShamsPower

EXECUTIVE SUMMARY

The feasibility study examines the costs, practicality, and likely outcome of a solar photovoltaic (PV) installation on the rooftop of Metro Cash & Carry Store Airport Road, Lahore.

The main outcomes of the feasibility report are given below:

Technical Site Analysis: The project site is suitable for a solar PV energy system. For the purpose of estimation of power generation potential, solar insolation is assumed to be "good" (1,719 kWh/ square meter/ year). Panel azimuth (35 & 145 degree), panel tilt (2 degrees) and satisfactory roof condition and structure are also assumed.

Anticipated System Information: The project will accommodate a 300 kW (AC) solar PV system with a projected annual production of 423195 kWh/ year. Use of a Canadian Solar Inc. CS6U – 330P (330 watt) PV panel as a basis for design will result in an acceptable system weight density of 2.36 lbs/sqft. The system will offset approximately 147 tons of carbon dioxide annually.

Financial Analysis: The project will be financed on a 100% equity model. The total estimated project cost is USD 427,680.

Based on the technical and financial analysis, the installation of a 300kW Solar PV System on the rooftop of Metro Cash & Carry Store Airport Road is deemed to be feasible.

Introduction

The project site is the rooftop of Metro Cash & Carry Store Airport Road, Lahore. Pakistan. Metro Cash & Carry Store is a single storied commercial building/retail store. The exact coordinates of the project site are:

Latitude: 31°30'5.44" North
Longitude: 74°25'8.80" East

A bird's eye view of the project site is given in the figure below:

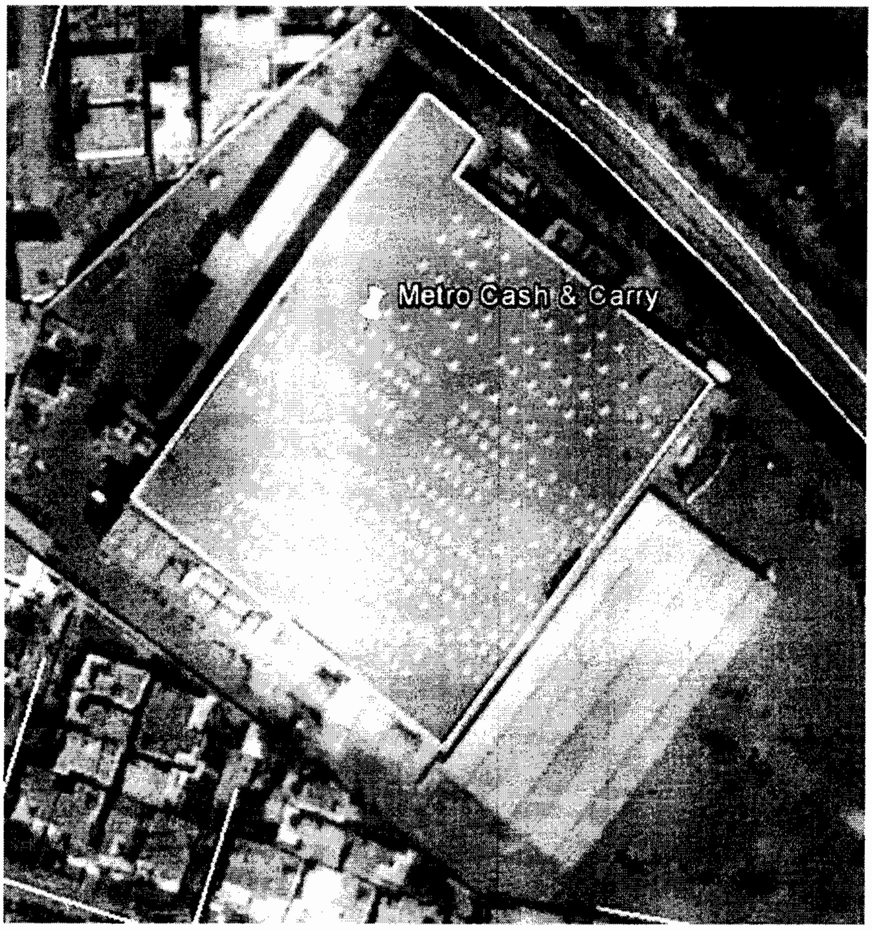


Figure 9: Overview of Project Site

Current Energy Demand and Supply Situation

As per the historical consumption data, the total electricity consumption during 2016 was 2,363,637 kWh.

Details of electricity generation/supply sources during this period are given below:

- Electricity imported from the national grid is 1,799,280 kWh
- In-house power generation from Diesel Generators is 564,357 kWh

Technical Analysis

Site Conditions

The following tasks were carried out:

- Global Horizontal Irradiation, annual and inter-annual variation was assessed.
- Near shading objects were taken into account for placement of PV modules.
- Area required for selected module technology was calculated. Keeping in view available area and minimum inter row shading, tilt angle and appropriate spacing was calculated from near shading objects.

Details of the finalized parameters are given under section 3.5.1

Technology Review and Selection

Technology Selection

PV Modules:

S. No	Specification	Data
1	Type of Module	CS6U-330P
2	Type of Cell	Polycrystalline
3	Dimensions of each module	1960*992*40 mm
4	Weight	22.4 Kg
5	No of Modules	1080
6	Module Area	1.94432 m^2
7	Total Land Area Used	Roof Top
8	Module Frame	Anodized aluminum alloy
9	Nominal Max. Power (Pmax)	330 W
10	Opt. Operating Voltage (Vmp)	37.2 V
11	Opt. Operating Current (Imp)	8.88 A
12	Open Circuit Voltage (Voc)	45.6 V
13	Short Circuit Current (Isc)	9.45 A
14	Module Efficiency	16.97%
15	Operating Temperature	-40°C ~ +85°C
16	Max. System Voltage	1000 V (IEC) or 1000 V (UL) or 600 V (UL)
17	Module Fire Performance	TYPE 1 (UL 1703) or CLASS C (IEC 61730)

PV Array

S. No	Specification	Data
1	No of Strings	72
2	Modules in String	15

PV Capacity

S. No	Specification	Data
1	Total Site	356.4 KW Peak
2	Net Capacity Factor	16.10%

Inverters

S. No	Specification	
1	Manufacturer	SMA
2	Capacity of each Unit	25 KW
3	No of Inverters	12
4	MPP Input Voltage Range	390 V to 800 V
5	Rated Input Voltage	600 V
6	Max Input Voltage	1000 V
7	Total Power (AC)	300 KW
8	Max Input Current Input A/Input B	33A/33A
9	Max Output Current	36.1 A
10	Output Electrical System	3 Phase AC (4 Wire)
11	AC Nominal Voltage	230/400 V
12	Rated Power Frequency	50 Hz
13	Efficiency	98.3%
14	Relative Humidity (Non-Condensing)	100%
15	Noise Emission	51 dB(A)
16	Degree of Protection	IP65

Junction Boxes

S. No	Specification	Data
1	Number of J/Box units	24
2	Input circuits in each box	3
3	Max. input current for each circuit	15A
4	Protection Level	IP 65
5	Over current protection	Fuse
6	Surge protection	>1000V

PV Mounting Structure

S. No	Specification	Data
1	Structure	Aluminum
2	Tilt of Array Frame	2°

Data Collecting System

S. No	Specification	Data
1	System Data	Continuous on-line logging and monitoring over web portal

Solar PV Yield Estimation and Simulation

The aim of yield estimation is to predict the average annual energy output of the site. PvSyst software is used for simulation and near shading analysis.

Working Conditions: Zero Export

The solar system will have automatic mechanism to ensure that PV power currently generated by the inverters always matches the current power consumption of the site load. A closed loop control system of inverter AC output is implemented in reference to energy flow at grid connection point which will reduce inverter AC output of the inverter if site load will be less than the solar production.

Plant Characteristics

Generation Voltage: 230/400 V three phase four wire system

Power Factor at rated power: 1

Frequency: 50 Hz

Generation characteristic: Inverter has built-in features of controllable active power ramp following grid disturbance or normal connection, voltage regulation and frequency response. There are no additional control metering and instrumentations.

Design Parameters

The following tasks were carried out for PV layout and shading.

- Assessment of shading (horizon and nearby building)

- Outline layout of area suitable for PV development
- Designing row spacing to reduce inter-row shading and associated shading losses.
- Designing the layout to minimize cable runs and associated electrical losses
- Creating access routes and sufficient space to allow movement for maintenance purposes
- Choosing a tilt angle that optimizes the annual energy yield according to the latitude of the site and the annual distribution of solar resource
- Module cleaning strategy
- Simulating the annual energy losses associated with various configurations of tilt angle, orientation and row spacing. The optimized configuration and simulation results are given in section "Energy Yield Prediction"
- PV layouts of the site are given in 3D and 2D view in the following section.

Layout

The detailed layout (2D and 3D) of the solar panels is given below. PV layout may change depending upon site constraints before or during installation. PvSyst simulation is also performed as per following layout:

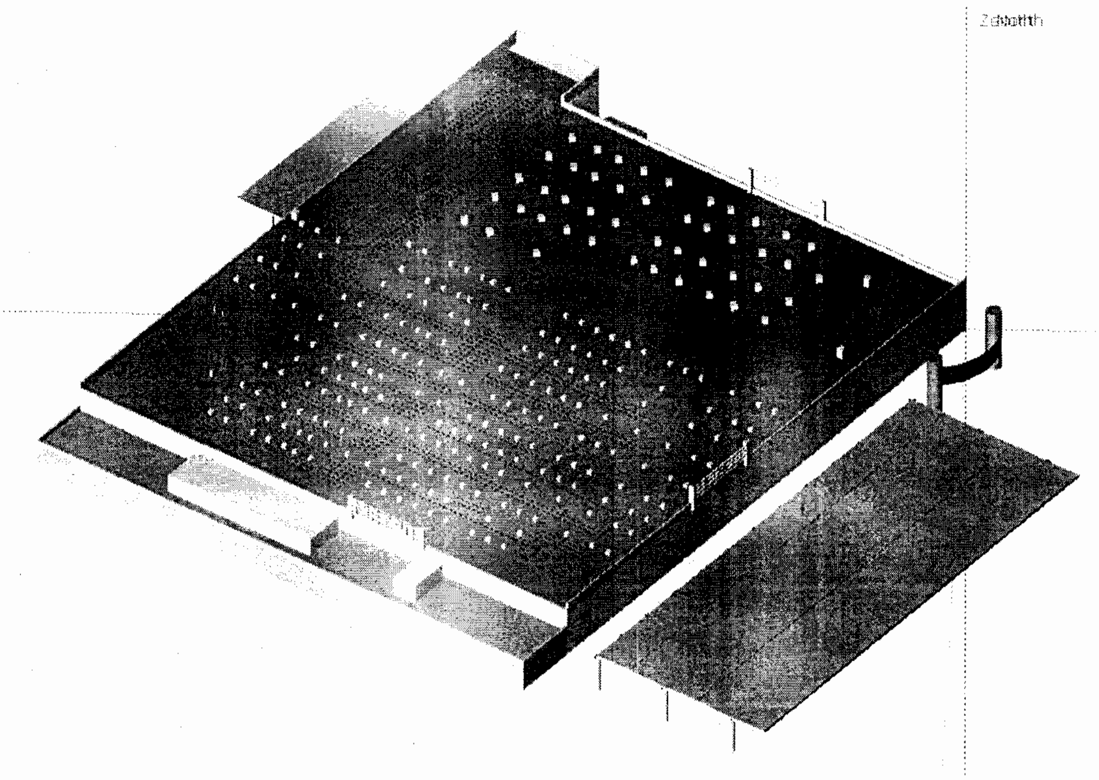


Figure 10: 3D Layout of rooftop of Metro Cash & Carry Airport Road

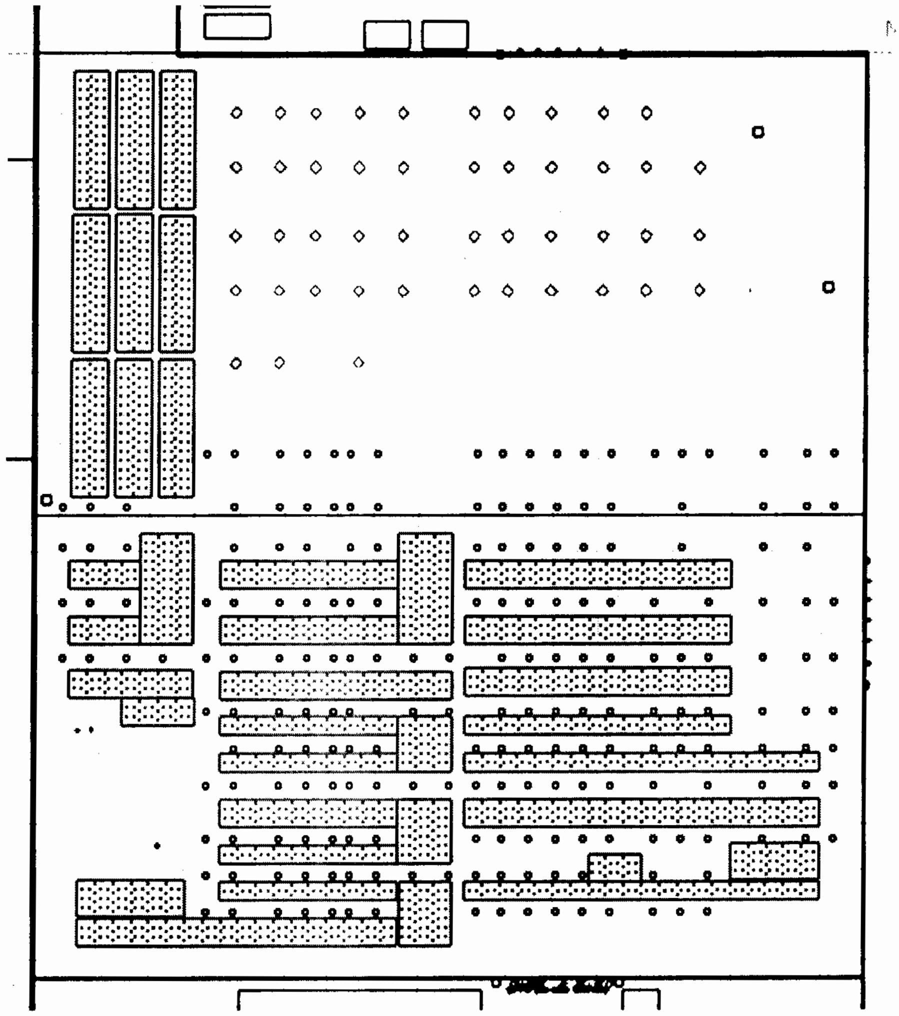


Figure 11: 2D Layout of rooftop of Metro Cash & Carry Airport Road showing solar panel locations

Electrical Design

The electrical system comprises the following components:

- Array(s) of PV modules
- DC/AC cabling (module, string and main cable)
- DC connectors (plugs and sockets)
- Junction boxes
- Disconnects/switches
- Protection devices e.g. fuses, surge protective devices, beakers
- Energy Metering
- Earthing

The single line diagram is given below. The single line diagram includes the protection devices that will be used for safe and smooth operation of the system.

Protections DC Side: String Fuses, Surge Protective Device and DC Disconnect Switches

Protections AC Side: MCBs, Main Breaker and Surge Protective Device

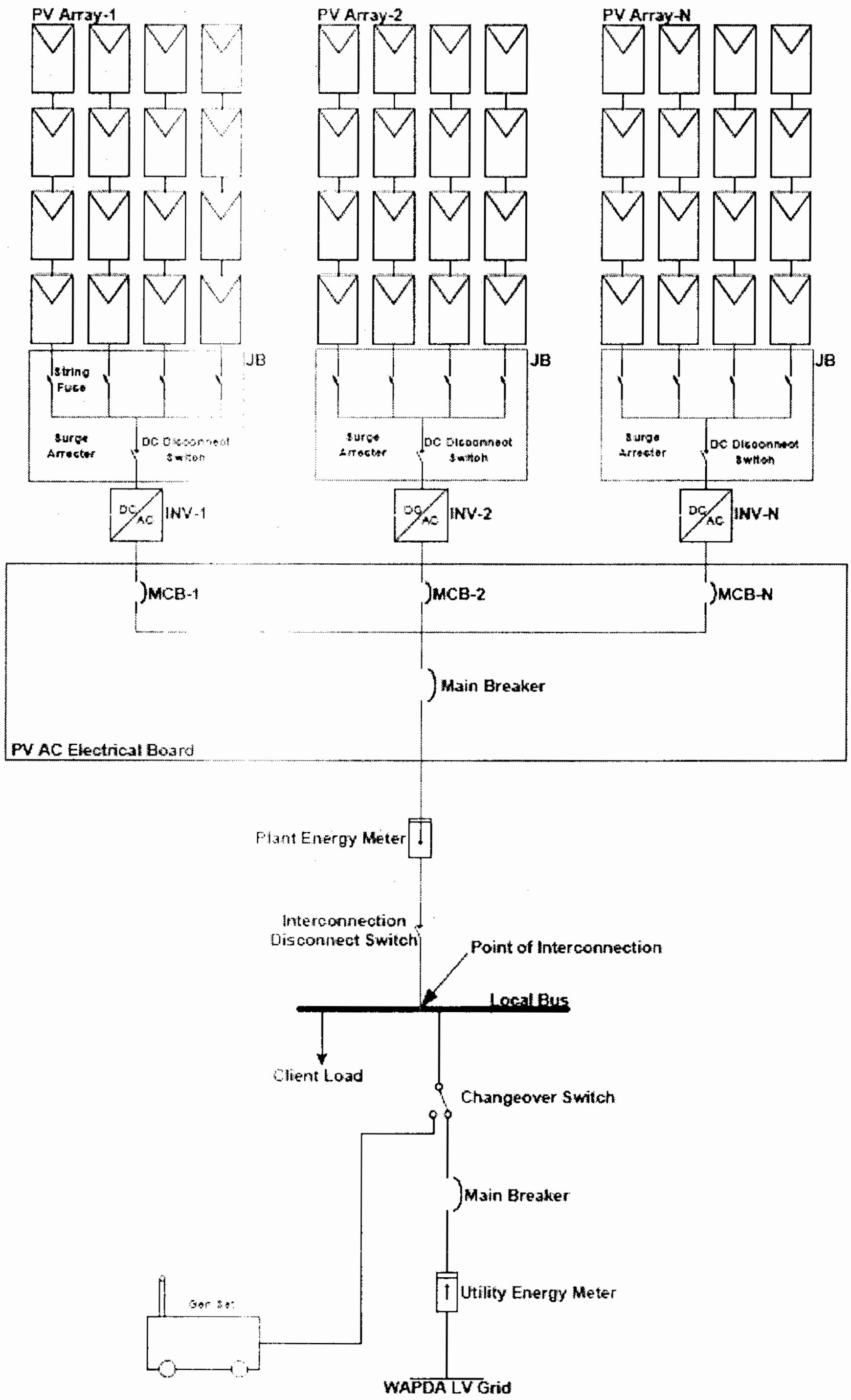


Figure 12: Single Line Diagram of PV Plant

Energy Yield Estimation

The energy yield prediction provides the basis for calculating project revenues. The aim is to predict the average annual energy output for the lifetime of the proposed power plant.

To estimate accurately the energy produced from a PV power plant, information is needed on the solar resource and temperature conditions of the site. Also required are the layout and technical specifications of the plant components.

A number of solar energy yield prediction software packages are available in the market. These packages use time step simulation to model the performance of a project over the course of a year. PvSyst software has been used for energy yield prediction for this site and its results are given below.

Details of the simulation steps are presented in the following sections:

Simulation Parameters

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Grid-Connected System: Simulation parameters

Project :	Metro Cash & Carry, Near Airport, Lahore			
Geographical Site	Metro CC airport		Country	**Pakistan**
Situation	Latitude	31.50° N	Longitude	74.42° E
Time defined as	Legal Time	Time zone UT+5	Altitude	212 m
	Albedo	0.20		
Meteo data:	Metro CC airport	Meteonorm 7.1 - Synthetic		

Simulation variant :	metro airport 330cs li	
	Simulation date	03/06/17 14h48

Simulation parameters

2 orientations	Tilts/Azimuths	2°/35° and 2°/-145°		
Models used	Transposition	Perez	Diffuse	Perez, Meteonorm
Horizon	Free Horizon			
Near Shadings	According to strings		Electrical effect	100 %

PV Arrays Characteristics (2 kinds of array defined)

PV module Si-poly	Model	**CS6U - 330P**		
Custom parameters definition	Manufacturer	Canadian Solar Inc.		
Sub-array "Sub-array #1"	Orientation	#1	Tilt/Azimuth	2°/35°
Number of PV modules	In series	15 modules	In parallel	54 strings
Total number of PV modules	Nb. modules	810	Unit Nom. Power	330 Wp
Array global power	Nominal (STC)	**267 kWp**	At operating cond.	239 kWp (50°C)
Array operating characteristics (50°C)	U mpp	497 V	I mpp	481 A
Sub-array "Sub-array #2"	Orientation	#2	Tilt/Azimuth	2°/-145°
Number of PV modules	In series	15 modules	In parallel	18 strings
Total number of PV modules	Nb. modules	270	Unit Nom. Power	330 Wp
Array global power	Nominal (STC)	**89.1 kWp**	At operating cond.	79.8 kWp (50°C)
Array operating characteristics (50°C)	U mpp	497 V	I mpp	160 A
Total Arrays global power	Nominal (STC)	**356 kWp**	Total	1080 modules
	Module area	**2100 m²**	Cell area	1893 m²

Inverter	Model	**Sunny Tripower 25000TL-30**		
Original PVsyst database	Manufacturer	SMA		
Characteristics	Operating Voltage	390-800 V	Unit Nom. Power	25.0 kWac
Sub-array "Sub-array #1"	Nb. of inverters	9 units	Total Power	225 kWac
Sub-array "Sub-array #2"	Nb. of inverters	3 units	Total Power	75 kWac
Total	Nb. of inverters	12	Total Power	300 kWac

PV Array loss factors

Array Soiling Losses			Loss Fraction	3.0 %
Thermal Loss factor	Uc (const)	20.0 W/m²K	Uv (wind)	0.0 W/m²K / m/s
Wiring Ohmic Loss	Array#1	13 mOhm	Loss Fraction	1.1 % at STC
	Array#2	52 mOhm	Loss Fraction	1.5 % at STC
	Global		Loss Fraction	1.2 % at STC

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Grid-Connected System: Simulation parameters (continued)

LID - Light Induced Degradation		Loss Fraction	2.5 %
Module Quality Loss		Loss Fraction	2.0 %
Module Mismatch Losses		Loss Fraction	1.0 % at MPP

Incidence effect (IAM): User defined IAM profile

10°	20°	30°	40°	50°	60°	70°	80°	90°
0.998	0.998	0.995	0.992	0.986	0.970	0.917	0.763	0.000

System loss factors

Wiring Ohmic Loss	Wires 3x500.0 mm² 367 m	Loss Fraction	3.0 % at STC
Unavailability of the system	34.0 days, 4 periods	Time fraction	9.3 %

User's needs : Unlimited load (grid)

Near Shading Definition

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Grid-Connected System: Near shading definition

Project : **Metro Cash & Carry, Near Airport, Lahore**

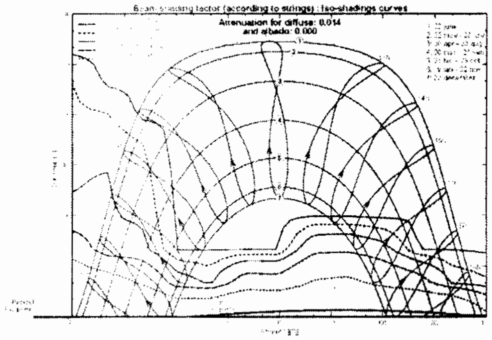
Simulation variant : **metro airport 330cs li**

Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	2 orientations	Tilt/Azimuth = 2°/35° and 2°/-145°		
PV modules	Model	CS6U - 330P	Pnom	330 Wp
PV Array	Nb. of modules	1080	Pnom total	**356 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
Inverter pack	Nb. of units	12.0	Pnom total	**300 kW ac**
User's needs	Unlimited load (grid)			

Perspective of the PV-field and surrounding shading scene

Iso-shadings diagram

Metro Cash & Carry, Near Airport, Lahore



Losses

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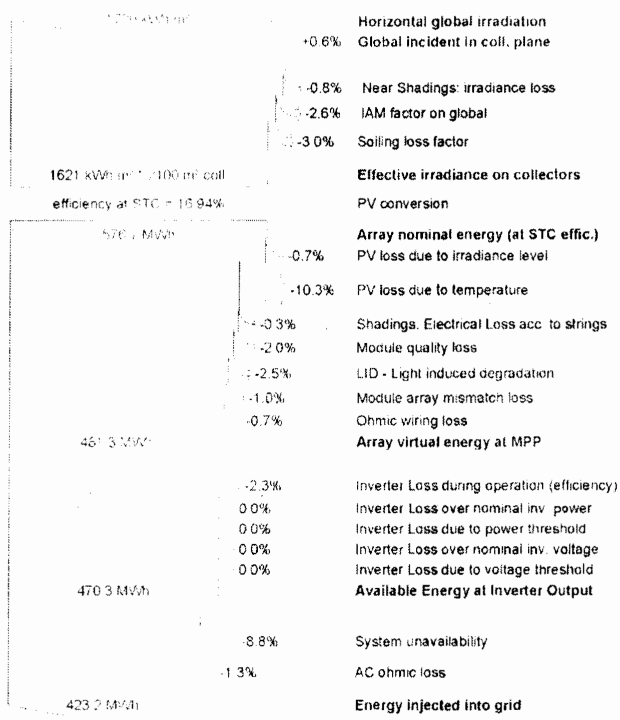
Grid-Connected System: Loss diagram

Project : Metro Cash & Carry, Near Airport, Lahore

Simulation variant : metro airport 330cs li

Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	2 orientations	Tilt/Azimuth = 2°/35° and 2°/-145°		
PV modules	Model	CS6U - 330P	Pnom	330 Wp
PV Array	Nb. of modules	1080	Pnom total	**356 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
Inverter pack	Nb. of units	12.0	Pnom total	**300 kW ac**
User's needs	Unlimited load (grid)			

Loss diagram over the whole year



Simulation Results

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Grid-Connected System: Main results

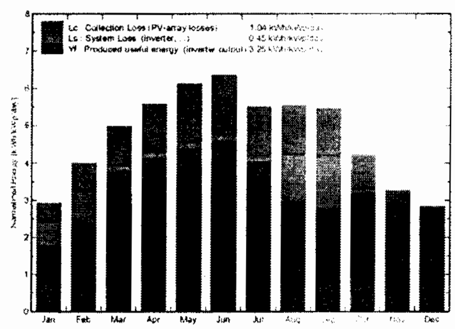
Project : Metro Cash & Carry, Near Airport, Lahore

Simulation variant : metro airport 330cs li

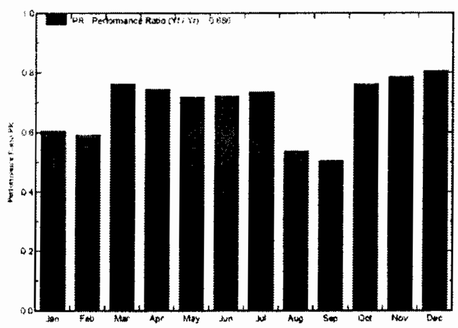
Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	2 orientations	Tilt/Azimuth = 2°/35° and 2°/-145°		
PV modules	Model	CS6U - 330P	Pnom	330 Wp
PV Array	Nb. of modules	1080	Pnom total	**356 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
Inverter pack	Nb. of units	12.0	Pnom total	**300 kW ac**
User's needs	Unlimited load (grid)			

Main simulation results				
System Production	Produced Energy	**423.2 MWh/year**	Specific prod.	1187 kWh/kWp/year
	Performance Ratio PR	68.63 %		

Normalized productions (per installed kWp): Nominal power 356 kWp



Performance Ratio PR



metro airport 330cs li

Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_Grid MWh	PR
January	[illegible]	[illegible]	[illegible]	90.6	84.2	27.08	19.56	0.606
February	[illegible]	[illegible]	[illegible]	112.3	105.0	32.81	23.69	0.592
March	[illegible]	[illegible]	21.49	154.7	145.2	43.63	42.05	0.763
April	[illegible]	[illegible]	[illegible]	167.7	157.3	46.10	44.42	0.745
May	[illegible]	[illegible]	[illegible]	189.9	178.6	50.83	48.70	0.719
June	[illegible]	[illegible]	[illegible]	190.6	179.4	51.08	49.12	0.723
July	[illegible]	[illegible]	30.90	170.8	160.1	46.52	44.84	0.736
August	[illegible]	[illegible]	30.32	172.1	161.5	47.08	32.95	0.537
September	[illegible]	[illegible]	28.12	164.3	154.4	45.19	29.65	0.506
October	130.1	[illegible]	24.67	131.3	122.9	36.85	35.60	0.761
November	[illegible]	[illegible]	[illegible]	98.2	91.3	28.42	27.53	0.786
December	[illegible]	[illegible]	13.29	87.4	81.0	25.85	25.06	0.804
Year	[illegible]	[illegible]	23.78	1730.0	1620.8	481.25	423.16	0.688

Legends			
GlobHor	[illegible]	GlobEff	Effective Global, corr. for IAM and shadings
DiffHor	[illegible]	EArray	Effective energy at the output of the array
T Amb	[illegible]	E_Grid	Energy injected into grid
GlobInc	[illegible]	PR	Performance Ratio

Financial Analysis

Cost/watt: **USD 1.2**

Total Project Cost for 356.4 KWp (DC) Solar PV System: **USD 427,680**

Equity: **100%**

Debt: **0%**

Safety and Emergency Plans

- Only qualified and authorized electricians will be allowed to undertake servicing or maintenance tasks.
- The authorized personnel will wear appropriate equipment, including a safety harness to restrain from falling off the roof, sturdy shoes that will have thick rubber soles to provide electrical insulation and good grip and appropriate clothing for personal protection, including a hat, sunglasses, gloves and long pants and sleeves
- Lock out and tag out procedures will be used before commencement of maintenance tasks.
- On-going operation and maintenance concerns for solar power systems will be addressed properly. These systems are exposed to outdoor weather conditions that enhance the aging process, and the infrastructure needs to be in place for the on-going maintenance of these systems to assure their safe operation.
- Properly grounded or double insulated power tools will be used for maintenance tasks. Tools will be maintained in good condition.
- Working on electrical equipment and circuits will be carried out in de energized state.
- Proper pathways will be available for operation, maintenance and firefighting.
- Fire protection and suppression will be placed at site

Training and Capacity Development

Trained and qualified personnel will be available at site 24/7 with proper safety and firefighting training. Training program will focus on but not limited to Solar Resource Assessment, Site Survey, Technology, Engineering Design, Regulation, Policy, Metering & Billing, and Project Management of Rooftop Solar System. The following components will include in training and development program.

a. Collection of Resource Data
b. Variability and uncertainty of resource data
c. Site evaluation
d. Crystalline and Thin film technology comparison
e. Rooftop solar system components
f. Module mounting structure selection
g. Inverter selection
h. Design of PV Array
i. Shadow Analysis
j. DC cable sizing
k. DC cable layout
l. Protection and Metering
m. Installation and testing standards for solar PV plants
n. Solar Module testing standards
o. Economy of Roof top Solar System
p. Detailed Project Report
q. Operation and maintenance of rooftop solar system
r. Safety and firefighting training

Environmental Aspects

Every energy generation and transmission method affects the environment. Conventional generating options can damage air, climate, water, land and wildlife, landscape as well as raise the levels of harmful radiation. PV technology is substantially safer offering a solution to many environmental and social problems associated with fossil and nuclear fuels. Solar PV energy technology provides obvious environmental advantages in comparison to the conventional energy sources thus contributing to the sustainable development of human activities. Not counting the depletion of the exhausted natural resources, their main advantage is related to the reduced CO_2 emissions and normally absence of any air emissions or waste products during their operation.

The use of solar power has additional positive implications such as:

- Reduction of the emissions of the greenhouse gases (mainly CO_2, NO_x) and prevention of toxic gas emissions (SO_2,particulates)
- Reduction of the required transmission lines of the electricity grids

Socio-Economic Aspects

In regard to the socio-economic viewpoint, the benefits of exploitation of solar PV system comprise of:

- Increase of the regional/national energy independency
- Provision of significant work opportunities
- Diversification and security of energy supply
- Support of the deregulation of energy markets

Conclusion

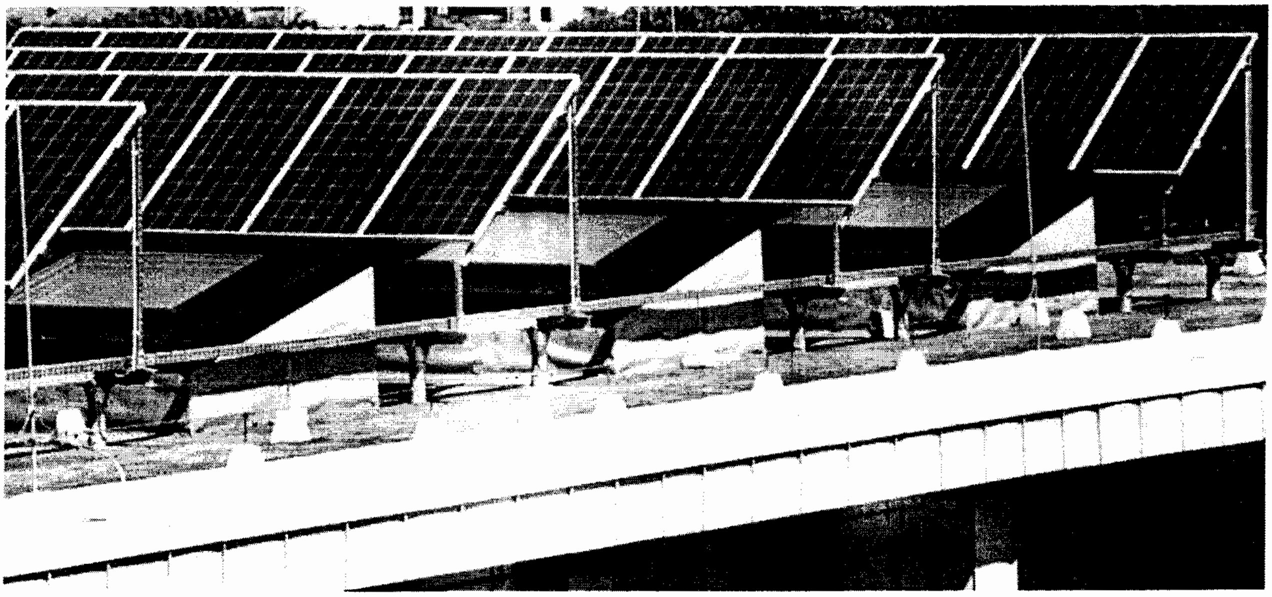
This feasibility study is conducted to ascertain the technical feasibility and commercial viability of installation of 300kW rooftop PV system installation at Metro Cash & Carry Airport Road, Lahore.

Installation of the PV system will result in annual power generation of 423,195 kWh.

The results of the financial analysis indicate that the project is feasible.

Based on the outcomes of both the technical and financial analysis, the project is deemed to be viable.

ShamsPower



4. FEASIBILITY STUDY FOR ROOFTOP SOLAR INSTALLATION AT METRO CASH & CARRY STORE, RAVI ROAD, LAHORE

SHAMS POWER (PVT) LIMITED

EXECUTIVE SUMMARY

The feasibility study examines the costs, practicality, and likely outcome of a solar photovoltaic (PV) installation on the rooftop of Metro Cash & Carry Store, Ravi Road, Lahore.

The main outcomes of the feasibility report are given below:

Technical Site Analysis: The project site is suitable for a solar PV energy system. For the purpose of estimation of power generation potential, solar insolation is assumed to be "good" (1,719 kWh/ square meter/ year). Panel azimuth (-38 degree), panel tilt (3 degrees) and satisfactory roof condition and structure are also assumed.

Anticipated System Information: The project will accommodate a 300 kW (AC) solar PV system with a projected annual production of 399,522 kWh/ year. Use of a Canadian Solar Inc. CS6U – 330P (330 watt) PV panel as a basis for design will result in an acceptable system weight density of 2.36 lbs/SF. The system will offset approximately 140 tons of carbon dioxide annually.

Financial Analysis: The project will be financed on a 100% equity model. The total estimated project cost is USD 399,168.

Based on the technical and financial analysis, the installation of a 300kW Solar PV System on the rooftop of Metro Cash & Carry Store Ravi Road is deemed to be feasible.

Introduction

The project site is the rooftop of Metro Cash & Carry Store, Ravi Road, Lahore, Pakistan. Metro Cash & Carry Store is a 2 storied commercial building/retail store. The exact coordinates of the project site are:

Latitude: 31°35'48.92" North
Longitude: 74°17'53.48" East

A bird's eye view of the project site is given in the figure below:

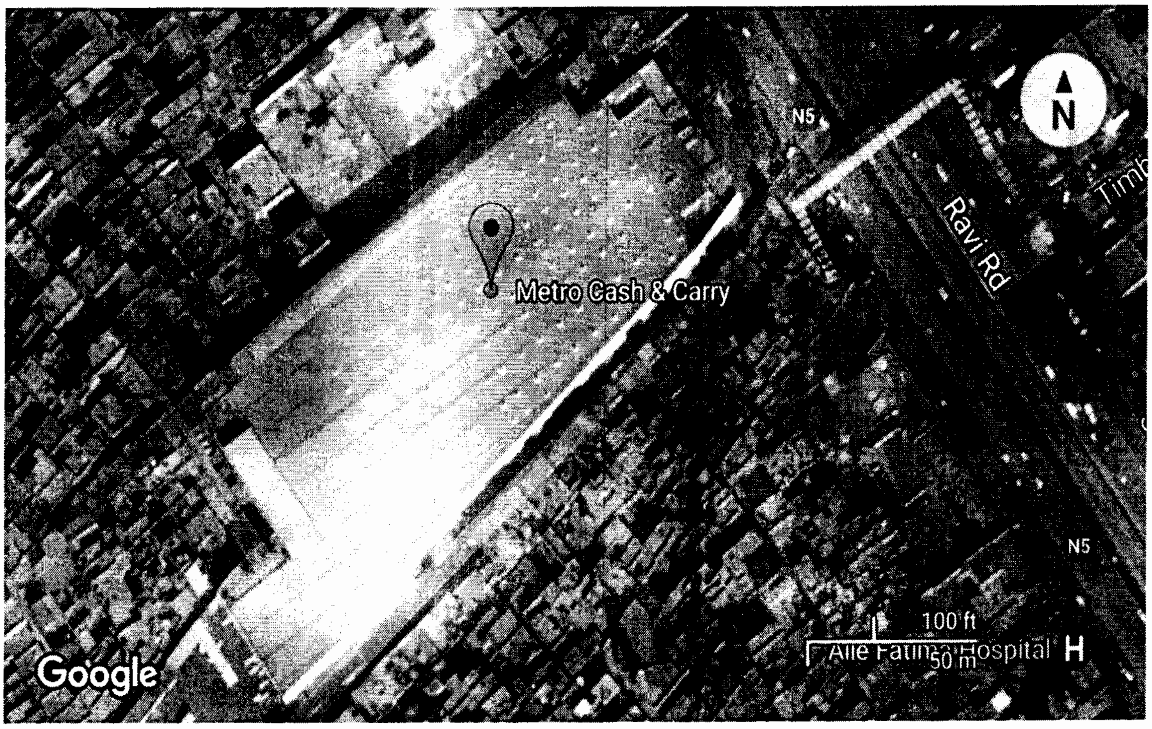


Figure 13: Overview of Project Site

Current Energy Demand and Supply Situation

As per the historical consumption data, the total electricity consumption during 2016 was 2,227,334 kWh.

Details of electricity generation/supply sources during this period are given below:

- Electricity imported from the national grid is 1,694,730 kWh
- In-house power generation from Diesel Generators is 532,604 kWh

Technical Analysis

Site Conditions

The following tasks were carried out:

- Global Horizontal Irradiation, annual and inter-annual variation was assessed.
- Near shading objects were taken into account for placement of PV modules.
- Area required for selected module technology was calculated. Keeping in view available area and minimum inter row shading, tilt angle and appropriate spacing was calculated from near shading objects.

Details of the finalized parameters are given under section 3.5.1

Technology Review and Selection

Technology Selection

PV Modules:

S. No	Specification	Data
1	Type of Module	CS6U-330P
2	Type of Cell	Polycrystalline
3	Dimensions of each module	1960*992*40 mm
4	Weight	22.4 Kg
5	No of Modules	1008
6	Module Area	1.94432 m^2
7	Total Land Area Used	Roof Top
8	Module Frame	Anodized aluminum alloy
9	Nominal Max. Power (Pmax)	330 W
10	Opt. Operating Voltage (Vmp)	37.2 V
11	Opt. Operating Current (Imp)	8.88 A
12	Open Circuit Voltage (Voc)	45.6 V
13	Short Circuit Current (Isc)	9.45 A
14	Module Efficiency	16.97%
15	Operating Temperature	-40°C ~ +85°C
16	Max. System Voltage	1000 V (IEC) or 1000 V (UL) or 600 V (UL)
17	Module Fire Performance	TYPE 1 (UL 1703) or CLASS C (IEC 61730)

PV Array

S. No	Specification	Data
1	No of Strings	72
2	Modules in String	14

PV Capacity

S. No	Specification	Data
1	Total Site	332.64 KW Peak
2	Net Capacity Factor	15.20%

Inverters

S. No	Specification	
1	Manufacturer	SMA
2	Capacity of each Unit	25 KW
3	No of Inverters	12
4	MPP Input Voltage Range	390 V to 800 V
5	Rated Input Voltage	600 V
6	Max Input Voltage	1000 V
7	Total Power	300 KW
8	Max Input Current Input A/Input B	33A/33A
9	Max Output Current	36.1 A
10	Output Electrical System	3 Phase AC (4 Wire)
11	AC Nominal Voltage	230/400 V
12	Rated Power Frequency	50 Hz
13	Efficiency	98.3%
14	Relative Humidity (Non-Condensing)	100%
15	Noise Emission	51 dB(A)
16	Degree of Protection	IP65

Junction Boxes

S. No	Specification	Data
1	Number of J/Box units	24
2	Input circuits in each box	3
3	Max. input current for each circuit	15A
4	Protection Level	IP 65
5	Over current protection	Fuse
6	Surge protection	>1000V

PV Mounting Structure

S. No	Specification	Data
1	Structure	Aluminum
2	Tilt of Array Frame	3°

Data Collecting System

S. No	Specification	Data
1	System Data	Continuous on-line logging and monitoring over web portal

Solar PV Yield Estimation and Simulation

The aim of yield estimation is to predict the average annual energy output of the site. PvSyst software is used for simulation and near shading analysis.

Working Conditions: Zero Grid Export

The solar system will have automatic mechanism to ensure that PV power currently generated by the inverters always matches the current power consumption of the site load. A closed loop control system of inverter AC output is implemented in reference to energy flow at grid connection point which will reduce inverter AC output of the inverter if site load will be less than the solar production.

Plant Characteristics
Generation Voltage: 230/400 V three phase four wire system
Power Factor at rated power: 1
Frequency: 50 Hz
Generation characteristic: Inverter has built-in features of controllable active power ramp following grid disturbance or normal connection, voltage regulation and frequency response. There are no additional control metering and instrumentations.

Design Parameters
The following tasks were carried out for PV layout and shading.

- Assessment of shading (horizon and nearby building)
- Outline layout of area suitable for PV development
- Designing row spacing to reduce inter-row shading and associated shading losses.
- Designing the layout to minimize cable runs and associated electrical losses
- Creating access routes and sufficient space to allow movement for maintenance purposes
- Choosing a tilt angle that optimizes the annual energy yield according to the latitude of the site and the annual distribution of solar resource

- Module cleaning strategy
- Simulating the annual energy losses associated with various configurations of tilt angle, orientation and row spacing. The optimized configuration and simulation results are given in section "Energy Yield Prediction"
- PV layouts of the site are given in 3D and 2D view in the following section.

Layout

The detailed layout (2D and 3D) of the solar panels is given below. PV layout may change depending upon site constraints before or during installation. PvSyst simulation is also performed as per following layout:

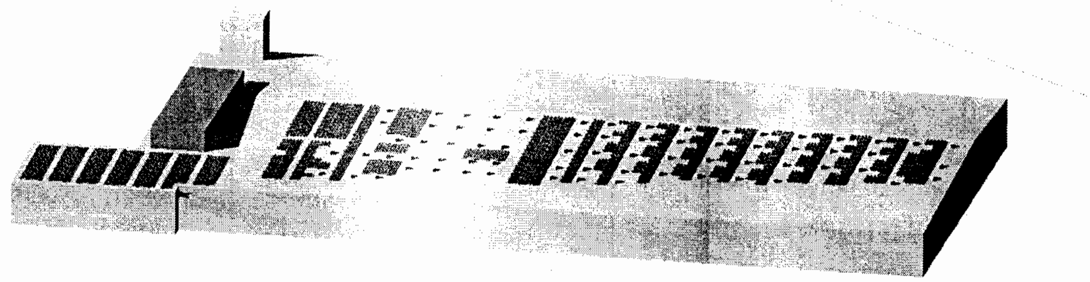


Figure 14: 3D Layout of rooftop of Metro Cash & Carry Ravi Road

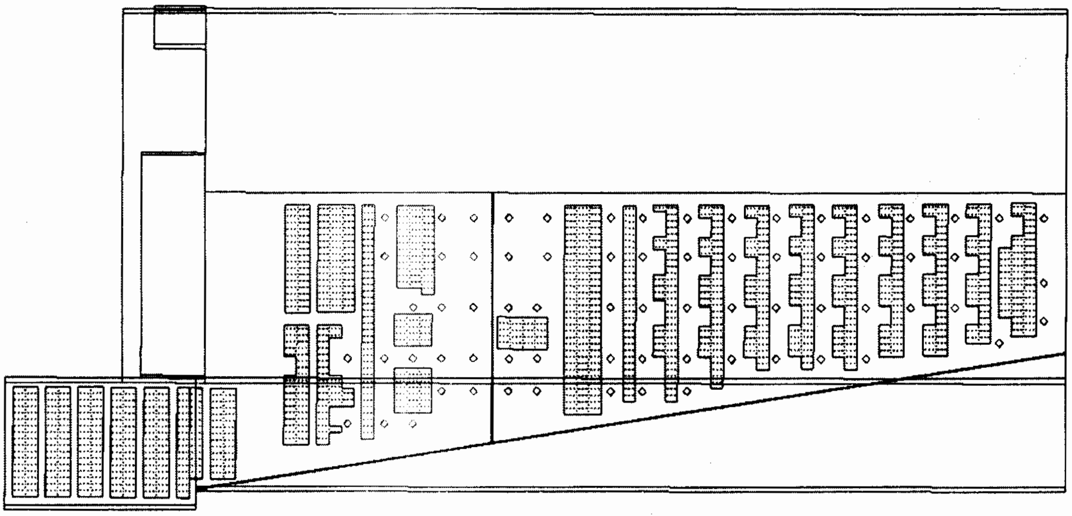


Figure 15: 2D Layout of rooftop of Metro Cash & Carry Ravi Road showing solar panel locations

Electrical Design

The electrical system comprises the following components:

- Array(s) of PV modules
- DC/AC cabling (module, string and main cable)
- DC connectors (plugs and sockets)
- Junction boxes
- Disconnects/switches
- Protection devices e.g. fuses, surge protective devices, beakers
- Energy Metering
- Earthing

The single line diagram is given below. The single line diagram includes the protection devices that will be used for safe and smooth operation of the system.

Protections DC Side: String Fuses, Surge Protective Device and DC Disconnect Switches

Protections AC Side: MCBs, Main Breaker and Surge Protective Device

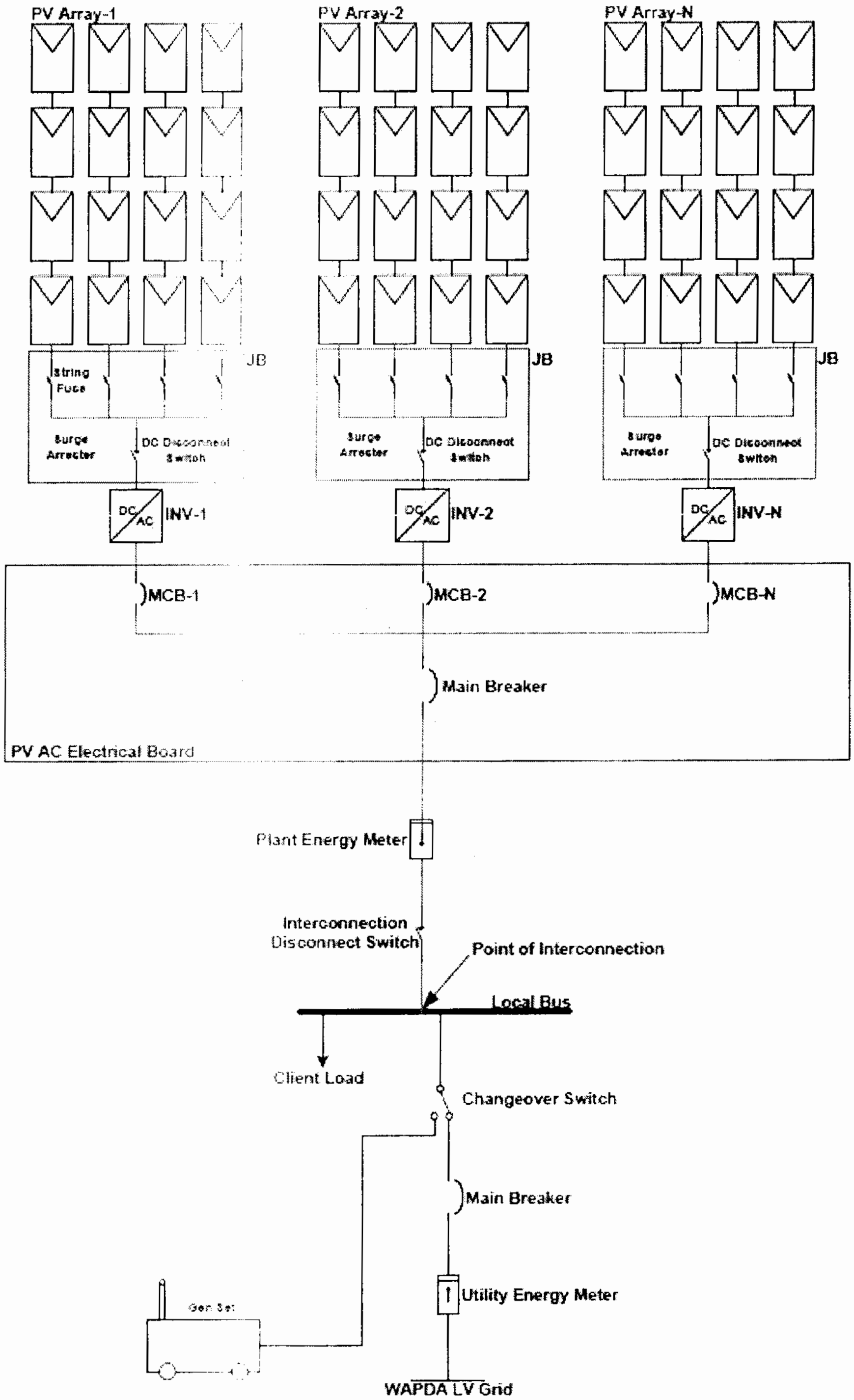


Figure 16: Single Line Diagram of PV Plant

Energy Yield Estimation

The energy yield prediction provides the basis for calculating project revenues. The aim is to predict the average annual energy output for the lifetime of the proposed power plant.

To estimate accurately the energy produced from a PV power plant, information is needed on the solar resource and temperature conditions of the site. Also required are the layout and technical specifications of the plant components.

A number of solar energy yield prediction software packages are available in the market. These packages use time step simulation to model the performance of a project over the course of a year. PvSyst software has been used for energy yield prediction for this site and its results are given below.

Details of the simulation steps are presented in the following sections:

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Simulation Parameters

PVSYST V6.40		05/06/17	Page 1/4

Metro Ravi Road

Grid-Connected System: Simulation parameters

Project :	**Metro Cash & Carry, Ravi Road, Lahore**				
Geographical Site	**Metro Cash & Carry, Ravi Road, Lahore**			Country	**Pakistan**
Situation		Latitude	31.60° N	Longitude	74.30° E
Time defined as		Legal Time	Time zone UT+5	Altitude	213 m
		Albedo	0.20		
Meteo data:	**Metro Cash & Carry, Ravi Road, Lahore**		Meteonorm 7.1 - Synthetic		

Simulation variant :	**metro ravi road 330**		
		Simulation date	05/06/17 13h17

Simulation parameters

Collector Plane Orientation		Tilt	3°	Azimuth	-38°
Models used		Transposition	Perez	Diffuse	Perez, Meteonorm
Horizon		Free Horizon			
Near Shadings		According to strings		Electrical effect	100 %

PV Array Characteristics

PV module	Si-poly	Model	**CS6U - 330 P**		
Custom parameters definition		Manufacturer	Canadian Solar Inc.		
Number of PV modules		In series	14 modules	In parallel	72 strings
Total number of PV modules		Nb. modules	1008	Unit Nom. Power	330 Wp
Array global power		Nominal (STC)	**333 kWp**	At operating cond.	299 kWp (50°C)
Array operating characteristics (50°C)		U mpp	464 V	I mpp	644 A
Total area		Module area	**1960 m²**	Cell area	1766 m²

Inverter	Model	**Sunny Tripower 25000TL-30**		
Original PVsyst database	Manufacturer	SMA		
Characteristics	Operating Voltage	390-800 V	Unit Nom. Power	25.0 kWac
Inverter pack	Nb. of inverters	12 units	Total Power	300 kWac

PV Array loss factors

Array Soiling Losses			Loss Fraction	3.0 %
Thermal Loss factor	Uc (const)	20.0 W/m²K	Uv (wind)	0.0 W/m²K / m/s
Wiring Ohmic Loss	Global array res.	12 mOhm	Loss Fraction	1.5 % at STC
LID - Light Induced Degradation			Loss Fraction	2.5 %
Module Quality Loss			Loss Fraction	2.0 %
Module Mismatch Losses			Loss Fraction	1.0 % at MPP

Incidence effect (IAM): User defined IAM profile

10°	20°	30°	40°	50°	60°	70°	80°	90°
0.998	0.998	0.995	0.992	0.986	0.970	0.917	0.763	0.000

System loss factors

Wiring Ohmic Loss	Wires: 3x300.0 mm²	236 m	Loss Fraction	3.0 % at STC
Unavailability of the system	34.0 days, 4 periods		Time fraction	9.3 %

User's needs : Unlimited load (grid)

Near Shading Definition

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Metro Ravi Road

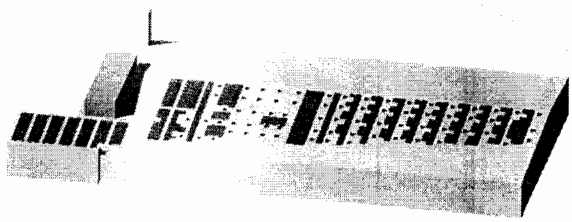
Grid-Connected System: Near shading definition

Project : Metro Cash & Carry, Ravi Road, Lahore

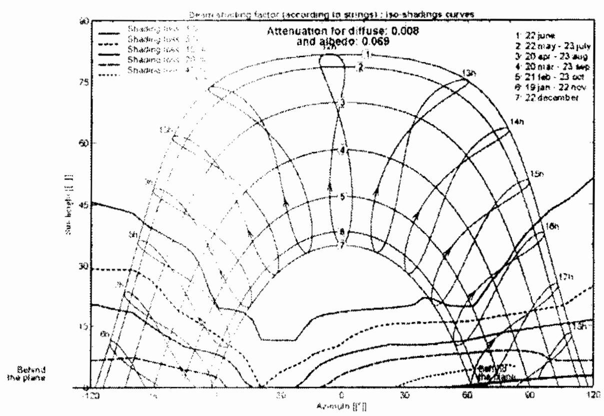
Simulation variant : metro ravi road 330

Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	tilt	3°	azimuth	-38°
PV modules	Model	CS6U - 330 P	Pnom	330 Wp
PV Array	Nb. of modules	1008	Pnom total	**333 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
Inverter pack	Nb. of units	12.0	Pnom total	**300 kW ac**
User's needs	Unlimited load (grid)			

Perspective of the PV-field and surrounding shading scene



Iso-shadings diagram



Losses

PVSYST V6.40		05/06/17	Page 4/4

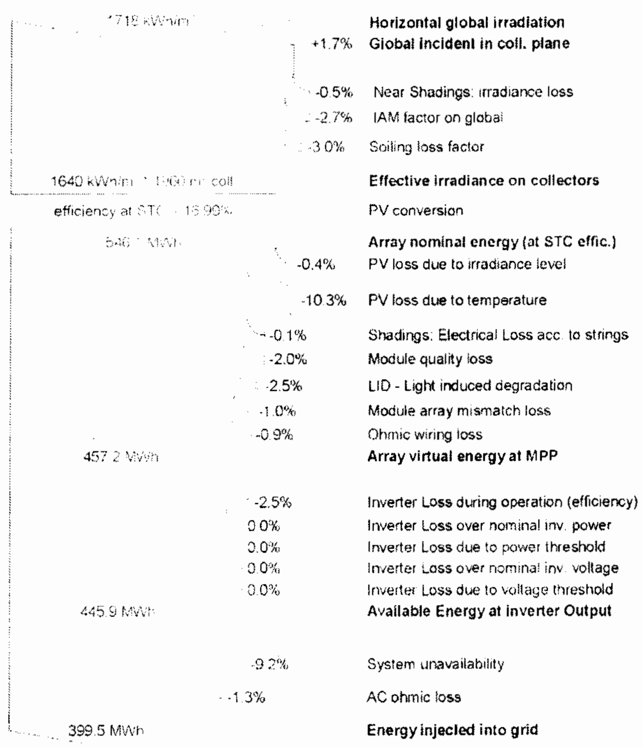
Grid-Connected System: Loss diagram

Project : **Metro Cash & Carry, Ravi Road, Lahore**

Simulation variant : metro ravi road 330

Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	tilt	3°	azimuth	-38°
PV modules	Model	CS6U - 330 P	Pnom	330 Wp
PV Array	Nb. of modules	1008	Pnom total	**333 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
Inverter pack	Nb. of units	12.0	Pnom total	**300 kW ac**
User's needs	Unlimited load (grid)			

Loss diagram over the whole year



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Simulation Results

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Grid-Connected System: Main results

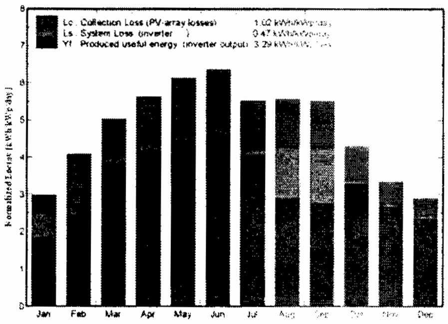
Project : **Metro Cash & Carry, Ravi Road, Lahore**

Simulation variant : **metro ravi road 330**

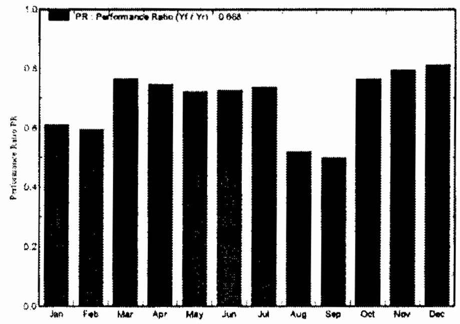
Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	tilt	3°	azimuth	-38°
PV modules	Model	CS6U - 330 P	Pnom	330 Wp
PV Array	Nb. of modules	1008	Pnom total	**333 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
Inverter pack	Nb. of units	12.0	Pnom total	**300 kW ac**
User's needs	Unlimited load (grid)			

Main simulation results				
System Production	Produced Energy	**399.5 MWh/year**	Specific prod.	1201 kWh/kWp/year
	Performance Ratio PR	68.75 %		

Normalized productions (per installed kWp): Nominal power 333 kWp



Performance Ratio PR



metro ravi road 330

Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_Grid MWh	PR
January	89.0	44.5	11.36	92.5	86.3	26.13	18.82	0.611
February	110.7	44.7	15.62	114.6	107.6	31.53	22.74	0.596
March	153.2	64.7	21.38	156.2	146.8	41.38	39.81	0.766
April	166.9	87.0	26.71	168.9	158.7	43.62	41.94	0.747
May	189.4	97.9	32.25	190.2	179.1	47.63	45.72	0.723
June	190.6	100.0	32.05	190.6	179.5	48.03	46.11	0.727
July	170.7	102.5	30.90	171.2	160.8	43.71	42.03	0.738
August	171.6	93.8	30.32	172.9	162.4	44.37	29.90	0.520
September	163.3	76.1	28.13	166.0	156.1	42.90	27.60	0.500
October	130.1	54.6	24.66	133.4	125.2	35.21	33.93	0.764
November	96.8	45.1	17.89	100.7	94.0	27.55	26.63	0.795
December	85.8	40.3	13.28	89.8	83.6	25.12	24.30	0.813
Year	1718.2	869.0	23.75	1747.0	1640.2	457.17	399.52	0.688

Legends:			
GlobHor	Horizontal global irradiation	GlobEff	Effective Global, corr. for IAM and shadings
DiffHor	Horizontal diffuse irradiation	EArray	Effective energy at the output of the array
T Amb	Ambient Temperature	E_Grid	Energy injected into grid
GlobInc	Global incident in coll. plane	PR	Performance Ratio

Financial Analysis

Cost/watt: **USD 1.2**

Total Project Cost for 332.64 KWp (DC) Solar PV System: **USD 399,168**

Equity: **100%**

Debt: **0%**

Safety and Emergency Plans

- Only qualified and authorized electricians will be allowed to undertake servicing or maintenance tasks.
- The authorized personnel will wear appropriate equipment, including a safety harness to restrain from falling off the roof, sturdy shoes that will have thick rubber soles to provide electrical insulation and good grip and appropriate clothing for personal protection, including a hat, sunglasses, gloves and long pants and sleeves
- Lock out and tag out procedures will be used before commencement of maintenance tasks.
- On-going operation and maintenance concerns for solar power systems will be addressed properly. These systems are exposed to outdoor weather conditions that enhance the aging process, and the infrastructure needs to be in place for the on-going maintenance of these systems to assure their safe operation.
- Properly grounded or double insulated power tools will be used for maintenance tasks. Tools will be maintained in good condition.
- Working on electrical equipment and circuits will be carried out in de energized state.
- Proper pathways will be available for operation, maintenance and firefighting.
- Fire protection and suppression will be placed at site

Training and Capacity Development

Trained and qualified personnel will be available at site 24/7 with proper safety and firefighting training. Training program will focus on but not limited to Solar Resource Assessment, Site Survey, Technology, Engineering Design, Regulation, Policy, Metering & Billing, and Project Management of Rooftop Solar System. The following components will include in training and development program.

a. Collection of Resource Data
b. Variability and uncertainty of resource data
c. Site evaluation
d. Crystalline and Thin film technology comparison
e. Rooftop solar system components
f. Module mounting structure selection
g. Inverter selection
h. Design of PV Array
i. Shadow Analysis
j. DC cable sizing
k. DC cable layout
l. Protection and Metering
m. Installation and testing standards for solar PV plants
n. Solar Module testing standards
o. Economy of Roof top Solar System
p. Detailed Project Report
q. Operation and maintenance of rooftop solar system
r. Safety and firefighting training

Environmental Aspects

Every energy generation and transmission method affects the environment. Conventional generating options can damage air, climate, water, land and wildlife, landscape as well as raise the levels of harmful radiation. PV technology is substantially safer offering a solution to many environmental and social problems associated with fossil and nuclear fuels. Solar PV energy technology provides obvious environmental advantages in comparison to the conventional energy sources thus contributing to the sustainable development of human activities. Not counting the depletion of the exhausted natural resources, their main advantage is related to the reduced CO2 emissions and normally absence of any air emissions or waste products during their operation.

The use of solar power has additional positive implications such as:

- Reduction of the emissions of the greenhouse gases (mainly CO2, NOx) and prevention of toxic gas emissions (SO2,particulates)
- Reduction of the required transmission lines of the electricity grids

Socio-Economic Aspects

In regard to the socio-economic viewpoint, the benefits of exploitation of solar PV system comprise of:

- Increase of the regional/national energy independency
- Provision of significant work opportunities
- Diversification and security of energy supply
- Support of the deregulation of energy markets

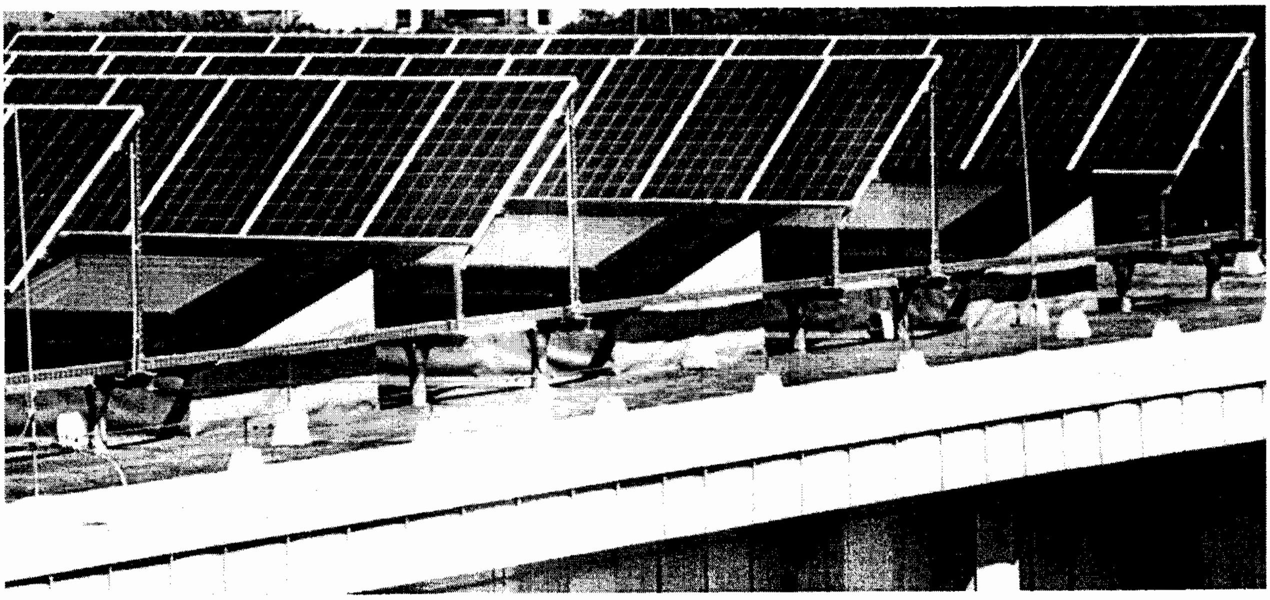
Conclusion

This feasibility study is conducted to ascertain the technical feasibility and commercial viability of installation of 300 kW rooftop PV system installations at Metro Cash & Carry Ravi Road, Lahore.

Installation of the PV system will result in annual power generation of 399,522 kWh.

The results of the financial analysis indicate that the project is feasible.

Based on the outcomes of both the technical and financial analysis, the project is deemed to be viable.



5. FEASIBILITY STUDY FOR ROOFTOP SOLAR INSTALLATION AT METRO CASH & CARRY STORE, MODEL TOWN, LAHORE

<u>SHAMS POWER (PVT) LIMITED</u>

EXECUTIVE SUMMARY

The feasibility study examines the costs, practicality, and likely outcome of a solar photovoltaic (PV) installation on the rooftop of Metro Cash & Carry Store Model Town, Lahore.

The main outcomes of the feasibility report are given below:

Technical Site Analysis: The project site is suitable for a solar PV energy system. For the purpose of estimation of power generation potential, solar insolation is assumed to be "good" (1,719 kWh/ square meter/ year). Panel azimuth (20 degree), panel tilt (8 degrees) and satisfactory roof condition and structure are also assumed.

Anticipated System Information: The project will accommodate a 225 kW (AC) solar PV system with a projected annual production of 309,084 kWh/ year. Use of a Canadian Solar Inc. CS6U – 330P (330 watt) PV panel as a basis for design will result in an acceptable system weight density of 2.36 lbs/SF. The system will offset approximately 111 tons of carbon dioxide annually.

Financial Analysis: The project will be financed on a 100% equity model. The total estimated project cost is USD 229,376

Based on the technical and financial analysis, the installation of a 225kW Solar PV System on the rooftop of Metro Cash & Carry Store Model Town is deemed to be feasible.

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Introduction

The project site is the rooftop of Metro Cash & Carry Store Model Town, Lahore. Pakistan. Metro Cash & Carry Store is a double storied commercial building/retail store. The exact coordinates of the project site are:

Latitude:	31°28'20.92" North
Longitude:	74°19'13.48" East

A bird's eye view of the project site is given in the figure below:

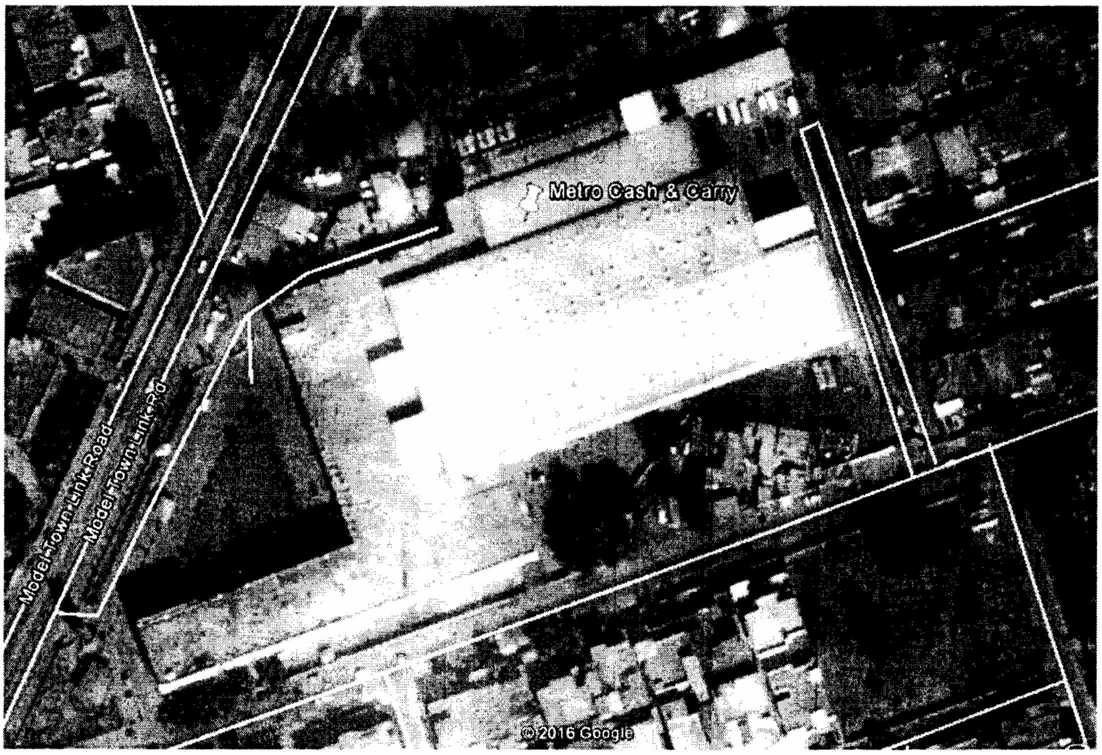

Figure 17: Overview of Project Site

Current Energy Demand and Supply Situation

As per the historical consumption data, the total electricity consumption during 2016 was 2,462,874 kWh.

Details of electricity generation/supply sources during this period are given below:

- Electricity imported from the national grid is 1,988,000 kWh
- In-house power generation from Diesel Generators is 474,874 kWh

Technical Analysis

Site Conditions

The following tasks were carried out:

- Global Horizontal Irradiation, annual and inter-annual variation was assessed.
- Near shading objects were taken into account for placement of PV modules.
- Area required for selected module technology was calculated. Keeping in view available area and minimum inter row shading, tilt angle and appropriate spacing was calculated from near shading objects.

Details of the finalized parameters are given under section 3.5.1

Technology Review and Selection

Technology Selection

PV Modules:

S. No	Specification	Data
1	Type of Module	CS6U-330P
2	Type of Cell	Polycrystalline
3	Dimensions of each module	1960*992*40 mm
4	Weight	22.4 Kg
5	No of Modules	756
6	Module Area	1.94432 m^2
7	Total Land Area Used	Roof Top
8	Module Frame	Anodized aluminum alloy
9	Nominal Max. Power (Pmax)	330 W
10	Opt. Operating Voltage (Vmp)	37.2 V
11	Opt. Operating Current (Imp)	8.88 A
12	Open Circuit Voltage (Voc)	45.6 V
13	Short Circuit Current (Isc)	9.45 A
14	Module Efficiency	16.97%
15	Operating Temperature	-40°C ~ +85°C
16	Max. System Voltage	1000 V (IEC) or 1000 V (UL) or 600 V (UL)
17	Module Fire Performance	TYPE 1 (UL 1703) or CLASS C (IEC 61730)

PV Array

S. No	Specification	Data
1	No of Strings	54
2	Modules in String	14

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PV Capacity

S. No	Specification	Data
1	Total Site	249.48 KW Peak
2	Net Capacity Factor	15.68%

Inverters

S. No	Specification	
1	Manufacturer	SMA
2	Capacity of each Unit	25 KW
3	No of Inverters	9
4	MPP Input Voltage Range	390 V to 800 V
5	Rated Input Voltage	600 V
6	Max Input Voltage	1000 V
7	Total Power (AC)	225 KW
8	Max Input Current Input A/Input B	33A/33A
9	Max Output Current	36.1 A
10	Output Electrical System	3 Phase AC (4 Wire)
11	AC Nominal Voltage	230/400 V
12	Rated Power Frequency	50 Hz
13	Efficiency	98.3%
14	Relative Humidity (Non-Condensing)	100%
15	Noise Emission	51 dB(A)
16	Degree of Protection	IP65

Junction Boxes

S. No	Specification	Data
1	Number of J/Box units	18
2	Input circuits in each box	3
3	Max. input current for each circuit	15A
4	Protection Level	IP 65
5	Over current protection	Fuse
6	Surge protection	>1000V

PV Mounting Structure

S. No	Specification	Data
1	Structure	Galvanized Steel
2	Tilt of Array Frame	8°

Foundation

S. No	Specification	Data
1	Ballast for counter weight	Concrete

Data Collecting System

S. No	Specification	Data
1	System Data	Continuous on-line logging and monitoring over web portal

Solar PV Yield Estimation and Simulation

The aim of yield estimation is to predict the average annual energy output of the site. PvSyst software is used for simulation and near shading analysis.

Working Conditions

The solar system will have automatic mechanism to ensure that PV power currently generated by the inverters always matches the current power consumption of the site load. A closed loop control system of inverter AC output is implemented in reference to energy flow at grid connection point which will reduce inverter AC output of the inverter if site load will be less than the solar production in case of Load shedding.

Plant Characteristics

Generation Voltage: 230/400 V three phase four wire system

Power Factor at rated power: 1

Frequency: 50 Hz

Generation characteristic: Inverter has built-in features of controllable active power ramp following grid disturbance or normal connection, voltage regulation and frequency response. There are no additional control metering and instrumentations.

Design Parameters

The following tasks were carried out for PV layout and shading.

- Assessment of shading (horizon and nearby building)
- Outline layout of area suitable for PV development
- Designing row spacing to reduce inter-row shading and associated shading losses.
- Designing the layout to minimize cable runs and associated electrical losses
- Creating access routes and sufficient space to allow movement for maintenance purposes

- Choosing a tilt angle that optimizes the annual energy yield according to the latitude of the site and the annual distribution of solar resource
- Module cleaning strategy
- Simulating the annual energy losses associated with various configurations of tilt angle, orientation and row spacing. The optimized configuration and simulation results are given in section "Energy Yield Prediction"
- PV layouts of the site are given in 3D and 2D view in the following section.

Layout

The detailed layout (2D and 3D) of the solar panels is given below, PV layout may change depending upon site constraints before or during installation. PvSyst simulation is also performed as per following layout:

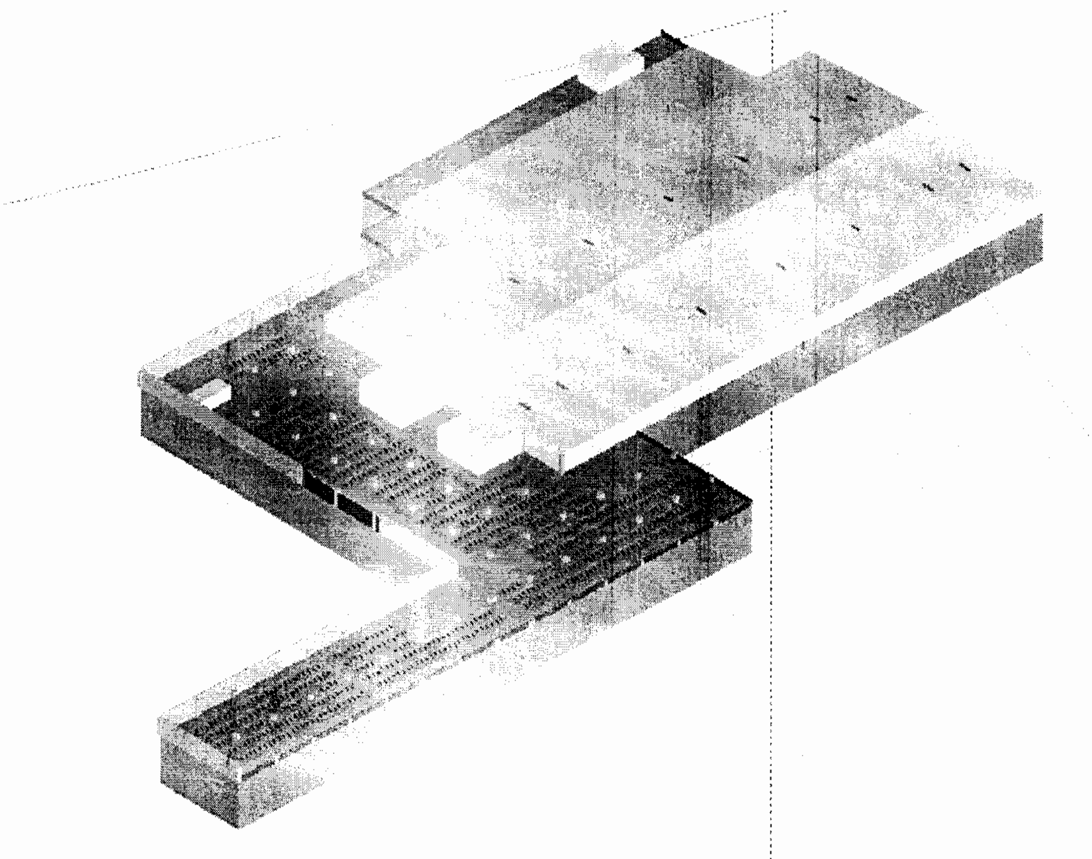

Figure 18: 3D Layout of rooftop of Metro Cash & Carry Model Town

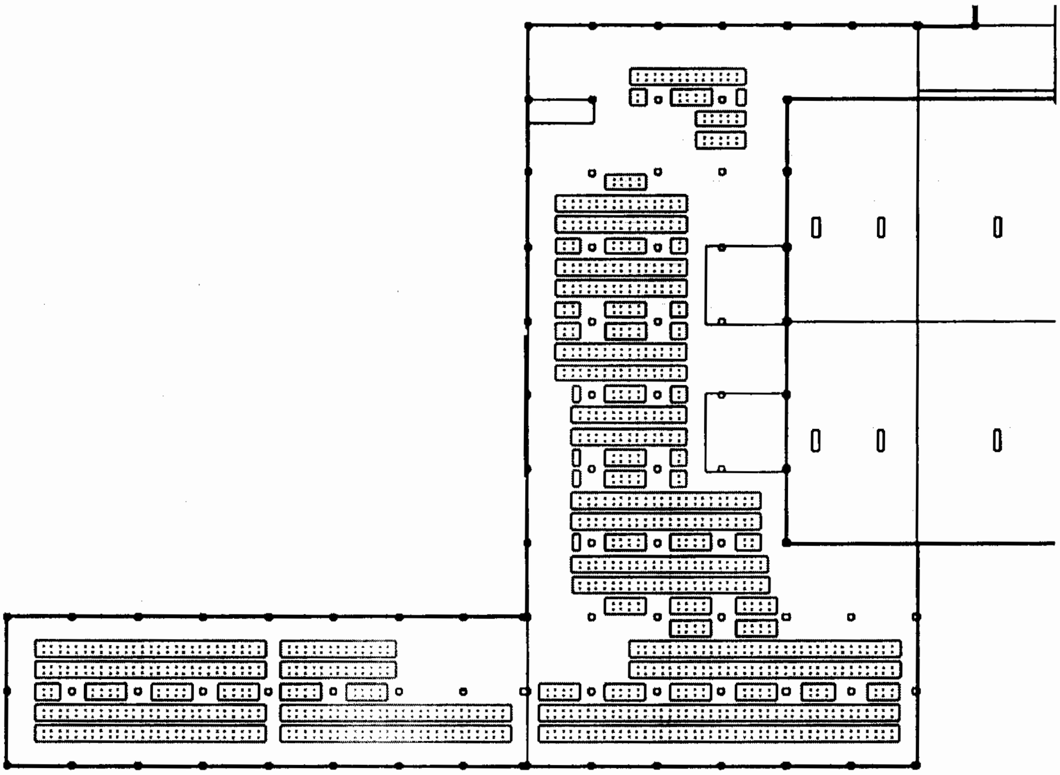

Figure 19: 2D Layout of rooftop of Metro Cash & Carry Model Town showing solar panel locations

Electrical Design

The electrical system comprises the following components:

- Array(s) of PV modules
- DC/AC cabling (module, string and main cable)
- DC connectors (plugs and sockets)
- Junction boxes
- Disconnects/switches
- Protection devices e.g. fuses, surge protective devices, beakers
- Energy Metering
- Earthing

The single line diagram is given below. The single line diagram includes the protection devices that will be used for safe and smooth operation of the system.

Protections DC Side: String Fuses, Surge Protective Device and DC Disconnect Switches

Protections AC Side: MCBs, Main Breaker and Surge Protective Device

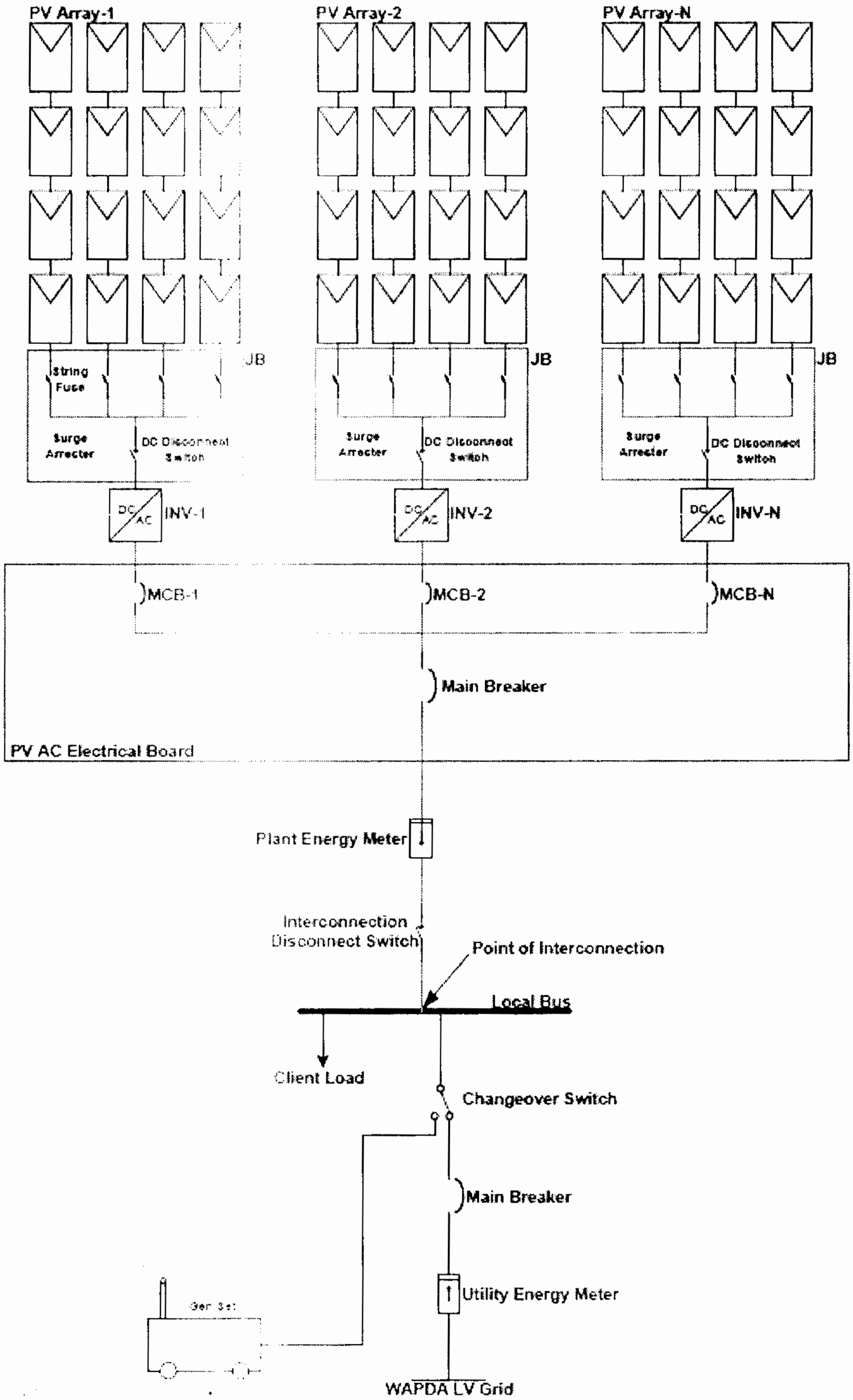

Figure 20: Single Line Diagram of PV Plant

Energy Yield Estimation

The energy yield prediction provides the basis for calculating project revenues. The aim is to predict the average annual energy output for the lifetime of the proposed power plant.

To estimate accurately the energy produced from a PV power plant, information is needed on the solar resource and temperature conditions of the site. Also required are the layout and technical specifications of the plant components.

A number of solar energy yield prediction software packages are available in the market. These packages use time step simulation to model the performance of a project over the course of a year. PvSyst software has been used for energy yield prediction for this site and its results are given below.

Details of the simulation steps are presented in the following sections:

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Simulation Parameters

PVSYST V6.40		29/05/17	Page 1/4

Grid-Connected System: Simulation parameters

Project : **Metro Cash & Carry, Model Town, Lahore**

Geographical Site	Metro model town		Country	**Pakistan**
Situation	Latitude	31.47° N	Longitude	74.32° E
Time defined as	Legal Time	Time zone UT+5	Altitude	212 m
	Albedo	0.20		
Meteo data:	**Metro Cash & Carry Model Town Lahore**	Meteonorm 7.1 - Synthetic		

Simulation variant : Metro 8-20 PT 330cs

Simulation date 29/05/17 14h47

Simulation parameters

Collector Plane Orientation	Tilt	8°	Azimuth	-20°
Models used	Transposition	Perez	Diffuse	Perez, Meteonorm
Horizon	Free Horizon			
Near Shadings	According to strings		Electrical effect	100 %

PV Array Characteristics

PV module Si-poly	Model	**CS6U - 330P**		
Custom parameters definition	Manufacturer	Canadian Solar Inc.		
Number of PV modules	In series	14 modules	In parallel	54 strings
Total number of PV modules	Nb. modules	756	Unit Nom. Power	330 Wp
Array global power	Nominal (STC)	**249 kWp**	At operating cond.	223 kWp (50°C)
Array operating characteristics (50°C)	U mpp	464 V	I mpp	481 A
Total area	Module area	**1470 m²**	Cell area	1325 m²

Inverter	Model	**Sunny Tripower 25000TL-30**		
Original PVsyst database	Manufacturer	SMA		
Characteristics	Operating Voltage	390-800 V	Unit Nom. Power	25.0 kWac
Inverter pack	Nb. of inverters	9 units	Total Power	225 kWac

PV Array loss factors

Array Soiling Losses			Loss Fraction	3.0 %
Thermal Loss factor	Uc (const)	29.0 W/m²K	Uv (wind)	0.0 W/m²K / m/s
Wiring Ohmic Loss	Global array res.	15 mOhm	Loss Fraction	1.4 % at STC
LID - Light Induced Degradation			Loss Fraction	1.1 %
Module Quality Loss			Loss Fraction	2.0 %
Module Mismatch Losses			Loss Fraction	1.0 % at MPP

Incidence effect (IAM): User defined IAM profile

10°	20°	30°	40°	50°	60°	70°	80°	90°
0.998	0.998	0.995	0.992	0.986	0.970	0.917	0.763	0.000

System loss factors

Wiring Ohmic Loss	Wires 3x240.0 mm²	227 m	Loss Fraction	2.7 % at STC
Unavailability of the system	34.0 days, 4 periods		Time fraction	9.3 %

User's needs : Unlimited load (grid)

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Near Shading Definition

PVSYST V6.40		29/05/17	Page 2/4

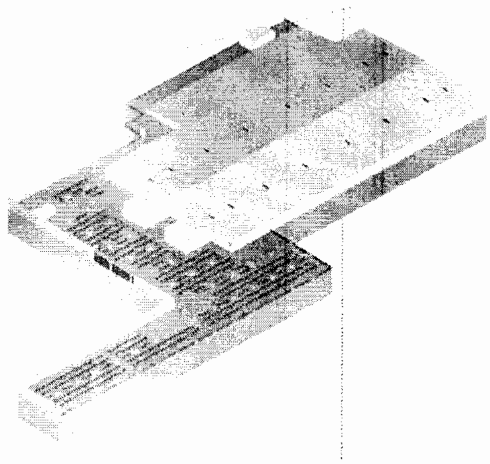
Grid-Connected System: Near shading definition

Project : **Metro Cash & Carry, Model Town, Lahore**

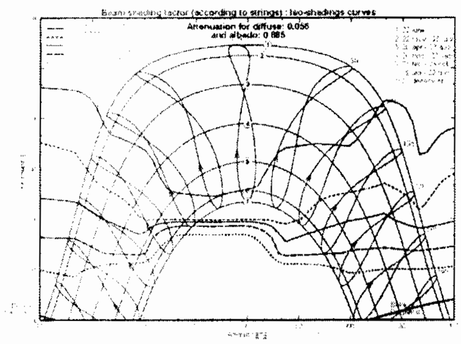
Simulation variant : **Metro 8-20 PT 330cs**

Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	tilt	8°	azimuth	-20°
PV modules	Model	CS6U - 330P	Pnom	330 Wp
PV Array	Nb. of modules	756	Pnom total	**249 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
Inverter pack	Nb. of units	9.0	Pnom total	**225 kW ac**
User's needs	Unlimited load (grid)			

Perspective of the PV-field and surrounding shading scene



Iso-shadings diagram



Losses

PVSYST V6.40		29/05/17	Page 4/4

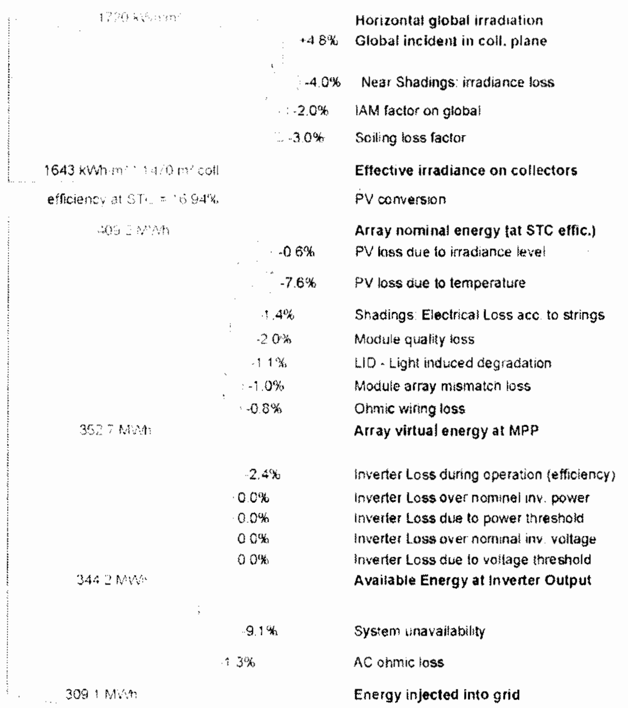
Grid-Connected System: Loss diagram

Project : **Metro Cash & Carry, Model Town, Lahore**

Simulation variant : **Metro 8-20 PT 330cs**

Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	tilt	8°	azimuth	-20°
PV modules	Model	CS6U - 330P	Pnom	330 Wp
PV Array	Nb. of modules	756	Pnom total	**249 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
Inverter pack	Nb. of units	9.0	Pnom total	**225 kW ac**
User's needs	Unlimited load (grid)			

Loss diagram over the whole year



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Simulation Results

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Grid-Connected System: Main results

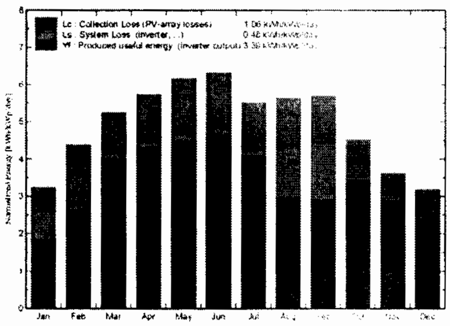
Project : Metro Cash & Carry, Model Town, Lahore

Simulation variant : Metro 8-20 PT 330cs

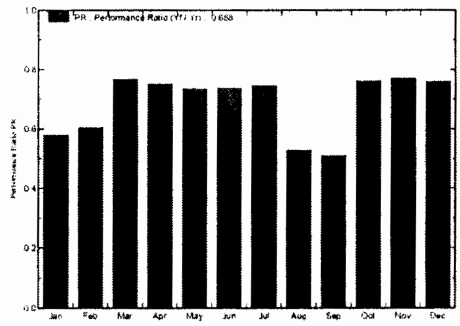
Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	tilt	8°	azimuth	-20°
PV modules	Model	CS6U - 330P	Pnom	330 Wp
PV Array	Nb. of modules	756	Pnom total	**249 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
Inverter pack	Nb. of units	9.0	Pnom total	**225 kW ac**
User's needs	Unlimited load (grid)			

Main simulation results				
System Production	Produced Energy	**309.1 MWh/year**	Specific prod.	1239 kWh/kWp/year
	Performance Ratio PR	68.76 %		

Normalized productions (per installed kWp): Nominal power 249 kWp



Performance Ratio PR



Metro 8-20 PT 330cs

Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_Grid MWh	PR
January	[illegible]	[illegible]	[illegible]	100.2	90.6	20.28	14.43	0.579
February	[illegible]	[illegible]	[illegible]	122.5	111.8	24.92	18.47	0.604
March	[illegible]	[illegible]	21.49	162.4	148.7	32.36	31.15	0.769
April	[illegible]	[illegible]	[illegible]	172.1	157.0	33.56	32.31	0.753
May	[illegible]	[illegible]	[illegible]	190.7	174.6	36.33	34.93	0.734
June	[illegible]	[illegible]	32.14	189.7	173.9	36.38	34.97	0.739
July	[illegible]	[illegible]	30.90	170.9	155.6	33.04	31.82	0.746
August	[illegible]	[illegible]	[illegible]	174.8	159.3	33.96	23.03	0.528
September	[illegible]	[illegible]	28.12	171.4	156.8	33.44	21.80	0.510
October	130.1	[illegible]	24.66	140.1	127.7	27.58	26.59	0.761
November	[illegible]	[illegible]	[illegible]	108.7	98.5	21.61	20.89	0.770
December	[illegible]	[illegible]	13.28	98.4	88.5	19.26	18.64	0.759
Year	[illegible]	[illegible]	[illegible]	1801.9	1643.1	352.69	309.08	0.688

Legends	GlobHor	[illegible]	GlobEff	Effective Global, corr. for IAM and shadings
	DiffHor	[illegible]	EArray	Effective energy at the output of the array
	T Amb	[illegible]	E_Grid	Energy injected into grid
	GlobInc	[illegible]	PR	Performance Ratio

Financial Analysis

Cost/watt: **USD 1.2**

Total Project Cost for 249.48 KWp (DC) Solar PV System: **USD 299,376**

Equity: **100%**

Debt: **0%**

Safety and Emergency Plans

- Only qualified and authorized electricians will be allowed to undertake servicing or maintenance tasks.
- The authorized personnel will wear appropriate equipment, including a safety harness to restrain from falling off the roof, sturdy shoes that will have thick rubber soles to provide electrical insulation and good grip and appropriate clothing for personal protection, including a hat, sunglasses, gloves and long pants and sleeves
- Lock out and tag out procedures will be used before commencement of maintenance tasks.
- On-going operation and maintenance concerns for solar power systems will be addressed properly. These systems are exposed to outdoor weather conditions that enhance the aging process, and the infrastructure needs to be in place for the on-going maintenance of these systems to assure their safe operation.
- Properly grounded or double insulated power tools will be used for maintenance tasks. Tools will be maintained in good condition.
- Working on electrical equipment and circuits will be carried out in de energized state.
- Proper pathways will be available for operation, maintenance and firefighting.
- Fire protection and suppression will be placed at site

Training and Capacity Development

Trained and qualified personnel will be available at site 24/7 with proper safety and firefighting training. Training program will focus on but not limited to Solar Resource Assessment, Site Survey, Technology, Engineering Design, Regulation, Policy, Metering & Billing, and Project Management of Rooftop Solar System. The following components will include in training and development program.

a. Collection of Resource Data
b. Variability and uncertainty of resource data
c. Site evaluation
d. Crystalline and Thin film technology comparison
e. Rooftop solar system components
f. Module mounting structure selection
g. Inverter selection
h. Design of PV Array
i. Shadow Analysis
j. DC cable sizing
k. DC cable layout
l. Protection and Metering
m. Installation and testing standards for solar PV plants
n. Solar Module testing standards
o. Economy of Roof top Solar System
p. Detailed Project Report
q. Operation and maintenance of rooftop solar system
r. Safety and firefighting training

Environmental Aspects

Every energy generation and transmission method affects the environment. Conventional generating options can damage air, climate, water, land and wildlife, landscape as well as raise the levels of harmful radiation. PV technology is substantially safer offering a solution to many environmental and social problems associated with fossil and nuclear fuels. Solar PV energy technology provides obvious environmental advantages in comparison to the conventional energy sources thus contributing to the sustainable development of human activities. Not counting the depletion of the exhausted natural resources, their main advantage is related to the reduced CO2 emissions and normally absence of any air emissions or waste products during their operation.

The use of solar power has additional positive implications such as:

- Reduction of the emissions of the greenhouse gases (mainly CO2, NOx) and prevention of toxic gas emissions (SO2,particulates)
- Reduction of the required transmission lines of the electricity grids

Socio-Economic Aspects

In regard to the socio-economic viewpoint, the benefits of exploitation of solar PV system comprise of:

- Increase of the regional/national energy independency
- Provision of significant work opportunities
- Diversification and security of energy supply
- Support of the deregulation of energy markets

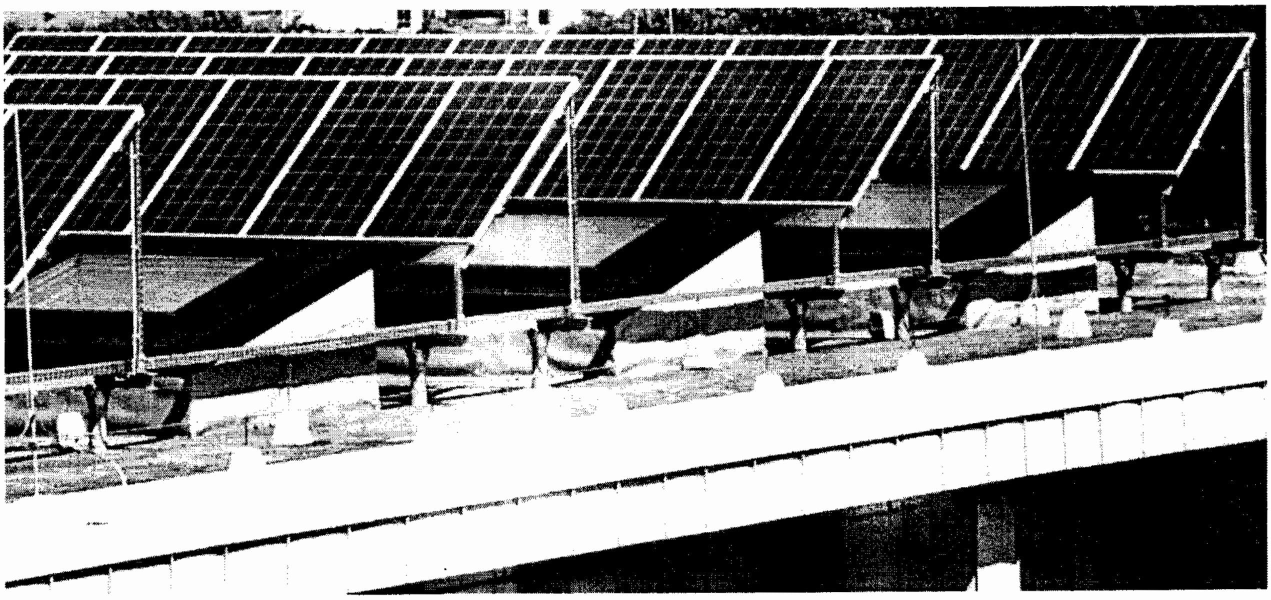
Conclusion

This feasibility study is conducted to ascertain the technical feasibility and commercial viability of installation of 225 kW rooftop PV system installation at Metro Cash & Carry Model Town, Lahore.

Installation of the PV system will result in annual power generation of 309,084 kWh.

The results of the financial analysis indicate that the project is feasible.

Based on the outcomes of both the technical and financial analysis, the project is deemed to be viable.



6. FEASIBILITY STUDY FOR ROOFTOP SOLAR INSTALLATION AT METRO CASH & CARRY STORE, SARGODHA ROAD, FAISALABAD

SHAMS POWER (PVT) LIMITED

ShamsPower

EXECUTIVE SUMMARY

The feasibility study examines the costs, practicality, and likely outcome of a solar photovoltaic (PV) installation on the rooftop of Metro Cash & Carry Store Sargodha Road, Faisalabad.

The main outcomes of the feasibility report are given below:

Technical Site Analysis: The project site is suitable for a solar PV energy system. For the purpose of estimation of power generation potential, solar insolation is assumed to be "good" (1,719 kWh/ square meter/ year). Panel azimuth (22 degree), panel tilt (2 degrees) and satisfactory roof condition and structure are also assumed.

Anticipated System Information: The project will accommodate a 250 kW (AC) solar PV system with a projected annual production of 348,433 kWh/ year. Use of a Canadian Solar Inc. CS6U – 330P (330 watt) PV panel as a basis for design will result in an acceptable system weight density of 2.36 lbs/sqft. The system will offset approximately 121 tons of carbon dioxide annually.

Financial Analysis: The project will be financed on a 100% equity model. The total estimated project cost is USD 356,400.

Based on the technical and financial analysis, the installation of a 250 kW Solar PV System on the rooftop of Metro Cash & Carry Faisalabad Store is deemed to be feasible.

Introduction

The project site is the rooftop of Metro Cash & Carry Store Faisalabad, Pakistan. Metro Cash & Carry Store is a single storied commercial building/retail store. The exact coordinates of the project site are:

Latitude:	31°30'29.87" North
Longitude:	73° 4'14.46" East

A bird's eye view of the project site is given in the figure below:

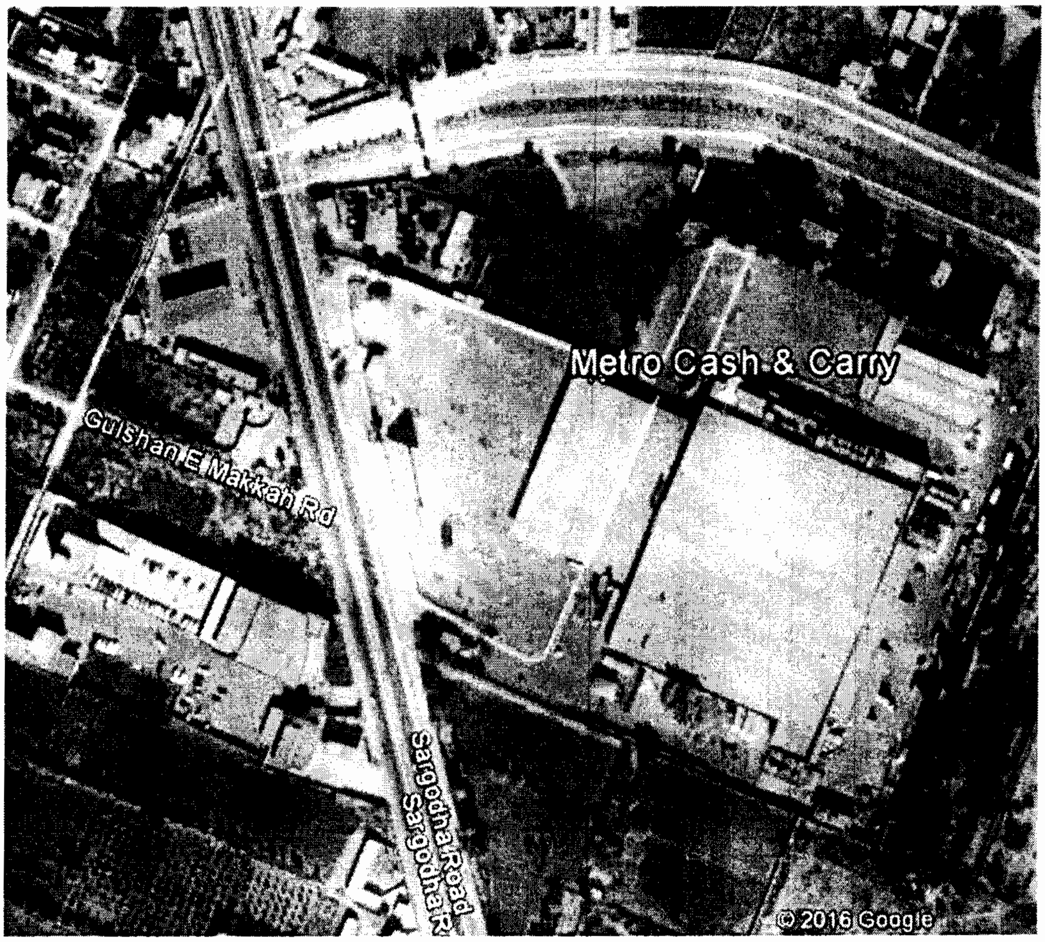


Figure 21: Overview of Project Site

Current Energy Demand and Supply Situation

As per the historical consumption data, the total electricity consumption during 2016 was 2,270,777 kWh.

Details of electricity generation/supply sources during this period are given below:

- Electricity imported from the national grid is 2,026,400 kWh
- In-house power generation from Diesel Generators is 244,377 kWh

Technical Analysis

Site Conditions

The following tasks were carried out:

- Global Horizontal Irradiation, annual and inter-annual variation was assessed.
- Near shading objects were taken into account for placement of PV modules.
- Area required for selected module technology was calculated. Keeping in view available area and minimum inter row shading, tilt angle and appropriate spacing was calculated from near shading objects.

Details of the finalized parameters are given under section 3.5.1

Technology Review and Selection

Technology Selection

PV Modules:

S. No	Specification	Data
1	Type of Module	CS6U-330P
2	Type of Cell	Polycrystalline
3	Dimensions of each module	1960*992*40 mm
4	Weight	22.4 Kg
5	No of Modules	900
6	Module Area	1.94432 m^2
7	Total Land Area Used	Roof Top
8	Module Frame	Anodized aluminum alloy
9	Nominal Max. Power (Pmax)	330 W
10	Opt. Operating Voltage (Vmp)	37.2 V
11	Opt. Operating Current (Imp)	8.88 A
12	Open Circuit Voltage (Voc)	45.6 V
13	Short Circuit Current (Isc)	9.45 A
14	Module Efficiency	16.97%
15	Operating Temperature	-40°C ~ +85°C
16	Max. System Voltage	1000 V (IEC) or 1000 V (UL) or 600 V (UL)
17	Module Fire Performance	TYPE 1 (UL 1703) or CLASS C (IEC 61730)

PV Array

S. No	Specification	Data
1	No of Strings	60
2	Modules in String	15

PV Capacity

S. No	Specification	Data
1	Total Site	297 KW Peak
2	Net Capacity Factor	15.91%

Inverters

S. No	Specification	
1	Manufacturer	SMA
2	Capacity of each Unit	25 KW
3	No of Inverters	10
4	MPP Input Voltage Range	390 V to 800 V
5	Rated Input Voltage	600 V
6	Max Input Voltage	1000 V
7	Total Power (AC)	250 KW
8	Max Input Current Input A/Input B	33A/33A
9	Max Output Current	36.1 A
10	Output Electrical System	3 Phase AC (4 Wire)
11	AC Nominal Voltage	230/400 V
12	Rated Power Frequency	50 Hz
13	Efficiency	98.3%
14	Relative Humidity (Non-Condensing)	100%
15	Noise Emission	51 dB(A)
16	Degree of Protection	IP65

Junction Boxes

S. No	Specification	Data
1	Number of J/Box units	20
2	Input circuits in each box	3
3	Max. input current for each circuit	15A
4	Protection Level	IP 65
5	Over current protection	Fuse
6	Surge protection	>1000V

PV Mounting Structure

S. No	Specification	Data
1	Structure	Aluminum
2	Tilt of Array Frame	2° (In line with shed rooftop)

Data Collecting System

S. No	Specification	Data
1	System Data	Continuous on-line logging and monitoring over web portal

Solar PV Yield Estimation and Simulation

The aim of yield estimation is to predict the average annual energy output of the site. PvSyst software is used for simulation and near shading analysis.

Working Conditions: Zero Export

The solar system will have automatic mechanism to ensure that PV power currently generated by the inverters always matches the current power consumption of the site load. A closed loop control system of inverter AC output is implemented in reference to energy flow at grid connection point which will reduce inverter AC output of the inverter if site load will be less than the solar production.

Plant Characteristics
Generation Voltage: 230/400 V three phase four wire system
Power Factor at rated power: 1
Frequency: 50 Hz
Generation characteristic: Inverter has built-in features of controllable active power ramp following grid disturbance or normal connection, voltage regulation and frequency response. There are no additional control metering and instrumentations.

Design Parameters
The following tasks were carried out for PV layout and shading.

- Assessment of shading (horizon and nearby building)
- Outline layout of area suitable for PV development
- Designing row spacing to reduce inter-row shading and associated shading losses.
- Designing the layout to minimize cable runs and associated electrical losses
- Creating access routes and sufficient space to allow movement for maintenance purposes

- Choosing a tilt angle that optimizes the annual energy yield according to the latitude of the site and the annual distribution of solar resource
- Module cleaning strategy
- Simulating the annual energy losses associated with various configurations of tilt angle, orientation and row spacing. The optimized configuration and simulation results are given in section "Energy Yield Prediction"
- PV layouts of the site are given in 3D and 2D view in the following section.

Layout

The detailed layout (2D and 3D) of the solar panels is given below. PV layout may change depending upon site constraints before or during installation. PvSyst simulation is also performed as per following layout:

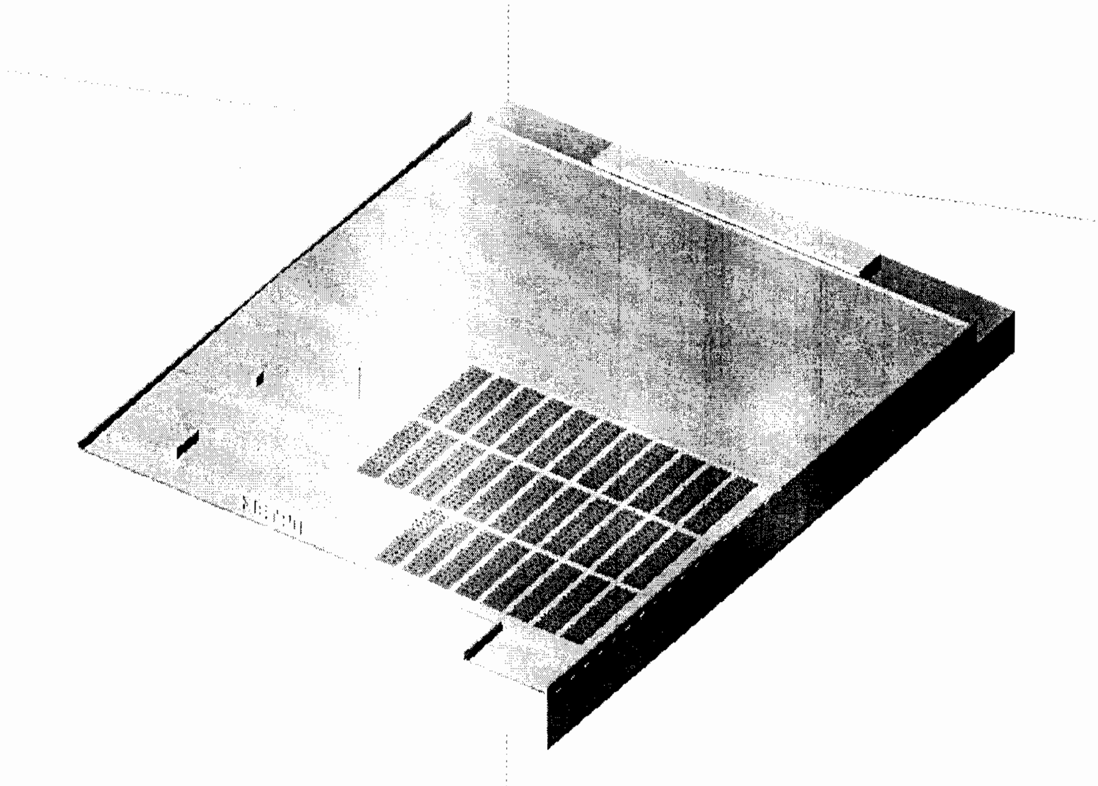


Figure 22: 3D Layout of rooftop of Metro Cash & Carry Faisalabad

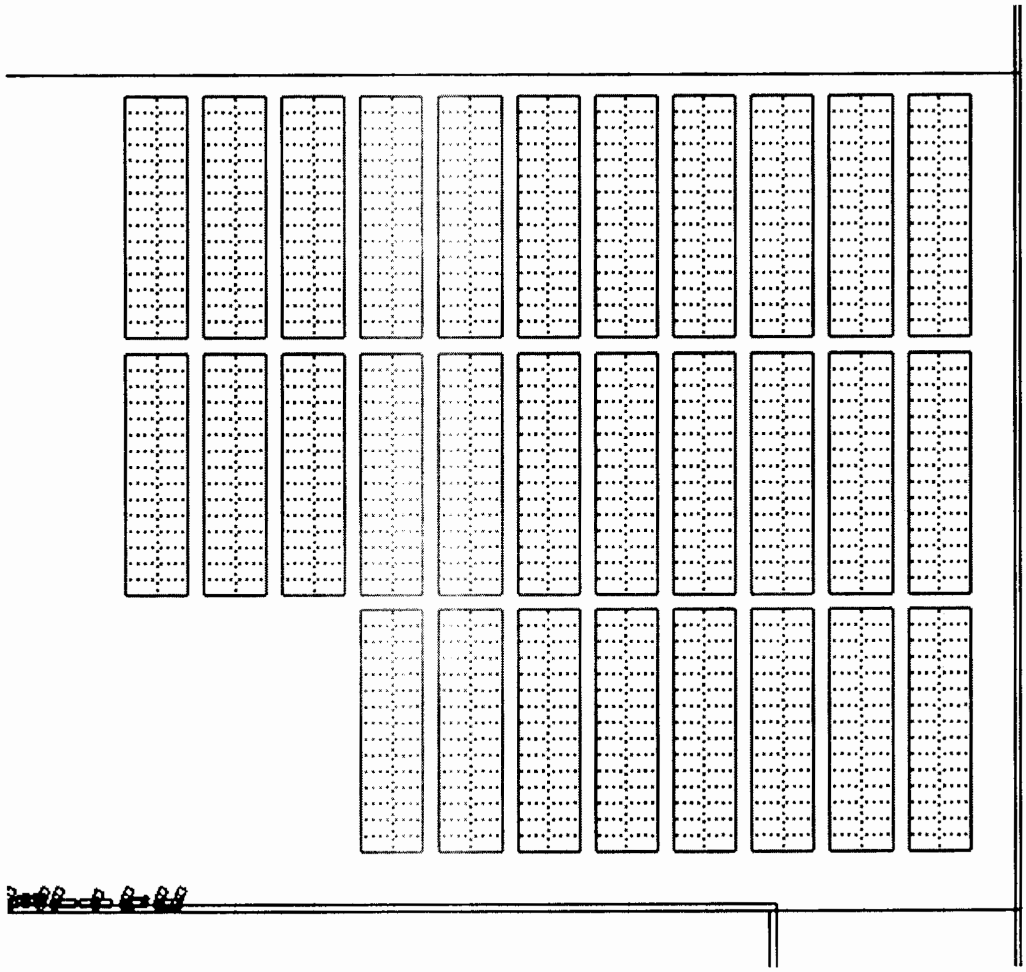


Figure 23: 2D Layout of rooftop of Metro Cash & Carry Faisalabad showing solar panel locations

Electrical Design

The electrical system comprises the following components:

- Array(s) of PV modules
- DC/AC cabling (module, string and main cable)
- DC connectors (plugs and sockets)
- Junction boxes
- Disconnects/switches
- Protection devices e.g. fuses, surge protective devices, beakers
- Energy Metering
- Earthing

The single line diagram is given below. The single line diagram includes the protection devices that will be used for safe and smooth operation of the system.

Protections DC Side: String Fuses, Surge Protective Device and DC Disconnect Switches

Protections AC Side: MCBs, Main Breaker and Surge Protective Device

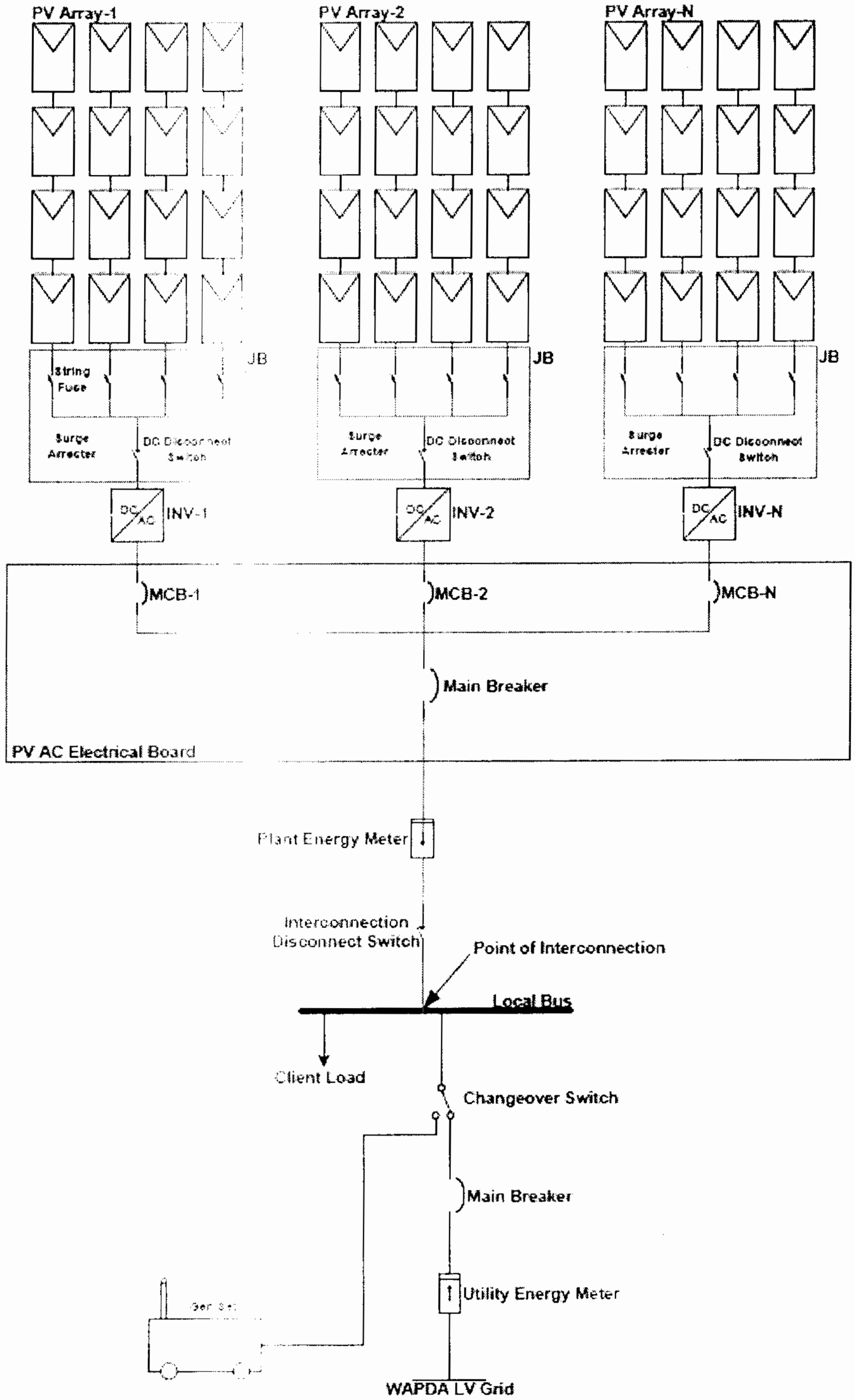


Figure 24: Single Line Diagram of PV Plant

Energy Yield Estimation

The energy yield prediction provides the basis for calculating project revenues. The aim is to predict the average annual energy output for the lifetime of the proposed power plant.

To estimate accurately the energy produced from a PV power plant, information is needed on the solar resource and temperature conditions of the site. Also required are the layout and technical specifications of the plant components.

A number of solar energy yield prediction software packages are available in the market. These packages use time step simulation to model the performance of a project over the course of a year. PvSyst software has been used for energy yield prediction for this site and its results are given below.

Details of the simulation steps are presented in the following sections:

ShamsPower

Simulation Parameters

PVSYST V6.40		05/06/17	Page 1/4

Grid-Connected System: Simulation parameters

Project :	Metro Cash & Carry, Faisalabad			
Geographical Site	**Metro Cash & Carry, Faisalabad**		Country	**Pakistan**
Situation	Latitude	31.51° N	Longitude	73.07° E
Time defined as	Legal Time	Time zone UT+5	Altitude	183 m
	Albedo	0.20		
Meteo data:	**Metro Cash & Carry, Faisalabad**	Meteonorm 7.1, Sat=54% - Synthetic		

Simulation variant :	Metro FSD 2/22			
	Simulation date	05/06/17 09h47		

Simulation parameters

Collector Plane Orientation	Tilt	2°	Azimuth	22°
Models used	Transposition	Perez	Diffuse	Perez, Meteonorm
Horizon	Free Horizon			
Near Shadings	According to strings		Electrical effect	100 %

PV Array Characteristics

PV module Si-poly	Model	**CS6U - 330P**		
Custom parameters definition	Manufacturer	Canadian Solar Inc.		
Number of PV modules	In series	15 modules	In parallel	60 strings
Total number of PV modules	Nb. modules	900	Unit Nom. Power	330 Wp
Array global power	Nominal (STC)	**297 kWp**	At operating cond.	266 kWp (50°C)
Array operating characteristics (50°C)	U mpp	497 V	I mpp	535 A
Total area	Module area	**1750 m²**	Cell area	1577 m²

Inverter	Model	**Sunny Tripower 25000TL-30**		
Original PVsyst database	Manufacturer	SMA		
Characteristics	Operating Voltage	390-800 V	Unit Nom. Power	25.0 kWac
Inverter pack	Nb. of inverters	10 units	Total Power	250 kWac

PV Array loss factors

Array Soiling Losses			Loss Fraction	3.0 %
Thermal Loss factor	Uc (const)	20.0 W/m²K	Uv (wind)	0.0 W/m²K / m/s
Wiring Ohmic Loss	Global array res.	39 mOhm	Loss Fraction	3.7 % at STC
LID - Light Induced Degradation			Loss Fraction	2.0 %
Module Quality Loss			Loss Fraction	2.0 %
Module Mismatch Losses			Loss Fraction	1.0 % at MPP

Incidence effect (IAM): User defined IAM profile

10°	20°	30°	40°	50°	60°	70°	80°	90°
0.998	0.998	0.995	0.992	0.986	0.970	0.917	0.763	0.000

System loss factors

Wiring Ohmic Loss	Wires: 3x185.0 mm²	176 m	Loss Fraction	3.2 % at STC
Unavailability of the system	34.0 days, 4 periods		Time fraction	9.3 %

User's needs : Unlimited load (grid)

Near Shading Definition

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Grid-Connected System: Near shading definition

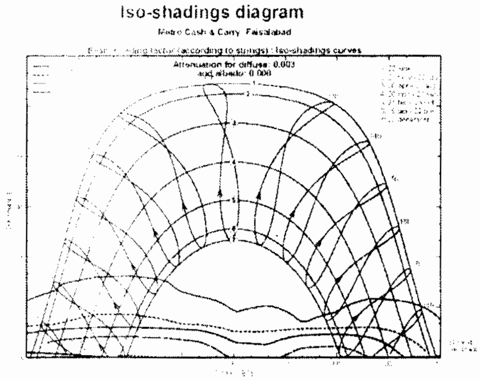
Project : Metro Cash & Carry, Faisalabad

Simulation variant : Metro FSD 2/22

Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	tilt	2°	azimuth	22°
PV modules	Model	CS6U - 330P	Pnom	330 Wp
PV Array	Nb. of modules	900	Pnom total	**297 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
Inverter pack	Nb. of units	10.0	Pnom total	**250 kW ac**
User's needs	Unlimited load (grid)			

Perspective of the PV-field and surrounding shading scene

Iso-shadings diagram



Losses

PVSYST V6.40		05/06/17	Page 4/4

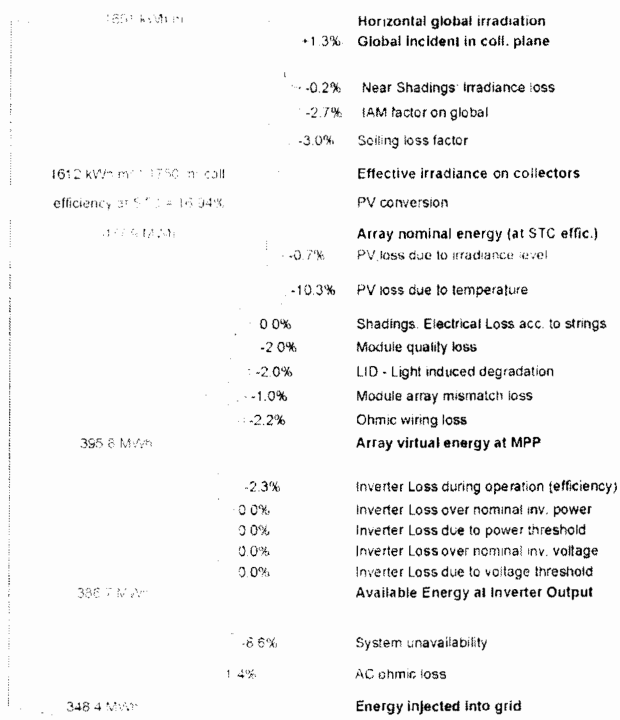
Grid-Connected System: Loss diagram

Project : Metro Cash & Carry, Faisalabad

Simulation variant : Metro FSD 2/22

Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	tilt	2°	azimuth	22°
PV modules	Model	CS6U - 330P	Pnom	330 Wp
PV Array	Nb. of modules	900	Pnom total	**297 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
Inverter pack	Nb. of units	10.0	Pnom total	**250 kW ac**
User's needs	Unlimited load (grid)			

Loss diagram over the whole year



Simulation Results

PVSYST V6.40		05/06/17	Page 3/4

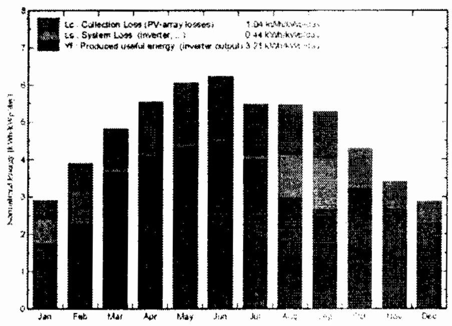
Grid-Connected System: Main results

Project : Metro Cash & Carry, Faisalabad
Simulation variant : Metro FSD 2/22

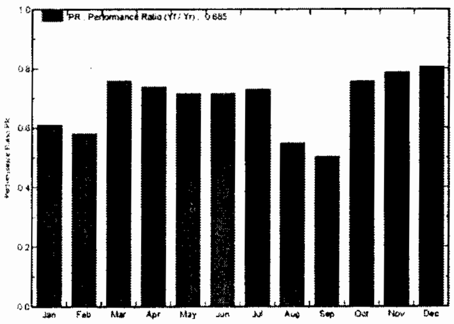
Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	tilt	2°	azimuth	22°
PV modules	Model	CS6U - 330P	Pnom	330 Wp
PV-Array	Nb. of modules	900	Pnom total	**297 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
Inverter pack	Nb. of units	10.0	Pnom total	**250 kW ac**
User's needs	Unlimited load (grid)			

Main simulation results				
System Production	Produced Energy	**348.4 MWh/year**	Specific prod.	1173 kWh/kWp/year
	Performance Ratio PR	68.49 %		

Normalized productions (per installed kWp): Nominal power 297 kWp



Performance Ratio PR



Metro FSD 2/22
Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_Grid MWh	PR
January	87.4	[illegible]	[illegible]	90.1	84.1	22.60	18.33	0.610
February	[illegible]	[illegible]	16.38	109.2	102.6	26.62	18.84	0.581
March	[illegible]	[illegible]	21.07	149.4	140.8	35.00	33.71	0.760
April	[illegible]	[illegible]	26.56	166.4	158.9	37.97	36.55	0.739
May	[illegible]	[illegible]	[illegible]	187.5	176.9	41.43	39.84	0.715
June	[illegible]	[illegible]	[illegible]	186.9	176.6	41.39	39.77	0.716
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December	[illegible]	[illegible]	[illegible]	89.1	83.0	22.04	21.34	0.806
Year	[illegible]	[illegible]	[illegible]	1712.8	1611.9	395.76	348.43	0.685

Legends:			
GlobHor	[illegible]	GlobEff	Effective Global, corr. for IAM and shadings
DiffHor	[illegible]	EArray	Effective energy at the output of the array
T Amb	[illegible]	E_Grid	Energy injected into grid
GlobInc	[illegible]	PR	Performance Ratio

Financial Analysis

Cost/watt: **USD 1.2**

Total Project Cost for 297 KWp (DC) Solar PV System: **USD 356,400**

Equity: **100%**

Debt: **0%**

Safety and Emergency Plans

- Only qualified and authorized electricians will be allowed to undertake servicing or maintenance tasks.
- The authorized personnel will wear appropriate equipment, including a safety harness to restrain from falling off the roof, sturdy shoes that will have thick rubber soles to provide electrical insulation and good grip and appropriate clothing for personal protection, including a hat, sunglasses, gloves and long pants and sleeves
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b. Variability and uncertainty of resource data
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e. Rooftop solar system components
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m. Installation and testing standards for solar PV plants
n. Solar Module testing standards
o. Economy of Roof top Solar System
p. Detailed Project Report
q. Operation and maintenance of rooftop solar system
r. Safety and firefighting training

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Every energy generation and transmission method affects the environment. Conventional generating options can damage air, climate, water, land and wildlife, landscape as well as raise the levels of harmful radiation. PV technology is substantially safer offering a solution to many environmental and social problems associated with fossil and nuclear fuels. Solar PV energy technology provides obvious environmental advantages in comparison to the conventional energy sources thus contributing to the sustainable development of human activities. Not counting the depletion of the exhausted natural resources, their main advantage is related to the reduced CO2 emissions and normally absence of any air emissions or waste products during their operation.

The use of solar power has additional positive implications such as:

- Reduction of the emissions of the greenhouse gases (mainly CO2, NOx) and prevention of toxic gas emissions (SO2,particulates)
- Reduction of the required transmission lines of the electricity grids

Socio-Economic Aspects

In regard to the socio-economic viewpoint, the benefits of exploitation of solar PV system comprise of:

- Increase of the regional/national energy independency
- Provision of significant work opportunities
- Diversification and security of energy supply
- Support of the deregulation of energy markets

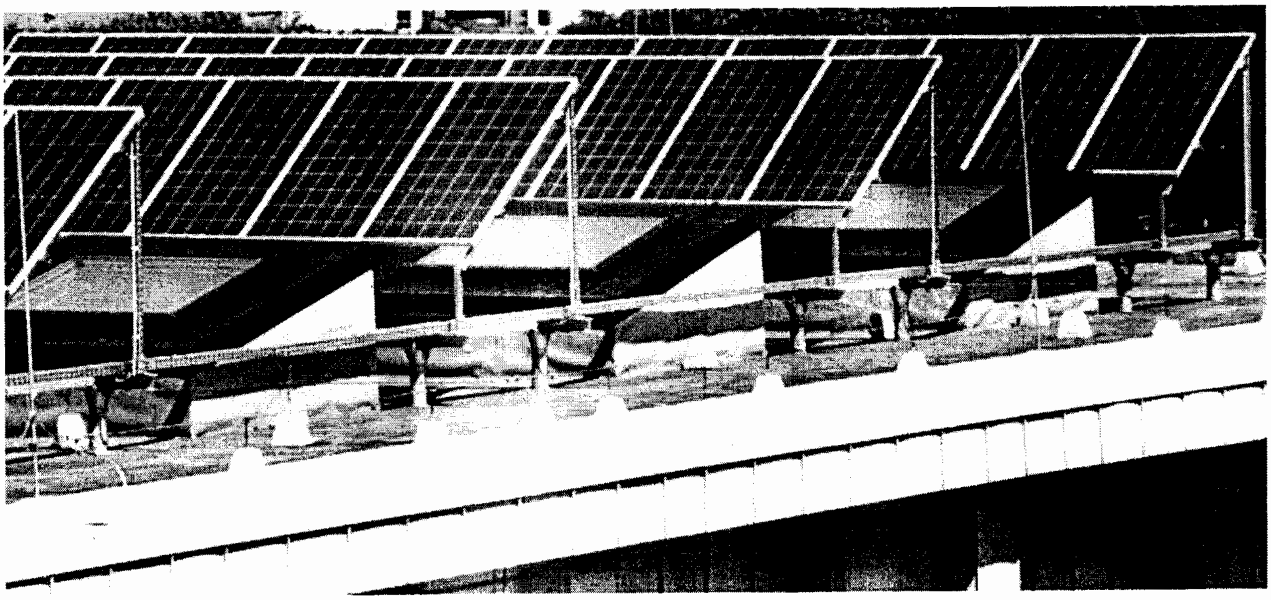
Conclusion

This feasibility study is conducted to ascertain the technical feasibility and commercial viability of installation of 250kW rooftop PV system installation at Metro Cash & Carry Sargodha Road Faisalabad.

Installation of the PV system will result in annual power generation of 348,433 kWh.

The results of the financial analysis indicate that the project is feasible.

Based on the outcomes of both the technical and financial analysis, the project is deemed to be viable.



7. FEASIBILITY STUDY FOR ROOFTOP SOLAR INSTALLATION AT METRO CASH & CARRY STORE, MANGHOPIR, KARACHI

SHAMS POWER (PVT) LIMITED

EXECUTIVE SUMMARY

The feasibility study examines the costs, practicality, and likely outcome of a solar photovoltaic (PV) installation on the rooftop of Metro Cash & Carry Store D-22, Manghopir Road, Karachi.

The main outcomes of the feasibility report are given below:

Technical Site Analysis: The project site is suitable for a solar PV energy system. For the purpose of estimation of power generation potential, solar insolation is assumed to be "very good" (1,834 kWh/ square meter/ year). Panel facing south (0 degree azimuth), panel tilt (2 degrees) and satisfactory roof condition and structure are also assumed.

Anticipated System Information: The project will accommodate a 200 kW (AC) solar PV system with a projected annual production of 315,797 kWh/ year. Use of a Canadian Solar Inc. CS6U – 330P (330 watt) PV panel as a basis for design will result in an acceptable system weight density of 2.36 lbs/sqft. The system will offset approximately 112 tons of carbon dioxide annually.

Financial Analysis: The project will be financed on a 100% equity model. The total estimated project cost is USD 285,120.

Based on the technical and financial analysis, the installation of a 200 kW Solar PV System on the rooftop of Metro Cash & Carry Store is deemed to be feasible.

Introduction

The project site is the rooftop of Metro Cash & Carry Store D-22 Manghopir Road, Karachi, Pakistan. Metro Cash & Carry Store is a double storied commercial building/retail store. The exact coordinates of the project site are:

Latitude: 24°55'11.57" North
Longitude: 67° 0'56.73" East

A bird's eye view of the project site is given in the figure below:

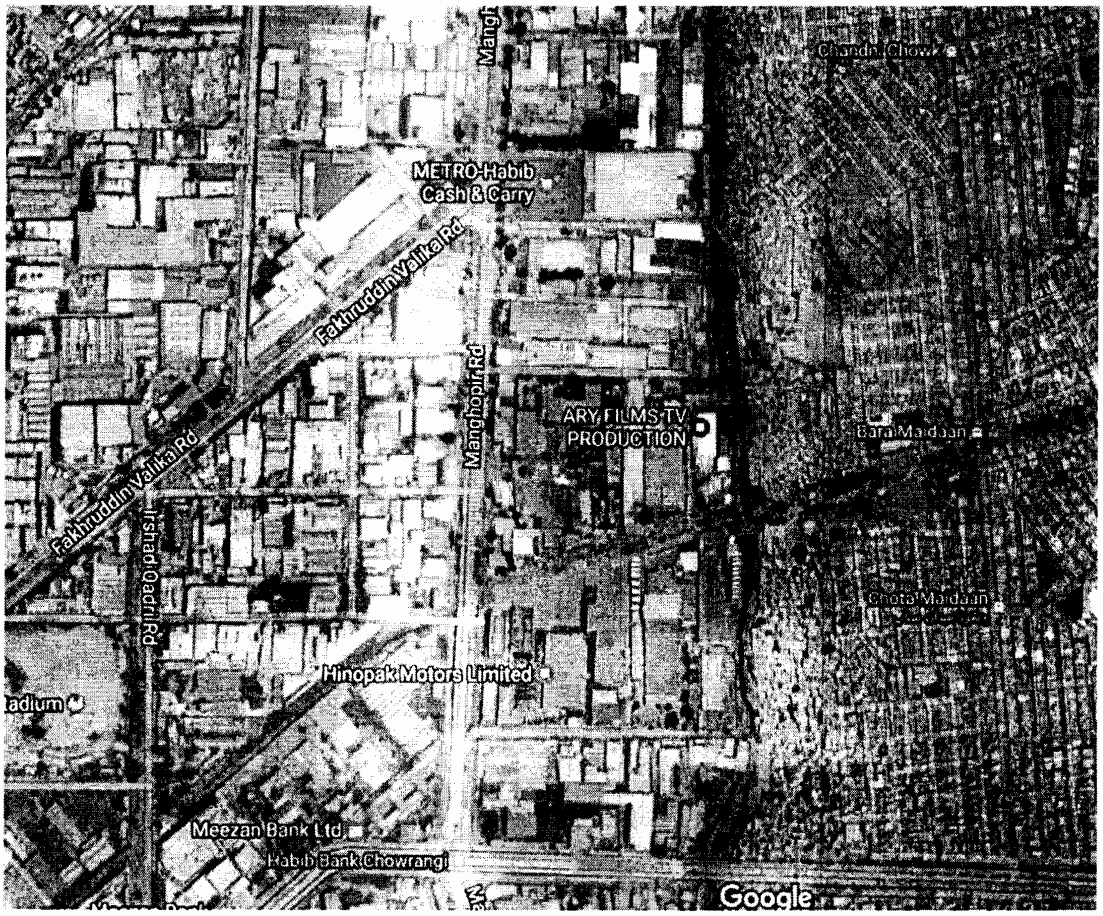


Figure 25: Overview of Project Site

Current Energy Demand and Supply Situation

As per the historical consumption data, the total electricity consumption during 2016 was 1,404,305 kWh.

Technical Analysis

Site Conditions

The following tasks were carried out:

- Global Horizontal Irradiation, annual and inter-annual variation was assessed.
- Near shading objects were taken into account for placement of PV modules.
- Area required for selected module technology was calculated. Keeping in view available area and minimum inter row shading, tilt angle and appropriate spacing was calculated from near shading objects.

Details of the finalized parameters are given under section 3.5.1

Technology Review and Selection

Technology Selection

PV Modules:

S. No	Specification	Data
1	Type of Module	CS6U-330P
2	Type of Cell	Polycrystalline
3	Dimensions of each module	1960*992*40 mm
4	Weight	22.4 Kg
5	No of Modules	720
6	Module Area	1.94432 m^2
7	Total Land Area Used	Roof Top
8	Module Frame	Anodized aluminum alloy
9	Nominal Max. Power (Pmax)	330 W
10	Opt. Operating Voltage (Vmp)	37.2 V
11	Opt. Operating Current (Imp)	8.88 A
12	Open Circuit Voltage (Voc)	45.6 V
13	Short Circuit Current (Isc)	9.45 A
14	Module Efficiency	16.97%
15	Operating Temperature	-40°C ~ +85°C
16	Max. System Voltage	1000 V (IEC) or 1000 V (UL) or 600 V (UL)
17	Module Fire Performance	TYPE 1 (UL 1703) or CLASS C (IEC 61730)

PV Array

S. No	Specification	Data

1	No of Strings	48
2	Modules in String	15

PV Capacity

S. No	Specification	Data
1	Total Site	237.6 KW Peak
2	Net Capacity Factor	18.02%

Inverters

S. No	Specification	
1	Manufacturer	SMA
2	Capacity of each Unit	25 KW
3	No of Inverters	8
4	MPP Input Voltage Range	390 V to 800 V
5	Rated Input Voltage	600 V
6	Max Input Voltage	1000 V
7	Total Power (AC)	200 KW
8	Max Input Current Input A/Input B	33A/33A
9	Max Output Current	36.1 A
10	Output Electrical System	3 Phase AC (4 Wire)
11	AC Nominal Voltage	230/400 V
12	Rated Power Frequency	50 Hz
13	Efficiency	98.3%
14	Relative Humidity (Non-Condensing)	100%
15	Noise Emission	51 dB(A)
16	Degree of Protection	IP65

Junction Boxes

S. No	Specification	Data
1	Number of J/Box units	16
2	Input circuits in each box	3
3	Max. input current for each circuit	15A
4	Protection Level	IP 65
5	Over current protection	Fuse
6	Surge protection	>1000V

PV Mounting Structure

S. No	Specification	Data
1	Structure	Aluminum
2	Tilt of Array Frame	2° (In line with shed rooftop)

Data Collecting System

S. No	Specification	Data
1	System Data	Continuous on-line logging and monitoring over web portal

Solar PV Yield Estimation and Simulation

The aim of yield estimation is to predict the average annual energy output of the site. PvSyst software is used for simulation and near shading analysis.

Working Conditions: Zero Export

The solar system will have automatic mechanism to ensure that PV power currently generated by the inverters always matches the current power consumption of the site load. A closed loop control system of inverter AC output is implemented in reference to energy flow at grid connection point which will reduce inverter AC output of the inverter if site load will be less than the solar production.

Plant Characteristics

Generation Voltage: 230/400 V three phase four wire system
Power Factor at rated power: 1
Frequency: 50 Hz
Generation characteristic: Inverter has built-in features of controllable active power ramp following grid disturbance or normal connection, voltage regulation and frequency response. There are no additional control metering and instrumentations.

Design Parameters

The following tasks were carried out for PV layout and shading.

- Assessment of shading (horizon and nearby building)
- Outline layout of area suitable for PV development
- Designing row spacing to provide proper maintenance space.
- Designing the layout to minimize cable runs and associated electrical losses

- Creating access routes and sufficient space to allow movement for maintenance purposes
- Choosing a tilt angle that optimizes the annual energy yield according to the latitude of the site and the annual distribution of solar resource
- Module cleaning strategy
- Simulating the annual energy losses associated with various configurations of tilt angle, orientation and row spacing. The optimized configuration and simulation results are given in section "Energy Yield Prediction"
- PV layouts of the site are given in 3D and 2D view in the following section.

Layout

The detailed layout (2D and 3D) of the solar panels is given below. PV layout may change depending upon site constraints before or during installation. PvSyst simulation is also performed as per following layout:

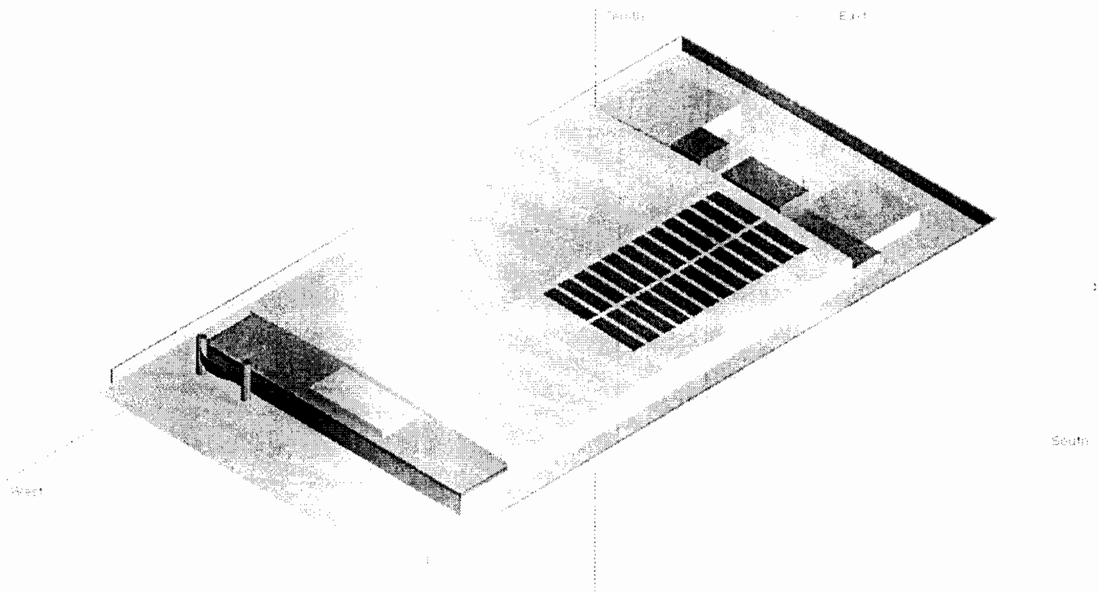


Figure 26: 3D Layout of rooftop of Metro Cash & Carry Manghopir

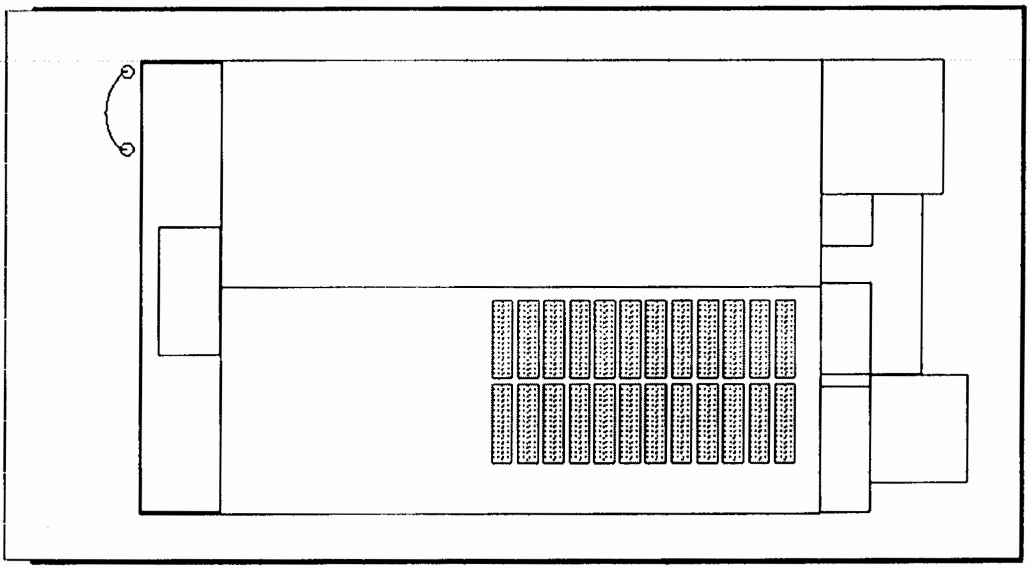


Figure 27: 2D Layout of rooftop of Metro Cash & Carry Manghopir showing solar panel locations

Electrical Design

The electrical system comprises the following components:

- Array(s) of PV modules
- DC/AC cabling (module, string and main cable)
- DC connectors (plugs and sockets)
- Junction boxes
- Disconnects/switches
- Protection devices e.g. fuses, surge protective devices, beakers
- Energy Metering
- Earthing

The single line diagram is given below. The single line diagram includes the protection devices that will be used for safe and smooth operation of the system.

Protections DC Side: String Fuses, Surge Protective Device and DC Disconnect Switches

Protections AC Side: MCBs, Main Breaker and Surge Protective Device

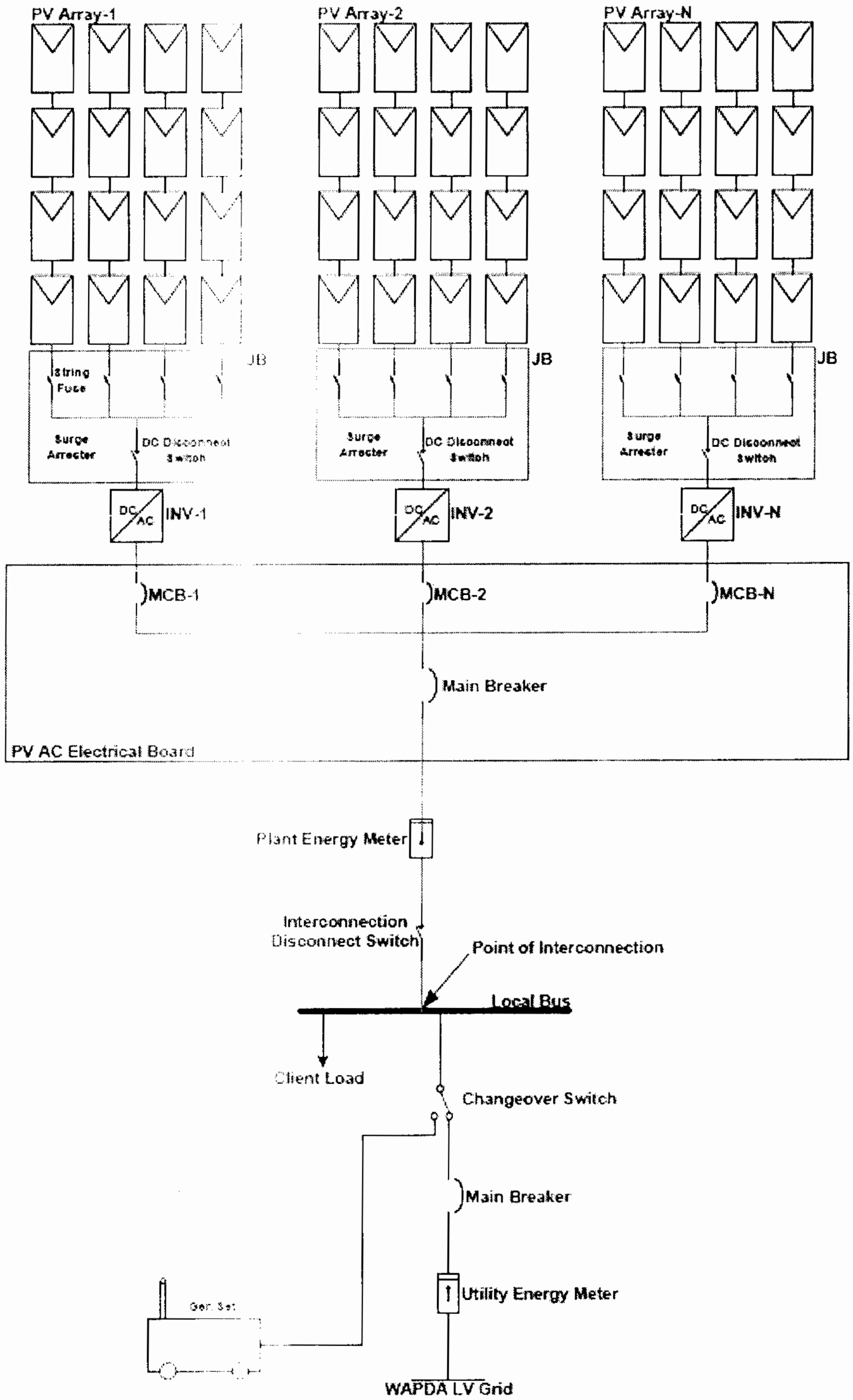


Figure 28 Single Line Diagram of PV Plant

Energy Yield Estimation

The energy yield prediction provides the basis for calculating project revenues. The aim is to predict the average annual energy output for the lifetime of the proposed power plant.

To estimate accurately the energy produced from a PV power plant, information is needed on the solar resource and temperature conditions of the site. Also required are the layout and technical specifications of the plant components.

A number of solar energy yield prediction software packages are available in the market. These packages use time step simulation to model the performance of a project over the course of a year. PvSyst software has been used for energy yield prediction for this site and its results are given below.

Details of the simulation steps are presented in the following sections:

Simulation Parameters

PVSYST V6.40	Shams Power (Pvt) Ltd.	05/06/17	Page 1/4

Grid-Connected System: Simulation parameters

Project :	Metro Mangopir Store, Karachi			
Geographical Site	Metro Mangopir, Karachi		Country	**Pakistan**
Situation	Latitude	24.92° N	Longitude	67.00° E
Time defined as	Legal Time	Time zone UT+5	Altitude	26 m
	Albedo	0.20		
Meteo data:	Metro Mangopir, Karachi	Meteonorm 7.1 (2001-2010) - Synthetic		

Simulation variant : metro mangopir 2-0 330cs

Simulation date 05/06/17 13h26

Simulation parameters

Collector Plane Orientation	Tilt	2°	Azimuth	0°
Models used	Transposition	Perez	Diffuse	Perez, Meteonorm
Horizon	Free Horizon			
Near Shadings	According to strings		Electrical effect	100 %

PV Array Characteristics

PV module Si-poly	Model	**CS6U - 330P**		
Custom parameters definition	Manufacturer	Canadian Solar Inc.		
Number of PV modules	In series	15 modules	In parallel	48 strings
Total number of PV modules	Nb. modules	720	Unit Nom. Power	330 Wp
Array global power	Nominal (STC)	**238 kWp**	At operating cond.	213 kWp (50°C)
Array operating characteristics (50°C)	U mpp	497 V	I mpp	428 A
Total area	Module area	**1400 m²**	Cell area	1262 m²

Inverter	Model	**Sunny Tripower 25000TL-30**		
Original PVsyst database	Manufacturer	SMA		
Characteristics	Operating Voltage	390-800 V	Unit Nom. Power	25.0 kWac
Inverter pack	Nb. of inverters	8 units	Total Power	200 kWac

PV Array loss factors

Array Soiling Losses			Loss Fraction	3.0 %
Thermal Loss factor	Uc (const)	20.0 W/m²K	Uv (wind)	0.0 W/m²K / m/s
Wiring Ohmic Loss	Global array res.	20 mOhm	Loss Fraction	1.5 % at STC
LID - Light Induced Degradation			Loss Fraction	1.1 %
Module Quality Loss			Loss Fraction	2.0 %
Module Mismatch Losses			Loss Fraction	1.0 % at MPP

Incidence effect (IAM): User defined IAM profile

10°	20°	30°	40°	50°	60°	70°	80°	90°
0.998	0.998	0.995	0.992	0.986	0.970	0.917	0.763	0.000

System loss factors

Wiring Ohmic Loss	Wires 3x185.0 mm²	208 m	Loss Fraction	3.1 % at STC
Unavailability of the system	20.0 days, 4 periods		Time fraction	5.5 %

User's needs : Unlimited load (grid)

Near Shading Definition

PVSYST V6.40	Shams Power (Pvt) Ltd.	05/06/17	Page 2/4

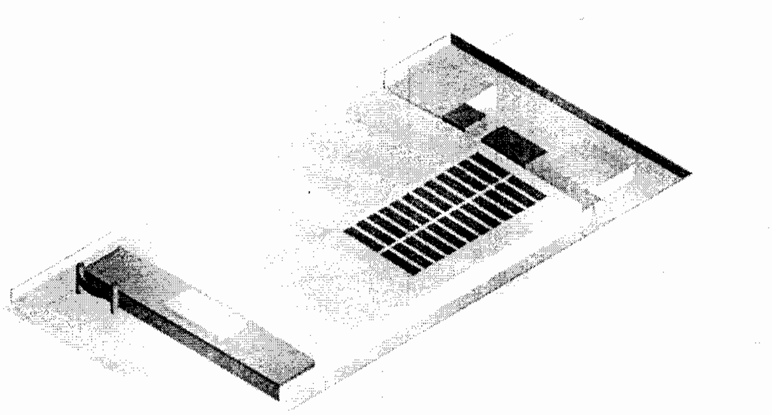
Grid-Connected System: Near shading definition

Project : Metro Mangopir Store, Karachi

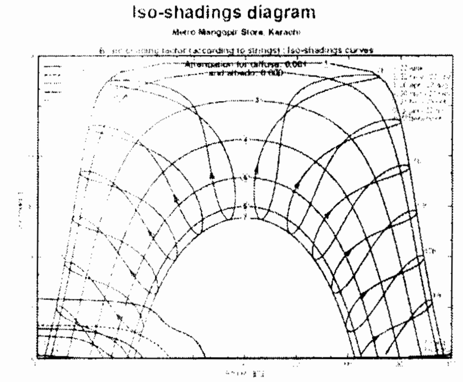
Simulation variant : metro mangopir 2-0 330cs

Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	tilt	2°	azimuth	0°
PV modules	Model	CS6U - 330P	Pnom	330 Wp
PV Array	Nb. of modules	720	Pnom total	**238 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
Inverter pack	Nb. of units	8.0	Pnom total	**200 kW ac**
User's needs	Unlimited load (grid)			

Perspective of the PV-field and surrounding shading scene



Iso-shadings diagram



Losses

PVSYST V6.40	Shams Power (Pvt) Ltd.	05/06/17	Page 4/4

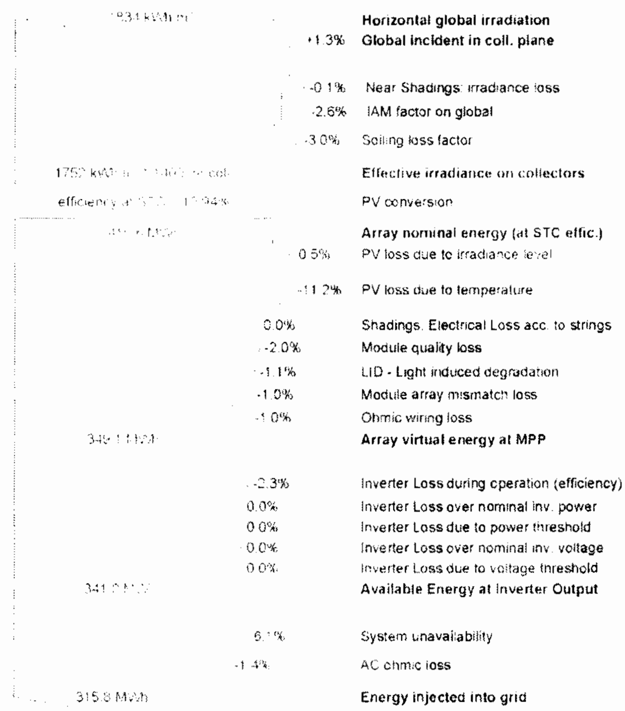
Grid-Connected System: Loss diagram

Project : Metro Mangopir Store, Karachi

Simulation variant : metro mangopir 2-0 330cs

Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	tilt	2°	azimuth	0°
PV modules	Model	CS6U - 330P	Pnom	330 Wp
PV Array	Nb. of modules	720	Pnom total	**238 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
Inverter pack	Nb. of units	8.0	Pnom total	**200 kW ac**
User's needs	Unlimited load (grid)			

Loss diagram over the whole year



Simulation Results

PVSYST V6.40	Shams Power (Pvt) Ltd.	05/06/17	Page 3/4

Grid-Connected System: Main results

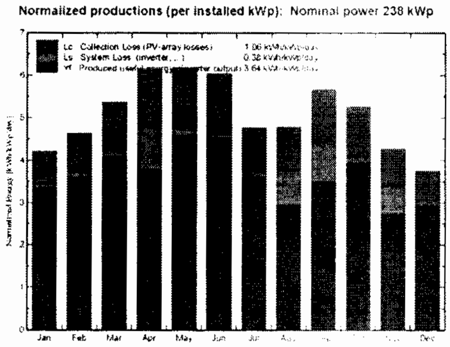
Project : **Metro Mangopir Store, Karachi**

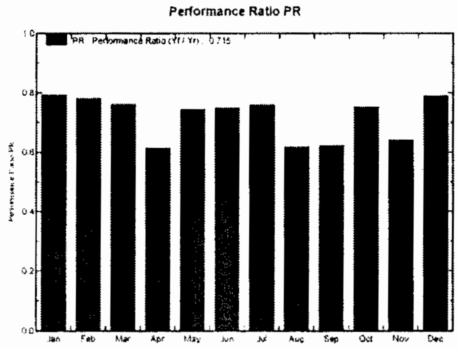
Simulation variant : **metro mangopir 2-0 330cs**

Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	tilt	2°	azimuth	0°
PV modules	Model	CS6U - 330P	Pnom	330 Wp
PV Array	Nb. of modules	720	Pnom total	**238 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
Inverter pack	Nb. of units	8.0	Pnom total	**200 kW ac**
User's needs	Unlimited load (grid)			

Main simulation results

System Production	Produced Energy	315.8 MWh/year	Specific prod.	1329 kWh/kWp/year
	Performance Ratio PR	71.55 %		





metro mangopir 2-0 330cs

Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_Grid MWh	PR
January	128.4	[illegible]	19.51	130.8	122.9	25.53	24.63	0.794
February	[illegible]	[illegible]	22.31	129.6	122.2	24.94	24.04	0.781
March	[illegible]	[illegible]	26.41	166.4	157.0	31.25	30.09	0.761
April	[illegible]	[illegible]	28.97	184.6	174.7	34.11	26.91	0.613
May	[illegible]	[illegible]	30.82	191.8	181.1	35.25	33.88	0.744
June	[illegible]	[illegible]	31.09	180.9	170.8	33.46	32.20	0.749
July	[illegible]	[illegible]	[illegible]	147.8	139.7	27.65	26.66	0.759
August	[illegible]	[illegible]	[illegible]	148.3	139.7	27.88	[illegible]	0.617
September	[illegible]	[illegible]	[illegible]	170.1	[illegible]	31.75	[illegible]	0.622
October	[illegible]	[illegible]	[illegible]	163.2	154.2	30.31	29.18	0.752
November	[illegible]	[illegible]	[illegible]	128.2	120.8	24.41	19.53	0.641
December	[illegible]	[illegible]	[illegible]	116.2	109.3	22.59	21.81	0.790
Year	[illegible]	[illegible]	[illegible]	1857.7	1752.2	349.10	315.63	0.715

Legends:			
GlobHor	[illegible]	GlobEff	Effective Global, corr. for IAM and shadings
DiffHor	[illegible]	EArray	Effective energy at the output of the array
T Amb	[illegible]	E_Grid	Energy injected into grid
GlobInc	[illegible]	PR	Performance Ratio

Financial Analysis

Cost/watt: **USD 1.2**

Total Project Cost for 237.6 KWp (DC) Solar PV System: **USD 285,120**

Equity: **100%**

Debt: **0%**

Safety and Emergency Plans

- Only qualified and authorized electricians will be allowed to undertake servicing or maintenance tasks.
- The authorized personnel will wear appropriate equipment, including a safety harness to restrain from falling off the roof, sturdy shoes that will have thick rubber soles to provide electrical insulation and good grip and appropriate clothing for personal protection, including a hat, sunglasses, gloves and long pants and sleeves
- Lock out and tag out procedures will be used before commencement of maintenance tasks.
- On-going operation and maintenance concerns for solar power systems will be addressed properly. These systems are exposed to outdoor weather conditions that enhance the aging process, and the infrastructure needs to be in place for the on-going maintenance of these systems to assure their safe operation.
- Properly grounded or double insulated power tools will be used for maintenance tasks. Tools will be maintained in good condition.
- Working on electrical equipment and circuits will be carried out in de energized state.
- Proper pathways will be available for operation, maintenance and firefighting.
- Fire protection and suppression will be placed at site

Training and Capacity Development

Trained and qualified personnel will be available at site 24/7 with proper safety and firefighting training. Training program will focus on but not limited to Solar Resource Assessment, Site Survey, Technology, Engineering Design, Regulation, Policy, Metering & Billing, and Project Management of Rooftop Solar System. The following components will include in training and development program.

a. Collection of Resource Data
b. Variability and uncertainty of resource data
c. Site evaluation
d. Crystalline and Thin film technology comparison
e. Rooftop solar system components
f. Module mounting structure selection
g. Inverter selection
h. Design of PV Array
i. Shadow Analysis
j. DC cable sizing
k. DC cable layout
l. Protection and Metering
m. Installation and testing standards for solar PV plants
n. Solar Module testing standards
o. Economy of Roof top Solar System
p. Detailed Project Report
q. Operation and maintenance of rooftop solar system
r. Safety and firefighting training

Environmental Aspects

Every energy generation and transmission method affects the environment. Conventional generating options can damage air, climate, water, land and wildlife, landscape as well as raise the levels of harmful radiation. PV technology is substantially safer offering a solution to many environmental and social problems associated with fossil and nuclear fuels. Solar PV energy technology provides obvious environmental advantages in comparison to the conventional energy sources thus contributing to the sustainable development of human activities. Not counting the depletion of the exhausted natural resources, their main advantage is related to the reduced CO2 emissions and normally absence of any air emissions or waste products during their operation.

The use of solar power has additional positive implications such as:

- Reduction of the emissions of the greenhouse gases (mainly CO2, NOx) and prevention of toxic gas emissions (SO2,particulates)
- Reduction of the required transmission lines of the electricity grids

Socio-Economic Aspects

In regard to the socio-economic viewpoint, the benefits of exploitation of solar PV system comprise of:

- Increase of the regional/national energy independency
- Provision of significant work opportunities
- Diversification and security of energy supply
- Support of the deregulation of energy markets

Conclusion

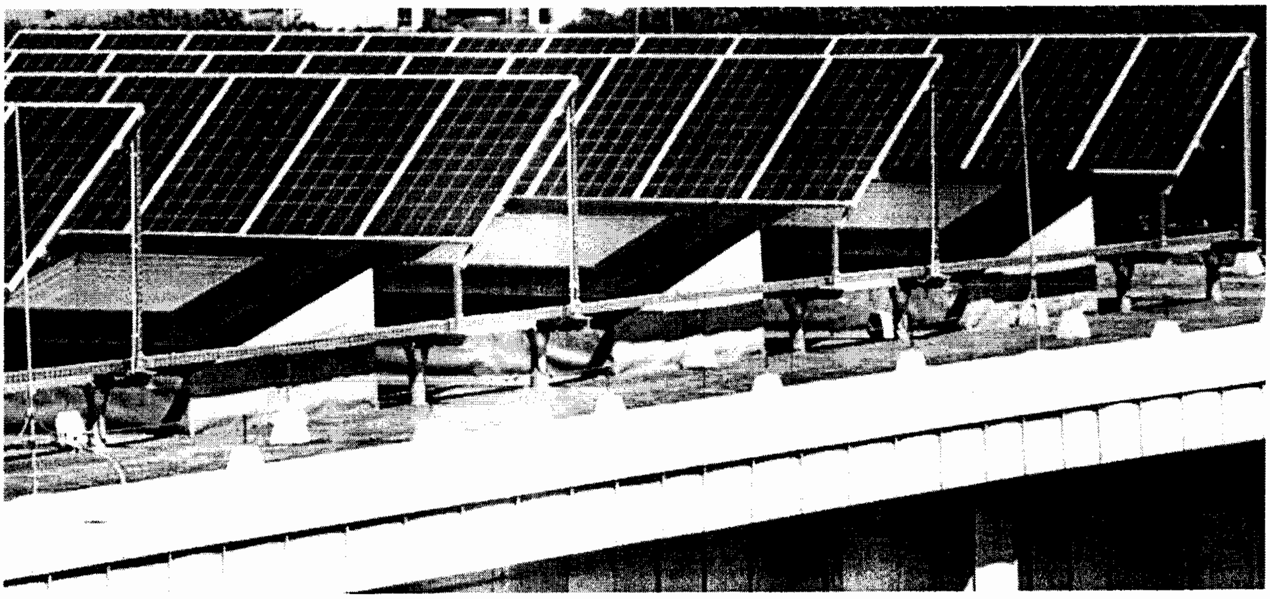
This feasibility study is conducted to ascertain the technical feasibility and commercial viability of installation of 200kW rooftop PV system installation at Metro Cash & Carry Manghopir Road, Karachi.

Installation of the PV system will result in annual power generation of 315,797 kWh.

The results of the financial analysis indicate that the project is feasible.

Based on the outcomes of both the technical and financial analysis, the project is deemed to be viable.

ShamsPower



8. FEASIBILITY STUDY FOR ROOFTOP SOLAR INSTALLATION AT METRO CASH & CARRY STORE, NEAR STARGATE, KARACHI

SHAMS POWER (PVT) LIMITED

EXECUTIVE SUMMARY

The feasibility study examines the costs, practicality, and likely outcome of a solar photovoltaic (PV) installation on the rooftop of Metro Cash & Carry Store near Stargate, Karachi.

The main outcomes of the feasibility report are given below:

Technical Site Analysis: The project site is suitable for a solar PV energy system. For the purpose of estimation of power generation potential, solar insolation is assumed to be "very good" (1,834 kWh/ square meter/ year). Panel facing south (0 degrees azimuth), panel tilt (2 degrees) and satisfactory roof condition and structure are also assumed.

Anticipated System Information: The project will accommodate a 300 kW (AC) solar PV system with a projected annual production of 478,607 kWh/ year. Use of a Canadian Solar Inc. CS6U – 330P (330 watt) PV panel as a basis for design will result in an acceptable system weight density of 2.36 lbs/sqft. The system will offset approximately 170 tons of carbon dioxide annually.

Financial Analysis: The project will be financed on a 100% equity model. The total estimated project cost is USD 427,680.

Based on the technical and financial analysis, the installation of a 300 kW Solar PV System on the rooftop of Metro Cash & Carry Store is deemed to be feasible.

Introduction

The project site is the rooftop of Metro Cash & Carry Store near Stargate, Karachi, Pakistan. Metro Cash & Carry Store is a double storied commercial building/retail store. The exact coordinates of the project site are:

Latitude: 24°53'17.05" North
Longitude: 67° 9' 5.08" East

A bird's eye view of the project site is given in the figure below:

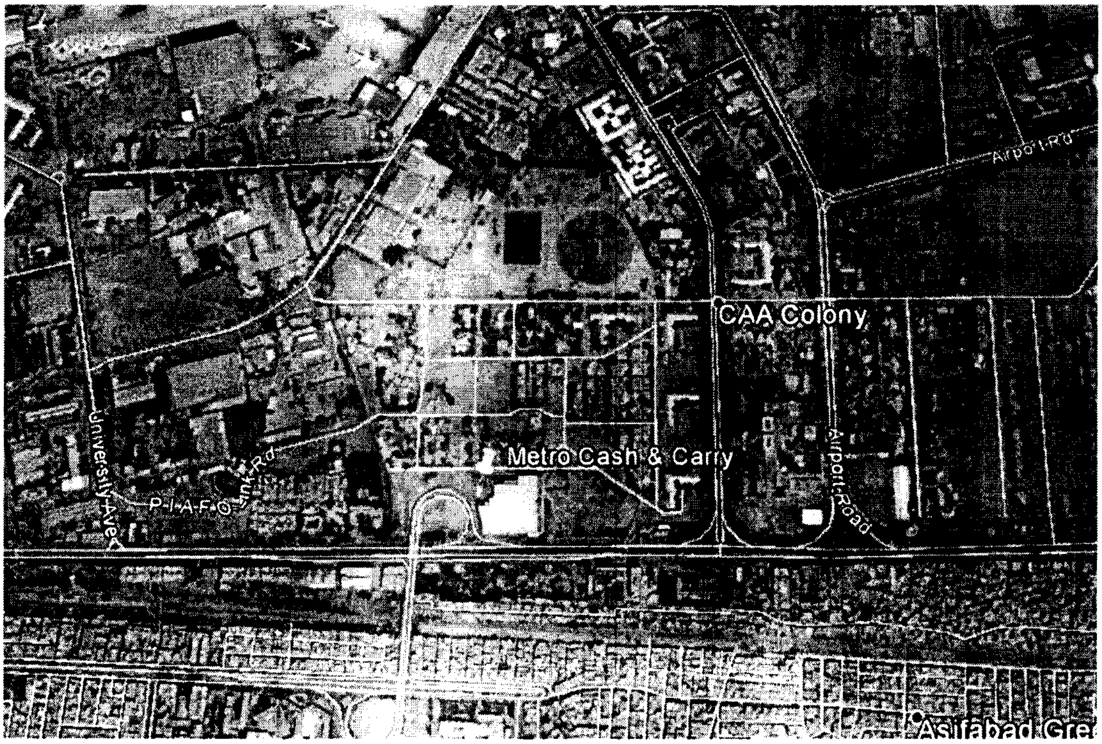


Figure 29: Overview of Project Site

Current Energy Demand and Supply Situation

As per the historical consumption data, the total electricity consumption during 2016 was 3,248,229 kWh.

Technical Analysis

Site Conditions

The following tasks were carried out:

- Global Horizontal Irradiation, annual and inter-annual variation was assessed.
- Near shading objects were taken into account for placement of PV modules.
- Area required for selected module technology was calculated. Keeping in view available area and minimum inter row spacing for maintenance, tilt angle and appropriate spacing was calculated from near shading objects.

Details of the finalized parameters are given under section 3.5.1

Technology Review and Selection

Technology Selection

PV Modules:

S. No	Specification	Data
1	Type of Module	CS6U-330P
2	Type of Cell	Polycrystalline
3	Dimensions of each module	1960*992*40 mm
4	Weight	22.4 Kg
5	No of Modules	1080
6	Module Area	1.94432 m^2
7	Total Land Area Used	Roof Top
8	Module Frame	Anodized aluminum alloy
9	Nominal Max. Power (Pmax)	330 W
10	Opt. Operating Voltage (Vmp)	37.2 V
11	Opt. Operating Current (Imp)	8.88 A
12	Open Circuit Voltage (Voc)	45.6 V
13	Short Circuit Current (Isc)	9.45 A
14	Module Efficiency	16.97%
15	Operating Temperature	-40°C ~ +85°C
16	Max. System Voltage	1000 V (IEC) or 1000 V (UL) or 600 V (UL)
17	Module Fire Performance	TYPE 1 (UL 1703) or CLASS C (IEC 61730)

PV Array

S. No	Specification	Data
1	No of Strings	72
2	Modules in String	15

PV Capacity

S. No	Specification	Data
1	Total Site	356.4 KW Peak
2	Net Capacity Factor	18.21%

Inverters

S. No	Specification	
1	Manufacturer	SMA
2	Capacity of each Unit	25 KW
3	No of Inverters	12
4	MPP Input Voltage Range	390 V to 800 V
5	Rated Input Voltage	600 V
6	Max Input Voltage	1000 V
7	Total Power (AC)	300 KW
8	Max Input Current Input A/Input B	33A/33A
9	Max Output Current	36.1 A
10	Output Electrical System	3 Phase AC (4 Wire)
11	AC Nominal Voltage	230/400 V
12	Rated Power Frequency	50 Hz
13	Efficiency	98.3%
14	Relative Humidity (Non-Condensing)	100%
15	Noise Emission	51 dB(A)
16	Degree of Protection	IP65

Junction Boxes

S. No	Specification	Data
1	Number of J/Box units	24
2	Input circuits in each box	3
3	Max. input current for each circuit	15A
4	Protection Level	IP 65
5	Over current protection	Fuse
6	Surge protection	>1000V

PV Mounting Structure

S. No	Specification	Data
1	Structure	Aluminum
2	Tilt of Array Frame	2° (In line with shed slope)

Data Collecting System

S. No	Specification	Data
1	System Data	Continuous on-line logging and monitoring over web portal

Solar PV Yield Estimation and Simulation

The aim of yield estimation is to predict the average annual energy output of the site. PvSyst software is used for simulation and near shading analysis.

Working Conditions: Zero Export

The solar system will have automatic mechanism to ensure that PV power currently generated by the inverters always matches the current power consumption of the site load. A closed loop control system of inverter AC output is implemented in reference to energy flow at grid connection point which will reduce inverter AC output of the inverter if site load will be less than the solar production.

Plant Characteristics

Generation Voltage: 230/400 V three phase four wire system
Power Factor at rated power: 1
Frequency: 50 Hz
Generation characteristic: Inverter has built-in features of controllable active power ramp following grid disturbance or normal connection, voltage regulation and frequency response. There are no additional control metering and instrumentations.

Design Parameters

The following tasks were carried out for PV layout and shading.

- Assessment of shading (horizon and nearby building)
- Outline layout of area suitable for PV development
- Designing row spacing to provide proper maintenance space.
- Designing the layout to minimize cable runs and associated electrical losses
- Creating access routes and sufficient space to allow movement for maintenance purposes
- Choosing a tilt angle that optimizes the annual energy yield according to the latitude of the site and the annual distribution of solar resource

- Module cleaning strategy
- Simulating the annual energy losses associated with various configurations of tilt angle, orientation and row spacing. The optimized configuration and simulation results are given in section "Energy Yield Prediction"
- PV layouts of the site are given in 3D and 2D view in the following section.

Layout

The detailed layout (2D and 3D) of the solar panels is given below. PV layout may change depending upon site constraints before or during installation. PvSyst simulation is also performed as per following layout:

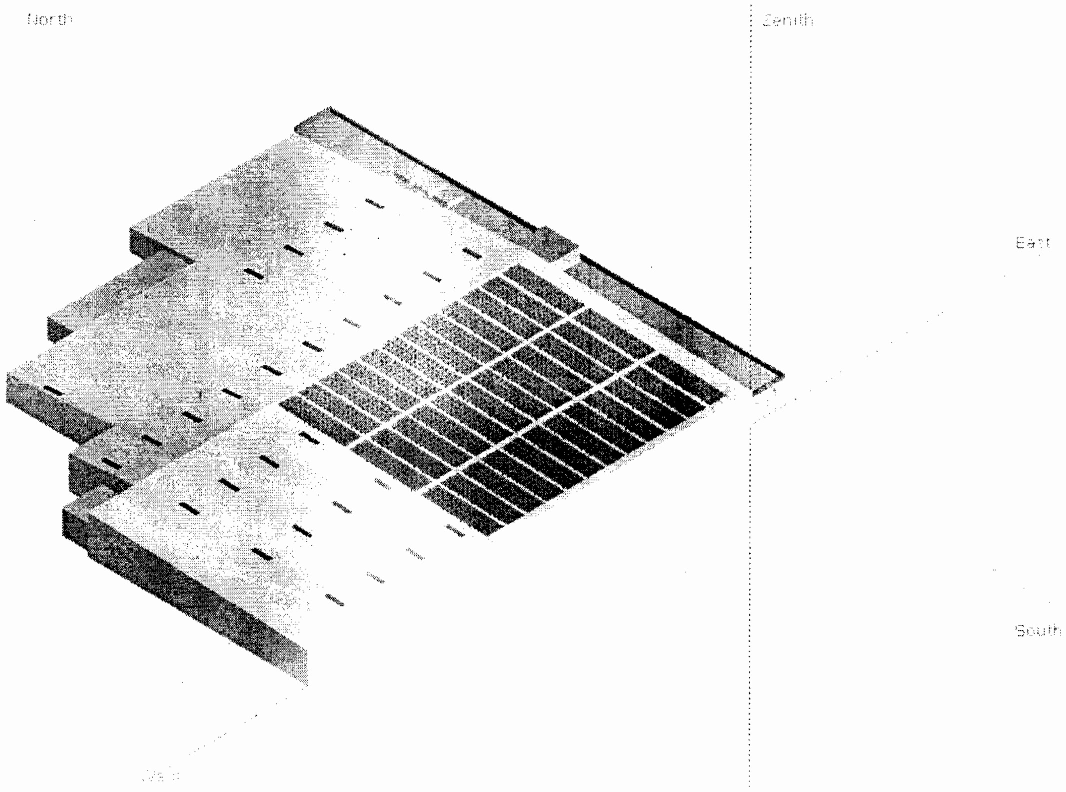


Figure 30: 3D Layout of rooftop of Metro Cash & Carry Stargate Store

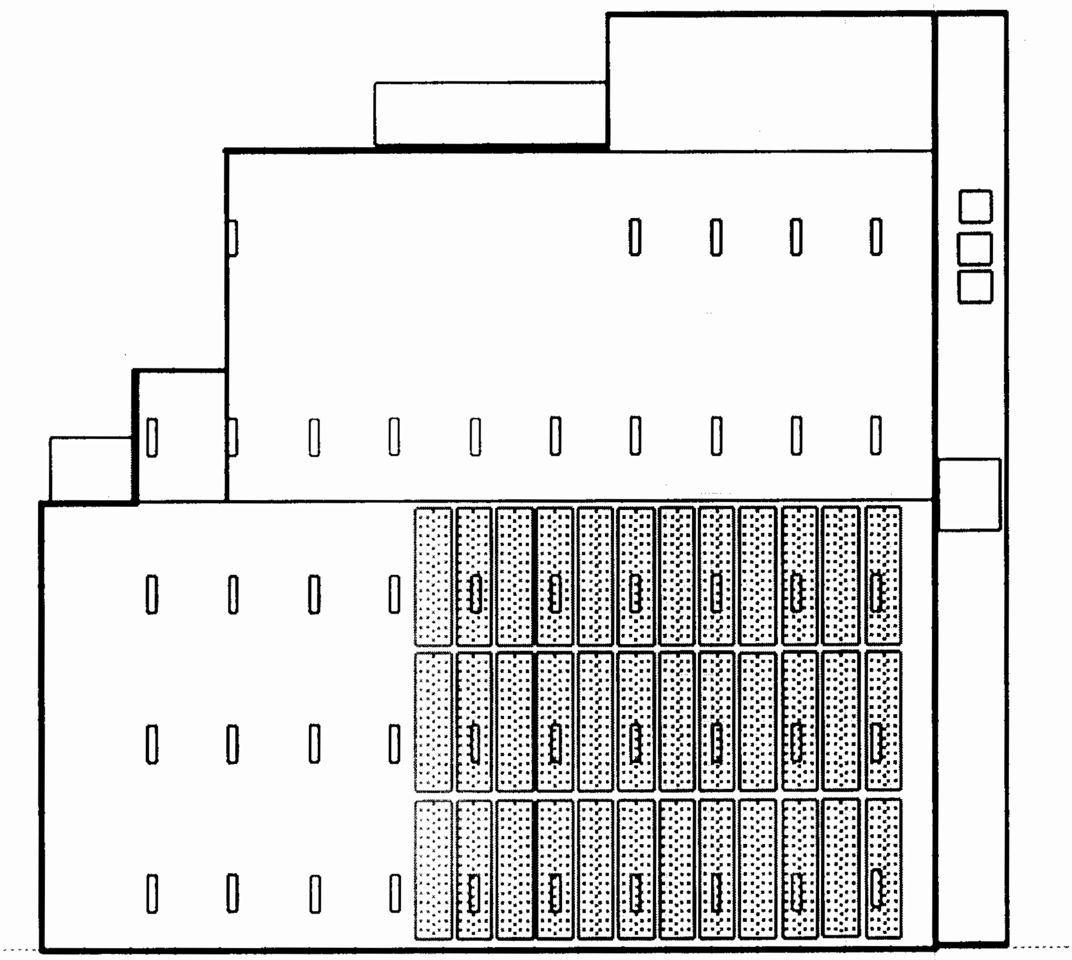


Figure 31: 2D Layout of rooftop of Metro Cash & Carry Stargate Store showing solar panel locations

Electrical Design

The electrical system comprises the following components:

- Array(s) of PV modules
- DC/AC cabling (module, string and main cable)
- DC connectors (plugs and sockets)
- Junction boxes
- Disconnects/switches
- Protection devices e.g. fuses, surge protective devices, beakers
- Energy Metering
- Earthing

The single line diagram is given below. The single line diagram includes the protection devices that will be used for safe and smooth operation of the system.

Protections DC Side: String Fuses, Surge Protective Device and DC Disconnect Switches

Protections AC Side: MCBs, Main Breaker and Surge Protective Device

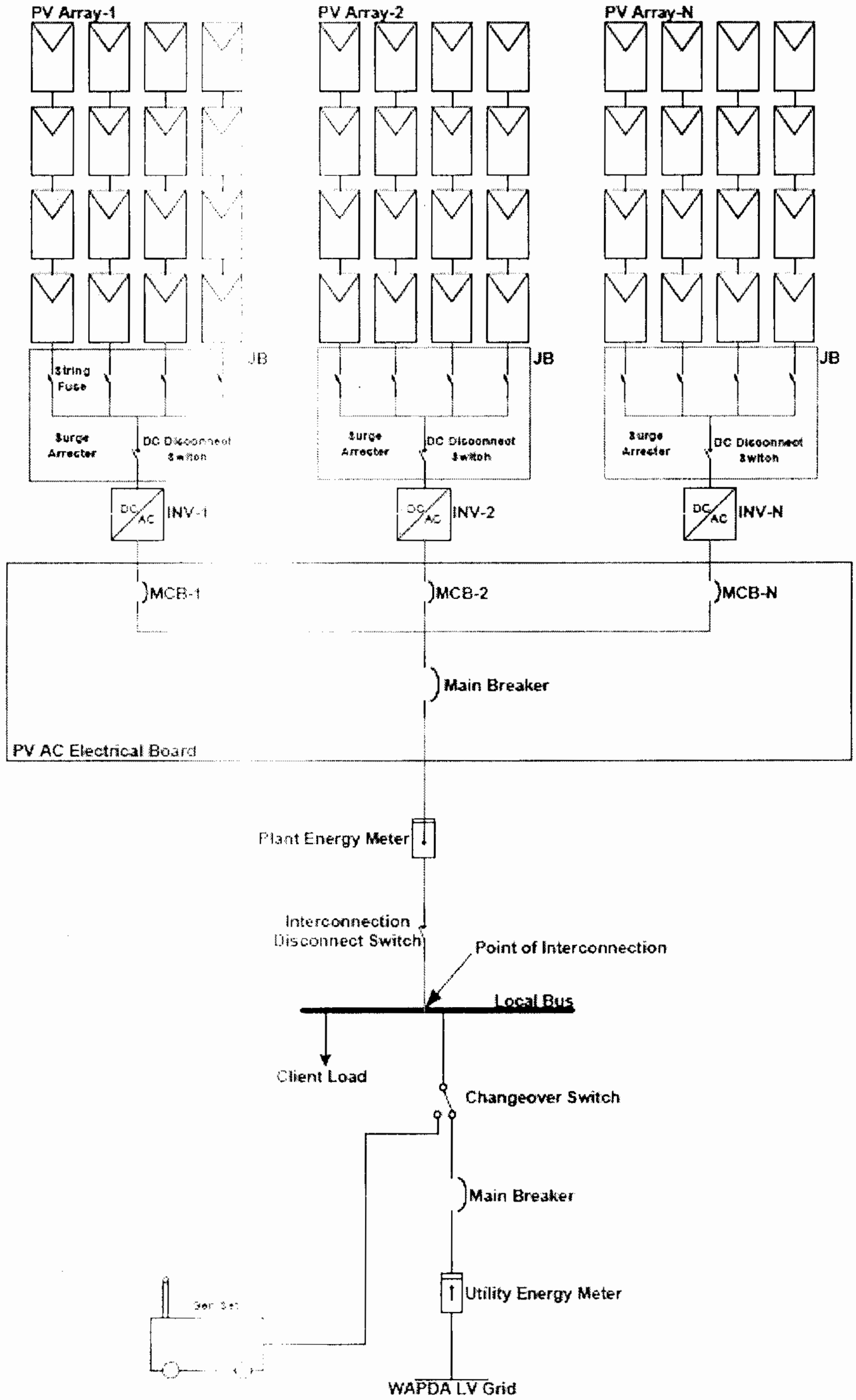


Figure 32: Single Line Diagram of PV Plant

Energy Yield Estimation

The energy yield prediction provides the basis for calculating project revenues. The aim is to predict the average annual energy output for the lifetime of the proposed power plant.

To estimate accurately the energy produced from a PV power plant, information is needed on the solar resource and temperature conditions of the site. Also required are the layout and technical specifications of the plant components.

A number of solar energy yield prediction software packages are available in the market. These packages use time step simulation to model the performance of a project over the course of a year. PvSyst software has been used for energy yield prediction for this site and its results are given below.

Details of the simulation steps are presented in the following sections:

Simulation Parameters

PVSYST V6.40	Shams Power (Pvt) Ltd.	06/06/17	Page 1/4

Grid-Connected System: Simulation parameters

Project : **Metro Cash & Carry, Near Airport, Karachi**

Geographical Site **Metro Cash & Carry**, Near Airport, Karachi — Country **Pakistan**

Situation — Latitude 24.88° N — Longitude 67.15° E
Time defined as — Legal Time Time zone UT+5 — Altitude 16 m
Albedo 0.20

Meteo data: Metro Cash & Carry, Near Airport, Karachi — Meteonorm 7.1 (2001-2010) - Synthetic

Simulation variant : Metro Karachi 2-0
Simulation date 06/06/17 10h51

Simulation parameters

Collector Plane Orientation — Tilt 2° — Azimuth 0°

Models used — Transposition Perez — Diffuse Perez, Meteonorm

Horizon — Free Horizon

Near Shadings — According to strings — Electrical effect 100 %

PV Array Characteristics

PV module — Si-poly — Model **CS6U - 330P**
Custom parameters definition — Manufacturer Canadian Solar Inc.
Number of PV modules — In series 15 modules — In parallel 72 strings
Total number of PV modules — Nb. modules 1080 — Unit Nom. Power 330 Wp
Array global power — Nominal (STC) **356 kWp** — At operating cond. 319 kWp (50°C)
Array operating characteristics (50°C) — U mpp 497 V — I mpp 642 A
Total area — Module area **2100 m²** — Cell area 1893 m²

Inverter — Model **Sunny Tripower 25000TL-30**
Original PVsyst database — Manufacturer SMA
Characteristics — Operating Voltage 390-800 V — Unit Nom. Power 25.0 kWac

Inverter pack — Nb. of inverters 12 units — Total Power 300 kWac

PV Array loss factors

Array Soiling Losses — Loss Fraction 3.0 %
Thermal Loss factor — Uc (const) 20.0 W/m²K — Uv (wind) 0.0 W/m²K / m/s
Wiring Ohmic Loss — Global array res. 14 mOhm — Loss Fraction 1.6 % at STC
LID - Light Induced Degradation — Loss Fraction 2.5 %
Module Quality Loss — Loss Fraction 2.0 %
Module Mismatch Losses — Loss Fraction 1.0 % at MPP
Incidence effect (IAM): User defined IAM profile

10°	20°	30°	40°	50°	60°	70°	80°	90°
0.998	0.998	0.995	[illegible]	0.986	0.970	0.917	0.763	0.000

System loss factors

Wiring Ohmic Loss — Wires: 3x300.0 mm² 241 m — Loss Fraction 3.3 % at STC

Unavailability of the system — 20.0 days, 4 periods — Time fraction 5.5 %

User's needs : Unlimited load (grid)

Near Shading Definition

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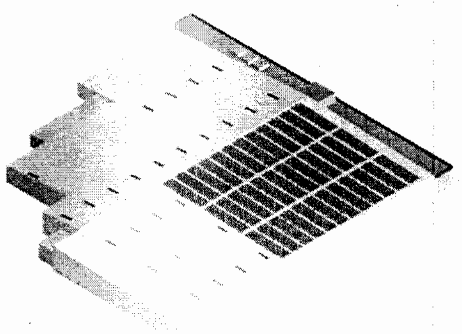
Grid-Connected System: Near shading definition

Project : **Metro Cash & Carry, Near Airport, Karachi**

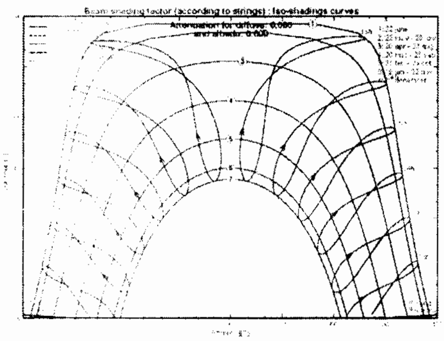
Simulation variant : Metro Karachi 2-0

Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	tilt	2°	azimuth	0°
PV modules	Model	CS6U - 330P	Pnom	330 Wp
PV Array	Nb. of modules	1080	Pnom total	**356 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
Inverter pack	Nb. of units	12.0	Pnom total	**300 kW ac**
User's needs	Unlimited load (grid)			

Perspective of the PV-field and surrounding shading scene



Iso-shadings diagram



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Losses

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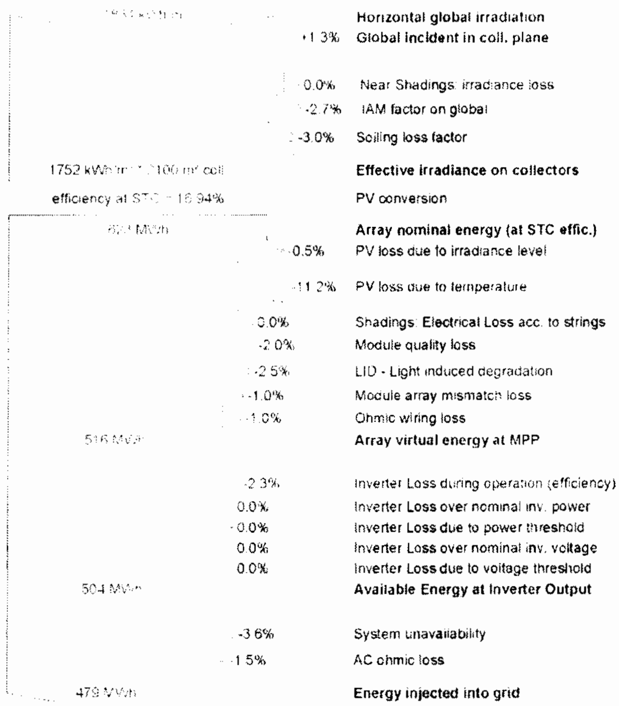
Grid-Connected System: Loss diagram

Project : Metro Cash & Carry, Near Airport, Karachi

Simulation variant : Metro Karachi 2-0

Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	tilt	2°	azimuth	0°
PV modules	Model	CS6U - 330P	Pnom	330 Wp
PV Array	Nb. of modules	1080	Pnom total	**356 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
Inverter pack	Nb. of units	12.0	Pnom total	**300 kW ac**
User's needs	Unlimited load (grid)			

Loss diagram over the whole year



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Simulation Results

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Grid-Connected System: Main results

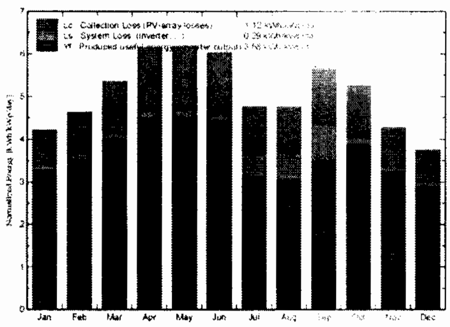
Project : Metro Cash & Carry, Near Airport, Karachi

Simulation variant : Metro Karachi 2-0

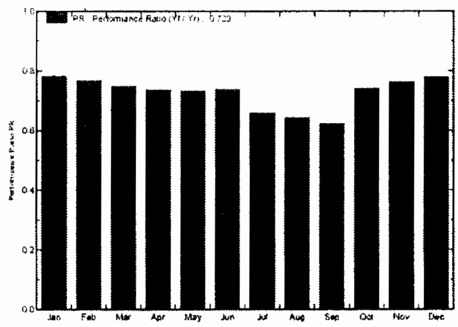
Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	tilt	2°	azimuth	0°
PV modules	Model	CS6U - 330P	Pnom	330 Wp
PV Array	Nb. of modules	1080	Pnom total	**356 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
Inverter pack	Nb. of units	12.0	Pnom total	**300 kW ac**
User's needs	Unlimited load (grid)			

Main simulation results				
System Production	Produced Energy	**478.6 MWh/year**	Specific prod.	1343 kWh/kWp/year
	Performance Ratio PR	72.32 %		

Normalized productions (per installed kWp): Nominal power 356 kWp



Performance Ratio PR



Metro Karachi 2-0

Balances and main results

	GlobHor	DiffHor	T Amb	GlobInc	GlobEff	EArray	E_Grid	PR
	kWh/m²	[illegible]	[illegible]	kWh/m²	kWh/m²	MWh	MWh	
January	[illegible]	[illegible]	[illegible]	130.7	123.0	37.80	36.46	0.782
February	[illegible]	[illegible]	[illegible]	129.9	122.5	36.93	35.57	0.759
March	[illegible]	[illegible]	26.41	166.2	157.0	46.07	44.30	0.748
April	[illegible]	[illegible]	[illegible]	184.3	174.4	50.29	48.26	0.735
May	[illegible]	[illegible]	[illegible]	191.8	181.3	52.15	50.09	0.733
June	[illegible]	[illegible]	31.09	180.8	170.7	49.45	47.57	0.738
July	[illegible]	[illegible]	[illegible]	147.8	139.3	40.75	34.65	0.658
August	[illegible]	[illegible]	[illegible]	147.7	139.1	41.08	33.50	0.642
September	[illegible]	[illegible]	[illegible]	169.9	160.6	46.82	37.67	0.622
October	[illegible]	[illegible]	[illegible]	163.2	154.2	44.80	43.10	0.741
November	[illegible]	[illegible]	24.85	128.3	120.7	36.14	34.85	0.762
December	[illegible]	[illegible]	20.92	116.2	109.3	33.43	32.26	0.779
Year	[illegible]	[illegible]	[illegible]	1856.9	1752.1	515.73	478.61	0.723

Legends	GlobHor	[illegible]	GlobEff	Effective Global, corr. for IAM and shadings
	DiffHor	[illegible]	EArray	Effective energy at the output of the array
	T Amb	[illegible]	E_Grid	Energy injected into grid
	GlobInc	[illegible]	PR	Performance Ratio

Financial Analysis

Cost/watt: **USD 1.2**

Total Project Cost for 356.4 KWp (DC) Solar PV System: **USD 427,680**

Equity: **100%**

Debt: **0%**

Safety and Emergency Plans

- Only qualified and authorized electricians will be allowed to undertake servicing or maintenance tasks.
- The authorized personnel will wear appropriate equipment, including a safety harness to restrain from falling off the roof, sturdy shoes that will have thick rubber soles to provide electrical insulation and good grip and appropriate clothing for personal protection, including a hat, sunglasses, gloves and long pants and sleeves
- Lock out and tag out procedures will be used before commencement of maintenance tasks.
- On-going operation and maintenance concerns for solar power systems will be addressed properly. These systems are exposed to outdoor weather conditions that enhance the aging process, and the infrastructure needs to be in place for the on-going maintenance of these systems to assure their safe operation.
- Properly grounded or double insulated power tools will be used for maintenance tasks. Tools will be maintained in good condition.
- Working on electrical equipment and circuits will be carried out in de energized state.
- Proper pathways will be available for operation, maintenance and firefighting.
- Fire protection and suppression will be placed at site

Training and Capacity Development

Trained and qualified personnel will be available at site 24/7 with proper safety and firefighting training. Training program will focus on but not limited to Solar Resource Assessment, Site Survey, Technology, Engineering Design, Regulation, Policy, Metering & Billing, and Project Management of Rooftop Solar System. The following components will include in training and development program.

a. Collection of Resource Data
b. Variability and uncertainty of resource data
c. Site evaluation
d. Crystalline and Thin film technology comparison
e. Rooftop solar system components
f. Module mounting structure selection
g. Inverter selection
h. Design of PV Array
i. Shadow Analysis
j. DC cable sizing
k. DC cable layout
l. Protection and Metering
m. Installation and testing standards for solar PV plants
n. Solar Module testing standards
o. Economy of Roof top Solar System
p. Detailed Project Report
q. Operation and maintenance of rooftop solar system
r. Safety and firefighting training

Environmental Aspects

Every energy generation and transmission method affects the environment. Conventional generating options can damage air, climate, water, land and wildlife, landscape as well as raise the levels of harmful radiation. PV technology is substantially safer offering a solution to many environmental and social problems associated with fossil and nuclear fuels. Solar PV energy technology provides obvious environmental advantages in comparison to the conventional energy sources thus contributing to the sustainable development of human activities. Not counting the depletion of the exhausted natural resources, their main advantage is related to the reduced CO_2 emissions and normally absence of any air emissions or waste products during their operation.

The use of solar power has additional positive implications such as:

- Reduction of the emissions of the greenhouse gases (mainly CO_2, NO_x) and prevention of toxic gas emissions (SO_2,particulates)
- Reduction of the required transmission lines of the electricity grids

Socio-Economic Aspects

In regard to the socio-economic viewpoint, the benefits of exploitation of solar PV system comprise of:

- Increase of the regional/national energy independency
- Provision of significant work opportunities
- Diversification and security of energy supply
- Support of the deregulation of energy markets

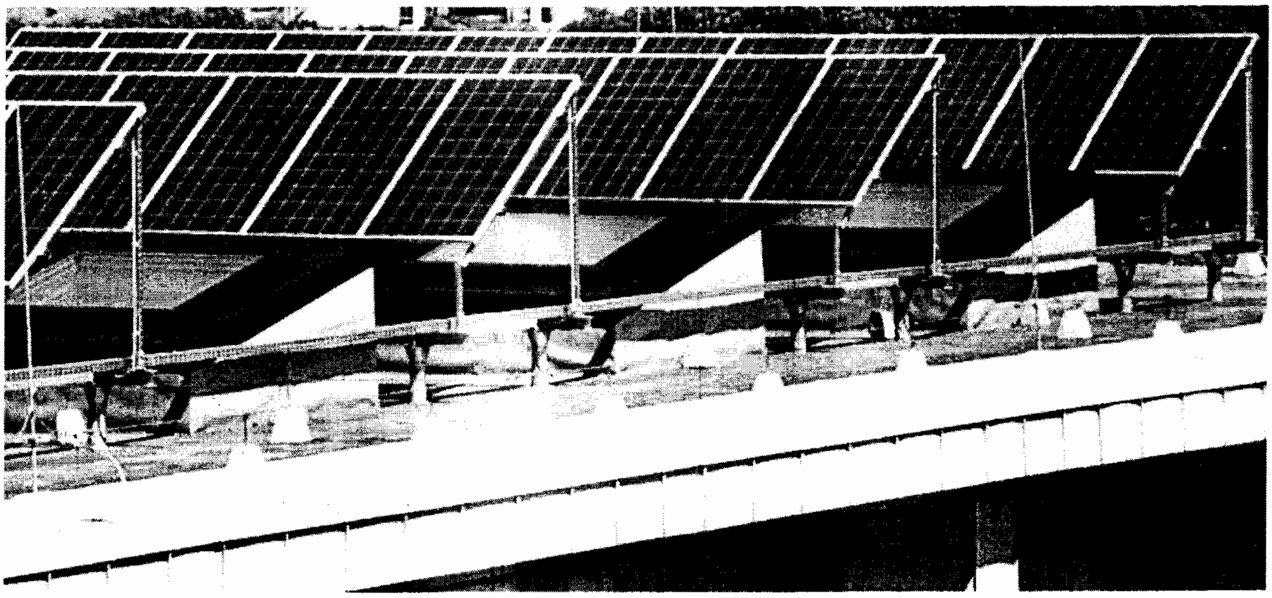
Conclusion

This feasibility study is conducted to ascertain the technical feasibility and commercial viability of installation of 300 kW (AC) rooftop PV system installation at Metro Cash & Carry near Stargate, Karachi.

Installation of the PV system will result in annual power generation of 478,607 kWh.

The results of the financial analysis indicate that the project is feasible.

Based on the outcomes of both the technical and financial analysis, the project is deemed to be viable.



9. FEASIBILITY STUDY FOR ROOFTOP SOLAR INSTALLATION AT METRO CASH & CARRY STORE, NEAR SAFARI PARK, KARACHI

SHAMS POWER (PVT) LIMITED

EXECUTIVE SUMMARY

The feasibility study examines the costs, practicality, and likely outcome of a solar photovoltaic (PV) installation on the rooftop of Metro Cash & Carry Store near Safari Park, Karachi.

The main outcomes of the feasibility report are given below:

Technical Site Analysis: The project site is suitable for a solar PV energy system. For the purpose of estimation of power generation potential, solar insolation is assumed to be "very good" (1,834 kWh/ square meter/ year). Panel azimuth (90 degrees east/west), panel tilt (2 degrees) and satisfactory roof condition and structure are also assumed.

Anticipated System Information: The project will accommodate a 375 kW (AC) solar PV system with a projected annual production of 593,365 kWh/ year. Use of a Canadian Solar Inc. CS6U – 330P (330 watt) PV panel as a basis for design will result in an acceptable system weight density of 2.36 lbs/sqft. The system will offset approximately 210 tons of carbon dioxide annually.

Financial Analysis: The project will be financed on a 100% equity model. The total estimated project cost is USD 534,600.

Based on the technical and financial analysis, the installation of a 375 kW Solar PV System on the rooftop of Metro Cash & Carry Store is deemed to be feasible.

Introduction

The project site is the rooftop of Metro Cash & Carry Store near Safari Park, Karachi, Pakistan. Metro Cash & Carry Store is a double storied commercial building/retail store. The exact coordinates of the project site are:

Latitude: 24°55'17.60" North
Longitude: 67° 6'19.45" East

A bird's eye view of the project site is given in the figure below:

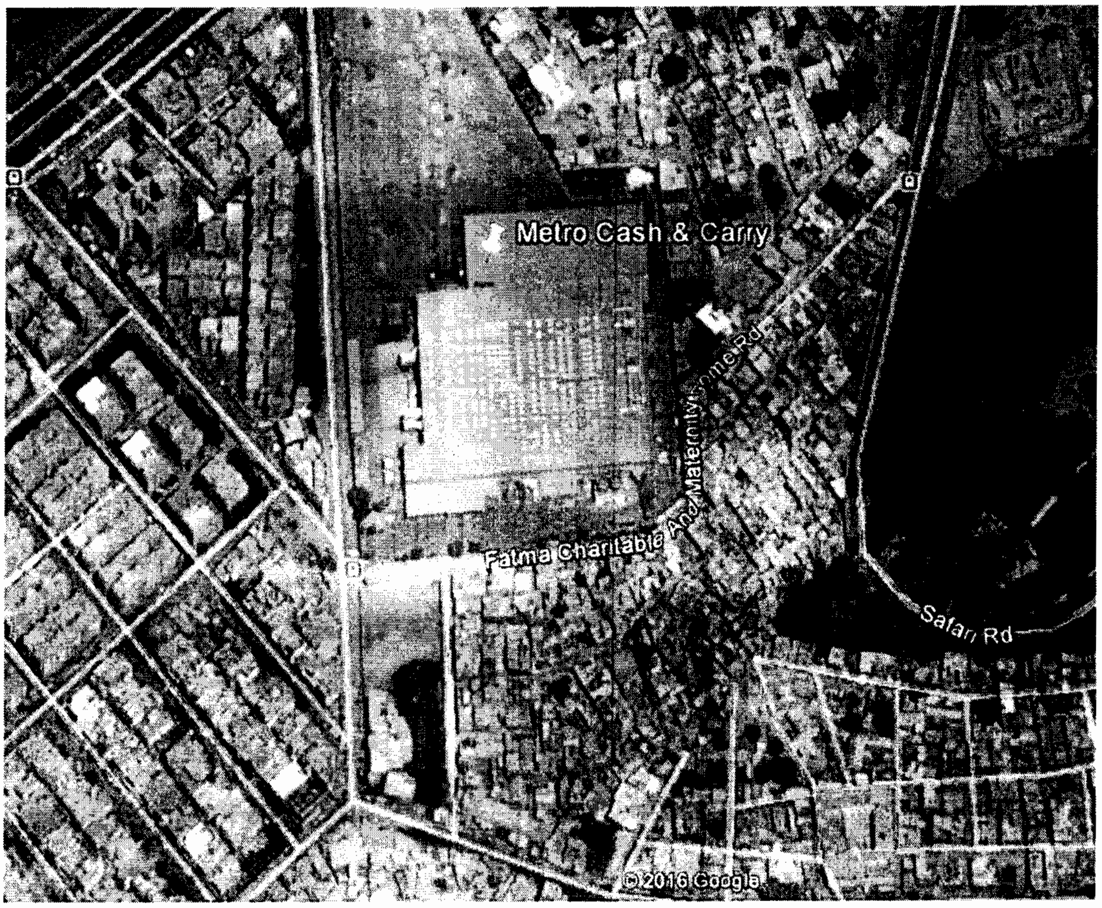


Figure 33. Overview of Project Site

Current Energy Demand and Supply Situation

As per the historical consumption data, the total electricity consumption during 2016 was 2,629,089 kWh.

Technical Analysis

Site Conditions

The following tasks were carried out:

- Global Horizontal Irradiation, annual and inter-annual variation was assessed.
- Near shading objects were taken into account for placement of PV modules.
- Area required for selected module technology was calculated. Keeping in view available area and minimum inter row spacing, tilt angle and appropriate spacing was calculated from near shading objects.

Details of the finalized parameters are given under section 3.5.1

Technology Review and Selection

Technology Selection

PV Modules:

S. No	Specification	Data
1	Type of Module	CS6U-330P
2	Type of Cell	Polycrystalline
3	Dimensions of each module	1960*992*40 mm
4	Weight	22.4 Kg
5	No of Modules	1350
6	Module Area	1.94432 m^2
7	Total Land Area Used	Roof Top
8	Module Frame	Anodized aluminum alloy
9	Nominal Max. Power (Pmax)	330 W
10	Opt. Operating Voltage (Vmp)	37.2 V
11	Opt. Operating Current (Imp)	8.88 A
12	Open Circuit Voltage (Voc)	45.6 V
13	Short Circuit Current (Isc)	9.45 A
14	Module Efficiency	16.97%
15	Operating Temperature	-40°C ~ +85°C
16	Max. System Voltage	1000 V (IEC) or 1000 V (UL) or 600 V (UL)
17	Module Fire Performance	TYPE 1 (UL 1703) or CLASS C (IEC 61730)

PV Array

S. No	Specification	Data
1	No of Strings	90
2	Modules in String	15

PV Capacity

S. No	Specification	Data
1	Total Site	445.5 KW Peak
2	Net Capacity Factor	18.10%

Inverters

S. No	Specification	
1	Manufacturer	SMA
2	Capacity of each Unit	25 KW
3	No of Inverters	15
4	MPP Input Voltage Range	390 V to 800 V
5	Rated Input Voltage	600 V
6	Max Input Voltage	1000 V
7	Total Power (AC)	375 KW
8	Max Input Current Input A/Input B	33A/33A
9	Max Output Current	36.1 A
10	Output Electrical System	3 Phase AC (4 Wire)
11	AC Nominal Voltage	230/400 V
12	Rated Power Frequency	50 Hz
13	Efficiency	98.3%
14	Relative Humidity (Non-Condensing)	100%
15	Noise Emission	51 dB(A)
16	Degree of Protection	IP65

Junction Boxes

S. No	Specification	Data
1	Number of J/Box units	30
2	Input circuits in each box	3
3	Max. input current for each circuit	15A
4	Protection Level	IP 65
5	Over current protection	Fuse
6	Surge protection	>1000V

PV Mounting Structure

S. No	Specification	Data
1	Structure	Aluminum
2	Tilt of Array Frame	2° (In line with shed rooftop)

Data Collecting System

S. No	Specification	Data
1	System Data	Continuous on-line logging and monitoring over web portal

Solar PV Yield Estimation and Simulation

The aim of yield estimation is to predict the average annual energy output of the site. PvSyst software is used for simulation and near shading analysis.

Working Conditions: Zero Export

The solar system will have automatic mechanism to ensure that PV power currently generated by the inverters always matches the current power consumption of the site load. A closed loop control system of inverter AC output is implemented in reference to energy flow at grid connection point which will reduce inverter AC output of the inverter if site load will be less than the solar production.

Plant Characteristics

Generation Voltage: 230/400 V three phase four wire system
Power Factor at rated power: 1
Frequency: 50 Hz
Generation characteristic: Inverter has built-in features of controllable active power ramp following grid disturbance or normal connection, voltage regulation and frequency response. There are no additional control metering and instrumentations.

Design Parameters

The following tasks were carried out for PV layout and shading.

- Assessment of shading (horizon and nearby building)
- Outline layout of area suitable for PV development
- Designing row spacing to provide proper maintenance space.
- Designing the layout to minimize cable runs and associated electrical losses
- Creating access routes and sufficient space to allow movement for maintenance purposes
- Choosing a tilt angle that optimizes the annual energy yield according to the latitude of the site and the annual distribution of solar resource
- Module cleaning strategy

- Simulating the annual energy losses associated with various configurations of tilt angle, orientation and row spacing. The optimized configuration and simulation results are given in section "Energy Yield Prediction"
- PV layouts of the site are given in 3D and 2D view in the following section.

Layout

The detailed layout (2D and 3D) of the solar panels is given below. PV layout may change depending upon site constraints before or during installation. PvSyst simulation is also performed as per following layout:

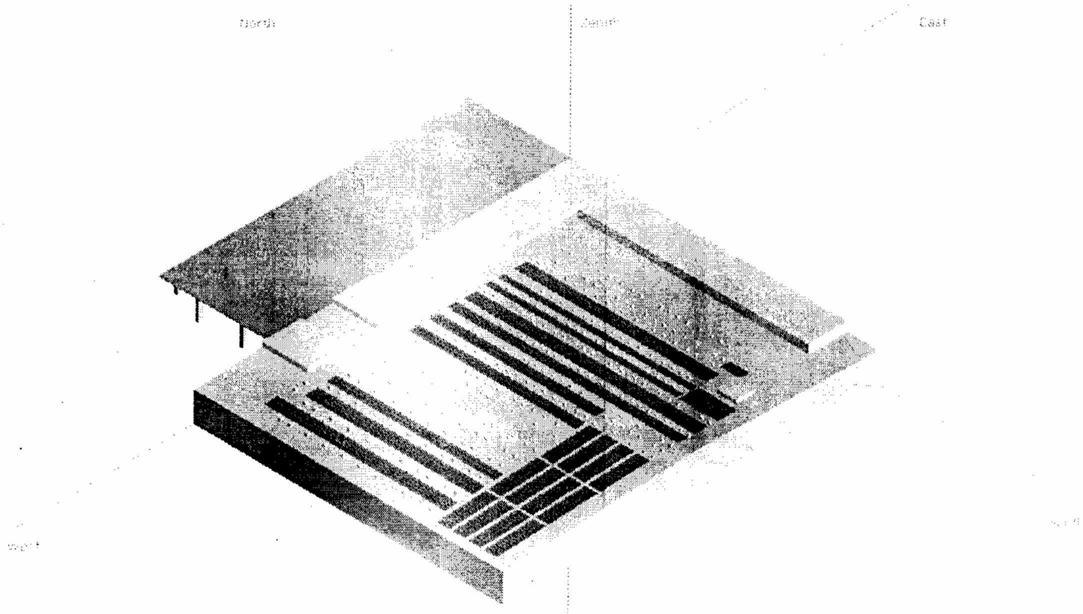


Figure 34: 3D Layout of rooftop of Metro Cash & Carry Safari Store

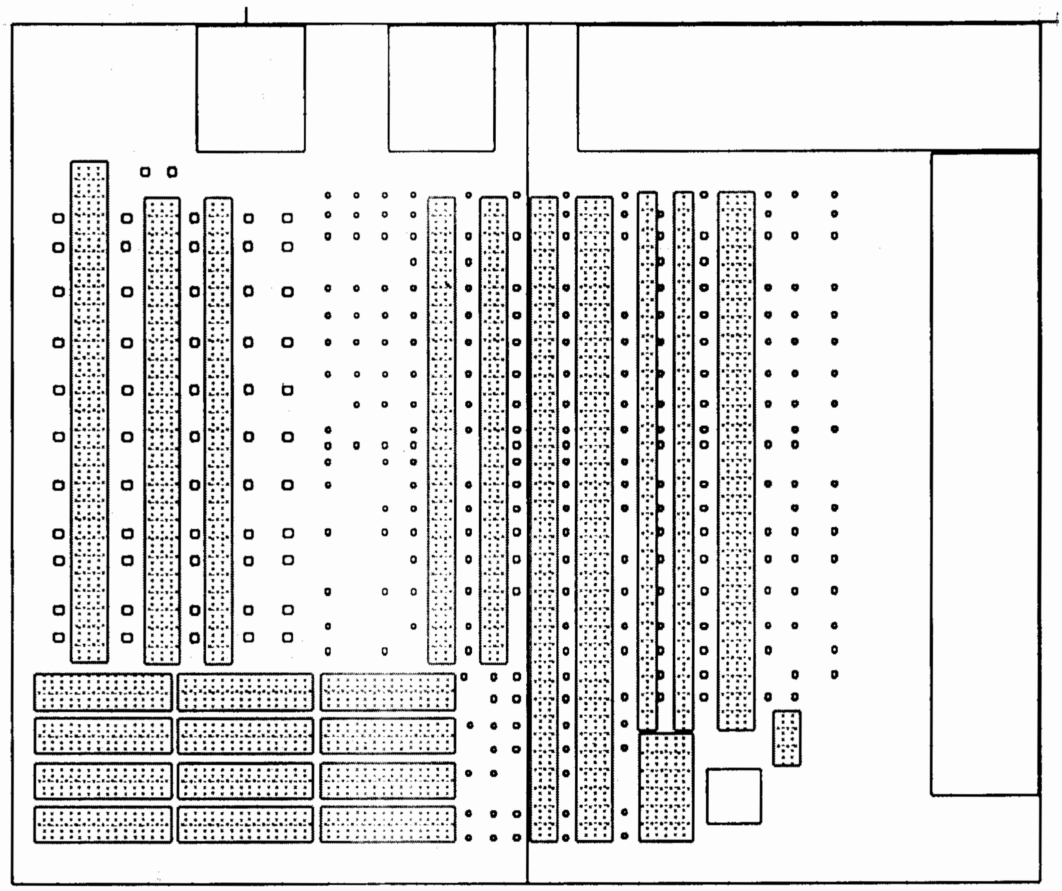


Figure 35: 2D Layout of rooftop of Metro Cash & Carry Safari Store showing solar panel locations

Electrical Design

The electrical system comprises the following components:

- Array(s) of PV modules
- DC/AC cabling (module, string and main cable)
- DC connectors (plugs and sockets)
- Junction boxes
- Disconnects/switches
- Protection devices e.g. fuses, surge protective devices, beakers
- Energy Metering
- Earthing

The single line diagram is given below. The single line diagram includes the protection devices that will be used for safe and smooth operation of the system.

Protections DC Side: String Fuses, Surge Protective Device and DC Disconnect Switches

Protections AC Side: MCBs, Main Breaker and Surge Protective Device

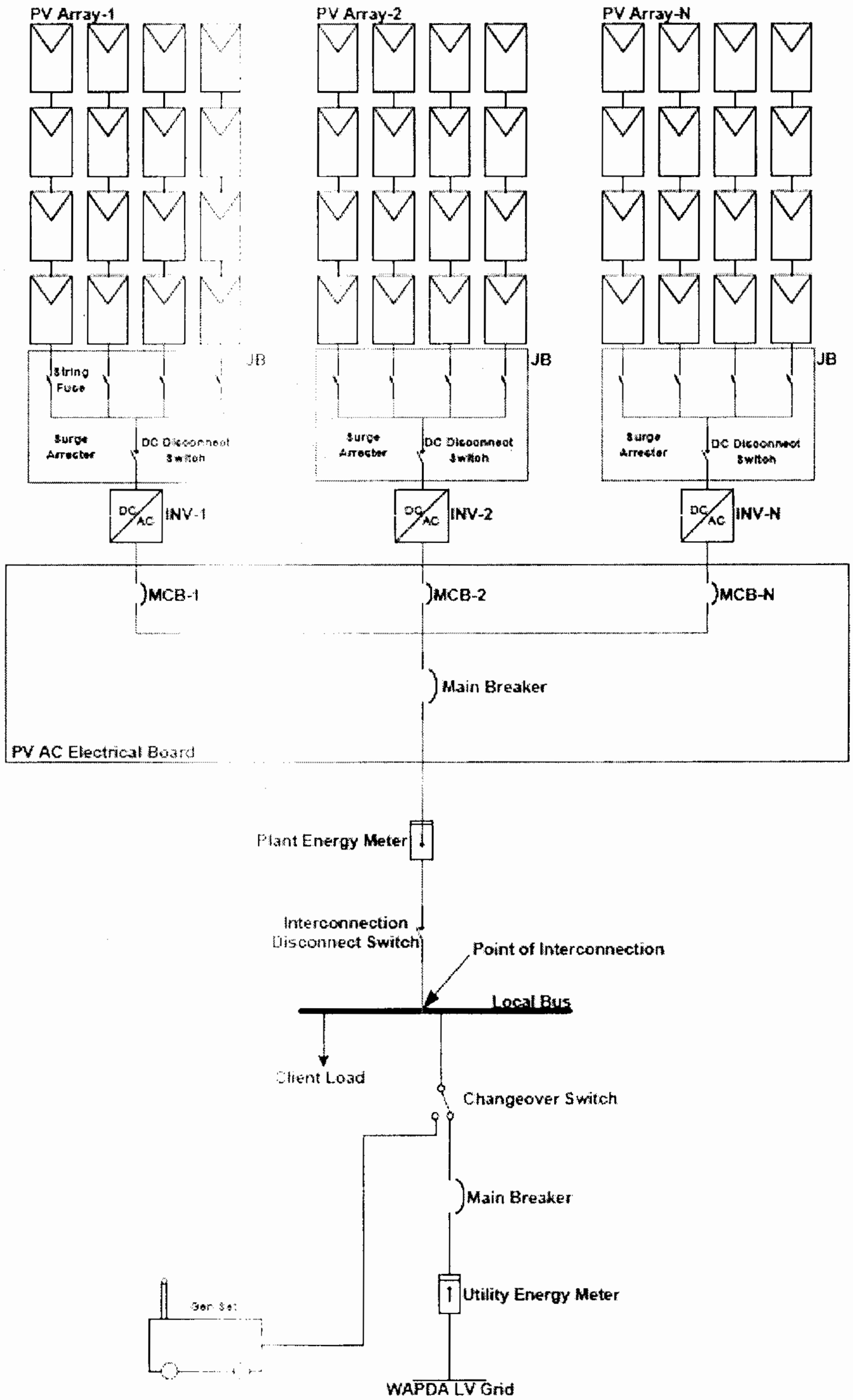


Figure [illegible] Single Line Diagram of PV Plant

Energy Yield Estimation

The energy yield prediction provides the basis for calculating project revenues. The aim is to predict the average annual energy output for the lifetime of the proposed power plant.

To estimate accurately the energy produced from a PV power plant, information is needed on the solar resource and temperature conditions of the site. Also required are the layout and technical specifications of the plant components.

A number of solar energy yield prediction software packages are available in the market. These packages use time step simulation to model the performance of a project over the course of a year. PvSyst software has been used for energy yield prediction for this site and its results are given below.

Details of the simulation steps are presented in the following sections:

Simulation Parameters

PVSYST V6.40	Shams Power (Pvt) Ltd.	05/06/17	Page 1/5

Grid-Connected System: Simulation parameters

Project :	Metro Safari Store, Karachi			
Geographical Site	Metro Safari Store, Karachi		Country	**Pakistan**
Situation	Latitude	24.92° N	Longitude	67.10° E
Time defined as	Legal Time	Time zone UT+5	Altitude	46 m
	Albedo	0.20		
Meteo data:	Metro Safari Store, Karachi	Meteonorm 7.1 (2001-2010) - Synthetic		

Simulation variant :	**Metro safari 2-E/W**			
	Simulation date	05/06/17 15h19		

Simulation parameters				
2 orientations	Tilts/Azimuths	2°/-90° and 2°/90°		
Models used	Transposition	Perez	Diffuse	Perez, Meteonorm
Horizon	Free Horizon			
Near Shadings	According to strings		Electrical effect	100 %
PV Arrays Characteristics (2 kinds of array defined)				
PV module Si-poly	Model	**CS6U - 330P**		
Custom parameters definition	Manufacturer	Canadian Solar Inc.		
Sub-array "Sub-array #1"	Orientation	#2	Tilt/Azimuth	2°/90°
Number of PV modules	In series	15 modules	In parallel	54 strings
Total number of PV modules	Nb. modules	810	Unit Nom. Power	330 Wp
Array global power	Nominal (STC)	**267 kWp**	At operating cond.	239 kWp (50°C)
Array operating characteristics (50°C)	U mpp	497 V	I mpp	481 A
Sub-array "Sub-array #2"	Orientation	#1	Tilt/Azimuth	2°/-90°
Number of PV modules	In series	15 modules	In parallel	36 strings
Total number of PV modules	Nb. modules	540	Unit Nom. Power	330 Wp
Array global power	Nominal (STC)	**178 kWp**	At operating cond.	160 kWp (50°C)
Array operating characteristics (50°C)	U mpp	497 V	I mpp	321 A
Total Arrays global power	Nominal (STC)	**446 kWp**	Total	1350 modules
	Module area	**2625 m²**	Cell area	2366 m²
Inverter	Model	**Sunny Tripower 25000TL-30**		
Original PVsyst database	Manufacturer	SMA		
Characteristics	Operating Voltage	390-800 V	Unit Nom. Power	25.0 kWac
Sub-array "Sub-array #1"	Nb. of inverters	9 units	Total Power	225 kWac
Sub-array "Sub-array #2"	Nb. of inverters	6 units	Total Power	150 kWac
Total	Nb. of inverters	15	Total Power	375 kWac
PV Array loss factors				
Array Soiling Losses			Loss Fraction	3.0 %
Thermal Loss factor	Uc (const)	20.0 W/m²K	Uv (wind)	0.0 W/m²K / m/s
Wiring Ohmic Loss	Array#1	10 mOhm	Loss Fraction	0.9 % at STC
	Array#2	10 mOhm	Loss Fraction	0.6 % at STC
	Global		Loss Fraction	0.7 % at STC

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Grid-Connected System: Simulation parameters (continued)

LID - Light Induced Degradation — Loss Fraction 2.5 %
Module Quality Loss — Loss Fraction 2.0 %
Module Mismatch Losses — Loss Fraction 1.0 % at MPP
Incidence effect (IAM): User defined IAM profile

10°	20°	30°	40°	50°	60°	70°	80°	90°
0.998	0.996	0.995	0.992	0.986	0.970	0.917	0.763	0.000

System loss factors

Wiring Ohmic Loss — Wires 3x500.0 mm² 294 m — Loss Fraction 3.0 % at STC
Unavailability of the system — 20.0 days, 4 periods — Time fraction 5.5 %

User's needs : Unlimited load (grid)

Near Shading Definition

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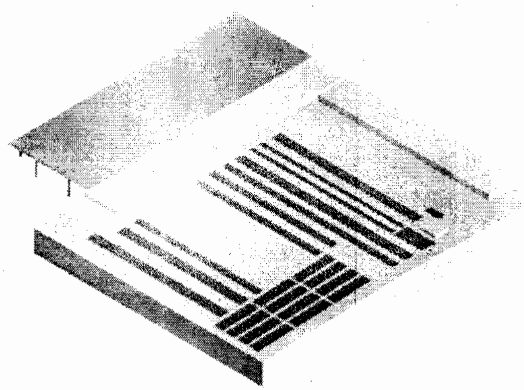
Grid-Connected System: Near shading definition

Project : **Metro Safari Store, Karachi**

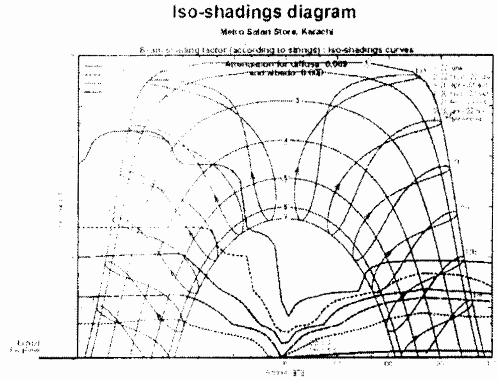
Simulation variant : **Metro safari 2-E/W**

Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	2 orientations	Tilt/Azimuth = 2°/-90° and 2°/90°		
PV modules	Model	CS6U - 330P	Pnom	330 Wp
PV Array	Nb. of modules	1350	Pnom total	**446 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
Inverter pack	Nb. of units	15.0	Pnom total	**375 kW ac**
User's needs	Unlimited load (grid)			

Perspective of the PV-field and surrounding shading scene



Iso-shadings diagram



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Losses

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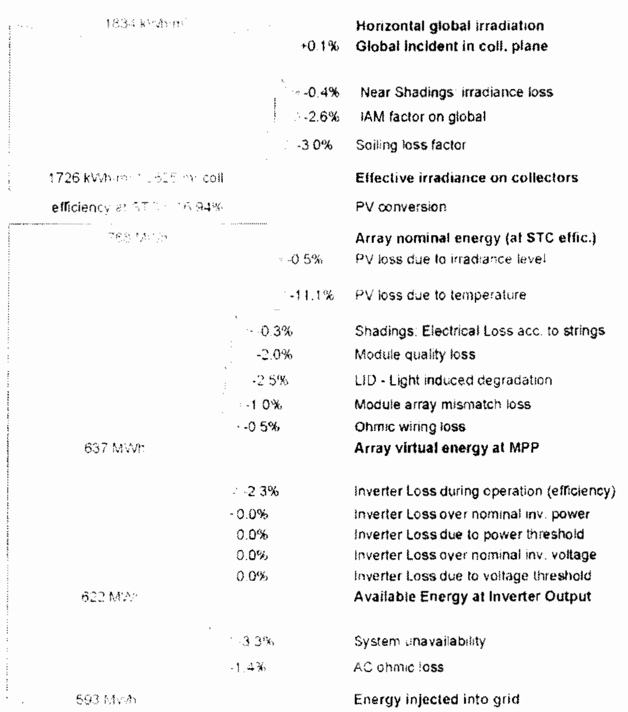
Grid-Connected System: Loss diagram

Project : Metro Safari Store, Karachi

Simulation variant : Metro safari 2-E/W

Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	2 orientations	Tilt/Azimuth = 2°/-90° and 2°/90°		
PV modules	Model	CS6U - 330P	Pnom	330 Wp
PV Array	Nb. of modules	1350	Pnom total	**446 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
Inverter pack	Nb. of units	15.0	Pnom total	**375 kW ac**
User's needs	Unlimited load (grid)			

Loss diagram over the whole year



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Simulation Results

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Grid-Connected System: Main results

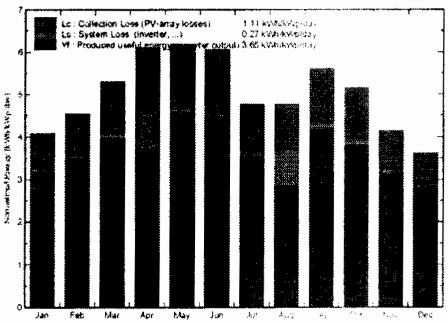
Project : **Metro Safari Store, Karachi**

Simulation variant : **Metro safari 2-E/W**

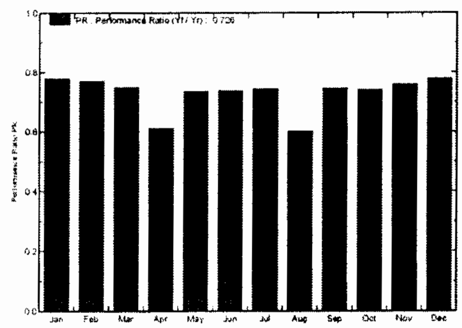
Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	2 orientations	Tilt/Azimuth = 2°/-90° and 2°/90°		
PV modules	Model	CS6U - 330P	Pnom	330 Wp
PV Array	Nb. of modules	1350	Pnom total	**446 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
Inverter pack	Nb. of units	15.0	Pnom total	**375 kW ac**
User's needs	Unlimited load (grid)			

Main simulation results				
System Production	Produced Energy	**593.4 MWh/year**	Specific prod.	1332 kWh/kWp/year
	Performance Ratio PR	72.56 %		

Normalized productions (per installed kWp): Nominal power 446 kWp



Performance Ratio PR



Metro safari 2-E/W

Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_Grid MWh	PR
January	126.4	[illegible]	19.52	126.5	118.4	45.52	43.97	0.780
February	126.9	[illegible]	22.31	127.0	119.3	45.16	43.57	0.770
March	164.2	[illegible]	26.41	164.4	154.7	56.95	54.85	0.749
April	[illegible]	[illegible]	28.97	183.4	173.1	62.75	49.95	0.611
May	[illegible]	[illegible]	30.82	192.0	180.8	65.45	62.98	0.736
June	[illegible]	[illegible]	31.09	181.4	170.9	61.99	59.68	0.738
July	[illegible]	[illegible]	30.31	148.0	139.0	50.86	49.02	0.744
August	[illegible]	[illegible]	[illegible]	147.9	138.9	51.39	38.58	0.601
September	[illegible]	[illegible]	28.91	168.6	158.8	58.21	56.04	0.746
October	[illegible]	[illegible]	29.06	159.9	150.5	54.75	52.73	0.740
November	124.4	[illegible]	24.65	124.5	116.6	43.64	42.13	0.760
December	[illegible]	[illegible]	20.92	112.2	104.8	40.24	38.90	0.779
Year	[illegible]		[illegible]	1835.7	1725.9	636.91	[illegible]	0.726

Legends:	GlobHor	[illegible]	GlobEff	Effective Global, corr. for IAM and shadings
	DiffHor	[illegible]	EArray	Effective energy at the output of the array
	T Amb	[illegible]	E_Grid	Energy injected into grid
	GlobInc	[illegible]	PR	Performance Ratio

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Financial Analysis

Cost/watt: **USD 1.2**

Total Project Cost for 445.5 KWp (DC) Solar PV System: **USD 534,600**

Equity: **100%**

Debt: **0%**

Safety and Emergency Plans

- Only qualified and authorized electricians will be allowed to undertake servicing or maintenance tasks.
- The authorized personnel will wear appropriate equipment, including a safety harness to restrain from falling off the roof, sturdy shoes that will have thick rubber soles to provide electrical insulation and good grip and appropriate clothing for personal protection, including a hat, sunglasses, gloves and long pants and sleeves
- Lock out and tag out procedures will be used before commencement of maintenance tasks.
- On-going operation and maintenance concerns for solar power systems will be addressed properly. These systems are exposed to outdoor weather conditions that enhance the aging process, and the infrastructure needs to be in place for the on-going maintenance of these systems to assure their safe operation.
- Properly grounded or double insulated power tools will be used for maintenance tasks. Tools will be maintained in good condition.
- Working on electrical equipment and circuits will be carried out in de energized state.
- Proper pathways will be available for operation, maintenance and firefighting.
- Fire protection and suppression will be placed at site

Training and Capacity Development

Trained and qualified personnel will be available at site 24/7 with proper safety and firefighting training. Training program will focus on but not limited to Solar Resource Assessment, Site Survey, Technology, Engineering Design, Regulation, Policy, Metering & Billing, and Project Management of Rooftop Solar System. The following components will include in training and development program.

a. Collection of Resource Data
b. Variability and uncertainty of resource data
c. Site evaluation
d. Crystalline and Thin film technology comparison
e. Rooftop solar system components
f. Module mounting structure selection
g. Inverter selection
h. Design of PV Array
i. Shadow Analysis
j. DC cable sizing
k. DC cable layout
l. Protection and Metering
m. Installation and testing standards for solar PV plants
n. Solar Module testing standards
o. Economy of Roof top Solar System
p. Detailed Project Report
q. Operation and maintenance of rooftop solar system
r. Safety and firefighting training

Environmental Aspects

Every energy generation and transmission method affects the environment. Conventional generating options can damage air, climate, water, land and wildlife, landscape as well as raise the levels of harmful radiation. PV technology is substantially safer offering a solution to many environmental and social problems associated with fossil and nuclear fuels. Solar PV energy technology provides obvious environmental advantages in comparison to the conventional energy sources thus contributing to the sustainable development of human activities. Not counting the depletion of the exhausted natural resources, their main advantage is related to the reduced CO2 emissions and normally absence of any air emissions or waste products during their operation.

The use of solar power has additional positive implications such as:

- Reduction of the emissions of the greenhouse gases (mainly CO2, NOx) and prevention of toxic gas emissions (SO2,particulates)
- Reduction of the required transmission lines of the electricity grids

Socio-Economic Aspects

In regard to the socio-economic viewpoint, the benefits of exploitation of solar PV system comprise of:

- Increase of the regional/national energy independency
- Provision of significant work opportunities
- Diversification and security of energy supply
- Support of the deregulation of energy markets

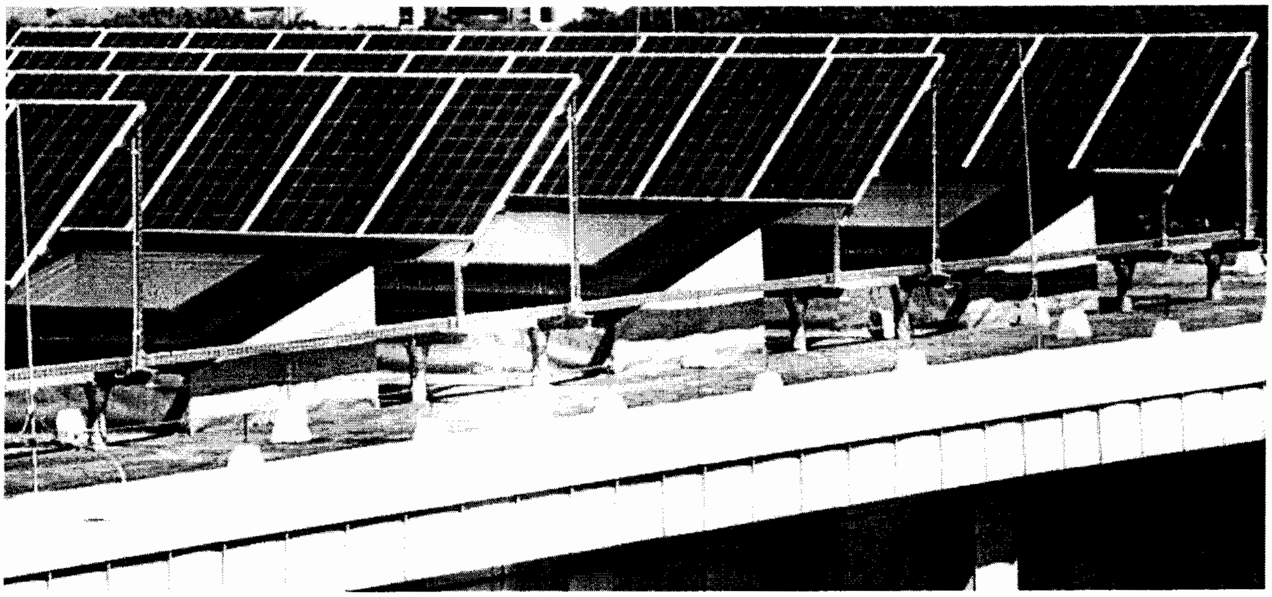
Conclusion

This feasibility study is conducted to ascertain the technical feasibility and commercial viability of installation of 375 kW (AC) rooftop PV system installation at Metro Cash & Carry near Safari Park, Karachi.

Installation of the PV system will result in annual power generation of 593,365 kWh.

The results of the financial analysis indicate that the project is feasible.

Based on the outcomes of both the technical and financial analysis, the project is deemed to be viable.



10. FEASIBILITY STUDY FOR ROOFTOP SOLAR INSTALLATION AT AKZONOBEL PAKISTAN, LAHORE

Shams Power (Private) Limited

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EXECUTIVE SUMMARY

The feasibility study examines the costs, practicality, and likely outcome of a solar photovoltaic (PV) installation on multiple rooftops and car parking of Akzonobel, Lahore.

The main outcomes of the feasibility report are given below:

Technical Site Analysis: The project site is suitable for a solar PV energy system. For the purpose of estimation of power generation potential, solar insolation is assumed to be "good" (1,719 kWh/ square meter/ year). Panel azimuth (70, 110, 20 degree), panel tilt (8 degrees) and satisfactory roof & ground condition and structure are also assumed.

Anticipated System Information: The project will accommodate a 400 kW (AC) solar PV system with a projected annual production of 559,040 kWh/year. Use of a Canadian Solar Inc. CS6U – 330P (330 watt) PV panel as a basis for design will result in an acceptable system weight density of 2.36 lbs/SF. The system will offset approximately 190 tons of carbon dioxide annually.

Financial Analysis: The project will be financed on a 100% equity model. The total estimated project cost is USD 549,648.

Based on the technical and financial analysis, the installation of a 400 kW Solar PV System on the rooftop and Car Parking of Akzonobel is deemed to be feasible.

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Introduction

The project site is the rooftop of Akzonobel, Lahore. Pakistan. Akzonobel area has multiple building blocks, sheds and parkings. The exact coordinates of the project site are:

Latitude: 31°28'38.70" North
Longitude: 74°20'27.63" East

A bird's eye view of the project site is given in the figure below:

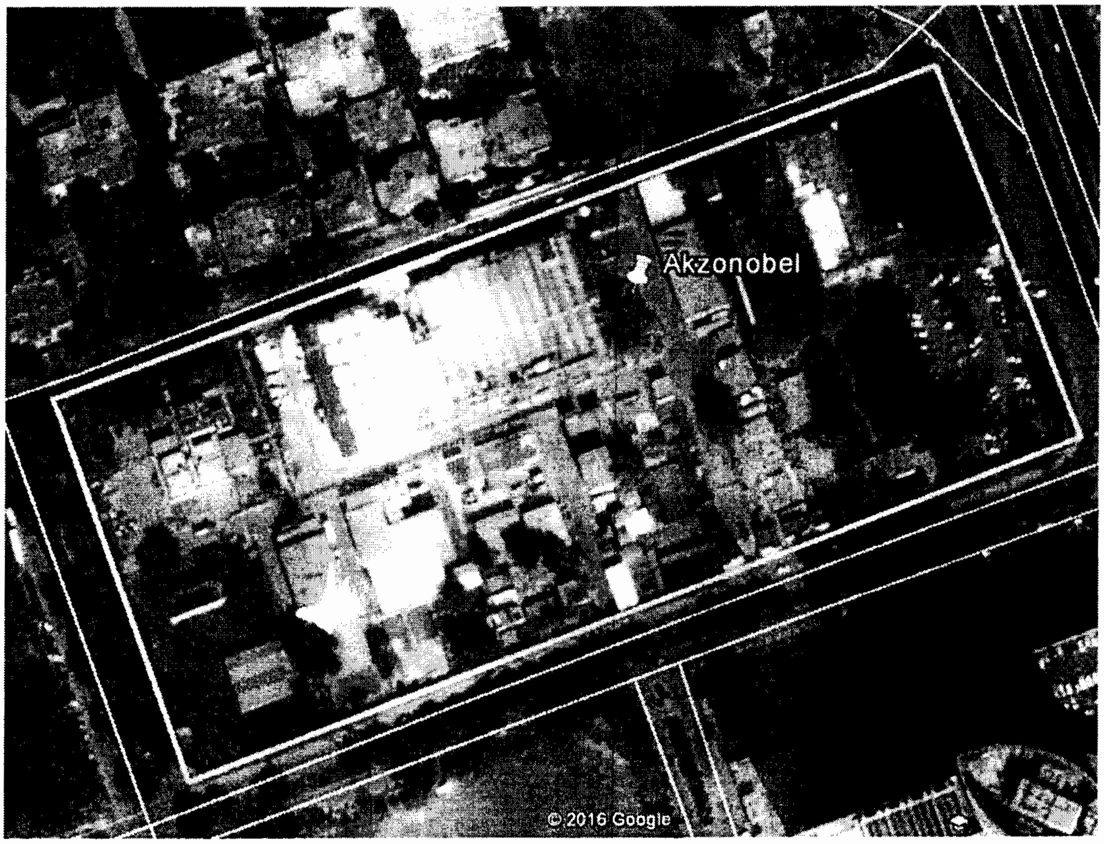

Figure 37: Overview of Project Site

Current Energy Demand and Supply Situation

As per the historical consumption data, the total electricity consumption during 2016 was 1,804,789 kWh.

Details of electricity generation/supply sources during this period are given below:

- Electricity imported from the national grid is 1,504,000 kWh
- In-house power generation from Diesel Generators is 300,789 kWh

Technical Analysis

Site Conditions

The following tasks were carried out:

- Global Horizontal Irradiation, annual and inter-annual variation was assessed.
- Near shading objects were taken into account for placement of PV modules.
- Area required for selected module technology was calculated. Keeping in view available area and minimum inter row shading, tilt angle and appropriate spacing was calculated from near shading objects.

Details of the finalized parameters are given under section 3.5.1

Technology Review and Selection

Technology Selection

PV Modules:

S. No	Specification	Data
1	Type of Module	CS6U-330P
2	Type of Cell	Polycrystalline
3	Dimensions of each module	1960*992*40 mm
4	Weight	22.4 Kg
5	No of Modules	1388
6	Module Area	1.6368 m^2
7	Total Land Area Used	Roof Tops, Sheds and Car Parking (2698 m^2)
8	Module Frame	Anodized aluminum alloy
9	Nominal Max. Power (Pmax)	330 W
10	Opt. Operating Voltage (Vmp)	37.2 V
11	Opt. Operating Current (Imp)	8.88 A
12	Open Circuit Voltage (Voc)	45.6 V
13	Short Circuit Current (Isc)	9.45 A
14	Module Efficiency	16.97%
15	Operating Temperature	-40°C ~ +85°C
16	Max. System Voltage	1000 V (IEC) or 1000 V (UL) or 600 V (UL)
17	Module Fire Performance	TYPE 1 (UL 1703) or CLASS C (IEC 61730)

PV Array

S. No	Specification	Data
1	No of Strings	92
2	Modules in String	15

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PV Capacity

S. No	Specification	Data
1	Total Site	458.04 KW Peak
2	Net Capacity Factor	15.95%

Inverters

S. No	Specification	
1	Manufacturer	SMA
2	Capacity of each Unit	25 KW
3	No of Inverters	16
4	MPP Input Voltage Range	390 V to 800 V
5	Rated Input Voltage	600 V
6	Max Input Voltage	1000 V
7	Total Power (AC)	400 KW
8	Max Input Current Input A/Input B	33A/33A
9	Max Output Current	36.1 A
10	Output Electrical System	3 Phase AC (4 Wire)
11	AC Nominal Voltage	230/400 V
12	Rated Power Frequency	50 Hz
13	Efficiency	98.3%
14	Relative Humidity (Non-Condensing)	100%
15	Noise Emission	51 dB(A)
16	Degree of Protection	IP65

DC Protection

S. No	Specification	Data
1	Number of Fuses per Inverter	12 (SMA Inline Fuses)
2	DC Surge Protection	>1000V Integrated (SMA)
3	Max. input current for each circuit	15A

PV Mounting Structure

S. No	Specification	Data
1	Structure	Galvanized Steel

2	Tilt of Array Frame	8°

Data Collecting System

S. No	Specification	Data
1	System Data	Continuous on-line logging and monitoring over web portal & LAN

Solar PV Yield Estimation and Simulation

The aim of yield estimation is to predict the average annual energy output of the site. PvSyst software is used for simulation and near shading analysis.

Working Conditions

The solar system will have automatic mechanism to ensure that PV power currently generated by the inverters always matches the current power consumption of the site load. A closed loop control system of inverter AC output is implemented in reference to energy flow at grid connection point which will reduce inverter AC output of the inverter if site load will be less than the solar production in case of Load shedding.

Plant Characteristics
Generation Voltage: 230/400 V three phase four wire system
Power Factor at rated power: 1
Frequency: 50 Hz
Generation characteristic: Inverter has built-in features of controllable active power ramp following grid disturbance or normal connection, voltage regulation and frequency response. There are no additional control metering and instrumentations.

Design Parameters
The following tasks were carried out for PV layout and shading.

- Assessment of shading (horizon and nearby building)
- Outline layout of area suitable for PV development
- Designing row spacing to reduce inter-row shading and associated shading losses.
- Designing the layout to minimize cable runs and associated electrical losses
- Creating access routes and sufficient space to allow movement for maintenance purposes
- Choosing a tilt angle that optimizes the annual energy yield according to the latitude of the site and the annual distribution of solar resource
- Module cleaning strategy

- Simulating the annual energy losses associated with various configurations of tilt angle, orientation and row spacing. The optimized configuration and simulation results are given in section "Energy Yield Prediction"
- PV layouts of the site are given in 3D and 2D view in the following section.

Layout

The detailed layout (2D and 3D) of the solar panels is given below. PV layout may change depending upon site constraints before or during installation. PvSyst simulation is also performed as per following layout:

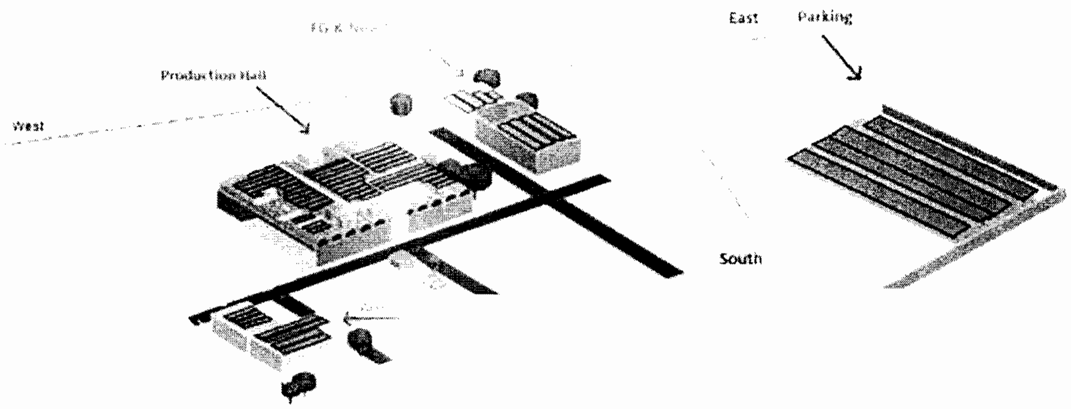

Figure 38: 3D Layout of PV Plant at Akzonobel Lahore

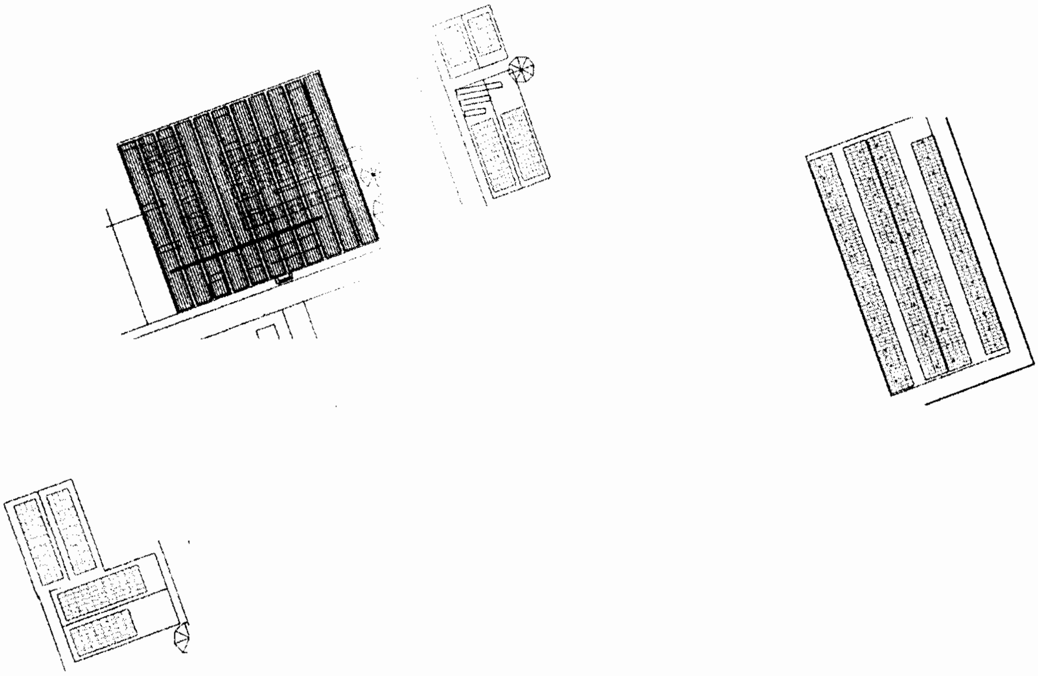

Figure 39: 2D Layout of Akzonobel Lahore showing PV Panel Locations

Electrical Design

The electrical system comprises the following components:

- Array(s) of PV modules
- DC/AC cabling (module, string and main cable)
- DC connectors (plugs and sockets)
- Junction boxes
- Disconnects/switches
- Protection devices e.g. fuses, surge protective devices, beakers
- Energy Metering
- Earthing

The single line diagram is given below. The single line diagram includes the protection devices that will be used for safe and smooth operation of the system.

Protections DC Side: String Fuses, Surge Protective Device and DC Disconnect Switches

Protections AC Side: MCBs, Main Breaker and Surge Protective Device

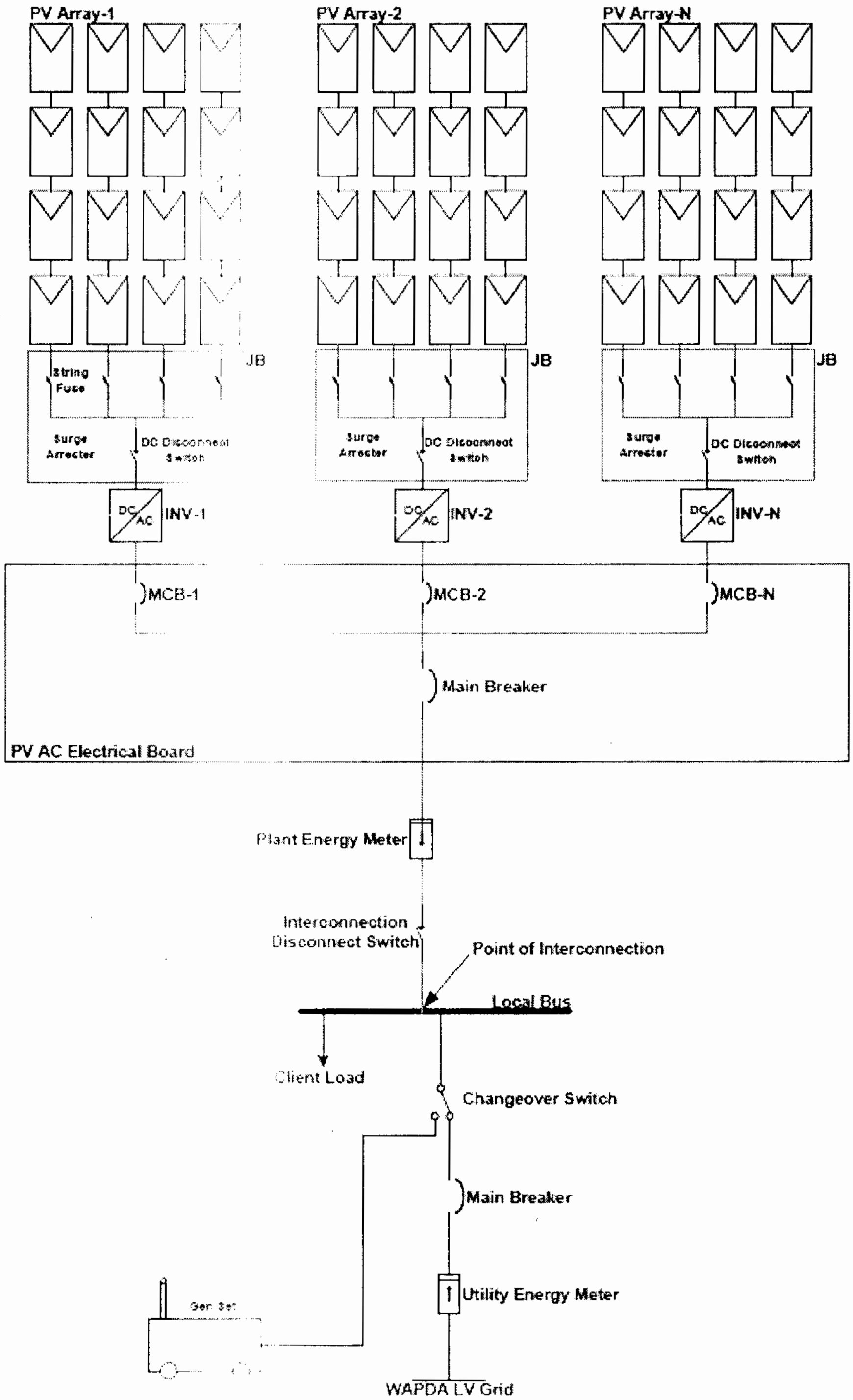

Figure [illegible] Single Line Diagram of PV Plant

Energy Yield Estimation

The energy yield prediction provides the basis for calculating project revenues. The aim is to predict the average annual energy output for the lifetime of the proposed power plant.

To estimate accurately the energy produced from a PV power plant, information is needed on the solar resource and temperature conditions of the site. Also required are the layout and technical specifications of the plant components.

A number of solar energy yield prediction software packages are available in the market. These packages use time step simulation to model the performance of a project over the course of a year. PvSyst software has been used for energy yield prediction for this site and its results are given below.

Details of the simulation steps are presented in the following sections:

Akzonobel Lahore has concrete rooftops, Sheds and Car Parking. Various Small systems are then combined to sum the total energy to inject in the Local LT system. PvSyst software simulate limited different orientations in single variant. Therefore, simulation is also done separately for these different building blocks and car parking.

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Simulation Parameters

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Grid-Connected System: Simulation parameters

Project : **Akzo Nobel Pakistan**

Geographical Site	Akzo Nobel Pakistan			Country	**Pakistan**
Situation		Latitude	31.47° N	Longitude	74.33° E
Time defined as		Legal Time	Time zone UT+5	Altitude	212 m
		Albedo	0.20		
Meteo data:	Azko Nobel Pakistan		Meteonorm 7.1 - Synthetic		

Simulation variant : area 31 a

Simulation date 29/06/17 09h09

Simulation parameters

2 orientations	Tilts/Azimuths	8°/-20° and 8°/160°		
Models used	Transposition	Perez	Diffuse	Perez, Meteonorm
Horizon	Free Horizon			
Near Shadings	According to strings		Electrical effect	100 %

PV Array Characteristics

PV module	Si-poly	Model	**CS6U - 330P**		
Custom parameters definition		Manufacturer	Canadian Solar Inc.		
Number of PV modules		In series	15 modules	In parallel	6 strings
Total number of PV modules		Nb. modules	90	Unit Nom. Power	330 Wp
Array global power		Nominal (STC)	**29.70 kWp**	At operating cond.	26.60 kWp (50°C)
Array operating characteristics (50°C)		U mpp	497 V	I mpp	53 A
Total area		Module area	175 m²	Cell area	158 m²

Inverter	Model	**Sunny Tripower 25000TL-30**		
Original PVsyst database	Manufacturer	SMA		
Characteristics	Operating Voltage	390-800 V	Unit Nom. Power	25.0 kWac
Inverter pack	Nb. of inverters	1 units	Total Power	25 kWac

PV Array loss factors

Array Soiling Losses			Loss Fraction	3.0 %
Thermal Loss factor	Uc (const)	29.0 W/m²K	Uv (wind)	0.0 W/m²K / m/s
Wiring Ohmic Loss	Global array res.	157 mOhm	Loss Fraction	1.5 % at STC
LID - Light Induced Degradation			Loss Fraction	1.1 %
Module Quality Loss			Loss Fraction	2.0 %
Module Mismatch Losses			Loss Fraction	1.0 % at MPP

Incidence effect (IAM): User defined IAM profile

10°	20°	30°	40°	50°	60°	70°	80°	90°
0.998	0.998	0.995	0.992	0.986	0.970	0.917	0.763	0.000

System loss factors

Wiring Ohmic Loss	Wires: 3x16.0 mm²	144 m	Loss Fraction	3.1 % at STC
Unavailability of the system	34.0 days, 4 periods		Time fraction	9.3 %

User's needs : Unlimited load (grid)

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Grid-Connected System: Simulation parameters

Project :	Akzo Nobel Pakistan			
Geographical Site	Akzo Nobel Pakistan		Country	**Pakistan**
Situation	Latitude	31.47° N	Longitude	74.33° E
Time defined as	Legal Time	Time zone UT+5	Altitude	212 m
	Albedo	0.20		
Meteo data:	**Azko Nobel Pakistan**	Meteonorm 7.1 - Synthetic		

Simulation variant : area 31 b

Simulation date 29/06/17 09h27

Simulation parameters

2 orientations	Tilts/Azimuths	8°/70° and 8°/-110°		
Models used	Transposition	Perez	Diffuse	Perez, Meteonorm
Horizon	Free Horizon			
Near Shadings	According to strings		Electrical effect	100 %

PV Array Characteristics

PV module Si-poly	Model	**CS6U - 330P**		
Custom parameters definition	Manufacturer	Canadian Solar Inc.		
Number of PV modules	In series	17 modules	In parallel	4 strings
Total number of PV modules	Nb. modules	68	Unit Nom. Power	330 Wp
Array global power	Nominal (STC)	**22.44 kWp**	At operating cond.	20.10 kWp (50°C)
Array operating characteristics (50°C)	U mpp	564 V	I mpp	36 A
Total area	Module area	**132 m²**	Cell area	119 m²

Inverter	Model	**Sunny Tripower 25000TL-30**		
Original PVsyst database	Manufacturer	SMA		
Characteristics	Operating Voltage	390-800 V	Unit Nom. Power	25.0 kWac
Inverter pack	Nb. of inverters	1 units	Total Power	25 kWac

PV Array loss factors

Array Soiling Losses			Loss Fraction	3.0 %
Thermal Loss factor	Uc (const)	29.0 W/m²K	Uv (wind)	0.0 W/m²K / m/s
Wiring Ohmic Loss	Global array res.	266 mOhm	Loss Fraction	1.5 % at STC
LID - Light Induced Degradation			Loss Fraction	2.5 %
Module Quality Loss			Loss Fraction	2.0 %
Module Mismatch Losses			Loss Fraction	1.0 % at MPP

Incidence effect (IAM): User defined IAM profile

10°	20°	30°	40°	50°	60°	70°	80°	90°
0.998	0.998	0.995	0.992	0.986	0.970	0.917	0.763	0.000

Unavailability of the system	34.0 days, 4 periods		Time fraction	9.3 %

User's needs : Unlimited load (grid)

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Grid-Connected System: Simulation parameters

Project :	**Akzo Nobel Pakistan**			
Geographical Site	Akzo Nobel Pakistan		Country	**Pakistan**
Situation	Latitude	31.47° N	Longitude	74.33° E
Time defined as	Legal Time	Time zone UT+5	Altitude	212 m
	Albedo	0.20		
Meteo data:	Azko Nobel Pakistan	Meteonorm 7.1 - Synthetic		

Simulation variant : fg & new fg

Simulation date 03/07/17 10h41

Simulation parameters				
2 orientations	Tilts/Azimuths	8°/70° and 8°/-110°		
Models used	Transposition	Perez	Diffuse	Perez, Meteonorm
Horizon	Free Horizon			
Near Shadings	According to strings		Electrical effect	100 %

PV Arrays Characteristics (2 kinds of array defined)				
PV module Si-poly	Model	**CS6U - 330P**		
Custom parameters definition	Manufacturer	Canadian Solar Inc.		
Sub-array "fg sheds"	Mixed orient.	#1/2: 3/3 strings	Tilt/Azimuth	8°/70°, 8°/-110°
Number of PV modules	In series	15 modules	In parallel	6 strings
Total number of PV modules	Nb. modules	90	Unit Nom. Power	330 Wp
Array global power	Nominal (STC)	**29.70 kWp**	At operating cond.	26.60 kWp (50°C)
Array operating characteristics (50°C)	U mpp	497 V	I mpp	53 A
Sub-array "new fg"	Mixed orient.	#1/2: 2/2 strings	Tilt/Azimuth	8°/70°, 8°/-110°
Number of PV modules	In series	15 modules	In parallel	4 strings
Total number of PV modules	Nb. modules	60	Unit Nom. Power	330 Wp
Array global power	Nominal (STC)	**19.80 kWp**	At operating cond.	17.73 kWp (50°C)
Array operating characteristics (50°C)	U mpp	497 V	I mpp	36 A
Total Arrays global power	Nominal (STC)	**50 kWp**	Total	150 modules
	Module area	**292 m²**	Cell area	263 m²

Inverter	Model	**Sunny Tripower 25000TL-30**		
Original PVsyst database	Manufacturer	SMA		
Characteristics	Operating Voltage	390-800 V	Unit Nom. Power	25.0 kWac
Sub-array "fg sheds"	Nb. of inverters	1 units	Total Power	25 kWac
Sub-array "new fg"	Nb. of inverters	1 units	Total Power	25 kWac
Total	Nb. of inverters	2	Total Power	50 kWac

PV Array loss factors				
Array Soiling Losses			Loss Fraction	3.0 %
Thermal Loss factor	Uc (const)	20.0 W/m²K	Uv (wind)	0.0 W/m²K / m/s
Wiring Ohmic Loss	Array#1	160 mOhm	Loss Fraction	1.5 % at STC
	Array#2	192 mOhm	Loss Fraction	1.2 % at STC
	Global		Loss Fraction	1.4 % at STC
LID - Light Induced Degradation			Loss Fraction	2.5 %
Module Quality Loss			Loss Fraction	2.0 %
Module Mismatch Losses			Loss Fraction	1.0 % at MPP

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Grid-Connected System: Simulation parameters (continued)

Incidence effect (IAM): User defined IAM profile

10°	20°	30°	40°	50°	60°	70°	80°	90°
0.998	0.998	0.995	0.992	0.986	0.970	0.917	0.763	0.000

System loss factors

Wiring Ohmic Loss — Wires: 3x16.0 mm² 82 m — Loss Fraction 2.9 % at STC

Unavailability of the system — 34.0 days, 4 periods — Time fraction 9.3 %

User's needs : Unlimited load (grid)

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Grid-Connected System: Simulation parameters

Project :	**Akzo Nobel Pakistan**			
Geographical Site	**Akzo Nobel Pakistan**		Country	**Pakistan**
Situation	Latitude	31.47° N	Longitude	74.33° E
Time defined as	Legal Time	Time zone UT+5	Altitude	212 m
	Albedo	0.20		
Meteo data:	**Azko Nobel Pakistan**	Meteonorm 7.1 - Synthetic		

Simulation variant :	**AkzoNobel Parking**			
	Simulation date	03/07/17 11h02		

Simulation parameters

2 orientations	Tilts/Azimuths	5°/70° and 5°/-110°		
Models used	Transposition	Perez	Diffuse	Perez, Meteonorm
Horizon	Free Horizon			
Near Shadings	According to strings		Electrical effect	100 %

PV Arrays Characteristics (2 kinds of array defined)

PV module	Si-poly	Model	**CS6U - 330P**		
Custom parameters definition		Manufacturer	Canadian Solar Inc.		
Sub-array "Sub-array #1"		Orientation	#1	Tilt/Azimuth	5°/70°
Number of PV modules		In series	15 modules	In parallel	36 strings
Total number of PV modules		Nb. modules	540	Unit Nom. Power	330 Wp
Array global power		Nominal (STC)	**178 kWp**	At operating cond.	160 kWp (50°C)
Array operating characteristics (50°C)		U mpp	497 V	I mpp	321 A
Sub-array "Sub-array #2"		Mixed orient.	#1/2: 4/14 strings	Tilt/Azimuth	5°/70°, 5°/-110°
Number of PV modules		In series	15 modules	In parallel	18 strings
Total number of PV modules		Nb. modules	270	Unit Nom. Power	330 Wp
Array global power		Nominal (STC)	**89.1 kWp**	At operating cond.	79.8 kWp (50°C)
Array operating characteristics (50°C)		U mpp	497 V	I mpp	160 A
Total	Arrays global power	Nominal (STC)	**267 kWp**	Total	810 modules
		Module area	**1575 m²**	Cell area	1420 m²

Inverter	Model	**Sunny Tripower 25000TL-30**		
Original PVsyst database	Manufacturer	SMA		
Characteristics	Operating Voltage	390-800 V	Unit Nom. Power	25.0 kWac
Sub-array "Sub-array #1"	Nb. of inverters	6 units	Total Power	150 kWac
Sub-array "Sub-array #2"	Nb. of inverters	3 units	Total Power	75 kWac
Total	Nb. of inverters	9	Total Power	225 kWac

PV Array loss factors

Array Soiling Losses			Loss Fraction	3.0 %
Thermal Loss factor	Uc (const)	29.0 W/m²K	Uv (wind)	0.0 W/m²K / m/s
Wiring Ohmic Loss	Array#1	26 mOhm	Loss Fraction	1.5 % at STC
	Array#2	52 mOhm	Loss Fraction	1.5 % at STC
	Global		Loss Fraction	1.5 % at STC
LID - Light Induced Degradation			Loss Fraction	2.5 %
Module Quality Loss			Loss Fraction	2.0 %
Module Mismatch Losses			Loss Fraction	1.0 % at MPP

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Grid-Connected System: Simulation parameters (continued)

Incidence effect (IAM): User defined IAM profile

10°	20°	30°	40°	50°	60°	70°	80°	90°
0.998	0.998	0.995	0.992	0.986	0.970	0.917	0.763	0.000

System loss factors

Wiring Ohmic Loss	Wires: 3x240.0 mm² 235 m	Loss Fraction	3.0 % at STC
Unavailability of the system	34.0 days, 4 periods	Time fraction	9.3 %

User's needs : Unlimited load (grid)

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Grid-Connected System: Simulation parameters

Project :	Akzo Nobel Pakistan			
Geographical Site	Akzo Nobel Pakistan		Country	**Pakistan**
Situation	Latitude	31.47° N	Longitude	74.33° E
Time defined as	Legal Time	Time zone UT+5	Altitude	212 m
	Albedo	0.20		
Meteo data:	Azko Nobel Pakistan	Meteonorm 7.1 - Synthetic		

Simulation variant :	Prodcution hall			
	Simulation date	03/07/17 10h26		

Simulation parameters

Collector Plane Orientation	Tilt	8°	Azimuth	-20°
Models used	Transposition	Perez	Diffuse	Perez, Meteonorm
Horizon	Free Horizon			
Near Shadings	According to strings		Electrical effect	100 %

PV Array Characteristics

PV module	Si-poly Model	**CS6U - 330P**		
Custom parameters definition	Manufacturer	Canadian Solar Inc.		
Number of PV modules	In series	15 modules	In parallel	18 strings
Total number of PV modules	Nb. modules	270	Unit Nom. Power	330 Wp
Array global power	Nominal (STC)	**89.1 kWp**	At operating cond.	79.8 kWp (50°C)
Array operating characteristics (50°C)	U mpp	497 V	I mpp	160 A
Total area	Module area	**525 m²**	Cell area	473 m²

Inverter	Model	**Sunny Tripower 25000TL-30**		
Original PVsyst database	Manufacturer	SMA		
Characteristics	Operating Voltage	390-800 V	Unit Nom. Power	25.0 kWac
Inverter pack	Nb. of inverters	3 units	Total Power	75 kWac

PV Array loss factors

Array Soiling Losses			Loss Fraction	3.0 %
Thermal Loss factor	Uc (const)	29.0 W/m²K	Uv (wind)	0.0 W/m²K / m/s
Wiring Ohmic Loss	Global array res.	52 mOhm	Loss Fraction	1.5 % at STC
LID - Light Induced Degradation			Loss Fraction	2.5 %
Module Quality Loss			Loss Fraction	2.0 %
Module Mismatch Losses			Loss Fraction	1.0 % at MPP

Incidence effect (IAM): User defined IAM profile

10°	20°	30°	40°	50°	60°	70°	80°	90°
0.998	0.998	0.995	0.992	0.986	0.970	0.917	0.763	0.000

System loss factors

Wiring Ohmic Loss	Wires: 3x50.0 mm²	138 m	Loss Fraction	2.8 % at STC
Unavailability of the system	34.0 days, 4 periods		Time fraction	9.3 %

Grid-Connected System: Simulation parameters (continued)

User's needs : Unlimited load (grid)

Near Shading Definition

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Grid-Connected System: Near shading definition

Project : **Akzo Nobel Pakistan**

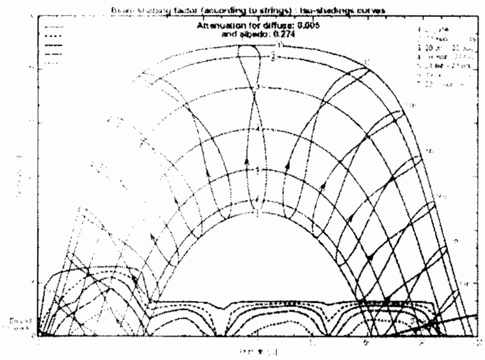
Simulation variant : **area 31 a**

Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	2 orientations	Tilt/Azimuth = 8°/-20° and 8°/160°		
PV modules	Model	CS6U - 330P	Pnom	330 Wp
PV Array	Nb. of modules	90	Pnom total	**29.70 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
User's needs	Unlimited load (grid)			

Perspective of the PV-field and surrounding shading scene

Iso-shadings diagram

Akzo Nobel Pakistan



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Grid-Connected System: Near shading definition

Project : Akzo Nobel Pakistan

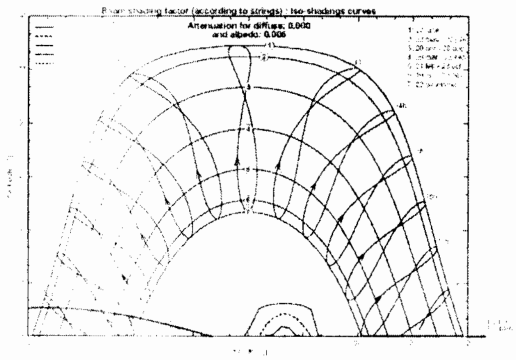
Simulation variant : area 31 b

Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	2 orientations	Tilt/Azimuth = 8°/70° and 8°/-110°		
PV modules	Model	CS6U - 330P	Pnom	330 Wp
PV Array	Nb. of modules	68	Pnom total	**22.44 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
User's needs	Unlimited load (grid)			

Perspective of the PV-field and surrounding shading scene

Iso-shadings diagram

Akzo Nobel Pakistan



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Grid-Connected System: Near shading definition

Project : Akzo Nobel Pakistan

Simulation variant : fg & new fg

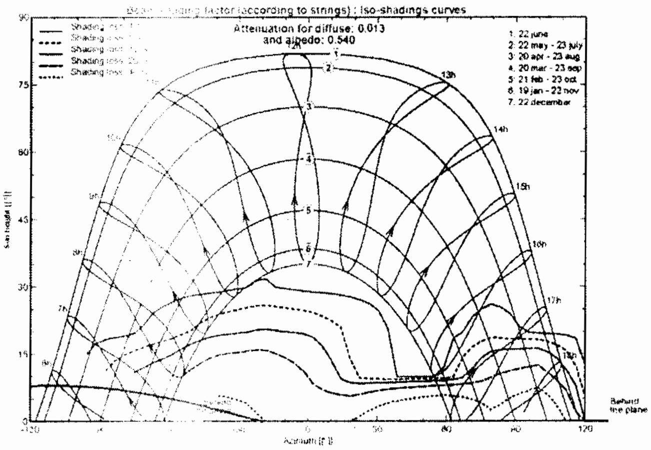
Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	2 orientations	Tilt/Azimuth = 8°/70° and 8°/-110°		
PV modules	Model	CS6U - 330P	Pnom	330 Wp
PV Array	Nb. of modules	150	Pnom total	**49.5 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
Inverter pack	Nb. of units	2.0	Pnom total	**50.0 kW ac**
User's needs	Unlimited load (grid)			

Perspective of the PV-field and surrounding shading scene

South

Iso-shadings diagram

Akzo Nobel Pakistan



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Grid-Connected System: Near shading definition

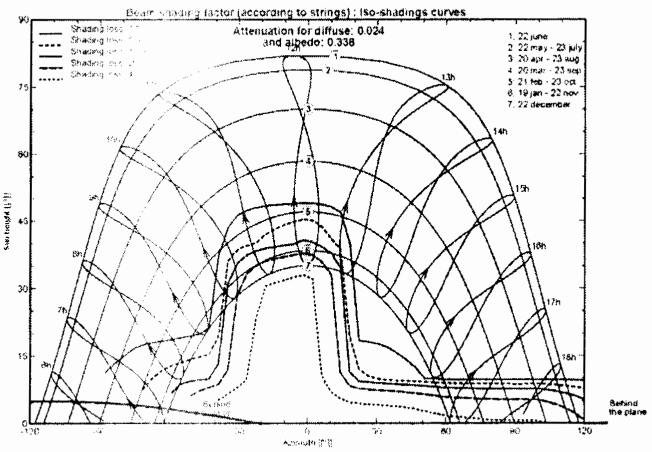
Project : Akzo Nobel Pakistan

Simulation variant : AkzoNobel Parking

Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	2 orientations	Tilt/Azimuth = 5°/70° and 5°/-110°		
PV modules	Model	CS6U - 330P	Pnom	330 Wp
PV Array	Nb. of modules	810	Pnom total	**267 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
Inverter pack	Nb. of units	9.0	Pnom total	**225 kW ac**
User's needs	Unlimited load (grid)			

Iso-shadings diagram

Akzo Nobel Pakistan



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Grid-Connected System: Near shading definition

Project : **Akzo Nobel Pakistan**

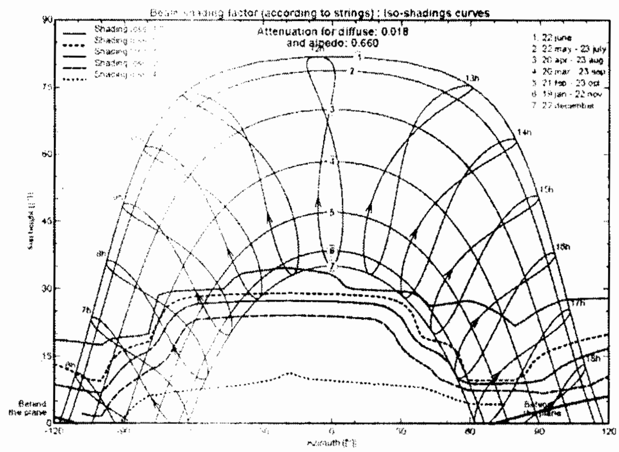
Simulation variant : **Prodcution hall**

Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	tilt	8°	azimuth	-20°
PV modules	Model	CS6U - 330P	Pnom	330 Wp
PV Array	Nb. of modules	270	Pnom total	**89.1 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
Inverter pack	Nb. of units	3.0	Pnom total	**75.0 kW ac**
User's needs	Unlimited load (grid)			

Perspective of the PV-field and surrounding shading scene

Iso-shadings diagram

Akzo Nobel Pakistan



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Losses

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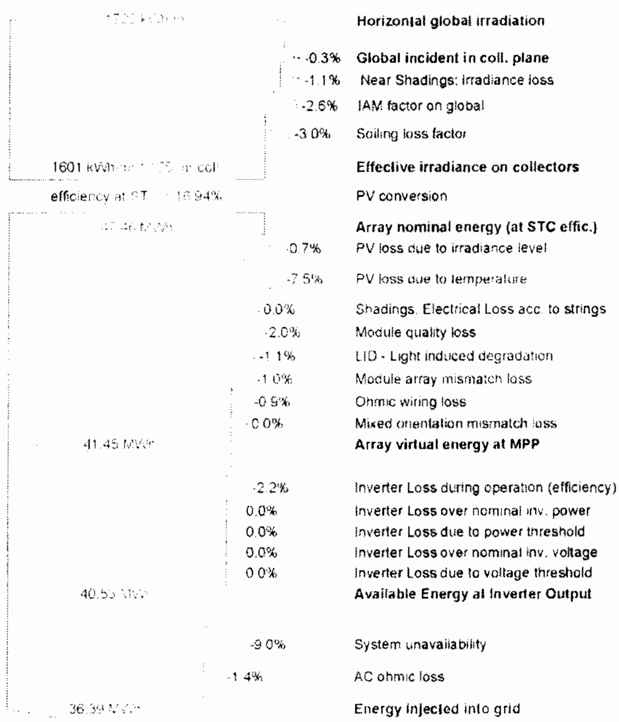
Grid-Connected System: Loss diagram

Project : Akzo Nobel Pakistan

Simulation variant : area 31 a

Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	2 orientations	Tilt/Azimuth = 8°/-20° and 8°/160°		
PV modules	Model	CS6U - 330P	Pnom	330 Wp
PV Array	Nb. of modules	90	Pnom total	**29.70 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
User's needs	Unlimited load (grid)			

Loss diagram over the whole year



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Grid-Connected System: Loss diagram

Project :	Akzo Nobel Pakistan
Simulation variant :	area 31 b

Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	2 orientations	Tilt/Azimuth = 8°/70° and 8°/-110°		
PV modules	Model	CS6U - 330P	Pnom	330 Wp
PV Array	Nb. of modules	68	Pnom total	**22.44 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
User's needs	Unlimited load (grid)			

Loss diagram over the whole year

[illegible] kWh/m²		**Horizontal global irradiation**
	-0.3%	**Global incident in coll. plane**
	-0.2%	Near Shadings: irradiance loss
	-2.7%	IAM factor on global
	-3.0%	Soiling loss factor
1615 kWh/m² * [illegible] m² coll.		**Effective irradiance on collectors**
efficiency at STC = 16.94%		PV conversion
36.18 MWh		**Array nominal energy (at STC effic.)**
	-0.7%	PV loss due to irradiance level
	-7.6%	PV loss due to temperature
	0.0%	Shadings: Electrical Loss acc. to strings
	-2.0%	Module quality loss
	-2.5%	LID - Light induced degradation
	-1.0%	Module array mismatch loss
	-0.9%	Ohmic wiring loss
	0.0%	Mixed orientation mismatch loss
31.1[illegible] MWh		**Array virtual energy at MPP**
	-2.0%	Inverter Loss during operation (efficiency)
	0.0%	Inverter Loss over nominal inv. power
	0.0%	Inverter Loss due to power threshold
	0.0%	Inverter Loss over nominal inv. voltage
	0.0%	Inverter Loss due to voltage threshold
30.54 MWh		**Available Energy at Inverter Output**
	-9.0%	System unavailability
27.60 MWh		**Energy injected into grid**

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Grid-Connected System: Loss diagram

Project : Akzo Nobel Pakistan

Simulation variant : fg & new fg

Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	2 orientations	Tilt/Azimuth = 8°/70° and 8°/-110°		
PV modules	Model	CS6U - 330P	Pnom	330 Wp
PV Array	Nb. of modules	150	Pnom total	**49.5 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
Inverter pack	Nb. of units	2.0	Pnom total	**50.0 kW ac**
User's needs	Unlimited load (grid)			

Loss diagram over the whole year

1720 kWh/m² — **Horizontal global irradiation**

-0.3% — **Global incident in coll. plane**

-0.7% — Near Shadings: irradiance loss

-2.6% — IAM factor on global

-3.0% — Soiling loss factor

1608 kWh/m² — **Effective irradiance on collectors**

efficiency at STC = 16.94% — PV conversion

79.5 MWh — **Array nominal energy (at STC effic.)**

-0.7% — PV loss due to irradiance level

-10.2% — PV loss due to temperature

0.0% — Shadings: Electrical Loss acc. to strings

-2.0% — Module quality loss

-2.5% — LID - Light induced degradation

-1.0% — Module array mismatch loss

-0.8% — Ohmic wiring loss

0.0% — Mixed orientation mismatch loss

66.4 MWh — **Array virtual energy at MPP**

-2.3% — Inverter Loss during operation (efficiency)

0.0% — Inverter Loss over nominal inv. power

0.0% — Inverter Loss due to power threshold

0.0% — Inverter Loss over nominal inv. voltage

0.0% — Inverter Loss due to voltage threshold

64.9 MWh — **Available Energy at Inverter Output**

-9.0% — System unavailability

-1.2% — AC ohmic loss

58.4 MWh — **Energy injected into grid**

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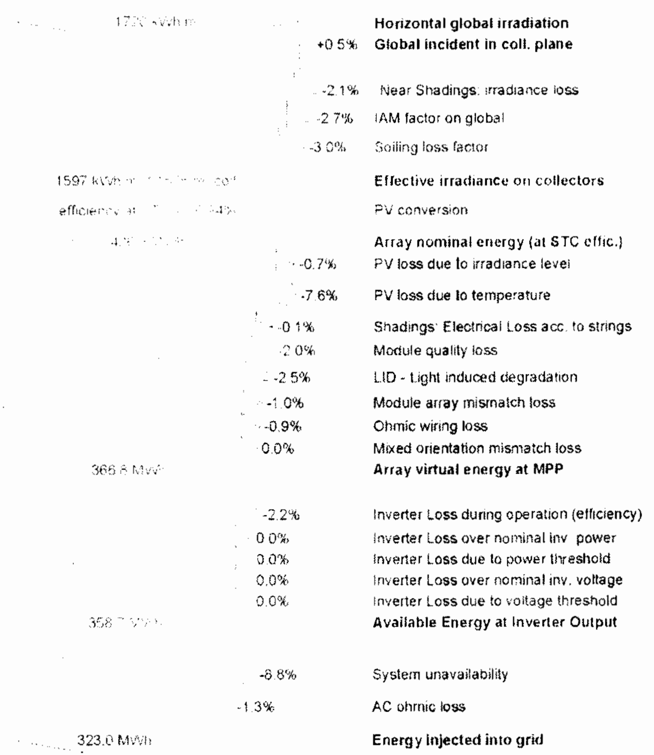
Grid-Connected System: Loss diagram

Project : Akzo Nobel Pakistan

Simulation variant : AkzoNobel Parking

Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	2 orientations	Tilt/Azimuth = 5°/70° and 5°/-110°		
PV modules	Model	CS6U - 330P	Pnom	330 Wp
PV Array	Nb. of modules	810	Pnom total	**267 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
Inverter pack	Nb. of units	9.0	Pnom total	**225 kW ac**
User's needs	Unlimited load (grid)			

Loss diagram over the whole year



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Grid-Connected System: Loss diagram

Project : Akzo Nobel Pakistan

Simulation variant : Prodcution hall

Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	tilt	8°	azimuth	-20°
PV modules	Model	CS6U - 330P	Pnom	330 Wp
PV Array	Nb. of modules	270	Pnom total	**89.1 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
Inverter pack	Nb. of units	3.0	Pnom total	**75.0 kW ac**
User's needs	Unlimited load (grid)			

Loss diagram over the whole year

1720 kWh/m²		**Horizontal global irradiation**
	+4.7%	**Global incident in coll. plane**
	-1.1%	Near Shadings: irradiance loss
	-2.4%	IAM factor on global
	-3.0%	Soiling loss factor
1686 kWh/m² [illegible] coll		**Effective irradiance on collectors**
efficiency at [illegible]		PV conversion
[illegible]		**Array nominal energy (at STC effic.)**
	-0.6%	PV loss due to irradiance level
	-7.6%	PV loss due to temperature
	-0.4%	Shadings: Electrical Loss acc. to strings
	-2.0%	Module quality loss
	-2.5%	LID - Light induced degradation
	-1.0%	Module array mismatch loss
	-0.9%	Ohmic wiring loss
128641 kW		**Array virtual energy at MPP**
	-2.2%	Inverter Loss during operation (efficiency)
	0.0%	Inverter Loss over nominal inv. power
	0.0%	Inverter Loss due to power threshold
	0.0%	Inverter Loss over nominal inv. voltage
	0.0%	Inverter Loss due to voltage threshold
125785 [illegible]		**Available Energy at Inverter Output**
	-8.6%	System unavailability
	-1.3%	AC ohmic loss
1135[illegible]		**Energy injected into grid**

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Simulation Results

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Grid-Connected System: Main results

Project : **Akzo Nobel Pakistan**

Simulation variant : **area 31 a**

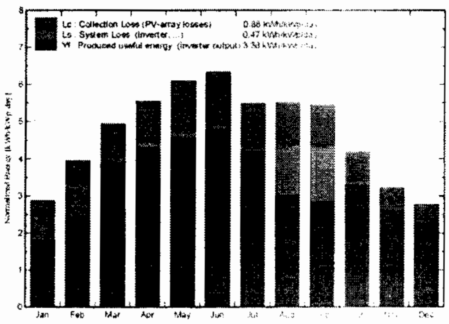
Main system parameters — System type: **Grid-Connected**

Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	2 orientations	Tilt/Azimuth = 8°/-20° and 8°/160°		
PV modules	Model	CS6U - 330P	Pnom	330 Wp
PV Array	Nb. of modules	90	Pnom total	**29.70 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
User's needs	Unlimited load (grid)			

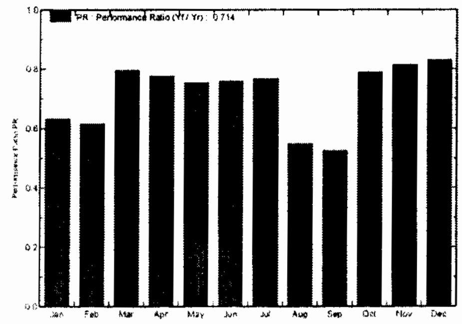
Main simulation results

System Production	Produced Energy	**36.39 MWh/year**	Specific prod.	1225 kWh/kWp/year
	Performance Ratio PR	71.45 %		

Normalized productions (per installed kWp): Nominal power 29.70 kWp



Performance Ratio PR



area 31 a

Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_Grid MWh	PR
January	89.4	[illegible]	11.37	89.1	82.4	2.291	1.675	0.633
February	[illegible]	[illegible]	15.72	110.8	103.4	2.801	2.027	0.816
March	[illegible]	[illegible]	[illegible]	153.0	143.1	3.752	3.616	0.796
April	[illegible]	[illegible]	26.71	166.6	155.7	3.990	3.844	0.777
May	[illegible]	[illegible]	32.34	189.1	177.1	4.402	4.234	0.754
June	[illegible]	[illegible]	32.14	189.9	178.0	4.450	4.280	0.759
July	[illegible]	[illegible]	30.80	170.2	158.6	4.029	3.883	0.768
August	[illegible]	[illegible]	[illegible]	171.1	156.7	4.073	2.785	0.548
September	[illegible]	[illegible]	[illegible]	163.2	152.6	3.911	2.548	0.526
October	[illegible]	[illegible]	[illegible]	129.8	121.0	3.153	3.045	0.790
November	[illegible]	[illegible]	[illegible]	96.7	89.5	2.418	[illegible]	0.815
December	[illegible]	[illegible]	[illegible]	85.7	79.1	2.182	2.115	0.831
Year	[illegible]	[illegible]	[illegible]	1715.0	1600.6	41.450	[illegible]	0.714

Legends:	GlobHor	[illegible]	GlobEff	Effective Global, corr. for IAM and shadings
	DiffHor	[illegible]	EArray	Effective energy at the output of the array
	T Amb	[illegible]	E_Grid	Energy injected into grid
	GlobInc	[illegible]	PR	Performance Ratio

ShamsPower

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Grid-Connected System: Main results

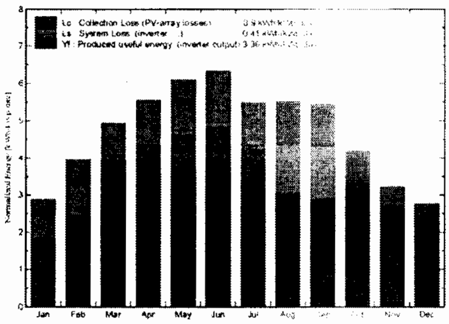
Project : Akzo Nobel Pakistan

Simulation variant : area 31 b

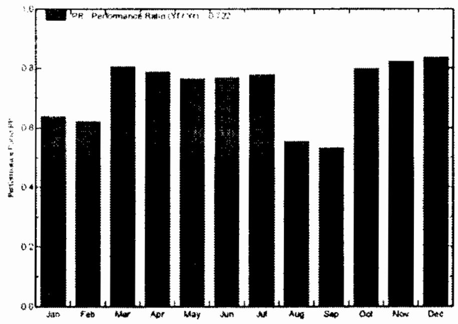
Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	2 orientations	Tilt/Azimuth = 8°/70° and 8°/-110°		
PV modules	Model	CS6U - 330P	Pnom	330 Wp
PV Array	Nb. of modules	68	Pnom total	**22.44 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
User's needs	Unlimited load (grid)			

Main simulation results				
System Production	Produced Energy	**27.80 MWh/year**	Specific prod.	1239 kWh/kWp/year
	Performance Ratio PR	72.23 %		

Normalized productions (per installed kWp): Nominal power 22.44 kWp



Performance Ratio PR



area 31 b

Balances and main results

	GlobHor	DiffHor	T Amb	GlobInc	GlobEff	EArray	E_Grid	PR
	kWh/m²	kWh/m²	°C	kWh/m²	kWh/m²	MWh	MWh	
January	89.4	[illegible]	[illegible]	89.1	83.2	1.725	1.275	0.638
February	[illegible]	[illegible]	[illegible]	110.8	104.1	2.103	1.544	0.621
March	[illegible]	[illegible]	[illegible]	153.1	144.4	2.821	2.766	0.805
April	[illegible]	[illegible]	[illegible]	166.6	157.1	2.999	2.941	0.787
May	[illegible]	[illegible]	[illegible]	189.1	178.6	3.305	3.238	0.763
June	[illegible]	[illegible]	[illegible]	189.9	179.5	3.344	3.276	0.769
July	170.9	[illegible]	[illegible]	170.2	160.3	3.030	2.969	0.778
August	[illegible]	[illegible]	[illegible]	171.1	161.2	3.062	2.130	0.555
September	163.6	[illegible]	28.12	163.2	154.1	2.939	1.949	0.532
October	[illegible]	[illegible]	24.66	129.8	122.0	2.368	2.322	0.797
November	96.9	[illegible]	17.89	96.7	90.4	1.818	1.733	0.821
December	85.9	[illegible]	13.26	85.7	79.8	1.641	1.607	0.835
Year	1720.1	[illegible]	23.76	1715.3	1614.8	31.155	27.802	0.722

Legends:			
GlobHor	[illegible]	GlobEff	Effective Global, corr. for IAM and shadings
DiffHor	[illegible]	EArray	Effective energy at the output of the array
T Amb	[illegible]	E_Grid	Energy injected into grid
GlobInc	[illegible]	PR	Performance Ratio

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Grid-Connected System: Main results

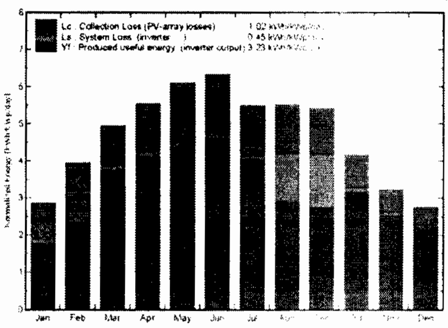
Project : **Akzo Nobel Pakistan**

Simulation variant : **fg & new fg**

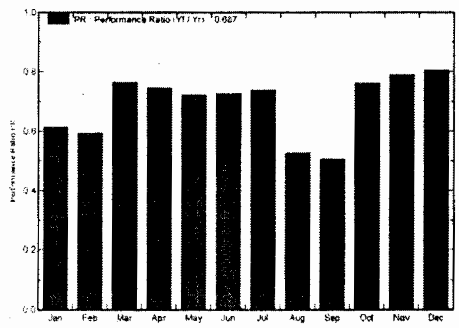
Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	2 orientations	Tilt/Azimuth = 8°/70° and 8°/-110°		
PV modules	Model	CS6U - 330P	Pnom	330 Wp
PV Array	Nb. of modules	150	Pnom total	**49.5 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
Inverter pack	Nb. of units	2.0	Pnom total	**50.0 kW ac**
User's needs	Unlimited load (grid)			

Main simulation results				
System Production	Produced Energy	**58.36 MWh/year**	Specific prod.	1179 kWh/kWp/year
	Performance Ratio PR	68.73 %		

Normalized productions (per installed kWp): Nominal power 49.5 kWp



Performance Ratio PR



fg & new fg

Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_Grid MWh	PR
January	89.4	44.6	11.37	89.1	82.7	3.709	2.709	0.614
February	111.1	[illegible]	15.72	110.8	103.7	4.504	3.252	0.593
March	153.4	64.8	21.48	153.1	143.8	6.009	5.796	0.765
April	167.1	56.4	26.71	166.6	156.5	6.382	6.153	0.746
May	189.7	[illegible]	32.34	189.1	178.0	7.013	6.751	0.721
June	190.5	99.5	32.14	189.9	178.9	7.098	6.832	0.727
July	170.9	[illegible]	30.90	170.2	159.7	6.455	6.224	0.739
August	171.7	[illegible]	30.32	171.1	160.6	6.521	4.461	0.527
September	163.6	[illegible]	[illegible]	163.2	153.5	6.253	4.086	0.506
October	130.2	64.7	24.66	129.8	121.5	5.064	4.893	0.761
November	96.9	46.4	17.39	96.7	90.0	3.905	3.783	0.790
December	85.9	42.0	13.28	85.7	79.3	3.527	3.419	0.806
Year	1720.1	871.4	23.78	1715.3	1608.2	66.440	58.358	0.687

Legends:				
	GlobHor	Horizontal global irradiation	GlobEff	Effective Global, corr. for IAM and shadings
	DiffHor	Horizontal diffuse irradiation	EArray	Effective energy at the output of the array
	T Amb	Ambient Temperature	E_Grid	Energy injected into grid
	GlobInc	Global incident in coll. plane	PR	Performance Ratio

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Grid-Connected System: Main results

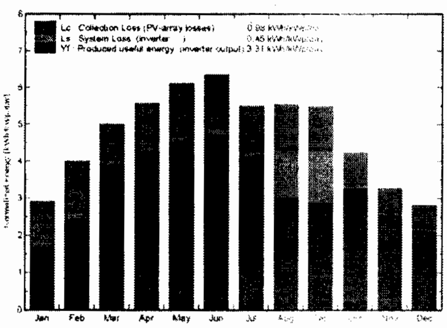
Project : **Akzo Nobel Pakistan**

Simulation variant : **AkzoNobel Parking**

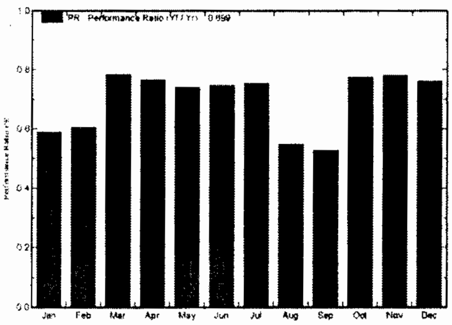
Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	2 orientations	Tilt/Azimuth = 5°/70° and 5°/-110°		
PV modules	Model	CS6U - 330P	Pnom	330 Wp
PV Array	Nb. of modules	810	Pnom total	**267 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
Inverter pack	Nb. of units	9.0	Pnom total	**225 kW ac**
User's needs	Unlimited load (grid)			

Main simulation results				
System Production	Produced Energy	323.0 MWh/year	Specific prod.	1208 kWh/kWp/year
	Performance Ratio PR	69.89 %		

Normalized productions (per installed kWp): Nominal power 267 kWp



Performance Ratio PR



AkzoNobel Parking

Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_Grid MWh	PR
January	89.4	44.6	11.37	90.6	79.8	19.68	14.27	0.589
February	111.1	44.7	15.72	112.1	103.6	24.90	16.14	0.605
March	153.4	64.3	21.48	155.0	144.9	33.70	32.50	0.784
April	167.1	86.4	26.71	167.3	156.1	35.49	34.20	0.765
May	189.7	97.4	32.34	189.6	177.2	39.08	37.61	0.742
June	190.5	99.5	32.14	190.6	178.2	39.54	38.05	0.747
July	170.9	[illegible]	30.90	170.2	158.3	35.64	34.37	0.756
August	171.7	100.3	30.02	171.9	160.1	36.22	25.16	0.547
September	163.6	[illegible]	28.12	164.5	153.8	34.91	23.18	0.527
October	130.2	64.7	24.66	131.3	121.9	28.16	27.21	0.775
November	96.9	44.4	17.89	98.5	88.6	21.19	20.53	0.780
December	85.9	42.0	13.26	87.3	75.0	18.31	17.77	0.761
Year	1720.1	871.4	23.78	1728.8	1597.4	366.83	322.97	0.699

Legends:	GlobHor	Horizontal global irradiation	GlobEff	Effective Global, corr. for IAM and shadings
	DiffHor	Horizontal diffuse irradiation	EArray	Effective energy at the output of the array
	T Amb	Ambient Temperature	E_Grid	Energy injected into grid
	GlobInc	Global incident in coll. plane	PR	Performance Ratio

Grid-Connected System: Main results

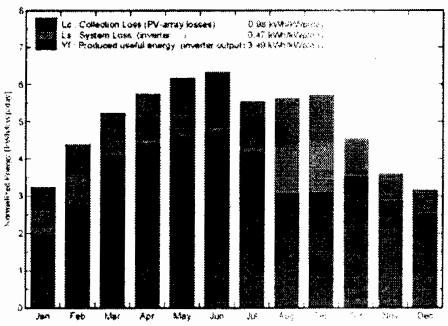
Project : Akzo Nobel Pakistan

Simulation variant : Prodcution hall

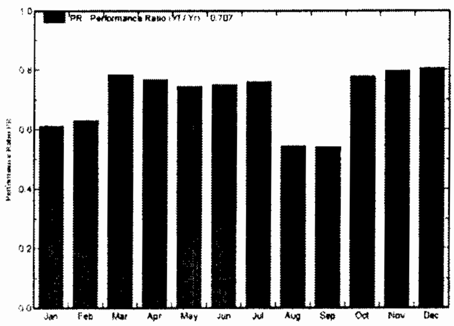
Main system parameters	System type	**Grid-Connected**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	tilt	8°	azimuth	-20°
PV modules	Model	CS6U - 330P	Pnom	330 Wp
PV Array	Nb. of modules	270	Pnom total	**89.1 kWp**
Inverter	Model	Sunny Tripower 25000TL-30		25.00 kW ac
Inverter pack	Nb. of units	3.0	Pnom total	**75.0 kW ac**
User's needs	Unlimited load (grid)			

Main simulation results				
System Production	Produced Energy	**113518 kWh/year**	Specific prod.	1274 kWh/kWp/year
	Performance Ratio PR	70.73 %		

Normalized productions (per installed kWp): Nominal power 89.1 kWp



Performance Ratio PR



Prodcution hall

Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray kWh	E_Grid kWh	PR
January	89.4	44.6	[illegible]	100.2	93.2	7532	5468	0.613
February	111.1	44.7	16.72	122.5	114.9	9140	6886	0.631
March	153.4	[illegible]	21.48	162.1	152.2	11751	11327	0.784
April	167.1	[illegible]	26.71	172.1	161.3	12200	11762	0.767
May	189.7	[illegible]	32.34	191.2	179.4	13173	12683	0.745
June	190.5	99.5	32.14	189.8	178.2	13174	12686	0.750
July	170.9	[illegible]	30.90	171.4	160.3	12019	11592	0.759
August	171.7	[illegible]	30.32	174.5	163.3	12291	8458	0.544
September	163.6	[illegible]	28.12	171.3	160.9	12137	8249	0.541
October	130.2	[illegible]	24.66	140.5	131.5	10075	9731	0.777
November	96.9	[illegible]	17.89	107.8	100.4	7906	7655	0.797
December	85.9	[illegible]	13.26	97.7	90.6	7244	7019	0.806
Year	1720.1	[illegible]	23.78	1801.3	1686.3	128641	113518	0.707

Legends:			
GlobHor	Horizontal global irradiation	GlobEff	Effective Global, corr. for IAM and shadings
DiffHor	Horizontal diffuse irradiation	EArray	Effective energy at the output of the array
T Amb	Ambient Temperature	E_Grid	Energy injected into grid
GlobInc	Global incident in coll. plane	PR	Performance Ratio

Financial Analysis

Cost/watt: **USD 1.2**

Total Project Cost for 458.04 KWp (DC) Solar PV System: **USD 549,648**

Equity: **100%**

Debt: **0%**

Safety and Emergency Plans

- Only qualified and authorized electricians will be allowed to undertake servicing or maintenance tasks.
- The authorized personnel will wear appropriate equipment, including a safety harness to restrain from falling off the roof, sturdy shoes that will have thick rubber soles to provide electrical insulation and good grip and appropriate clothing for personal protection, including a hat, sunglasses, gloves and long pants and sleeves
- Lock out and tag out procedures will be used before commencement of maintenance tasks.
- On-going operation and maintenance concerns for solar power systems will be addressed properly. These systems are exposed to outdoor weather conditions that enhance the aging process, and the infrastructure needs to be in place for the on-going maintenance of these systems to assure their safe operation.
- Properly grounded or double insulated power tools will be used for maintenance tasks. Tools will be maintained in good condition.
- Working on electrical equipment and circuits will be carried out in de energized state.
- Proper pathways will be available for operation, maintenance and firefighting.
- Fire protection and suppression will be placed at site

Training and Capacity Development

Trained and qualified personnel will be available at site 24/7 with proper safety and firefighting training. Training program will focus on but not limited to Solar Resource Assessment, Site Survey, Technology, Engineering Design, Regulation, Policy, Metering & Billing, and Project Management of Rooftop Solar System. The following components will include in training and development program.

a. Collection of Resource Data
b. Variability and uncertainty of resource data
c. Site evaluation
d. Crystalline and Thin film technology comparison
e. Rooftop solar system components
f. Module mounting structure selection
g. Inverter selection
h. Design of PV Array
i. Shadow Analysis
j. DC cable sizing
k. DC cable layout
l. Protection and Metering
m. Installation and testing standards for solar PV plants
n. Solar Module testing standards
o. Economy of Roof top Solar System
p. Detailed Project Report
q. Operation and maintenance of rooftop solar system
r. Safety and firefighting training

Environmental Aspects

Every energy generation and transmission method affects the environment. Conventional generating options can damage air, climate, water, land and wildlife, landscape as well as raise the levels of harmful radiation. PV technology is substantially safer offering a solution to many environmental and social problems associated with fossil and nuclear fuels. Solar PV energy technology provides obvious environmental advantages in comparison to the conventional energy sources thus contributing to the sustainable development of human activities. Not counting the depletion of the exhausted natural resources, their main advantage is related to the reduced CO2 emissions and normally absence of any air emissions or waste products during their operation.

The use of solar power has additional positive implications such as:

- Reduction of the emissions of the greenhouse gases (mainly CO2, NOx) and prevention of toxic gas emissions (SO2,particulates)
- Reduction of the required transmission lines of the electricity grids

Socio-Economic Aspects

In regard to the socio-economic viewpoint, the benefits of exploitation of solar PV system comprise of:

- Increase of the regional/national energy independency
- Provision of significant work opportunities
- Diversification and security of energy supply
- Support of the deregulation of energy markets

Conclusion

This feasibility study is conducted to ascertain the technical feasibility and commercial viability of installation of 400kW (AC) rooftop PV system installation at Akzonobel, Lahore.

Installation of the PV system will result in annual power generation of 559,040 kWh.

The results of the financial analysis indicate that the project is feasible.

Based on the outcomes of both the technical and financial analysis, the project is deemed to be viable.