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 Procedu. a) 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 documentsin-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

Usman Hamid Malik

Chief Executive Officer

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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

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TRUE COPY OF THE RESOLUTION OF BOARD OF DIRECTORS SHAMSPOWER (PRIVATE) LIMITED

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 9^{th} 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

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



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

í,

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.



Annel

Company Secretary

Stamp of the Company



AFFIDAVIT

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

ATTEST M. ABID ADV A LAHORE





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



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.



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).



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				
February				
March				
April	Energies and the second se			
May	678-678-678-678-678-678-678-678-678-678-			
June	6y.or/2016			
July	24:836			

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





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.



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 <u>(Schedule I and Schedule II)</u> 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.

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

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



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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)

Single Line Diagram AC Side



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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	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	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). <u>Technical Details of Equipment</u>

(a).	Solar Panels-PV Modules		
(i).	Type of Module	Polycrystalline PV Ty CS6P-260P	pe Module
(ii).	Surface Area of Module	1.605240 m²	
(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	
		For 1 st Year	For 2 nd Year to 25 th Year
(viii).	Module output warranty	97.5% or above	Not more than 0.7% output reduction each year
(ix).	Number of Solar Cells in each Module	60 Cells	Lenner, ,
(X).	Efficiency of Module	16.16 %	. <u>.</u>
(xi).	Environment Protection System	Encapsulation and s protection from enviro	ealing arrangements for nment.
(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 ∨	
(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	2)	
(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		
		Operating Temperature Range	-25° C to 60° C	
(xvii).	vii). Environmental Enclosures	Relative Humidity	100% non- condensing	
		Audible Noise	51 dB(A)	
		Operating Elevation	<3000m	
(e).	Junction Boxes			
(i).	Number of Junction Box units	6	, <u>, , , , , , , , , , , , , , , , , , </u>	
(ii).	Input circuits in each box	1 box with 2 inputs, 5 box	es with 3 inputs	
(iii).	Max. Input current for each circuit	15 A	15 A	
(iv).	Max. Input voltage	1000 V		
(V).	Power at each box	28kW _p		
(vi).	Protection Level	IP 65	IP 65	
(vii).	Over-Current protection	Fuse		
(viii).	DC Disconnect switch	6		
(ix).	Surge protection	Yes (1000V)		

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(x).	Purpose of Junction Box	(a).	Combining the strings
		(b).	DC Side Protection
(f).	Data Collecting System		
(i).	Weather Data	(a) <i>.</i>	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 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



PV module: Canadian Solar Inc., CS6P - 260P



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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



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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



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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.

(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). <u>Technical Details of Equipment</u>

(a).	Solar Panels-PV Modules			
(i)	Type of Module	Polycrystalline PV Ty	pe Module	
(1).		CS6U-330P		
(ii).	Surface Area of Module	1.94432 m²		
(iii).	Dimension of each Module	1960 mm x 992 mm x	40mm	
(iv)	Total area of roof top for Solar Panels-PV Modules	2100 m²	2100 m ²	
(V).	No. of Modules	1080		
(vi).	Frame of Module	Anodised Aluminium	Alloy	
(vii).	Weight of one Module	22.4 kg	and a second	
	Module Output Warranty	For 1 st Year	For 2 nd Year to 25 th Year	
(viii).		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 %	<u></u>	
(xi).	Environment Protection System	Encapsulation and s protection from enviro	ealing arrangements for onment.	
(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. _{nax})	8.88 A		
(xvi).	Open circuit voltage (V _{oc})	45.6 V	<u></u>	
(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	2 Phase 4 Wire
(//)	Output electrical system	S-Fridse, 4-Wile

(xii).	Rated Frequency	50 Hz		
(xiii).	Power Factor	1		
(xiv).	Power Control	MPP Tracker (2 MPPT/Inverter)		
		Operating Temperature Range -25°		-25° C to 60° C
		Relative Humidi	ity	100% non- condensing
(xv).	Environmental Enclosures	Protection Class	S	IP65
		Audible Noise		51 dB(A)
		Operating Eleva	ation	<3000m
	Protection Devices	(a).	DC Disco	onnect Switch
		(b).	Ground Fault Monitoring	
(xvi)		(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 Stri output	ing inputs	and 1 Combined
(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)	Yes (>1000V)	
(ix).	Purpose of Junction Box	(a).	Combir	ning 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)
		(a).	DC input voltage (V) & current (A) of each Inverter (Phase, Line)
(ii).	System Data	(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

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2. <u>METRO Cash & Carry, Thokkar Niaz Baig,</u> <u>Lahore</u>

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



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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°28'1.18"	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	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, 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

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(C). <u>Technical Details of Equipment</u>

(a).	Solar Panels-PV Modules			
(i)	(i) Type of Medule Polycrystalline PV Type		pe Module	
(1).	l ype of Module	CS6U-330P		
(ii).	Surface Area of Module	1.94432 m²		
(iii).	Dimension of each Module	1960 mm x 992 mm x 40mm		
(iv)	Total area of roof top for Solar Panels-PV Modules	2287 m²		
(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 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	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 Eleve	ation	<3000m
	Protection Devices	(a).	DC Disconnect Switch	
		(b).	Ground Fault Monitoring	
(xvi)		(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	13.86kWp		
(vi).	Protection Level	IP 65 & Fire Protection		
(vii).	Over-Current protection	Fuse		
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(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

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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

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3. <u>METRO Cash & Carry, Airport Road, DHA,</u> <u>Lahore</u>

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



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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	2 nd Floor, Al-Maalik Building 19-Davis Road Lahore	
(iii).	Principal Office	2 nd Floor, Al-Maalik Building 19-Davis Road Lahore	
(i v) .	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) <i>.</i>	Installed Capacity of the Generation Facility (MW)	0.3564 MW _P DC

(C). <u>Technical Details of Equipment</u>

(a).	Solar Panels-PV Modules				
(i).	Type of Module	Polycrystalline PV Type Module CS6U-330P			
(ii).	Surface Area of Module	1.94432 m²			
(iii).	Dimension of each Module	1960 mm x 992 mm x	1960 mm x 992 mm x 40mm		
(iv)	Total area of roof top for Solar Panels-PV Modules	2100 m²			
(v).	No. of Modules	1080			
(vi).	Frame of Module	Anodised Aluminium Alloy			
vii).	Weight of one Module	22.1 kg			
		For 1 st Year	For 2 nd Year to 25 th Year		
(viii).	(viii). Module Output Warranty	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 su protection from enviro	ealing arrangements for nment.		
(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	2 MPPT/In	verter)
		Operating Tem Range	perature	-25° C to 60° C
		Relative Humid	lity	100% non- condensing
(xv).	Environmental Enclosures	Protection Clas	S	IP65
		Audible Noise		51 dB(A)
		Operating Eleve	ation	<3000m
		(a).	DC Disco	onnect Switch
	Protection Devices	(b).	Ground Fault Monitoring	
(xvi)		(C).	Reverse Polarity Protection	
		(d).	Reverse current protection	
		(e).	Over-voltage protection	
(e).	Junction Boxes	dan manana ang sa		
(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	14.85 kW _p	
(vi).	Protection Level	IP 65	IP 65	
(vii).	Over-Current protection	Fuse		
(∨iii).	Surge protection	Yes (>1000V)		

	Purpose of Junction Box	(a).	Combining the strings
(ix).		(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) <i>.</i>	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 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



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

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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



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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



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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





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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	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, 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) <i>.</i>	Type of Cell	Polycrystalline
(ii).	Type of System	Grid Tied
(iii).	Installed Capacity of the Generation Facility (MW)	0.33264 MW _P DC

(C). <u>Technical Details of Equipment</u>

(a).	Solar Panels-PV Modules		
(i).	Type of Module	Polycrystalline PV Type Module CS6U-330P	
(ii).	Surface Area of Module	1.94432 m²	
(iii).	Dimension of each Module	1960 mm x 992 mm x	40mm
(iv)	Total area of roof top for Solar Panels-PV Modules	1960 m²	
(v).	No. of Modules	1008	
(vi).	Frame of Module	Anodised Aluminium Alloy	
(∨ii).	Weight of one Module	22.4 kg	
		For 1 st Year	For 2 nd Year to 25 th Year
(viii).	(viii). Module Output Warranty	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

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(xi).	Rated Output Voltage	AC 230/400 V	AC 230/400 V	
(xii).	Rated Frequency	50 Hz	50 Hz	
(xiii).	Power Factor	1	1	
(xiv).	Power Control	MPP Tracker (2 MPPT/Inverter)		
		Operating Tem Range	perature	-25° C to 60° C
		Relative Humid	lity	100% non- condensing
(xv).	Environmental Enclosures	Protection Clas	S	IP65
		Audible Noise		51 dB(A)
		Operating Elev	ation	<3000m
		(a).	DC Disco	onnect Switch
(xvi)	Protection Devices	(b).	Ground Fault Monitoring	
		(c).	Reverse Polarity Protection	
		(d).	Reverse	current protection
		(e).	Over-vol	tage 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	15 A	
(iv).	Max. Input voltage	1000 V	1000 V	
(V).	Power at each box	13.86kWp	13.86kW _p	
(vi).	Protection Level	IP 65	IP 65	
(vii).	Over-Current protection	Fuse	Fuse	
(viii).	DC Disconnect switch	3 per DC Box (on +ve side only)		

(ix).	Surge protection	Yes (>1000V)	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) <i>.</i>	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



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

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5. <u>METRO Cash & Carry, Model Town,</u> <u>Lahore</u>

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



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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



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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



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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). <u>General Information</u>

(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, 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). <u>Technical Details of Equipment</u>

(a).	Solar Panels-PV Modules		
(i).	Type of Module	Polycrystalline PV Type Module CS6U-330P	
(ii).	Surface Area of Module	1.94432 m²	
(iii).	Dimension of each Module	1960 mm x 992 mm x	40mm
(iv)	Total area of roof top for Solar Panels-PV Modules	1470 m²	
(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 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 su protection from enviro	ealing arrangements for nment.
(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	

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(xviii).	Optimum Operating Voltage at NOCT	33.9 ∨	
(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	
(i v).	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	

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

	Purpose of Junction Box	(a).	Combining the strings	
(ix).		(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)	
	System Data	(a).	DC input voltage (V) & current (A) of each Inverter (Phase, Line)	
		(b).	Total DC power (kW) generated by PV array.	
(ii).		(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>

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(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



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



6. <u>METRO Cash & Carry, Sargodha Road,</u> <u>Faisalabad</u>

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



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



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

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	2 nd Floor, Al-Maalik Building 19-Davis Road Lahore
(iii) <i>.</i>	Principal Office	2 nd 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). <u>Technical Details of Equipment</u>

(a).	Solar Panels-PV Modules		
(i).	Type of Module	Polycrystalline PV Type Module CS6U-330P	
(ii).	Surface Area of Module	1.94432 m²	
(iii).	Dimension of each Module	1960 mm x 992 mm x	40mm
(iv)	Total area of roof top for Solar Panels-PV Modules	1750 m²	
(V).	No. of Modules	900	
(vi).	Frame of Module	Anodised Aluminium	Alloy
(vii).	Weight of one Module	22.4 kg	
	Module Output Warranty	For 1 st Year	For 2 nd Year to 25 th Year
(viii).		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	50 Hz	
(xiii).	Power Factor	1		
(xiv).	Power Control	MPP Tracker (2	MPP Tracker (2 MPPT/Inverter)	
		Operating Tem Range	perature	-25° C to 60° C
		Relative Humid	lity	100% non- condensing
(xv).	Environmental Enclosures	Protection Clas	S	IP65
		Audible Noise		51 dB(A)
		Operating Elev	ation	<3000m
		(a).	DC Disco	onnect Switch
		(b).	Ground I	ault Monitoring
(xvi)	Protection Devices	(c).	Reverse	Polarity Protection
		(d).	Reverse	current protection
		(e).	Over-vol	tage 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		and 1 Combined
(iii).	Max. Input current for each circuit	15 A	15 A	
(iv).	Max. Input voltage	1000 V	1000 V	
(V).	Power at each box	14.85kW _p	14.85kWp	
(vi).	Protection Level	IP 65		
(vii).	Over-Current protection	Fuse	Fuse	
(viii).	Surge protection	Yes (>1000V)		

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	(ix). Purpose of Junction Box	(a).	Combining the strings
(ix).		(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)
	System Data	(a).	DC input voltage (V) & current (A) of each Inverter (Phase, Line)
		(b).	Total DC power (kW) generated by PV array.
(ii).		(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



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

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7. <u>METRO Cash & Carry, Manghopir Road,</u> <u>Karachi</u>

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



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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



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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	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, 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). <u>Technical Details of Equipment</u>

(a).	Solar Panels-PV Modules			
(i).	Type of Module	Polycrystalline PV Typ CS6U-330P	be Module	
(ii).	Surface Area of Module	1.94432 m²	1.94432 m²	
(iii).	Dimension of each Module	1960 mm x 992 mm x	40mm	
(iv)	Total area of roof top for Solar Panels-PV Modules	1400 m²		
(v).	No. of Modules	720		
(vi).	Frame of Module	Anodised Aluminium	Alloy	
(vii).	Weight of one Module	22.4 kg		
		For 1 st Year	For 2 nd Year to 25 th Year	
(∨iii).	(viii). Module Output Warranty	97.5% or above	Not more than 0.7% output reduction each year	
(ix).	Number of Solar Cells in each Module	72 Cells	L	
(x).	Efficiency of Module	16.97 %		
(xi).	Environment Protection System	Encapsulation and s protection from enviro	ealing arrangements for nment.	
(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 (Voc.)	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	50 Hz	
(xiii).	Power Factor	1		
(xiv).	Power Control	MPP Tracker (2 MPPT/Inverter)		
		Operating Tem Range	perature	-25° C to 60° C
		Relative Humid	lity	100% non- condensing
(xv).	Environmental Enclosures	Protection Clas	S	IP65
		Audible Noise		51 dB(A)
		Operating Eleve	ation	<3000m
		(a).	DC Disc	onnect Switch
		(b).	Ground	Fault Monitoring
(xvi)	Protection Devices	(c).	Reverse Polarity Protection	
		(d).	Reverse current protection	
		(e).	Over-voltage protection	
(e).	Junction Boxes	- fenne		
(i).	Number of Junction Box units	16		
(ii).	Input circuits in each box	1 box with 3 Str output	ring inputs	and 1 Combined
(iii).	Max. Input current for each circuit	15 A		
(iv).	Max. Input voltage	1000 V		
(V).	Power at each box	14.85 kWp	14.85 kW _p	
(vi).	Protection Level	IP 65		
(vii).	Over-Current protection	Fuse	Fuse	
(viii).	Surge protection	Yes (>1000V)	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	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

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8. <u>METRO Cash & Carry, Near Stargate,</u> <u>Karachi</u>

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



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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



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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



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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	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, 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). <u>Technical Details of Equipment</u>

(a).	Solar Panels-PV Modules		
(i).	Type of Module	Polycrystalline PV Type Module CS6U-330P	
(ii).	Surface Area of Module	1.94432 m²	
(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	
		For 1 st Year	For 2 nd Year to 25 th Year
(viii).	(viii). Module Output Warranty	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 ∨	
(xvii).	Short circuit current (I _{sc})	9.45 A	

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(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	MPP Tracker (2 MPPT/Inverter)	
		Operating Tem Range	perature	-25° C to 60° C
		Relative Humid	ity	100% non- condensing
(xv).	Environmental Enclosures	Protection Clas	S	IP65
		Audible Noise		51 dB(A)
		Operating Eleva	ation	<3000m
		(a).	DC Disco	onnect Switch
		(b).	Ground I	Fault Monitoring
(xvi)	Protection Devices	(c).	Reverse	Polarity Protection
		(d). Reverse current p (e). Over-voltage prot		current protection
				tage 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)
	System Data	(a).	DC input voltage (V) & current (A) of each Inverter (Phase, Line)
		(b).	Total DC power (kW) generated by PV array.
(ii). Syst		(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	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



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

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9. <u>METRO Cash & Carry, Near Safari Park,</u> <u>Karachi</u>

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



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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



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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



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

Latitude (North)
24°55'17.60"

Longitude (East)

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	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, 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). <u>Technical Details of Equipment</u>

(a).	Solar Panels-PV Modules			
(i).	Type of Module	Polycrystalline PV Type Module CS6U-330P		
(ii).	Surface Area of Module	1.94432 m²		
(iii).	Dimension of each Module	1960 mm x 992 mm x	40mm	
(iv)	Total area of roof top for Solar Panels-PV Modules	2624 m²		
(v).	No. of Modules	1350		
(vi).	Frame of Module	Anodised Aluminium Alloy		
(vii).	Weight of one Module	22.4 kg		
		For 1 st Year	For 2 nd Year to 25 th Year	
(viii).	(viii). Module Output Warranty	97.5% or above	Not more than 0.7% output reduction each year	
(ix).	Number of Solar Cells in each Module	72 Cells	L	
(X).	Efficiency of Module	16.97 %		
(xi).	Environment Protection System	Encapsulation and s protection from enviro	ealing arrangements for nment.	
(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		

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(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 ∨		
(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		
(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)			
	Environmental Enclosures	Operating Temperature Range		-25° C to 60° C	
		Relative Humidity		100% non- condensing	
(xv).		Protection Class		IP65	
		Audible Noise		51 dB(A)	
		Operating Elevation		<3000m	
	Protection Devices	(a).	DC Disconnect Switch		
		(b).	Ground Fault Monitoring		
(xvi)		(c).	Reverse Polarity Protection		
		(d).	Reverse	current protection	
		(e).	Over-volt	tage protection	
(e).	Junction Boxes				
(i).	Number of Junction Box units	30	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	14.85 kW _p		
(vi).	Protection Level	IP 65	IP 65		
(vii).	Over-Current protection	Fuse			
(viii).	Surge protection	Yes (>1000V)			

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(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>

B

(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



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

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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



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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 inhouse 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.
- (I). 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

Shams Power (Private) Limited Name of the Company/ Licensee (i). 2nd Floor, Al-Maalik Building 19-Davis Road Registered/Business Office of (ii). the Company Lahore 2nd Floor, Al-Maalik Building 19-Davis Road (iii). Principal Office Lahore Akzonobel (ICI) Pakistan, 346 Ferozepur Plants Location (iv). 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)

(A). General Information

(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). <u>Technical Details of Equipment</u>

(a).	Solar Panels-PV Modules		
(i).	Type of Module	Polycrystalline PV Ty CS6U-330P	pe Module
(ii).	Surface Area of Module	1.94432 m²	
(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 m²	
(V).	No. of Modules	1388	
(vi).	Frame of Module	Anodised Aluminium	Alloy
(vii).	Weight of one Module	22.4 kg	
		For 1 st Year	For 2 nd Year to 25 th Year
(viii).	Module Output Warranty	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.,ax)	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 ∨
(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	÷ L
(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
(i v) .	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	2 MPPT/In	verter)
		Operating Temp Range	perature	-25° C to 60° C
		Relative Humid	ity	100% non- condensing
(xv).	Environmental Enclosures	Protection Class	S	IP65
		Audible Noise		51 dB(A)
		Operating Eleva	ation	<3000m
		(a).	DC Disco	onnect Switch
		(b).	Ground I	ault Monitoring
(xvi)	Protection Devices	(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 kWp		
(vi).	Over-Current protection	Fuse (SMA Inlin	Fuse (SMA Inline Fuses)	
(vii).	Surge protection	Yes (>1000∨) Ir	Yes (>1000∨) Integrated DC SPD (SMA)	
(viii).	DC Protection	(a).	Revers	e Polarity

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		(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	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



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

SECTION 3: AMENDED & RESTATED SCHEDULE II

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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.

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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)	399 522 KW h
(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.

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1.FEASIBILITY STUDY FOR ROOFTOP SOLAR INSTALLATION AT METRO CASH & CARRY STORE I-11/4 ISLAMABAD SHAMS POWER (PVT) LIMITED

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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

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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

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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:



Simulation Parameters

PVSYST V6.40 Shams Power (Pvt) Ltd.						05/06/17 Page 1/		
	Grid-Co	nnected Systen	n: Simulatio	on parameters				
Project :	Metro Cas	sh & Carry Store, Is	amabad					
Geographical Si	te	Metro Islamabad		Country	Pa	kistan		
Situation Time defined Meteo data:	85	Latitude Legal Time Albedo Metro Islamabad	33.63° N Time zone UT 0.20 Meteonorm 7.	Longitude 7+5 Altitude 1 - Synthetic	73. 51	.02° E 1 m		
Simulation vari	iant : metro isb	unter et al						
		Simulation date	05/06/17 12h4	17				
Simulation para	meters							
2 orientations		Tilts/Azimuths	2°/-32° and 2°	°/148°				
Models used		Transposition	Perez	Diffuse	Per	rez, Meteo	onorm	
Horizon		Free Horizon						
Near Shadings		According to strings		Electrical effect	100)%		
PV Arrays Chara PV module Custom param Sub-array "Sub- Number of PV mod Total number of P Array global powe Array operating cl Sub-array "Sub- Number of PV mod Total number of P Array global powe Array operating cl Total Arrays g	acteristics (2 kinds eters definition array #1" odules PV modules er haracteristics (50°C) array #2" odules PV modules er haracteristics (50°C) ilobal power	s of array defined) Si-poly Model Manufacturer Orientation In series Nominal (STC) U mpp Orientation In series Not modules Nominal (STC) U mpp Nominal (STC) Module area	CS6U - 330P Canadian Sola #1 15 modules 630 208 kWp 497 V #2 15 modules 450 149 kWp 497 V 356 kWp 2100 m ²	ar Inc. Tilt/Azimuth In parallel Unit Nom. Power At operating cond. Impp Tilt/Azimuth In parallel Unit Nom. Power At operating cond. Impp Total Cell area	2°/- 42 : 330 374 2°/- 330 133 267 108 189	32° strings 3 kWp (50 4 A 148° strings 3 kWp (50 7 A 30 module 33 m ²	°C) s	
Inverter Original PVsys	t database	Model Manufacturer	Sunny Tripov SMA	wer 25000TL-30	25			
Sub-array "Sub- Sub-array "Sub-	array #1" array #2"	Nb. of inverters	390-000 ∨ 7 units 5 units	Total Power Total Power	25. 175 125	5 kWac 5 kWac 5 kWac		
Total	-	Nb. of inverters	12	Total Power	300) kWac		
PV Array loss far Array Soiling Loss Thermal Loss fac Wiring Ohmic Los	ctors ses tor ss	Uc (const) Array#1 Array#2 Global	20.0 W/m²K 29 mOhm 31 mOhm	Loss Fraction Uv (wind) Loss Fraction Loss Fraction Loss Fraction	2.0 0.0 1.9 1.5 1.7	% W/m²K / / % at STC % at STC % at STC	n/s	



PVSYST V6.40			Shams f	Power (Pvt)	Ltd.			05/06/17	Page 2/
	Grid-Con	nected	System:	Simulatio	on param	eters (c	ontinu	ed)	
LID - Light Induce Module Quality Lo Module Mismatch Incidence effect (ed Degradation oss 1 Losses IAM): User def	ined IAM p	rofile			Loss F Loss F Loss F	raction raction raction	2.5 % 2.0 % 1.0 % at MP	Ρ
10°	20*	30°	401	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 fact Wiring Ohmic Los Unavailability of th	tors ss he system	Wie	es 3x500.0 34 0 days. 4	mm² 367 r periods	n	Loss F Time f	raction raction	3.0 % at ST(9.3 %	c
User's needs :		Unli	imited load (grid)					
				- -					



Near Shading Definition





Losses

	PVSYST V6.40	Shams Power (Pvt) Ltd		05/06/17 Page 5/5						
		Grid-Connected System: Lo	oss diagram							
	Project : Metro Cash & Carry Store, Islamabad									
	Simulation variar									
	Main system parar	neters System type Grid-Con	inected							
	Near Shadings PV Field Orientation PV modules PV Array Inverter Inverter pack User's needs	Near Shadings According to strings Electrical effect PV Field Orientation 2 orientations Till/Azimuth = 2°/-32° and 2°/148° PV modules Model CS6U - 330P Pnom PV Array Nb of modules 1080 Pnom 2 Inverter Model Sunny Tripower 25000TL-30 2 Inverter pack Nb. of units 12.0 Pnom total								
		Loss diagram over the who	ole year							
		1720 Kohmei H +0.3% G	lorizontal global irradiation Global Incident in coll. plane							
		-0.6% N	Vear Shadings: irradiance loss							
)-2.6% U	AM factor on global							
		-2.0% S	oiling loss factor							
		1635 kWh/min 2100 millio0	ffective irradiance on collectors							
1		efficiency at STC = 16.94% P	V conversion							
		581 6 Much A. -0.6% P	rray nominal energy (at STC effic.) V loss due to irradiance level							
		-10.1% P	V loss due to temperature							
		- 0.3% S	hadings: Electrical Loss acc. to strings	5						
		-2.0% M	lodule quality loss							
			lodule array mismatch loss							
		-1.1% O	hmic wiring loss							
		484.7 MWh A	rray virtual energy at MPP							
		⇒-2. 3% In	werter Loss during operation (efficienc	(¥)						
		0.0% In	verter Loss over nominal inv. power							
		0.0% In 0.0% In	werter Loss due to power threshold werter Loss over nominal inv. voltage							
		-0,0% In 473.5 MV:th A	werter Loss due to voltage threshold valiable Energy at Inverter Output							
		-8.3% S	ystein unavailability							
		: 3% At	C ohmic loss							
		426 4 M/w	nergy injected into grid							

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Simulation Results

PVSYST V6.40	T V6.40 Shams Power (Pvt) Ltd.								05/06/17	Page 4/5
	Grid-Connected System: Main results									
Project :	Metro Casł	& Carr	y Store,	Islama	bad					
Simulation variant :	metro isb									
Main system parameters		Sy	stem type	Grid	Connec	ted				
Near Shadings PV Field Orientation PV modules PV Array Inverter Inverter pack User's needs	Ļ	According 2 of Nb. c Nb. c	to strings rientations Model of modules Model Ib. of units load (grid)	Till/A CS6I 1080 Sunn 12.0	zimuth = J - 330P y Tripow	Ele 2°/-32° 8 er 25000	ectrical ef and 2°/1 Pr Pnom t TL-30 Pnom t	ffect 1 48° nom 3 lotal 3 2 lotal 3	00 % 30 Wp 56 kW p 5.00 kW ac 00 kW ac	
Main simulation results System Production	Per	Produce formance	ed Energy Ratio PR	428 .4 69.68	I MWh/y 3 %	ear S	pecific p	rođ. 1	202 kWh/k\	Np/year
Normalized productions (per in	nstalled kWp): No	ninal power	356 kWp				Performanc	e Ratio PR		
			Baiances a	nd main re	sults					
	GlobHor	DeftHor	T Amb	Globinc	GlobEn	EArray	E_Grid	PR	7	
January	8999-07 83-0	• • • • • • • • • • • • • • • • • • •	10.25	83.5	78.1	25 14	18.30	0.615	-	
February	85.5	47.94	13.42	83.7	787	25 07	17,74	0 594		
March	1407	11.80	19:04	141.1	1337	40.58	39 15	0779		
A pril Mav	165 -	5.575	24/02	105 / 204 1	197.4	46.50	44 80 52.92	0.758		
June	196.5	5.35	30.89	196.0	186.8	52.97	50.91	6 729		
ylut	163 1	1 12 39	30 19	183.5	174.4	50.04	48 15	0.736		
August	166.0 163.0	1 10 10 10 10 10 10 10 10 10 10 10 10 10	28.97	168 7 164 4	160.2	46 63	32.81 29.43	0.546		
October	144.3	1.2	32.54	145.0	137.5	41 16	39.71	0.768		
Novembo	м 108 б		15.82	109.4	102.4	31.88	30.84	0 791		
Decembe	if 79.5	1.5.65	11.71	80.0	747	23.95	23 21	0.814	4	
Year	1720.2	1. ***	21.99	1725.0	1634 7	464 66	428 36	0.697		
Legends	GlobHo Horz	um a she n	rtaði et		GkobEtt	Effective Giol	oal, corr for (A	M and shadir	n 0 %	
1	Definition inclusion 7 Annte militari	oriano trusz Miniski awalo	a-2-68000	EArray Effective anergy at the bibliot of the anay						
	Globine Crow	a an an sa	slace		PR	Pestormance	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%**

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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
- I. 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.

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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

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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					30/05/17 Pa	age 1,
	Grid-Co	nnected Systen	n: Simulatior	n parameters		
Project :	Metro Cas	sh & Carry, Thokar	Niaz Baig, Lal	nore		
Geographical Site	Metro Cas	h & Carry, Thokar Ni	az Baig, Lahore	Country	Pakistan	
Situation Time defined as		Latitude Legal Time Albedo	31.45° N Time zone UT+ 0.20	-5 Longitude -5 Altitude	74.23° E 209 m	
Meteo data Metro	Cash & Car	ry, Thokar Niaz Baig,	Lahore Meteo	onorm 7.1- Synthetic		
Simulation variant :	metro 2-3	3 330cs				
		Simulation date	30/05/17 13h32	2		
Simulation parameters						
2 orientations		Tilts/Azimuths	2°/-33° and 2°/	147°		
Models used		Transposition	Perez	Diffuse	Perez, Meteono	m
Horizon		Free Horizon				
Near Shadings		According to strings		Electrical effect	100 %	
PV Arrays Characteristic PV module Custom parameters det Sub-array "Sub-array #1 Number of PV modules Total number of PV modules Array global power Array operating characteri Sub-array "Sub-array #2 Number of PV modules Total number of PV modules Total number of PV modules Mumber of PV modules Total number of PV modules	cs (3 kinds finition les istics (50°C) r'' les istics (50°C) r'' les istics (50°C) wer	si of array defined) Si-poly Model Manufacturer Orientation In series Nominal (STC) U mpp Orientation In series Nb. modules Nominal (STC) U mpp Mixed orient. In series Nb. modules Nb. modules	CS6U - 330P Canadian Solar #1 14 modules 924 305 kWp 464 V #2 14 modules 168 55.4 kWp 464 V #1/2: 3/3 strings 14 modules 84 27.72 kWp 464 V 388 kWp	r Inc. Tilt/Azimuth In parallel Unit Nom. Power Al operating cond. I mpp Tilt/Azimuth In parallel Unit Nom. Power At operating cond. I mpp s Tilt/Azimuth In parallel Unit Nom. Power At operating cond. I mpp Total	2°/-33° 66 strings 330 Wp 273 kWp (50°C) 588 A 2°/147° 12 strings 330 Wp 49.7 kWp (50°C 107 A 2°/-33°, 2°/147° 6 strings 330 Wp 24.83 kWp (50°C 53 A 1176 modules)
Total Anays global po	44.61	Module area	2287 m ²	Cell area	2061 m²	
Inverter Original PVsyst databa	se	Model Manufacturer	Sun ny Tripow SMA	er 25000TL-30		
Characteristics		Operating Voltage	390-800 V	Unit Nom. Power	25.0 kWac	
Sub-array "Sub-array #1 Sub-array "Sub-array #2 Sub-array "Sub-array #3	511 511	Nb. of inverters Nb. of inverters Nb. of inverters	11 units 2 units 1 units	Total Power Total Power Total Power	275 kWac 50 kWac 25 kWac	
•			1.4	Total Power	350 kMac	



Grid-Connected System: Simulation parameters (continued) rray Solling Losses Loss Fraction 3.0 % bermail Loss factor Uv (vind) 0.0 WirrK / m/s Grobal Uv (wind) 0.0 WirrK / m/s Clobal Uv (wind) 0.0 WirrK / m/s Clobal Uv (wind) 0.0 WirrK / m/s D- Light Induced Degradation Clobal Global Loss Fraction 0.9 % at STC Loss Fraction 1.0 % at MPP Wires 3x300 0 mm² 203 m Loss Fraction 3.0 % at STC navailability of the system 3x300 0 mm² 203 m Loss Fraction 3.0 % at STC navailability of the system 3x300 0 mm² 203 m Loss Fraction 3.0 % at STC navailability of the system 3x300 0 mm² 203 m Loss Fraction 3.0 % at STC navailability of the system 3x300 0 mm² 203 m Loss Fraction 3.0 % at STC navailability of the system 3x300 0 mm² 203 m Loss Fraction 3.0 % at STC navailability of the system 3x300 0 mm² 203 m Loss Fraction 3.0 % at STC ser's needs : Unlimited load (grid) Unlimited load (grid)									:	30/05/17	Page
ray Soling Losses hermal Loss factorLoss Fraction3.0 % Uv (wind)Uv (wind)0.0 W/m/K / m/s M array#2Ming Ohmic LossArray#229 mOhm Array#3Loss Fraction0.6 % at STC Loss Fraction0.6 % at STC M storeD - Light Induced Degradation todied Quality LossGlobalLoss Fraction0.9 % at STC Loss Fraction0.9 % at STC Loss FractionD - Light Induced Degradation todied Quality Loss todied Quality Loss todied Cuality LossTo % at MPPTodied Cuality Loss todied Cuality Loss to		(Grid-Con	nected S	System:	Simulatio	on param	eters (co	ontinued)	
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ser s needs : Unimitted load (grid)		,	•	£ 1 6 -	• • • • • • • • • •	arid)					
	lser's i	needs:		Unlir	nited load (grid)					
·											



Near Shading Definition



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Losses	
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ALC: NOTION

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	Grid-Connected Sy	/stem:	Loss diagram					
Project -	Metro Cash & Carry Thokar	Niaz Ba	ia Labore					
Simulation variant	Metro Cash & Carry, Thokar Maz Baig, Lanore							
Simulation variant :	metro 2-33 33005							
Main system parameters	System type	Grid-C	onnected					
Near Shadings PV Field Orientation PV modules PV Array Inverter Inverter pack User's needs	According to strings 2 orientations Model Nb. of modules Model Nb. of units Unlimited load (orid)	Tilt/Azir CS6U - 1176 Sunny 14.0	Electrical effect nuth = 2°/-33° and 2°/147° 330P Pnom Pnom total Tripower 25000TL-30 Pnom total	100 % 330 Wp 388 kWp 25.00 kW ac 350 kW ac				
	Loss diagram ov	ver the w	hole year					
	720 kW/ium	+0.8%	Horizontal global irradiation Global incident in coll. plane					
		-0.9%	Near Shadings: irradiance loss					
		-2.6%	IAM factor on global					
		.: -3.0%	Solling loss factor					
	1622 KV/mm11 2287 m/ coll		Effective irradiance on collectors					
	efficiency at STC = 16.94%		PV conversion					
	628 MWh 	-0.7%	Array nominal energy (at STC effic PV loss due to irradiance level	c.)				
		7.6%	PV loss due to temperature					
	-0	1%	Shadings. Electrical Loss acc. to stri	ngs				
	÷-2	2.0% ©0/	Module quality loss					
	-10	57%)%	Module array mismatch loss					
	-0.6	%	Ohmic wiring loss					
	- 0.09 542 MWh	ί.	Mixed orientation mismatch loss Array virtual energy at MPP					
	-2.4	%	Inverter Loss during operation (efficient	ency)				
	0.0%		Inverter Loss over nominal inv. powe	F				
	- 0.0%		Inverter Loss due to power threshold Inverter Loss over nominal inv. volta:	l oe				
	0.0%		inverter Loss due to voltage threshol	d				
	529 MWh		Available Energy at Inverter Output	ut				
		ж.	System unavailability					
	-9.2°	73	AC obmic loss					
	-1.476 47.4 Mitch		Energy inicated into grid					
	47.41 (V) € 201		chergy injected into grid					



Simulation Results



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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
- I. 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.

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

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S. States

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

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1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 -



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

No. of the State

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:



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Simulation Parameters

PVSYST V6.40				03/06/17	Page 1/5
Grid-Connected S	System	n: Simulatior	n parameters		
Project : Metro Cash & Carry,	Near Ai	rport, Lahore			
Geographical Site Metro CC	airport		Country	Pakistan	
Situation Leg Time defined as Leg Meteo data: Metro CC	atitude al Time Albedo airport	31.50° N Time zone UT+ 0.20 Meteonorm 7.1	Longitude 5 Altitude - Synthetic	74.42° E 212 m	
Simulation variant : metro airport 330cs I	i				
Simulati	on date	03/06/17 14h48	3	e-m	
Simulation parameters					
2 orientations Tilts/A:	zimuths	2°/35° and 2°/-	145°		
Models used Transp	position	Perez	Diffuse	Perez, Meter	onorm
Horizon Free H	Horizon				
Near Shadings According to	strings		Electrical effect	100 %	
PV Arrays Characteristics (2 kinds of array def PV module Si-poly Custom parameters definition Manuf Sub-array "Sub-array #1" Orie Number of PV modules In Total number of PV modules Nb. m Array global power Nomina Array operating characteristics (50°C) Sub-array "Sub-array #2" Sub-array "Sub-array #2" Orie Number of PV modules In Total number of PV modules Nb. m Array operating characteristics (50°C) Sub-array "Sub-array #2" Orie Nomina Array global power Nomina Array operating characteristics (50°C) Total Total Arrays global power Nomina Array operating characteristics (50°C) Total Arrays global power	ined) Model facturer entation iseries nodules I (STC) U mpp entation iseries nodules I (STC) U mpp I (STC) le area	CS6U - 330P Canadian Sola: #1 15 modules 810 267 kWp 497 V #2 15 modules 270 89.1 kWp 497 V 356 kWp 2100 m ²	r Inc. Tilt/Azimuth In parallel Unit Nom. Power At operating cond. I mpp Tilt/Azimuth In parallel Unit Nom. Power At operating cond. I mpp Total Cell area	2°/35° 54 strings 330 Wp 239 kWp (50 481 A 2°/-145° 18 strings 330 Wp 79.8 kWp (50 160 A 1080 module 1893 m ²	°C))°C) s
Inverter Original PVsyst database Manuf	Model	Sunny Tripowo SMA	er 25000TL-30		
Characteristics Operating	Voltage	390-800 ∨	Unit Nom. Power	25.0 kWac	
Sub-array "Sub-array #1" Nb. of in Sub-array "Sub-array #2" Nb of in	iverters iverters	9 units 3 units	Total Power Total Power	225 kWac 75 kWac	
Total Nb. of in	verters	12	Total Power	300 kWac	
PV Array loss factors Array Soiling Losses Thermal Loss factor Uc Wiring Ohmic Loss	(const) Array#1 Array#2 Global	20.0 W/m²K 13 mOhm 52 mOhm	Loss Fraction Uv (wind) Loss Fraction Loss Fraction Loss Fraction	3.0 % 0.0 W/m²K / 1.1 % at STC 1.5 % at STC 1.2 % at STC	m/s ; ;



LID - Ligt Module C Module N Incidence	nt Induced I Quality Loss Nismatch Lo	Degradation s osses M): User del	n fined IAM pi	refile			Loss F Loss F Loss F	raction 2 raction 2 raction 1	.5 % .0 % .0 % at MP	P
ſ	10*	20*	30'	40	50°	60°	70*	80*	90°	ב
	0.998	0.998	0 995	0.992	0.986	0.970	0.917	0.763	0.000	
System Wiring Ol Unavailal	oss factor amic Loss bility of the	s system	Wire	?s=3x500.0 34.0 days, 4	mm² 367 r periods	n	Loss F Time f	raction 3 raction 9	.0 % at STC .3 %	2
User's n	eds:		Unli	mited load (grid)					

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Near Shading Definition





Losses

PVSYST V6.40					03/06/17	Page 5/5		
	Grid-Connect	ed Sv	stem:	Loss diagram				
Project :	Matro Cash & Carry I	loorAi	mort 1	shara				
Filipet. Metro Cash & Carry, Near Airport, Lanore								
Simulation variant .	inerro airpoit 550cs il							
Main system parameters	Syste	m type	Grid-C	onnected				
Near Shadings PV Field Orientation PV modules PV Array Inverter Inverter pack User's needs	According to 2 orien Nb. of m Nb. c Unlimited load	strings tations Model odules Model of units 1 (grid)	Tilt/Azir CS6U - 1080 Sunny 12.0	Electrical effect nuth = 2°/35° and 2°/-145° 330P Pnom Pnom total Tripower 25000TL-30 Pnom total	100 % 330 Wp 356 kWp 25.00 kW ac 300 kW ac			
	Loss diag	gram ov	er the w	hole year				
			+0.6%	Horizontal global irradiation Global incident in coll, plane				
		- 1	-0.8%	Near Shadings: irradiance loss IAM factor on global Soilling loss factor				
	1501 (1114) (1114)			Soliding loss lactor				
	efficiency at STC = 16.949	 6		PV conversion				
	576 / MWb		-0.7%	Array nominal energy (at STC effic PV loss due to irradiance level	z.)			
			-10.3%	PV loss due to temperature				
		os	3%	Shadings. Electrical Loss acc. to stri	ngs			
		-20)%	Module quality loss				
1.5		-2.5	аж. ,	LID - Light induced degradation				
		-0.7%	9 9	Ohmic wiring loss				
	461 3 MW			Array virtual energy at MPP				
		-2.3%		Inverter Loss during operation (efficie Inverter Loss over nominal inv. powe	ency) r			
	470 3 M∿h	00%		Inverter Loss due to power inteshold Inverter Loss over nominal inv. voltag Inverter Loss due to voltage threshol Available Energy at Inverter Output	ge d It			
		-8.8%		System unavailability				
	100 0 1 1 1 1	-13%		AC ohmic loss				
	°			Energy injected into grid				



Simulation Results





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
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- Properly grounded or double insulated power tools will be used for maintenance tasks. Tools will be maintained in good condition.
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- g. Inverter selection
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- i. Shadow Analysis
- j. DC cable sizing
- k. DC cable layout
- I. 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 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.





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



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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 (I			
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
L			

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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	3 3A/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

A STREET STREET STREET

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 roofton 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

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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:



Simulation Parameters

PVSYST V6.40					05/06/17 Page 1/4	
		Metro F	Ravi Road	·······		
	Grid-Co	onnected System	n: Simulatior	n parameters		
Project :						
Geographical Sit	te Metro C	ash & Carry, Ravi Ro	ad, Lahore	id, Lahore Country		
Situation Time defined	as	Latitude Legal Time Albedo	31.60° N Longitude Time zone UT+5 Altitude 0.20		74.30° E 213 m	
Meteo data: Me	etro Cash & Carr	y, Ravi Road, Lahore	Meteonorm 7.1	- Synthetic		
Simulation vari	ant : metro	ravi road 330				
		Simulation date	05/06/17 13h17			
Simulation param	neters					
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 module Custom parame Number of PV mo Total number of P Array global powe Array operating ch Total area	eters definition dules V modules r naracteristics (50°C	Si-poly Model Manufacturer In series Nb. modules Nominal (STC) C) U mpp Module area	CS6U - 330 P Canadian Solar 14 modules 1008 333 kWp 464 V 1960 m ²	Inc. In parallel Unit Nom. Power At operating cond. I mpp Cell area	72 strings 330 Wp 299 kWp (50°C) 644 A 1766 m²	
Inverter Original PVsyst Characteristics	t database	Model Manufacturer Operating Voltage	Sunny Tripowe SMA 390-800 V	r 25000TL-30 Unit Nom. Power	25.0 kWac	
Inverter pack		Nb of inverters	12 units	Total Power	300 kWac	
PV Array loss fac Array Soiling Loss Thermal Loss fact Wiring Ohmic Los LID - Light Induce Module Quality Lo	ctors tes tor s d Degradation	Uc (const) Global array res.	20.0 W/m²K 12 mOhm	Loss Fraction Uv (wind) Loss Fraction Loss Fraction	3.0 % 0.0 W/m²K / m/s 1.5 % al STC 2.5 %	
Module Mismatch Incidence effect (I.	Losses AM): User defined	IAM profile	a na a sa na gana na kata na Matala Matal	Loss Fraction	1.0 % at MPP	
10* 0.998	20° (30° 40° 5 995 0.992 <u>0.</u>	50° 60° 986 0.970	70° 80° 0.917 0.763	90° 3 0.000	
System loss facto Wiring Ohmic Loss	ors s	Wires: 3x300.0 mm ²	236 m	Loss Fraction	3.0 % at STC	
Unavailability of th	e system	34 U days, 4 peric	005	Time fraction	9.3 %	
User's needs :		Unlimited load (grid)				



Near Shading Definition





Losses

PVSYST V6.40				05/06/17	Page 4/4	
	Grid-Connected Sy					
Project :						
Simulation variant :	metro ravi road 330					
Main system parameters	System type	Grid-Co	onnected			
Near Shadings PV Field Orientation PV modules PV Array Inverter Inverter pack User's needs	According to strings Electrical effect tilt 3° azimuth Model CS6U - 330 P Pnom Nb of modules 1008 Pnom total Model Sunny Tripower 25000TL-30 Nb. of units 12.0 Pnom total Unlimited load (grid)		100 % -38° 330 Wp 333 kWp 25.00 kW ac 300 kW ac	3		
	Loss diagram ov	er the w	hole year			
		+1.7%	Horizontal global irradiation Global incident in coll. plane			
	ž.	-0.5%	Near Shadings: irradiance loss			
		2.7%	Soling loss factor			
	1640 kWh/m 11960 mill coll		Effective irradiance on collectors	5		
	efficiency at STC 15 99%		PV conversion	-		
	546 ° MMR - N.	-0.4%	Array nominal energy (at STC eff PV loss due to irradiance level	îc.)		
		-10.3%	PV loss due to temperature			
	0	1%	Shadings: Electrical Loss acc. to st	trings		
	-2.5	J% %	LID - Light induced degradation			
	-1.09	6	Module array mismatch loss			
	-0.9% 457-2 Mysh	b.	Ohmic wiring loss Array virtual energy at MPP			
			Anay virtual energy at their			
	-2.5%	>	Inverter Loss during operation (effic	ciency)		
	0.0%		Inverter Loss due to power thresho	ld		
	0.0%		Inverter Loss over nominal inv. volt	age		
	445.9 MW		Available Energy at inverter Outp	out		
	-9.2%		System unavailability			
	1.3%		AC ohmic loss			
L	399.5 MWh		Energy injected into grid			
				, <u> </u>		

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Simulation Results

VSYST V6.40								05/06/17 F	Page
		C	Grid-Cor	nected S	yster	n: Main i	results		
Project :		Metro	Cash & C	Carry, Ravi	Road,	Lahore			
Simulation var	riant :	metro	ravi roac	1 330					
Main system pa	rameters	3		System type	Grid	Connected			
Vear Shadings ² V Field Orientat ² V modules ² V Array Inverter Inverter pack User's needs	lion	•	Accordi Nb Unlimite	ng to strings tilt Model of modules Model Nb. of units d load (grid)	3° CS6L 1008 Sunn 12.0	J - 330 P y Tripower 2	Electrical effect azimuth Pnom Pnom total 25000TL-30 Pnom total	100 % -38° 330 Wp 333 kWp 25.00 kW ac 300 kW ac	
Main simulation System Production	results		Produ Performan	ced Energy ce Ratio PR	399.5 68.75	MWh/year %	Specific prod.	1201 kWh/kW	/p/yea
Normalized produc	tions (per Ir	stailed kWp): Nominal po	wei 333 kWp			Performance Rati	o PR	
retro ravi road 330									
		GlobHor	DiffHor	TAmb	Clables	ClobEff	EAHAY E C	DD DD	
	-	kWh/m²	kWtsm/	*C	kWh/m²	kWh/m²	MWh MW	h	
January		89 0	44.6	11 36	92.5	86.3	26.13 18.8	2 0.611	
February		110.7	44.7	15.62	114.6	107.6	31.53 22.7	4 0.596	
March		153.2	64 7	21.38	156 2	146.8	41.38 39.8	0.766	
Аргіі Мах		166.9	97.6	26.71	168.9	158.7	43.62 41.9	9 U.747	
June	a change of the	190 6	160.0	32.05	190.6	179 5	48.03 46.1	1 0.727	
July	1	170.7	102 5	30.90	171.2	160.8	43.71 42.0	0 729	
								3 0.730	
August		171.6	98.8	30.32	172.9	162.4	44,37 29.9	0 0.520	
August Septembe	er	171.6 163.3	95.8 74 -	30.32 28.13	172.9 166.0	162.4 156.1	44,37 29.9 42,90 27.6 26.21 27.6	0 0.520	
August Septembe October Novembe	er	171.6 163.3 130.1 96.8	95.8 28 54 5	30.32 28.13 24.66 17.89	172.9 166.0 133.4 100.7	162.4 156.1 125.2 94.0	44,37 29.9 42.90 27.6 35.21 33.9 27.55 26.6	0 0.520 0 0.500 3 0.764 3 0.795	
August Septembe October Novembe December	er r	171.6 163.3 130.1 96.8 85.8	90 8 78 1 40 3	30.32 28.13 24.66 17.89 13.28	172.9 166.0 133.4 100.7 89.8	162.4 156.1 125 2 94.0 83.6	44,37 29.9 42.90 27.6 35.21 33.9 27.55 26.6 25.12 24.3	0 0.520 0 0.500 0 0.764 3 0.795 0 0.813	
August Septembe October Novembe December Year	er r	171.6 163.3 130 1 96 8 85.8 1718.2	98 8 28 1 54 m 45 1 40 3 869 0	30.32 28.13 24.66 17.89 13.28 23.75	172.9 166.0 133.4 100.7 89.8 1747 0	162.4 156.1 125.2 94.0 83.6 1640.2	44,37 29.9 42,90 27.6 35,21 33.9 27.55 26.6 25.12 24.3 457.17 399.5	3 0.738 0 0.520 0 0.500 3 0.764 3 0.795 0 0.813 62 0.688	



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
- I. 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 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 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.



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 Кg
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



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 ∨
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









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:



Simulation Parameters

PVSYST V6.40									29/05/17	Page 1/
	Gri	d-Conne	ected Sys	sten	n: Sir	nulation	paramet	ers		
Project :	Meti	ro Cash &	Carry, Mo	del '	Town,	Lahore				
Geographical Site		Met	ro model te	own	Country			ountry	Pakistan	
Situation			Latitude		31.47	° N	Lor	igitude	74.32° E	
Time defined as	;		Legal T	Time	Time	zone UT+	5 A	Altitude	212 m	
Meteo data: Met	ro Cash & (Carry Mode	el Town Lat	nore	Mete	onorm 7.1	- Synthetic			
Simulation variar	nt: Metr	ro 8-20 PT	330cs							
			Simulation	date	29/05	5/17 14h47				
Simulation parame	ters									
Collector Plane Or	ientation			Tilt	8.		A	zimuth	-20°	
Models used			Transpos	ition	Perez	z	(Diffuse	Perez, Meter	non
Horizon			Free Hor	izon						
Near Shadings		Acc	ording to str	ings			Electrica	leffect	100 %	
PV module Custom paramete Number of PV modu Total number of PV Array global power Array operating chan Total area	ers definition iles modules racteristics (i	Si-p∂ 50°C)	oly M Manufact In se Nb modi Nominal (S U r Module a	odel turer tules (TC) mpp trea	CS6U Cana 14 me 756 249 k 464 V 1470	J - 330P dian Solar odules Wp / m ²	Inc. In p Unit Nom. Al operating Ce	erallel Power cond. I mpp II area	54 strings 330 Wp 223 kWp (50 481 A 1325 m ²	°C)
Inverter Original PVsyst d	atabase	0	M Manufact	odel	Sunn SMA	y Tripowe	r 25000TL-3	0 Dowor	25.0 1/10/20	
Inverter pack		0,	Nb of inver	tere	0 unit		Total	Power	20.0 KWac	
invener pack			TAD: OF HIVE	(CI3	5 uni	5	TOLAT	FOWER	225 80000	
PV Array loss facto Array Soiling Losses Thermal Loss factor Wring Ohmic Loss LID - Light Induced I Module Quality Loss Module Mismatch Lo Incidence effect (IAP	Degradation S Degradation S Desses M): User defi	ined IAM pr	Uc (co Global array ofile	inst) res.	29.0 ^v 15 mi	W/m²K Ohm	Loss F Uv Loss F Loss F Loss F Loss F	raction (wind) raction raction raction	3.0 % 0.0 W/m²K / 1.4 % at ST0 1.1 % 2.0 % 1.0 % at MP0	m/s D
10*	20°	30°	401	:	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 factor Wiring Ohmic Loss Unavailability of the	s system	Wire	s 3x240.0 m 34.0 days, 4	nm² peric	227 n ods	n	Loss Fi Time f	raction raction	2.7 % at ST(9.3 %	2
User's needs :		Unlir	nited load (g	grid)						

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Second Second

• ...



Near Shading Definition





Losses

PVSYST V6.40				29/05/17	Page 4/4
	Grid-Connected Sy	/stem:	Loss diagram		
Project :	Metro Cash & Carry, Model	Town, L	ahore		
Simulation variant :	Metro 8-20 PT 330cs				
Main system parameter	s System type	Grid-C	onnected		
Near Shadings PV Field Orientation PV modules PV Array Inverter Inverter pack User's needs	According to strings filt Model Nb. of modules Model Nb. of units Unlimited load (grid)	8° CS6U - 756 Sunny 9.0	Electrical effect azimuth 330P Pnom Pnom total Tripower 25000TL-30 Pnom total	100 % .20° 330 Wp 249 kWp 25.00 kW ac 225 kW ac	
	Loss diagram o	ver the w	hole year		
	1720 kt/som	+4.8%	Horizontal global irradiation Global incident in coll, plane		
		-4.0%	Near Shadings: irradiance loss		
	,	-2.0%	AM factor on global		
		-3.0%	Soiling loss factor		
	1643 kWh-m1114/0 m1 coll		Effective irradiance on collectors		
	efficiency at STr. = 16 94%		PV conversion		
	409 3 M"Ath	-0 6%	Array nominal energy (at STC effic PV loss due to irradiance level	.)	
		-7.6%	PV loss due to temperature		
	1	.4%	Shadings: Electrical Loss acc. to strin	gs	
	-21	0% %	Module quality loss		
	-1.0	%	Module array mismatch loss		
	-0.8	*	Ohmic wiring loss		
	352.7 MWh		Array virtual energy at MPP		
	-2.49	Ň	Inverter Loss during operation (efficie	псу)	
	· O O%		inverter Loss over nominel inv. power		
	0.0%		Inverter Loss due to power threshold		
	00%		Inverter Loss due to voltage threshold	le I	
	344 2 MW+		Available Energy at Inverter Output	t	
	; -9.1%	h	System unavailability		
	-1 3%		AC ohmic loss		
	309.1 Mi∆n		Energy injected into grid		
L					

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Simulation Results





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
- I. 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

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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



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 Кg	
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)	
1			

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

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

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- 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 cayout of rooftop of Metro Cash & Carry Faisalabad



Figure 23: 2D Layout of roottop 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:



Simulation Parameters

PVSYST V6.40							05/06/17	Page 1/4
	Grid-Conne	ected Syste	em: Si	mulation	paramet	ers		
Project :	Metro Cash &	Carry, Faisa	labad					
Geographical Site M	etro Cash & Ca	rry, Faisalaba	d		ountry	Pakistan		
Situation Time defined as Meteo data: Ma	etro Cash & Ca	Latitud Legal Tim Albed rry, Faisalaba	le 31.5 ae Time io 0.20 d Mete	1° N e zone UT+) eonorm 7.1,	Lon 5 A , Sat=54% - S	igitude Ititude Synthetic	73.07° E 183 m	
Simulation variant :	Metro FSD 2/2	22						
		Simulation dat	e 05/0	6/17 09h47				
Simulation parameters								
Collector Plane Orientatio	ภา	Т	ilt 2°		A	zimuth	22°	
Models used		Transpositio	n Pere	z	C	Diffuse	Perez, Meter	onorm
Horizon		Free Horizo	n					
Near Shadings	Áco	ording to string	S		Electrical	effect	100 %	
PV module Custorn parameters defin Number of PV modules Total number of PV module Array global power Array operating characterist Total area	Si-po s lics (50°C)	Manufacture Manufacture In serie Nb module Nominal (STC U mp Module are	el CS6 er Can s 15 m s 900 c) 297 p 497 a 1750	U - 330P adian Solar nodules kWp V V	Inc. In p Unit Nom. I At operating Ce	arallel Power cond. I mpp II area	60 strings 330 Wp 266 kWp (50 535 A 1577 m ²	°C)
Inverter Original PVsyst database	e	Mode Manufacture	el Sun er SMA	ny Tripowe	er 25000TL-3	0		
Characteristics	Ot	erating Voltag	e 390-	800 V	Unit Nom.	Power	25.0 kWac	
Inverter pack		Nb of inverter	rs 10 u	nits	Total	Power	250 kWac	
PV Array loss factors Array Soiling Losses Thermal Loss factor Wiring Ohmic Loss LID - Light Induced Degrada Module Quality Loss Module Mismatch Losses Incidence effect (IAM): Use	etion r defined IAM pr	Uc (cons Global array res ofile	t) 20.0 s. 39 m	W/m²K iOhm	Loss Fr Uv Loss Fr Loss Fr Loss Fr	action (wind) action action action action	3.0 % 0.0 W/m²K / 3.7 % at STC 2.0 % 2.0 % 1.0 % at MPI	m/s
10° 20°	. 30°	40%	50°	60°	70°	80°	90°	٦
0.998 0.99	8 0.995	0.092	0 986	0.970	0.917	0.763	0.000	
System loss factors Wiring Ohmic Loss Unavailability of the system User's needs :	Wire 3 Unlir	s: 3x185.0 mm 4 0 days. 4 pe nited load (gric	n² 176 riods I)	m	Loss Fr Time fr	action action	3.2 % at STC 9.3 %	•



Near Shading Definition





PVSYST V6.40					05/06/17	Page 4/4
	Grid-Connect	ed Sy	/stem:	Loss diagram		
Project :	Metro Cash & Carry, F	aisala	bad			
Simulation varia	nt: Metro FSD 2/22					
Main system para	meters System	m type	Grid-C	onnected		
Near Shadings	According to s	strings		Electrical effect	100 %	
PV Field Orientation	n	tilt Model	2"	azimuth .	22°	
PV Array	Nb of me	odules	900	Pnom total	297 kWp	
Inverter		Model	Sunny	Tripower 25000TL-30	25.00 kW ac	
Inverter pack	Nb. o	f units	10.0	Pnom total	250 kW ac	
Users needs	Unimited load	(gria)				
	Loss diag	jram ov	ver the w	/hole year		
	en i SSP kvVten			Horizontal global irradiation		
			+1.3%	Global Incident in coll. plane		
				Near Shadings' Irradiance loss		
			-2.7%	IAM factor on global		
			-3.0%	Seiling loss factor		
	1612 kWh mill 1750 mildal	11		Effective irradiance on collectors		
	• efficiency at 5 " 3 ≈ 16 04%	t,		PV conversion		
	37754533			Array nominal energy (at STC effic	:.)	
	1		0.7%	PV,loss due to irradiance level		
	241		-10.3%	PV loss due to temperature		
		00)%	Shadings. Electrical Loss acc. to strin	ngs	
		-2	0%	Module quality loss	·	
		-2.0	1%	LID - Light induced degradation		
		1.0	*	Module array mismatch loss		
	205.6 14.4%		%	Ohmic wiring loss		
	3AO GIAAAB			Array virtual energy at MPP		
		-2.3%	þ	Inverter Loss during operation (efficie	incy)	
		0.0%		Inverter Loss over nominal inv. powe	r	
		0.0%		Inverter Loss due to power threshold	10	
		0.0%		Inverter Loss due to voltage threshold	d	
	386 7 M W			Available Energy al Inverter Outpu	t	
		-6.6%		System unavailability		
		1.4%		AC ohmic loss		
	348.4 M///**			Energy intected into grid		
	and a rest of			energy injected into grid		

Losses

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Simulation Results





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
- 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
- I. 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 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 Кg
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 ∨
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

Specification	Data	
Number of J/Box units	16	
Input circuits in each box	3	
Max. input current for each circuit	15A	
Protection Level	IP 65	
Over current protection	Fuse	
Surge protection	>1000V	
	Specification Number of J/Box units Input circuits in each box Max. input current for each circuit Protection Level Over current protection Surge protection	SpecificationDataNumber of J/Box units16Input circuits in each box3Max. input current for each circuit15AProtection LevelIP 65Over current protectionFuseSurge 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 rootton or 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	
	Gri	d-Conne	ected Sys	sten	n: Sir	nulation	paramet	ers			
Project :	Met	ro Mangoj	oir Store, I	Kara	chi						
Geographical Site		Metro Mar	ngopir, Kar	achi			C	ountry	Pa	akistan	
Situation Time defined as Meteo data:	ituation Latitude Time defined as Legal Time Albedo eteo data: Metro Mangopir, Karachi			tude Fime Dedo achi	24.92° N Longitude 67.00° E Time zone UT+5 Altitude 26 m 0.20 Meteonorm 7.1 (2001-2010) - Synthetic						
Simulation variant :	met	ro mango	nir 2-0 330				-				
		io mungo	Simulation	date	05/06	5/17 13h26					
Simulation parameters											
Collector Plane Oriental	ion			Titt	2"		A	zimuth	0 °		
Models used			Transpos	ition	Pere:	z	C	Diffuse	Pe	erez, Meteo	morm
Horizon			Free Hor	izon							
Near Shadings		ÀCC:	According to strings				Electrica	effect	10	0 %	
PV Array Characteristic PV module Custorn parameters de Number of PV modules Totai number of PV modu Array global power Array operating character Total area	s finition les stics (Si-pu 50°C)	ly M Manufact In se No mod Nominat (S U r Module a	odel turer tries ules TC) mpp area	CS6U Cana 15 m 720 238 k 497 V 1400	J - 330P dian Solar odules Wp / m ²	Inc. In p Unit Nom. I At operating Ce	arallel Power cond. I mpp II area	48 33 21 42 12	8 strings 0 Wp 3 kWp (50 18 A 162 m ²	°C)
Inverter Original PVsyst databa Characteristics	se	Or	M Manufact	odel urer	Sunn SMA	iy Tripowe	er 25000TL-3	0 Power	26	0 k\M/ac	
Inverter pack			Nb of inver	ters	8 unit	s	Total	Power	20	0 kWac	
PV Array loss factors Array Soiling Losses Thermal Loss factor Wiring Ohmic Loss LID - Light Induced Degra Module Quality Loss Module Mismatch Losses Incidence effect (IAM): Us	dation er defi	ined IAM pr	Uc (cc Global array	nst) res.	20.0 [°] 20 m	W/m²K Ohm	Loss Fi Uv Loss Fr Loss Fr Loss Fr	action (wind) action action action action	3.0 0.0 1.3 1.7 2.0 1.0	0 % 0 W/m²K / 1 5 % at STC 1 % 0 % 0 % 0 % at MPF	m/s) o
10° 2	0°	30'	40"	5	50°	60°	70°	80°		90*	7
0.998 0.9	98	0.965	0.992	0	986	0.970	0.917	0.763		0.000]
System loss factors Wiring Ohmic Loss Unavailability of the syste User's needs :	m	Wire 2 Unla	s: 3×185.0 + 0.0 days: 4 nited load (g	n m² perio grid)	208 n ods	n	Loss Fr Time fr	action action	3.1 5.1	1 % al STC 5 %	;

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Near Shading Definition





Losses

PVSYST V6.40	Shanis Po	wer (Pvt) l	_td.	05/06/17	Page
	Grid-Connected	System:	Loss diagram		
Project :	Metro Mangopir Store, Ka	rachi			
Simulation variant :	metro mangopir 2-0 330cs	5			
Main system parameter	rs System typ	e Grid-C	onnected		
Near Shadings PV Field Orientation PV modules PV Array Inverter Inverter pack User's needs	According to string t Mod ND ⇒t module Mod ND, of uni Unlimited load (gri	as ilit 2° el CS6U es 720 el Sunny ts 8.0 d)	Electrical effect azimuth 330P Phom Phom total Tripower 25000TL-30 Phom total	100 % 0° 330 Wp 238 kWp 25.00 kW ac 200 kW ac	
	Loss diagram	over the v	vhole year		
		+1.3%	Horizontal global irradiation Global incident in coll. plane		
		-0.1%	Near Shadings: irradiance loss IAM factor on global		
		3 0%	Seiling loss factor		
	1752 kg/3 a 115460 m col-		Effective irradiance on collectors		
	efficiency at 157.0 - 17-94%		PV conversion		
	435 - 6 <u>T</u> V76	0.5%	Array nominal energy (at STC effi- PV loss due to irradiance level	C.)	
		-11.2%	PV loss due to temperature		
		0.0% -2.0%	Shadings. Electrical Loss acc. to stri Module quality loss	ings	
	-	-1.1% 1.0%	LID - Light induced degradation Module array mismatch loss		
	348-11173-	0.6	Array virtual energy at MPP		
		2.3% 0% 0% 0% 0%	Inverter Loss during operation (effici Inverter Loss over nominal Inv. powe Inverter Loss due to power threshold Inverter Loss over nominal Inv. volta Inverter Loss due to voltage threshol Available Energy at Inverter Outpr	ency) ar 1 ge Id ut	
	6	1 %	System unavailability		
	-1.4	Pik:	AC chmic ioss		
	315.8 Mv/h		Energy injected into grid		



Simulation Results





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
- I. 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.





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:



France 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 Кg
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 (III) or 600 V (III)
10	iviax. System voltage	
17	Module Fire Performance	TYPE 1 (UL 1703) or CLASS C (IEC 61730)

PV Array

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

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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 Layour at rooftop of Metro Cash & Carry Stargate Store





Figure 31: 2D Layout of rooftop of Metro Cash & Carry Stargate Store showing solar panel locations



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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	Powe	er (Pvt) Ltd.			06/06/17	Page 1/4
	Gri	d-Conne	ected Sy	sten	n: Sir	nulation	paramet	ers		
Project :	Met	ro Cash 8	Carry, Ne	ear Ai	irport	Karachi				
GeographicaNaite	Cash & Ca	rry, Near A	Airport, Kar	rachi			С	ountry	Pakistan	
Situation Time defined as	5 5 Cash & Ca	rry Near /	Lati Legal All Airport Kar	itude Time bedo rachi	24.8 Time 0.20 Mete	B° N zone UT+:	Lon 5 A	igitude Altitude	67.15° E 16 m	
Cimulation waring	A Mat		: 2.0				(2001 2010)			
Simulation variar	it: wet	ro Karach	a 2-0 Simulation	date	06/06	5/17 10h51				
Simulation parame	eters									
Collector Plane Or	ientation			Tilt	2"		A	zimuth	0°	
Models used			Transpos	sition	Pere	z	(Diffuse	Perez, Mete	onorm
Horizon			Free Ho	rizon						
Near Shadings		Acc	ording to sti	rings			Electrical	leffect	100 %	
PV Array Characte PV module Custom paramete Number of PV modu Total number of PV Array global power Array operating char Total area	ristics ers definition lles modules racteristics (:	S⊩po 50°C)	oly M Manufac In so No mod Nominal (S U Module i	lodel turer eries lules STC) mpp area	CS60 Cana 15 m 1080 356 H 497 \ 2100	J - 330P Idian Solar Idules Wp / m ²	Inc. In p Unit Nom. At operating Ce	erallel Power cond. I mpp II area	72 strings 330 Wp 319 kWp (50 642 A 1893 m ²)°C)
Inverter Original PVsyst d	latabase	0	M Manufac	lodel turer	Sunr SMA	ny Tripowe	r 25000TL-3	0 Dowor	25.0 110/20	
Inverter pack		01	Nb of inve	iters	12 ur	nits	Total	Power	300 kWac	
PV Array loss facto Array Soiling Lossee Thermal Loss factor Wiring Ohmic Loss LID - Light Induced Module Quality Loss Module Mismatch L Incidence effect (IAI	ors s Degradation s osses M): User defi	(ned IAM pr	Ue (cc Giebal array otile	onst) res.	20.0 14 m	W/m²K Ohm	Loss Fr Uv Loss Fr Loss Fr Loss Fr	action (wind) action action action action	3.0 % 0.0 W/m²K / 1.6 % at ST0 2.5 % 2.0 % 1.0 % at MP	m/s C P
10*	20°	30'	-0	1	50°	60°	70°	80°	90°	٦
0.998	0 998	0.995	2.942	0	986	0.970	0.917	0 763	0.000	
System loss factor Wring Ohmic Loss Unavailability of the User's needs :	s	Wire 2 Unin	es: 3x300.0 i 20.0 days, 4 mited load (j	mm² · perio grid)	241 m ds	n	Loss Fr Time fr	action	3.3 % at ST(5.5 %	c

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Near Shading Definition





Losses

PVSYST V6.40	Shams	Powe	er (Pvt) L	.td.	06/06/17	Page 4/4
	Grid-Connecte	d S	ystem:	Loss diagram		
Project :	Metro Cash & Carry N	ear Δ	irnort K	arachi		
Simulation variant :	Metro Karachi 2-0		mpon, r			
Main system parameters	Suctor	tune	Crid C	ana afa d		
Near Shadings PV Field Orientation PV modules PV Array Inverter Inverter pack	According to st Nb. of moi Nb. of moi Nb. of	tings tilt Aodel dules Aodel units	2° CS6U - 1080 Sunny 12.0	Electrical effect azimuth 330P Pnom Pnom total Tripower 25000TL-30 Pnom total	100 % 0° 330 Wp 356 kWp 25.00 kW ac 300 kW ac	
User's needs	Unimited load	(grid)				
	Loss diagr	am o	ver the w	/hole year		
	14 (Carto) (C		+13%	Horizontal global irradiation Global incl de nt in coll, plane		
			0.0%	Near Shadings: irradiance loss		
			2.7%	IAM factor on global		
	1760 0446 001 1 1100 004 004		2-3.0%	Soiling loss factor		
	efficiency at ST-C = 16.94%			Effective irradiance on collectors		
	67.4 M826		-0.5%	Array nominal energy (at STC effic. PV loss due to irradiance level	.)	
			-11.2%	PV loss due to temperature		
		0.0 -2	0% 0%	Shadings: Electrical Loss acc. to strin Module quality loss	gs	
		-2	5%	LID - Light induced degradation		
		1.0	% %	Module array mismatch loss Ohmic wiring loss		
	516 MV#			Array virtual energy at MPP		
	504 MV-n	-2 39 0.0% - 0.0% 0.0% 0.0%	ж.	Inverter Loss during operation (efficie Inverter Loss over nominal inv. power Inverter Loss due to power threshold Inverter Loss over nominal inv. voltag Inverter Loss due to voltage threshold Available Energy at Inverter Output	ncy) e t	
		-3 6%	5	System unavailability		
		15%		AC ohmic loss		
	479 MWh			Energy injected into grid		

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Simulation Results





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
- I. 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

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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 (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:



Hourse 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
10	Man Contant Viela	
16	iviax. 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
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: 30 Learne at rooftop of Metro Cash & Carry Safari Store





Figure 35: 2D Layout of roofton of Metro Cash & Carry Safari Store showing solar panel locations

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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





Sigure 18 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 Powe	er (Pvt) Ltd.		05/06/17 Page	e 1/5
	Grid-Connected System	n: Simulatio	n parameters		
Project :	Metro Safari Store, Karachi				
Geographical Site	Metro Safari Store, Karachi		Country	Pakistan	
Situation Time defined as Meteo data:	Latitude Legal Time Albedo Metro Safari Store, Karachi	24.92° N Time zone UT 0.20 Meteonorm 7.	Longitude +5 Altitude 1 (2001-2010) - Synth	67.10° E 46 m etic	
Simulation variant :	Metro safari 2-E/W				
	Simulation date	05/06/17 15h1	9		
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 Characteristic PV module Custom parameters del Sub-array "Sub-array #1 Number of PV modules Total number of PV modul Array global power Array operating characteri	cs (2 kinds of array defined) Si-poly Model finition Manufacturer "Orientation In series les Nb. modules Nominal (STC) stics (50°C) U mpp	CS6U - 330P Canadian Sola #2 15 modules 810 267 kWp 497 V	ar Inc. Tilt/Azimuth In parallel Unit Nom. Power At operating cond. I mpp	2°/90° 54 strings 330 Wp 239 kWp (50°C) 481 A	
Sub-array "Sub-array #2 Number of PV modules Total number of PV modul Array global power Array operating characteri	" Orientation In series les Nb. modules Nominal (STC) stics (50°C) U mpp	#1 15 modules 540 178 kWp 497 V	Tilt/Azimuth In parallel Unit Nom. Power At operating cond. I mpp	2°/-90° 36 strings 330 Wp 160 kWp (50°C) 321 A	
Total Arrays global por	wer Nominal (STC) Module area	446 kWp 2625 m²	Total Cell area	1350 modules 2366 m ²	
Inverter Original PVsyst databa	Model se Manufacturer	Sunny Tripov SMA	ver 25000TL-30		
Characteristics	Operating Voltage	390-800 V	Unit Nom. Power	25.0 kWac	
Sub-array "Sub-array #1 Sub-array "Sub-array #2	" Nb. of inverters " Nb. of inverters	9 units 6 units	Total Power Total Power	225 KWac 150 kWac	
Total	Nb. of inverters	15	Total Power	375 kWac	
PV Array loss factors Array Soiling Losses Thermal Loss factor	Uc (const)	20.0 W/m²K	Loss Fraction Uv (wind)	3.0 % 0.0 W/m²K / m/s	
Winng Onnie Loss	Array#1 Array#2 Global	10 mOhm	Loss Fraction Loss Fraction	0.6 % at STC 0.7 % at STC	



PVSYST V6.40			Shams I	Power (Pvt	Ltd.			05/06/17	Page 2/
	Grid-Cor	nnected	System:	Simulatio	on param	neters (c	ontinue	ed)	
LID - Light Induc	ed Degradatio	n				Loss F	raction	2.5 %	
Module Quality I Module Mismato	e Quality Loss e Mismatch Losses ice effect (IAM): User defined IAM profile 10* 20* 30' 40: 50° 60*				Loss Fraction Loss Fraction			2.0 % 1.0 % at MPP	
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 fac	ctors	War	5 3x500.0 i	mm² 294 i	n	Loss F	raction 3	3.0 % at ST(2
Unavailability of	the system		20 0 days, 4	periods		Time f	raction	5.5 %	-
User's needs :		Unli	mited load (grid)					



Near Shading Definition





Losses

PVSYST V6.40	Sham s P o	Shams Power (Pvt) Ltd.				Page 5/5
Grid-Connected System: Loss diagram						
Project :	Metro Safari Store, Karac	chi				
Simulation varia	nt : Metro safari 2-E/W					
Main system para	meters System ty	pe	Grid-C	onnected		
Near Shadings PV Field Orientatio PV modules PV Array Inverter Inverter pack User's needs	According to strin n 2 orientatio Mo Nb: of modu Mo Nb: of ur Unlimited load (gr	According to strings 2 orientations Model Nb of modules Model Nb of units Unlimited load (grid)		Electrical effect 100 % Tilt/Azimuth = 2°/-90° and 2°/90° 330 Wp CS6U - 330P Pnom 330 Wp 1350 Pnom total 446 kWp Sunny Tripower 25000TL-30 25.00 kW ac 15.0 Pnom total 375 kW ac		
Loss diagram over the whole year						
	1834 khátení		+0.1%	Horizontal global irradiation Global incident in coll, plane		
		MARKING 1	-0.4% -2.6%	Near Shadings: irradiance loss IAM factor on global		
			-3 0%	Soiling loss factor		
	efficiency at ST 0 11694%			Effective irradiance on collectors		
	76.8 14:125		0 5%	Array nominal energy (at STC effic. PV loss due to irradiance level)	
			-11.1%	PV loss due to temperature		
		0.3	3%	Shadings: Electrical Loss acc. to strin	gs	
	1	-2.0	1% 1%	Module quality loss		
		-1 0%	6	Module array mismatch loss		
	· ·	-0 5%		Ohmic wiring loss		
	637 MWh			Array virtual energy at MPP		
	2.	-2 3%		Inverter Loss during operation (efficiency)		
	- 0.	- 0.0%		Inverter Loss over nominal inv. power		
	0.	0.0% 0.0%		Inverter Loss due to power threshold Inverter Loss over nominal inv. voltage		
	0	0.0%		Inverter Loss due to voltage threshold		
,	622 MAA			Available Energy at Inverter Output	1	
		3.3%		System anavajjability		
	-1.	4%		AC ohmic loss		
	593 Mv/h			Energy injected into grid		



Simulation Results





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
- I. 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



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.



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:



Galary 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

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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 Selector

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 m²
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 (lsc)	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
	0	



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 com

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 Loyout of PV Plant at Akzonobel Lahore









Figure 39: 2D LOVING 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 311 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.



Simulation Parameters

PVSYST V6.40	ананан Адариян Аланан Алан		annað karlað ginni ver m	29/06/17 Page 1/
	Grid-Connected Syster	n: Simulation	parameters	
Project :	Akzo Nobel Pakistan			
Geographical Site	Akzo Nobel Pakistan		Country	Pakistan
Situation Time defined as Meteo data:	Latitude Legal Time Albedo Azko Nobel Pakistan	31.47° N Time zone UT+ 0.20 Meteonorm 7.1	Longitude 5 Altitude - Synthetic	74.33° E 212 m
Simulation variant : a	irea 31 a			
	Simulation date	29/06/17 09h09		
Simulation parameters				
2 orientations	Tills/Azimuths	8°/-20° and 8°/1	60°	
Models used	Transposition	Perez	Diffuse	Perez, Meteonorm
Horizon	Free Horizon			
Near Shadings	According to strings		Electrical effect	100 %
Custom parameters defini Number of PV modules Total number of PV modules Array global power Array operating characteristic Total area	tion Manufacturer In series Nb. modules Nominal (STC) cs (50°C) U mpp Module area	Canadian Solar 15 modules 90 29.70 kWp 497 V 175 m ²	Inc. In parallel Unit Nom. Power At operating cond. I mpp Cell area	6 strings 330 Wp 26 60 kWp (50°C) 53 A 158 m²
Inverter Original PVsvst database	Model Manufacturer	Sunny Tripowe	er 25000TL-30	
Characteristics	Operating Voltage	390-800 V	Unit Nom. Power	25.0 kWac
Inverter pack	Dibliof inverters	1 units	Total Power	25 kWac
PV Array loss factors Array Soiling Losses Thermal Loss factor Wining Ohrnic Loss LID - Light Induced Degrada Module Quality Loss Module Mismatch Losses Incidence effect (IAM): User	Uc (const) Global array res. tion defined IAM profile	29.0 W/m²K 157 mOhm	Loss Fraction Uv (wind) Loss Fraction Loss Fraction Loss Fraction Loss Fraction	3.0 % 0.0 W/m²K / m/s 1.5 % at STC 1.1 % 2.0 % 1.0 % at MPP
10° 20°	30 40	50° 60°	70° 80°	90°
0.998 0.998	0 995 0 592 0	986 0.970	0.917 0.763	0.000
System loss factors Wiring Ohmic Loss Unavailability of the system User's needs :	Vares 3x16.0 mm² 34 0 days 4 perio Unlimited load (grid)	144 m ods	Loss Fraction Time fraction	3.1 % at STC 9.3 %



PVSYST V6.40									29/06/1	7 Page
	Grio	d-Conne	ected Sys	sten	n: Sir	nulatio	n paramet	ters		
Project :	Akzo	Nobel P	akistan							
Geographical Site		Akza	Nobel Pakis	stan			C	Country	Pakistan	
Situation Time defined as Meteo data:		Azko	Latii Legal T Alb Nobel Pakis	ude ime iedo stan	31.47 Time 0.20 Mete	7° N zone UT- onorm 7,1	Loi +5 /	ngitude Altitude	74.33° E 212 m	
		24.1								
Simulation variant :	area	310	Simulation of	late	29/06	5/17 09h2	7			
Simulation parameters										
2 orientations			Tilts/Azim	uths	8°/70	° and 8°/-	110°			
Models used			Transpos	ition	Pere	z		Diffuse	Perez, Me	teonorm
Horizon			Free Hori	izon						
Near Shadings		Acc	ംഷപ്പെ to stri	ings			Electrica	i effect	100 %	
Number of PV modules Total number of PV modu Array global power Array operating character Total area	iles istics (5	50°C)	In se Nb modu Nominal (S U r Module a	ries ules TC) npp irea	17 m 68 22.44 564 \ 132 m	odules kWp / n²	In p Unit Nom. At operating Ce	oarallel Power cond. I mpp I area	4 strings 330 Wp 20.10 kWp 36 A 119 m²	o (50°C)
Inverter Original PVsyst databa	ase		Mo Manufacti	odel urer	Sunr SMA	iy Tripow	er 25000TL-3	10		
Characteristics		0	perating Volt	age	390-8	800 V	Unit Nom.	Power	25.0 kWad	;
Inverter pack			Nb. of inver	ters	1 uni	5	Total	Power	25 kWac	
PV Array loss factors Array Soiling Losses Thermal Loss factor Wiring Ohmic Loss LID - Light Induced Degra Module Quality Loss Module Mismatch Losses Incidence effect (IAM): U:	adation i ser defir	(ned IAM pr	Uc (co Siobal array i ofile	nst) res.	29.0 266 r	W/m²K nOhm	Loss F Uv Loss F Loss F Loss F Loss F	raction (wind) raction raction raction raction	3.0 % 0.0 W/m²k 1.5 % at S 2.5 % 2.0 % 1.0 % at M	(/m/s TC IPP
10"	20°	30′	40 ⁻³	5	50°	60°	70°	80°	90*	
0.998 0.	998	0.995	0.992	0	986	0.970	0.917	0.763	3 0.00)
Unavailability of the syste	m	3	34 0 days. 4	perio	ds		Time f	raction	9.3 %	
las da manda i										

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				and the second
PVSYST V6.40				03/07/17 Page 1/5
	Grid-Connected Syster	n: Simulation	parameters	
Project :	Akzo Nobel Pakistan			
Geographical Site	Akzo Nobel Pakistan		Country	Pakistan
Situation Time defined as	Latitude Legal Time Albedo	31.47° N Time zone UT+ 0.20	Longitude 5 Altitude	74.33° E 212 m
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°/-1	10°	
Models used	Transposition	Perez	Diffuse	Perez, Meteonorm
Horizon	Free Horizon			
Near Shadings	According to strings		Electrical effect	100 %
PV Arrays Characterist PV module Custom parameters d Sub-array "fg sheds" Number of PV modules Total number of PV mod Array global power Array operating characte	tics (2 kinds of array defined) St-poly Model efinition Manufacturer Mixed orient. In series ules Nb. modules Nominal (STC) ristics (50°C) U mpp	CS6U - 330P Canadian Solar #1/2: 3/3 strings 15 modules 90 29.70 kWp 497 V	Inc. Till/Azimuth In parallel Unit Nom, Power At operating cond. I mpp	8°/70°, 8°/-110° 6 strings 330 Wp 26.60 kWp (50°C) 53 A
Sub-array "new fg" Number of PV modules Total number of PV mod Array global power Array operating characte	Mixed orient. In series ules Nb. modules Nominal (STC) ristics (50°C) U mpp	#1/2: 2/2 strings 15 modules 60 19.80 kWp 497 V	Tilt/Azimuth In parallel Unit Nom. Power At operating cond. I mpp	8°/70°, 8°/-110° 4 strings 330 Wp 17.73 kWp (50°C) 36 A
Total Arrays global po	ower Nominal (STC) Module area	50 kWp 292 m²	Total Cell area	150 modules 263 m²
Inverter	Model	Sunny Tripowe	r 25000TL-30	
Original PVsyst datab Characteristics	ase Manufacturer Operating Voltage	SMA 390-800 V	Unit Nom. Power	25.0 kWac
Sub-array "fg sheds" Sub-array "new fg"	Nb of inverters Nb of inverters	1 units 1 units	Total Power Total Power	25 kWac 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 LID - Light Induced Degr Module Quality Loss Module Mismatch Losse:	Array#1 Array#2 Global adation	160 mOhm 192 mOhm	Loss Fraction Loss Fraction Loss Fraction Loss Fraction Loss Fraction Loss Fraction	1.5 % at STC 1.2 % at STC 1.4 % at STC 2.5 % 2.0 % 1.0 % at MPP



PVSYST	I									
	G	irid-Coni	nected S	System: S	Simulatio	on paran	neters (c	continu	ued)	
Incidenc	e effect (IA	M): User de	efined 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 facto	rs								
Wiring O	hmic Loss		Wit	es (5x16.0 r	nm² 82 m		Loss F	raction	2.9 % at ST	С
Unavalla	ionity of the	system		o⊶ u uays, 4	penous		Thine i	action	5.5 70	
User's n	needs:		Unlir	mited load (g	grid)					



PVSYST V6.40				03/07/17	Page 1/5
C	Grid-Connected System	n: Simulatio	n parameters		
Project :	Akzo Nobel Pakistan				
Geographical Site	Akzo Nobel Pakistan		Country	Pakistan	
Situation Time defined as	Latitude Legal Time Albedo	31.47° N Time zone UT 0.20	+5 Altitude	74.33° E 212 m	
Meteo data:	Azko Nobel Pakistan	Meteonorm 7.	1 - Synthetic		
Simulation variant :	AkzoNobel Parking				
	Simulation date	03/07/17 11h0)2		
Simulation parameters					
2 orientations	Tilts/Azimuths	5°/70° and 5°/	-110°		
Models used	Transposition	Perez	Diffuse	Perez, Mete	onorm
Horizon	Free Horizon				
Near Shadings	According to strings		Electrical effect	100 %	
PV Arrays Characteristics PV module Custom parameters defin Sub-array "Sub-array #1" Number of PV modules Total number of PV module Array global power Array operating characterist	(2 kinds of array defined) Si-poly Model bition Manufacturer Orientation In series s Nb. modules Nominal (STC) U mpp	CS6U - 330P Canadian Sola #1 15 modules 540 178 kWp 497 V	ar Inc. Till/Azimuth In parallel Unit Nom. Power At operating cond. I mpp	5°/70° 36 strings 330 Wp 160 kWp (50 321 A	D°C)
Sub-array "Sub-array #2" Number of PV modules Total number of PV module Array global power Array operating characterist	Mixed orient: In series s No modules Nominal (STC) lics (50°C) U mpp:	#1/2: 4/14 strir 15 modules 270. 89.1 kWp 497 V	ngs Tilt/Azimuth In parallel Unil Nom. Power At operating cond. I mpp	5°/70°, 5°/-1 18 strings 330 Wp 79.8 kWp (5 160 A	10° 0°C)
Total Arrays global powe	er Nominal (STC) Module area	267 kWp 1575 m²	Total Cell area	810 modules 1420 m ²	5
Inverter	Model	Sunny Tripow	ver 25000TL-30		
Original PVsyst database Characteristics	e Manufacturer Operating Voltage	SMA 390-800 V	Unit Nom. Power	25.0 kWac	
Sub-array "Sub-array #1" Sub-array "Sub-array #2"	Nb. of inverters Nb. of inverters	6 units 3 units	Total Power Total Power	150 kWac 75 kWac	
Total	Nb. of inverters	9	Total Power	225 kWac	
DV A may loop factors					
Array Soiling Losses			Loss Fraction	30%	
Thermal Loss factor	Uc (const)	29.0 W/m²K	Uv (wind)	0.0 W/m²K /	m/s
Wiring Ohmic Loss LID - Light Induced Degrada Module Quality Loss Module Mismatch Losses	Array#1 Array#2 Global	26 mOhm 52 mOhm	Loss Fraction Loss Fraction Loss Fraction Loss Fraction Loss Fraction Loss Fraction	1.5 % at ST(1.5 % at ST(1.5 % at ST(2.5 % 2.0 % 1.0 % at MP	C C C



bit Defended byster: Simulation parameters (continued) status Defended bysters (continued) status
ncience effect (IAM): User efficie IAM profile i i i i i i i i i i i i i i i i i i i
ncience effect (IAM; User defined IAM profile
ncidence effect (IAM): User defined IAM profile <u>i u o o o o o o o o o o o o o o o o o o </u>
10* 20* 30 40* 50* 60* 70* 80* 90* System loss factors Ming Ohmic Loss Wins: 3x2400 mm² 235 m Loss Fraction: 3.0 % at STC Jnavailability of the system 3x0 days 4 periods Time fraction: 9.3 %
View 0998 0998 0996 0997 0793 0000
System loss factors Wires: 3x240.0 mm² 235 m Loss Fraction 3.0 % at STC Jaavailability of the system 34 0 days 4 periods Time fraction 9.3 %
Miring Ohmic Loss Wires: 3x240.0 mm² 235 m Loss Fraction: 3.0 % at STC Jnavailability of the system 3x 0 days 4 periods Time fraction: 9.3 % Jser's needs : Unlimited load (grid)
Jeer's needs : Unimited toad (grid)
Jser's needs : Uninnited toad (grid)



Grid-Conne Akzo Nobel Akzo Azko Prodcution ion Ac. S SEP inition es	ected Sy I Pakistan Nobel Paki Lati Legal Att Nobel Paki Simulation Transpos Free Hor Sidding to str Manufact In se Nb, mod Nominal (S	sten stan tude Fime bedo stan date Tilt ition izon ings odel urer mes ules	n: Sir 31.47 Time 0.20 Mete 03/07 8" Pere; CS6L Cana 15 mc	nulatio 7° N zone UT onorm 7. 7/17 10h2 z J - 330P dian Sola odules	on parame Lo 1 - Synthetic 26 Electric: ar Inc.	eters Country ingitude Altitude	03/07/17 Pakistan 74.33° E 212 m -20° Perez, Mete 100 %	Page 1/
Grid-Conne Akzo Nobel Akzo Azko Prodcution ion ion Sico Sico Sico Sico Sico Sico	ected Syi I Pakistan Nobel Paki Lati Legal Alt Nobel Paki hall Simulation Transpos Free Hor Octing to str Manufact In se Nb. mod Nominal (S	sten stan lude Dedo stan date Tilt ition ings odel urer eries ules	n: Sir 31.47 Time 0.20 Mete 03/07 8° Pere; CS6L Cana 15 mc	nulatio 7° N zone UT onorm 7. 7/17 10h2 z J - 330P dian Sola odules	Electric.	eters Country ingitude Altitude Altitude	Pakistan 74.33° E 212 m -20° Perez, Mete 100 %	io norm
Akzo Nobel Akzo Azko Prodcution ion Ac. S Si-p inition es	I Pakistan Nobel Paki Legal Alt Nobel Paki Simulation Transpos Free Hor Seding to str Manufact In se Nb. mod Nominal (S	stan tude fime bedo stan date Till tition tizon tings odel urer mes ules	31.47 Time 0.20 Mete 03/07 8" Pere: CS6L Cana 15 mc	7° N zone UT onorm 7. 7/17 10h2 z J - 330P dian Sola odules	Lo 1 - Synthetic 26 Electric: ar Inc.	Country ingitude Altitude S Azimuth Diffuse al effect	Pakistan 74.33° E 212 m -20° Perez, Mete 100 %	20 NO(M)
Akzo Azko Prodcution ion Ac. Sintion es stics (50°C)	Nobel Paki Lati Legal Alt Nobel Paki hall Simulation Transpos Free Hor Oding to str Manufact In se ND, mod Nominal (S	stan lude Fime bedo stan date Tilt ition izon ings odel urer eries ules	31.47 Time 0.20 Mete 03/07 8" Pere; CS6L Cana 15 mc	7 [°] N zone UT onorm 7. 7/17 10h2 z J - 330P dian Sola odules	Lo 1 - Synthetic 26 Electric. ar Inc.	Country ingitude Altitude : Azimuth Diffuse al effect	Pakistan 74.33° E 212 m -20° Perez, Mete 100 %	юлог т
Azko Prodcution ion Ac. S SEP inition es	Lati Legal T Alt Nobel Paki hall Simulation Transpos Free Hor Ording to str Manufact In se Nb. mod Nominal (S	tude Fime bedo stan date Tilt ition izon ings odel urer rries ules	31.47 Time 0.20 Mete 03/07 8° Pere; CS6L Cana 15 mo	7^ N zone UT 7/17 10h2 z J - 330P dian Sola odules	Lo 1 - Synthetic 26 Electric: ar Inc.	Altitude Altitude	74.33° E 212 m -20° Perez, Mete 100 %	30 NO(m
Azko Prodcution ion Ac. Ship inition es	Legal Alt Nobel Paki Simulation Transpos Free Hor Jording to str Manufact In se Nb. mod Nominal (S	Time bedo stan date Tilt ition izon ings odel urer rries ules	Time 0.20 Mete 03/07 8° Pere: Cana 15 mo 270	zone UT onorm 7. 7/17 10h2 z J - 330P dian Sola odules	+5 1 - Synthetic 26 Electric: ar Inc.	Altitude Azimuth Diffuse al effect	212 m -20° Perez, Mete 100 %	20 NO (M)
Azko Prodcution ion Accession shiftion es stics (50°C)	Nobel Paki hall Simulation Transpos Free Hor .ording to str holy M Manufact In se Nb. mod Nominal (S	date Tilt ition ings odel urer mes ules	Mete 03/07 8° Perez CS6L Cana 15 mc 270	onorm 7. 7/17 10h2 z J - 330P dian Sola odules	1 - Synthetic 26 Electric. ar Inc.	Azimuth Diffuse al effect	-20° Perez, Mete 100 %	20 Norm
Production	hall Simulation Transpos Free Hor .ocding to str Manufact In se Nb. mod Nominal (S	date Tilt ition izon ings odel urer mes ules	03/07 8" Pere: CS6L Cana 15 mc 270	z J - 330P dian Sola	26 , Electrica ar Inc.	Azimuth Diffuse al effect	-20° Perez, Mete 100 %	sonorm
ion Acc s inition es stlics (50°C)	Simulation Transpos Free Hor oding to str Manufact In se Nb. mod Nominal (S	Tilt ition izon ings odel urer eries ules	03/07 8" Pere: CS6L Cana 15 mc 270	z J - 330P dian Sola	Electric.	Azimuth Diffuse al effect	-20° Perez, Mete 100 %	20 NO M
ion Ac. S SEp inition es stics (50°C)	Transpos Free Hor ording to str Manufact In se Nb. mod Nominal (S	Tilt ition izon ings odel urer eries ules	8" Pere: CS6L Cana 15 mo 270	z J - 330P dian Sola	, Electric: ar Inc.	Azimuth Diffuse al effect	-20° Perez, Mete 100 %	90 NO (m
ion àca s inition es stlics (50°C)	Transpos Free Hor ook Manufact Manufact In se Nb. mod Nominal (S	Tilt ition izon ings odel urer eries ules	8" Perez CS6L Cana 15 mo 270	z J - 330P dian Sola	, Electric: ar Inc.	Azimuth Diffuse al effect	-20° Perez, Mete 100 %	30 NO(M
Ac. Si-p inition es stlics (50°C)	Transpos Free Hor Joeding to str Manufact In se Nb. mod Nominal (S	ition izon ings odel urer eries ules	Perez CS6L Cana 15 mo 270	z J - 330P dian Sola	Electric: ar Inc.	Diffuse al effect	Perez, Mete	eonorm
Ac. SHp inition es stlics (50°C)	Free Hor .ording to str ooly M Manufact In se Nb. mod Nominal (S	izon ings odel urer eries ules	CS6L Cana 15 mo 270	J - 330P dian Sola	Electric: ar Inc.	al effect	100 %	
Ac. Ship inition es stics (50°C)	ading to str oly M Manufact In se Nb. mod Nominal (S	odel odel urer eries ules	CS6L Cana 15 mo 270	J - 330P dian Sola	Electrica ar Inc.	al effect	100 %	
Si-p inition es stics (50°C)	oly M Manufact In se Nb. mod Nominal (S	odel urer eries ules	CS6L Cana 15 mo 270	J - 330P dian Sola	ar Inc.			
	U i Module a	npp area	89.1 497 V 525 m	kWp ′	In Unit Nom At operatin C	parallel Power g cond. I mpp ell area	18 strings 330 Wp 79.8 kWp (5 160 A 473 m²	0°C)
se	M Manufact	odel urer	Sunn SMA	iy Tripow	ver 25000TL	-30 Power	25 0 kW/ac	
	Nb. of inver	ters	3 unit	s	Tota	Power	75 kWac	
					Loss F	raction	3.0 %	
,	Uc (co	nst)	29.01	W/m²K	U	(wind)	0.0 W/m²K /	m/s
dation	овазя апау	res.	52 m	Onm	Loss F	raction	1.5 % at 51 2.5 %	C
					Loss F	raction	2.0 %	
er defined IAM	profile				LUSSI	action	1.0 70 dt ivin	F
30	40"	5	i0°	60°	70°	80*	90°	
0 995	0.992	0.	986	0.970	0.917	0.763	0.000	
Win n	res: 3x50.0 r 34 0 days, 4	nm² perio	138 m ods	ı	Loss F Time	raction fraction	2.8 % at ST 9.3 %	с
	dation er defined IAM 8 0.995 8 V/i n	Uc (co Glabal array attion er defined IAM profile <u>30 40°</u> 8 0 995 0 992 Wires 3x50.0 r n 34 0 days, 4	Uc (const) GE-bal array res. dation er defined IAM profile <u>30 40° 5</u> <u>6 0.995 0.992 0.</u> Wires 3x50.0 mm² n 34.0 days, 4 perio	Uc (const) 29.0 1 Gl-bat array res. 52 m dation er defined IAM profile <u>30 40° 50°</u> 8 0.995 0.992 0.986 Wires 3x50.0 mm ² 138 m n 34.0 days, 4 periods	Uc (const) 29.0 W/m²K Global array res. 52 mOhm dation er defined IAM profile <u>30 40° 50° 60°</u> <u>8 0.995 0.992 0.986 0.970</u> Wires 3x50.0 mm² 138 m n 34.0 days, 4 periods	Uc (const) 29.0 W/m²K UV Global array res. 52 mOhm Loss F Loss F Loss F Loss F er defined IAM profile 30 40° 50° 60° 70° 6 0.995 0.992 0.986 0.970 0.917 Wires 3x50.0 mm² 138 m Loss F n 34.0 days, 4 periods Time f	Uc (const) 29.0 W/m²K Loss Fraction Uv (wind) Global array res. 52 mOhm Loss Fraction Loss Fraction Loss Fraction Loss Fraction Loss Fraction Loss Fraction Loss Fraction Uv (wind) Loss Fraction Uv (wind) Loss Fraction Uv (wind) Loss Fraction Uv (wind) Loss Fraction Uv (wind) Loss Fraction Loss Fraction Uv (wind) Loss Fraction Uv (wind) Loss Fraction Uv (wind) Loss Fraction Uv (wind) Loss Fraction Uv (wind) Loss Fraction Uv (wind) Loss Fraction Time fraction	Uc (const) 29.0 W/m²K Loss Fraction 3.0 % Global array res. 52 mOhm Loss Fraction 1.5 % at ST dation Loss Fraction 2.5 % Loss Fraction 2.5 % er defined IAM profile 30 40° 50° 60° 70° 80° 90° ac 40° 50° 60° 70° 80° 90° 8 0.995 0.992 0.986 0.970 0.917 0.763 0.000



-VSYSI V6.40		03/07/17	Page 2
	Grid-Connected System: Simulation parameters (continu	ed)	
User's needs :	Unlimited load (orid)		
-			



Near Shading Definition

	PVSYST V6.40		29/06/17	Page 2/4
		Grid-Connected System: Near shading definition		
	Project :	Akzo Nobel Pakistan		
	Simulation variant	: area 31 a		
	Main system parame	eters System type Grid-Connected		
-	Near Shadings PV Field Orientation PV modules PV Array Inverter User's needs	According to strings Electrical effect 2 orientations Tilt/Azimuth = 8°/-20° and 8°/-80° Model CS6U - 330P Pnom 3 Nb. of modules 90 Pnom total Model Sunny Tripower 25000TL-30 2 Unlimited load (grid)	100 % 330 Wp 29,70 kWp 25.00 kW ac	
		Perspective of the PV-field and surrounding shading scene		
		Deschadings diagram According to adhere being the state of the state		





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System: The Grid-C IS IS TILL/Azi EI CS6U IS 90 EI SUNNY I) over the v 0.3% 1.1% -2.6% -3.0%	Electrical effect 100 % imuth = 8°/-20° and 8°/160° - 330P Pnom 330 Wp Pnom total 29.70 kWp Tripower 25000TL-30 25.00 kW ac whole year Horizonial global irradiation Global incident in coll. plane Near Shadings: irradiance loss IAM factor on global
e Grid-C IS IS Till/Azi El CS6U IS 90 El Sunny I) over the v 0.3% 1.1% 2.6% 3.0%	Connected Electrical effect 100 % imuth = 8°/-20° and 8°/160° - 330P Pnom 330 Wp Pnom total 29.70 kWp Tripower 25000TL-30 25.00 kW ac whole year Horizonial global irradiation Global incident in coll. plane Near Shadings: irradiance loss IAM factor on global
e Grid-C is Till/Azi el CS6U s 90 al Sunny i) over the v 0.3% 1.1% 2.6% 3.0%	Connected Electrical effect 100 % imuth = 8°/-20° and 8°/160° - 330 P Pnom 330 Wp Pnom total 29.70 kWp Tripower 25000TL-30 25.00 kW ac whole year Horizonial global irradiation Global incident in coll. plane Near Shadings: irradiance ioss IAM factor on global
e Grid-C is Till/Azi el CS6U is 90 el Sunny j) over the v 0.3% 1.1% 2.6%	Connected Electrical effect 100 % imuth = 8°/-20° and 8°/160° - 330P Pnom 330 Wp Pnom total 29.70 kWp Tripower 25000TL-30 25.00 kW ac whole year Horizonial global irradiation Global incident in coll. plane Near Shadings: irradiance loss IAM factor on global
IS Till/Azi el CS6U IS 90 al Sunny 1) over the v 0.3% 1.1% 2.6%	Electrical effect 100 % imuth = 8%-20° and 8%160° - 330P Pnom 330 Wp Pnom total 29.70 kWp Tripower 25000TL-30 25.00 kW ac whole year Horizonial global irradiation • Global incident in coll. plane Near Shadings: irradiance ioss IAM factor on global
over the v 0.3% 1.1% 2.6% 3.0%	whole year Horizontal global irradiation Global incident in coll. plane Near Shadings: irradiance loss IAM factor on global
0.3% -1.1% -2.6% -3.0%	Horizonial global irradiation Global incident in coll. plane Near Shadings: irradiance ioss IAM factor on global
	Global incident in coll. plane Near Shadings: irradiance ioss IAM factor on global
	Soiling loss factor
	Effective irradiance on collectors
	PV conversion
0.7%	Array nominal energy (at STC effic.) PV loss due to irradiance level
-7.5%	PV loss due to temperature
0.0%	Shadings. Electrical Loss acc. to strings Module quality lose
-1 1%	LID - Light induced degradation
10%	Module array mismatch loss
0%	Mixed onentation mismatch loss Array virtual energy at MPP
2.2% 0% 0% 0%	Inverter Loss during operation (efficiency) Inverter Loss over norminal inv. power Inverter Loss due to power threshold Inverter Loss due to voltage Inverter Loss due to voltage threshold
	Available Energy at Inverter Output
) O%	System unavailability
2	AC ohmic loss
	0% 0% 8 0%



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	Grid-Connected §	System:	Loss diagram		
Project :	Akzo Nobel Pakistan				
Simulation variant :	area 31 b				
Main system parameter	s System typ	e Grid-C	onnected		
Near Shadings PV Field Orientation PV modules PV Array Inverter User's needs	According to string 2 orientation Mode Nb: of module Mode Unlimited load (grid	s s Tilt/Azir el CS6U - s 68 el Sunny ⁻ l)	Electrical effect nuth = 8°/70° and 8°/-110° 330P Pnom Pnom total Tripower 25000TL-30	100 % 330 Wp 22.44 kWp 25.00 kW ac	
	Loss diagram	over the w	hole year		
	1. 1973° 1. 1945.		listente de la secieta		
		. 0.99	Horizontal global irradiation		
		0.2%	Near Shadings, irradiance loss		
		-27% 	IAM factor on global		
	1615 kWhen 11 Print colu	5.0 %	Effective irradiance on collectors		
	efficiency at ST-1 = 16.94%		PV conversion		
	36 18 VAb		Array nominal energy (at STC effic	c.)	
	• · · · · · · · · · · · · · · · · · · ·	-0.7%	PV loss due to irradiance level		
	:	-7.5%	PV loss due to temperature Shadipos: Electrical Loss acc. to stri	0.05	
		-2 0%	Module quality loss	iya	
		-2.5%	LID - Light induced degradation		
	· · · · · · · · · · · · · · · · · · ·	1.0% 0.9%	Module array mismatch loss Ohmic wiring loss		
	0 	0%	Mixed orientation mismatch loss Array virtual energy at MPP		
		2.0%	Inverter Loss during operation (efficient	ency)	
	0.	X °C	Inverter Loss over nominal inv. powe	ər	
	0	3%- 3%-	Inverter Loss due to power threshold Inverter Loss over nominal inv. voltai	j qe	
	-0. 30.54 MVA	2%	Inverter Loss due to voltage threshol Available Energy at Inverter Output	ld ut	
	 - 9	.0%	System unavailability		
	27.60 My/h		Energy injected into grid		



PVSYST VA 40	· · · · · · · · · · · · · · · · · · ·			03/07/17	Page 5/5
FV3131 V0.40			· · · · · · · · · · · · · · · · · · ·	05/07/17	Page 5/5
	Grid-Connected S	ystem:	Loss diagram		
Project :	Akzo Nobel Pakistan				
Simulation variant :	fo & new fa				
Main system parameter	Custom tuno	Crid C	oppostod		
Near Shadings	According to strings	Gilu-C	Flectrical effect	100 %	
PV Field Orientation	2 orientations	Tilt/Azi	muth = 8°/70° and 8°/-110°	100 /0	
PV modules PV Array	Model Nb. of modules	CS6U - 150	- 330P Pnom Pnom total	330 Wp	
Inverter	Model	Sunny	Tripower 25000TL-30	25.00 kW ac	;
Inverter pack User's needs	Nb. of units Unlimited load (orid)	2.0	Pnom total	50.0 kW ac	
	Loss diagram o	ver the w	whole year		
	Loss dagram e		noic year		
	1722183838		Horizontal global irradiation		
		0.3%	Global incident in coll. plane		
		2.6%	AM factor on global		
		-3 0%	Soiling loss factor		
	1608 kVvn → 1, + 1, + 10		Effective irradiance on collector	75	
	efficiency at tast in the 94%		PV conversion		
-	79 S MOH		Array nominal energy (at STC e	ffic.)	
		-0.7%	PV loss due to irradiance level		
		-10.2%	PV loss due to temperature		
	-2	0% 10%	Shadings: Electrical Loss acc. to s Module quality loss	ltrings	
	-2	5%	LID - Light induced degradation		
	-10	1%	Module array mismatch loss		
	8.0- 0.0	%u h	Ohmic wiring loss Mixed orientation mismatch loss		
	66 4 MM		Array virtual energy at MPP		
	-2 3'	%o	Inverter Loss during operation (eff	iciency)	
	0.0%		Inverter Loss over nominal inv. po	wer	
	0.0%		Inverter Loss due to power threshe Inverter Loss over nominal invited	bid Itage	
	0.0%		Inverter Loss due to voltage threst	blor	
	CH CHMANN		Available Energy at Inverter Out	put	
	-9.0%	X.	System unavailability		
	-1.2%		AC ohmic loss		
•			Energy injected into grid		



PVSYST V6.40						03/07/17	Page 5/
		Grid-Con	nected Sy	stem	Loss diagram		
Project :	4	Akzo Nobel Pal	cistan				
Simulation varia	ant:	AkzoNobel Par	king				
Main system para	ameters		System type	Grid-C	onnected		
Near Shadings PV Field Orientatio PV modules PV Array Inverter Inverter pack User's needs	on	Accordi 2 No	ng to strings onentations Model of modules Model Nb. of units d load (grid)	Tilt/Azir CS6U - 810 Sunny 9.0	Electrical effect nuth = 5°/70° and 5°/-110° 330P Pnom Pnom total Tripower 25000TL-30 Pnom total	100 % 330 Wp 267 kWp 25.00 kW ac 225 kW ac	•
		Los	s diagram ov	er the w	hole year		
	*	1720 «Veh)		+0.5%	Horizontal global irradiation Global incident in coll. plane		
			:		Near Shadings: irradiance loss		
			1	-2 7%	IAM factor on global		
				-3 0%	Soiling loss factor		
		1597 kWh m 11-1-1-			Effective irradiance on collecto	rs	
		efficiency at 11.	4 %		PV conversion		
		4.第一次行进		-0.7%	Array nominal energy (at STC e PV loss due lo irradiance levei	ffic.)	
				-7.6%	PV loss due lo temperature		
			- 0	1%	Shadings' Electrical Loss acc. to s	strings	
			-21	0% :ec	Module quality loss		
			1.09	5-26 15	Module array mismatch loss		
			-0.9%	6	Ohmic wiring loss		
		SEE & March	0.0%		Mixed orientation mismatch loss		
		0001) 1024			Anay valuat energy at mer		
			-2.2%	2	Inverter Loss during operation (eff	(ciency)	
			0.0%		Inverter Loss over nominal invipo	wer	
			0.0%		Inverter Loss over nominal inv. vo	Itage	
		350 D 5 5 5	0.0%		Inverter Loss due to voltage thresh	hold	
		abo 97.5			Avanable chergy at inverter Ou	iput	
			-8.8%		System unavailability		
			-1.3%		AC ohmic loss		
	·	323.0 MWh			Energy injected into grid		



PVSYST V6.40					03/07/17	Page 5/5
	Grid-Connecte	ed Sy	stem	Loss diagram		
Project :	Akzo Nobel Pakistan					
Simulation variant :	Prodcution hall					
Main system parameters	System	n type	Grid-C	onnected		
Near Shadings PV Field Orientation PV modules PV Array Inverter Inverter User's needs	According to s No of mo No of No of Unimited load	trings tilt Model dules Model units (grid)	8° CS6U - 270 Sunny [*] 3.0	Electrical effect azimuth 330P Pnom Pnom total Tripower 25000TL-30 Pnom total	100 % -20° 330 Wp 89.1 kWp 25.00 kW ac 75.0 kW ac	2
	Loss diagi	ram ov	er the w	hole year		
· .	1700 wWh m		+4.7%	Horizontal global irradiation Global incident in coll. plane		
			÷-1 1%	Near Shadings: madiance loss		
			-2.4%	IAM factor on global		
			.:-3.0%	Soiling loss factor		
	1686 kWhener 105 millooi			Effective irradiance on collectors	5	
	enciency across the 94%.			PV conversion		
	1 - 274 field and the second		-0.6%	PV loss due to irradiance level	IC.)	
			-7.6%	PV loss due to temperature		
		-2	4% 0%	Shadings: Electrical Loss acc. to st Module quality loss	rings	
		25	5%	LID - Light induced degradation		
	120211122	-1.09	ж 6	Module array mismatch loss Ohmic wiring loss		
	120041 KVV			Array virtual energy at MPP		
	125765 - Ar	2.2% - 0.0% - 0.0% - 0.0% - 0.0%	6	Inverter Loss during operation (effic Inverter Loss over nominal inv. pow Inverter Loss due to power thresho Inverter Loss over nominal inv. volt Inverter Loss due to voltage thresho Available Energy at Inverter Outp	ciency) id age bid bid	
		8 6%		System unavailability		
		1.3%		AC ohmic loss		
	113616 K. D			Energy injected into grid		

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Simulation Results

						29/06/17	Page 3
	Grid	-Connected S	System: Mai	n results			
Project :	Akzo Nobel	Pakistan					
Simulation variant :	area 31 a						
Main system parameters		System type	Grid-Connect	ted			
Near Shadings PV Field Orientation PV modules PV Array Inverter User's needs	A U.	ccording to strings 2 orientations Model Nb- of modules Model nirmited load (grid)	Tilt/Azimuth = CS6U - 330P 90 Sunny Tripow	Electric 8°/-20° and 3 Pri- er 25000TL-3	al effect B°/160° Pnom om total 0	100 % 330 Wp 29.70 kWp 25.00 kW ac	
Main simulation results System Production	Perf	Produced Energy ormance Ratio PR	36.39 MWh/ye 71.45 %	ar Specil	ic prod.	1225 kWh/kV	Vp/year
Normalized productions (per in	stalled kWp): Nomi	inal power 29.70 kWp		Perform	nance Ratio P	R	
	Jun Xi Aus		62- 62-				
uni neu Mair Aoir May		arez Balances an	a 31 a	Asar Apr May	ل کرد مرز ا	ιως Sep Οκ	Nov Dec
ven nev over nor May	GiobHor	area Balances an Difflor Tamp	a 31 a Id main results	Asar Apr May	Jun Jun J	ung Sep Ωx	Nov Dec
uni inu dar Apr May	Glob Hor kWh/m	arez Balances an Difflor T Amb	00 Jan Pab a 31 a id main results GlobErf kWh/m/ KWh/m/	Nar Apr May EArray E_ Mivin N	ر کرد مرز Grid PF	tug Sup Ox	Nov Dec
January	GlobHor KAM/m 38-4	ares Balances an Difflor T Amb Street C Street C Street Street	a 31 a di main results Globinc GlobEff kvMnm kvMhm' 66 1 62 4	Kar Apr May EArray E MWn N 2 291 1	Grid PF Wh 675 0.65	ουφ Sep Οα 8	Nov Dec
Jan teo dar yar May January February March	Glob Hor KMMm 89-4 131 + 153 -	Balances an Difflor T Amb 11-7 C 11-7 11-97 2 15-72 2 15-72 2 15-72	OD Jan Fee a 31 a di main results Globinc Globinc GlobEPf KMNm' KMNm' KMNm' 56 1 62 4 110 8 112 8 103 4 133 1	Kar Apr May EA may E_ Mivin M 2 291 1 2 801 2 3 752 3	Grid PF Mh 675 0.60 027 0.91	ug Sap Dα 33 66 86	Nov Des
January February Agril	Glob Hor KAMm 36.4 111 * 153.3 367 *	Drfflor T Amb brfflor C tir ti 107 tir ti 107 tir ti 107 tir ti 20	OB Jan Fee a 31 a dimain results Globler Globler Globler Side Eff 891 62 4 103 4 1530 143 1 153 7	Kar Apr Kby EArrey E_ MWin N 2.291 1 2.601 2 3.752 3 3.960 3	Grid PF Mrh 665 675 665 675 665 616 0.75 616 0.75 614 0.71	we 5mb Dα 33 36 36 36 37	Nov Dec
January February March April May	GlobHor k486/m 38-4 151 * 153 - 153 - 169 *	Difflor T Amb Difflor T Amb 11- 11 197 2 115 127 2 15 127 2 20 71 3 20 71 3 234	OD Jan Fee a 31 a dimain results Globine: GlobEff 691 62 4 110.8 103 4 153 0 143 1 166 6 155 7 186 1 177 1	Kar Apr Kby EArray E_ MWh A 2.801 2 3.762 3 4.402 4	Grid PF Mrh 66 675 0.65 616 0.75 644 0.77 234 0.75	we 5mb Dα 33 16 16 16 16	Nov Dec
January February March April May June June	GlobHor KAMm 36-4 111 * 153 -3 167 * 186 * 186 * 186 * 186 *	area Balances an Difflor T Amb 11- 11 37 11- 1	OD Jan Fee a 31 a dimain results GlobEff GlobEff KWhum' KWhum' 561 62 4 103 4 132.0 143 1 166 6 155 7 1569 177 1 158 9 178 0	Kar Apr Kby EA may E_ MVin N 2 201 1 2 201 2 3 752 3 3 960 3 4 402 2	Grid PF 007 0.65 007 0.65 007 0.93 016 0.72 027 0.93 016 0.72 023 0.72 024 0.72 0250 0.72 0260 0.72 0280 0.72	1449 5449 Dxt	Nuv Dec
January Pebruary March April May June July August	GlobHor KAM/m 36 4 111 * 153 3 167 * 189 * 190 1 170 1 170 1 177 *	area Balances an Difflor T Amb 11 11 27 11 11 27 11 11 27 11 11 27 11 11 27 11 11 27 11 12 24 12 254 12 30 80 11 10 32	Sib Jar Fee a 31 a dimain results discontraction Globinc GlobEff KWh/m² 801 62 4 132.0 132.0 143.1 166.6 155.7 156.9 178.0 170.2 158.9 178.0 172.1 156.7 156.7	Kar Apr Kby EAmay E_ MWn N 2 801 1 2 801 1 3 752 3 3 660 3 4 402 4 4 023 3	Grid PF Grid 0.0	tue Smp Dr. 13 13 13 13 13 13 13 13 13 13	Nov Dec
January February March April May June July Soptember	Glob Hor KAM/m 89-4 151 + 150 - 167 - 167 - 160 5 170 9 172 9 172 - 172 9 173 -	2014 2014	Sib Jar Fee a 31 a d <t< td=""><td>Kar Apr Kby EArray E MWh N 2 261 1 2 3752 3 3 950 3 4 425 4 4 023 3 4 073 2 9 911 2</td><td>Grid PF Mh 675 065 077 015 616 073 616 073 224 077 280 074 883 076 786 054 444 053</td><td>Nue San Dat 19 19 19 19 19 19 19 19 19 19 19 19 19</td><td>Nov Dec</td></t<>	Kar Apr Kby EArray E MWh N 2 261 1 2 3752 3 3 950 3 4 425 4 4 023 3 4 073 2 9 911 2	Grid PF Mh 675 065 077 015 616 073 616 073 224 077 280 074 883 076 786 054 444 053	Nue San Dat 19 19 19 19 19 19 19 19 19 19 19 19 19	Nov Dec
January February March April May June July August Soptember October	Glob Hor KXM/m 36r 4 151 + 150 0 167 - 186 7 186 7 186 5 172 9 472 - 103 1 163 1 164 - 165 -	<i>Deffici</i> Deffici TAmb Control TAmb Control TAmb Control TAmb Control TAmb Control	OD Jan Fee a 31 a d <td< td=""><td>Kar Apr Kby EArray E, MVA N 2 291 1 2 291 1 2 752 3 3 752 3 3 4 602 4 4 452 3 4 073 2 5 911 2 5 911 2 5 911 2 3 915 3</td><td>Grid PF Grid PF G77 043 677 043 677 043 676 077 678 054 678 054 678 054 644 07 785 054 645 055 645 055 645</td><td>we Smp Dr. 33 16 16 16 16 16 16 16 16 16 16</td><td>New Dec</td></td<>	Kar Apr Kby EArray E, MVA N 2 291 1 2 291 1 2 752 3 3 752 3 3 4 602 4 4 452 3 4 073 2 5 911 2 5 911 2 5 911 2 3 915 3	Grid PF Grid PF G77 043 677 043 677 043 676 077 678 054 678 054 678 054 644 07 785 054 645 055 645	we Smp Dr. 33 16 16 16 16 16 16 16 16 16 16	New Dec
January January Pebruary March April May June July August Soptember October November December	GlobHor KAMm 3844 111 + 150 - 160 - 160 - 1720 9 47* - 103 - 1720 9 47* - 103 - 1720 9 47* - 103 - 1750 - 260 - 260 - 260 -	Jrei Balances an Diffio T Amb 517 11 97 517 15 22 11 97 20 71 12 20 71 30 80 13 30 80 92 14 14 91 30 80 15 49 14 91 10 20 14 10 82 11 92 14 10 82 12 94 13 10 80 14 91 14 91 15 14 91 14 91	OB Jan Fee a 31 a dimain results Globing GlobEff 801 602 4 110.8 103 4 153.0 143 1 166.6 155 7 189.9 178 0 170 2 168 6 171 156 7 163.2 162 6 129.3 162 6 129.4 102 7 168.2 102 6 172 156 7 163.2 162 6 129.8 102 1 667 79 1	Kar Apr Kby EArray E, MVM N 2 291 1 2 891 1 2 891 2 3 762 3 3 762 3 4 402 3 4 402 3 4 450 4 5 911 2 3 153 3 2 182 2	Grid PF Grid PF G75 0 65 027 0 45 616 0 72 885 0 76 885 0 76 865 0	we Smp Dxt 33 16 16 16 16 16 16 16 16 16 16	Hav Dec
January January Pobruary March April May June July August Soptember October November Veat	GlobHor RXM/m 8844 111 + 150 d 167 - 189 * 169 5 172 9 475 - 193 1 169 - 169 - 169 - 169 - 169 - 169 - 169 - 169 -	Balances an Diffic T.Amb 11 5 12 15 13 20 14 15 20 14 20 71 20 71 20 71 20 71 20 214 20 71 20 214 20 214 20 214 20 214 20 214 20 214 20 214 20 214 20 214 20 214 20 214 20 214 20 214 20 214 20 214 20 214 20 214 20 214 21 214 21 214 21 214	OD Jan Fee a 31 a d d d fee d main results GlobEr/ KVMvm' KVMvm' 69 1 62 4 103 4 153 0 153 0 143 1 166 6 155 7 158 9 178 0 178 0 178 0 170 2 168 6 152 7 158 7 163 2 152 8 121 6 6 171 1 152 7 158 7 153 2 129 8 121 0 48 7 7 9 1 1715 0 1300 6 5 1300 6	Kar Apr Kby EArray É, MWA M 2 291 1 2 891 1 2 891 2 3 860 3 4 450 4 4 029 3 4 073 2 9 911 2 5 911 2 3 913 2 2 163 2 2 1163 2 41 450 38	Grid PF Grid PF G75 065 G77 083 G66 079 G78 07 G78 07 G	Nue San Dat 33 16 16 16 16 16 16 16 16 16 16 16 16 16	Nov Dec







PVSYST V6.40								03/07/17	Page 4/5
• • • • • • • • • • • • • • • • • • •	C	Grid-Cor	nnected S	Systen	n: Main	results			
Project :	Akzo	Nobel Pal	kistan						
Simulation varian	t: fg&n	ew fg							
Main system paran	neters		System type	Grid-	Connected				
Near Shadings		Accordi	ng to strings			Electrica	effect	100 %	
PV Field Orientation		2	orientations	Tilt/A:	zimuth = 8%	70° and 8	°/-110°	000.144	
PV modules PV Array		Nih	ot modules	150	- 330P	Pno	Phom m total	330 VVP	
Inverter		140	Model	Sunn	Tripower:	25000TL-3	0	25.00 kW a	0
Inverter pack			Nb. of units	2.0	,	Pnor	m total	50.0 kW ac	-
User's needs		Unlimite	d load (grid)						
Main simulation res System Production	sults	Produ Performan	ced Energy	58.36 68.73	MWh/year %	Specific	prod.	1179 kWh/k	Wp/year
Normalized productions	(per inslalled kWp): Nominal po	wer 49.5 kWp			Perform	ance Ratio F	PR .	
6 Lc . Callection Loss (P	(-array iosees) 102	ntestantis.		1.0	PR Performa	nce Ratio : YI / Yrs	1887		
7 - Y1 · Produced useful en	inter 3 0 451 wrgy (inventer ousput) 3 231	nanarian Nanarian	-						
				· 08		-			
		Martin Martine]						
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		图 書 3							
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					S. 31.		à		
Jan Feb Mar Apr	May Jur- Jur	40- 100 h	a Meri Des		Jan Feb Ma	r Apr May	Jun Jul -	Aug Sep Oot	New Dec
			fg &	new fg					
			Balances an	d main r	esuits				
	GlobHor	DiffHor	TAmb	Globinc	GlobEff	EArray	E_Grid	PR	ר
	kWh/m²	kV95-m ²	°C	kWh/m²	kWh/m²	MWh	MWh		
January	89.4	14 č.	11.37	89.1	82.7	3.709	2.709	0.614	1
February	111.1	44 /	15.72	110.8	103.7	4.504	3.252	0 593	
March	153 4	64.8	21:48	. 153. 1	1438	6.009	5.796	0 765	
April	167.1	50-4	26.71	166 6	156.5	6.382	6.153	0.746	
May	189.7	φ> a	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	16.7	30.90	170 2	159.7	6.455	6.224	0.739	
August	171.7	1001	10.32	171.1	160.6	6.521	4 461	0.527	
September	163.6		28.12	163 2	153.5	6 253	4 086	0 506	
October	130.2	64	24.65	129.8	121,5	5.064	4.893	0.761	
November	96,9	40.4	13.28	90.7	90.0	3,905	3./83	0.790	
Year	1720.1	37:4	23.78	1715.3	1608.2	66.440	58.358	0.687	-
L			L			I			-
Legends: Glo	bHor Horizo	ntal global ruad	ution .		GlobEff	Effective Glob	al, corr. for U	AM and shadings	
Diff	Hor Horizo	ntal diffuser i tac	liation		EArray	Effective ener	gy at the outp	put of the array	
TA	Ambie	nt Tempera con Tempera			E_Grid	Energy injecte	d into grid		
Glo	eoine Global	Incide 1117	rahe		PK	Performance i	Calio		



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	G	rid-Cor	nnected S	yster	n: Main	results				
Project :	Akzo N	lobel Pal	kistan							
Simulation variant :	AkzoN	obel Par	king							
Main system parameters			System type	Grid-	Connected]				
Near Shadings According to strings PV Field Orientation 2 orientations PV modules Model PV Array Nb of modules Inverter Model Inverter Model User's needs Unlimited load (grid)					Electrical effect 100 % Tilt/Azimuth = 5°/70° and 5°/-110° 200 % CS6U - 330P Pnorm 330 Wp 810 Pnorm total 267 kWp Sunny Tripower 25000TL-30 25.00 kW ac 9.0 Pnorm total 225 kW ac					
Main simulation results System Production	f	Produ Perlorman	ced Energy	323.0 69.89	MWh/year %	Specific	prod.	1208 kWh/k	Wp/year	
Normalized productions (per ins	stalled kWp)	: Nominal µõ	ower 267 kWp			Perform	ance Ratio F	PR		
AkzoNobel Parking										
			balances and	a main i	esuits					
	GlobHor	DiftHor	T Amb	Globinc	GlobEff	EArray	E_Grid	PR]	
January	89.4	44.5	11 37	90.6	79.8	19.68	14.27	0.589	1	
February	111.1	44.7	15 72	112.1	103.6	24.90	16.14	0.605		
March	153 4	64.3	23.48	155.0	144.9	33.70	32.50	0.784		
April	167.1	36 <i>4</i>	26-71	167 3	156.1	35.49	34 20	0.765		
May	189.7	914	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	19, 1	30.90	170.2	158.3	35.64	34.37	0.756		
September	163.6	2.2	28.12	164.5	153.8	36.22	23,16	0.527		
October	130.2	64.7	24.66	131 3	121,9	28.16	27.21	0.775		
November	96.9	42.4	17.59	98.5	58 6	21.19	20.53	0.780		
December	85.9	42.0	13.18	87.3	75.0	18.31	17.77	0.761		
Year	1720.1	8714	23 78	1728.8	1597.4	366.83	322.97	0.699		
Legends: GlobHor Horizontal global incidentee DiffHor Horizontal diffuse madiation T Amb Ambient Temperature GlobInc Global incident exist pane					GlobEff EArray E_Grid PR	Effective Global, corr. for IAM and shadings Effective energy at the output of the array Energy injected into grid Performance Ratio				



ST V6.40								03/07/17	Page 4/5	
		Grid-Co	nnected S	System	n: Main	results				
ct:	Ak	zo Nobel Pa	kistan							
lation vari	ant : Pro	odcution hal	1							
system par	ameters		System type	Grid-(Connected	t				
Shadings		Accord	ing to strings			Electrical	effect	100 %		
eld Orientati	on		tilt	8°		az	imuth	-20°		
odules		6.De	Model	CS6U	- 330P	Dnor	Pnom	330 Wp		
er		1918.	Model	Sunny	Tripower	25000TL-30)	25.00 kW a	-	
er pack			Nb. of units	3.0	1.1	Pnor	n total	75.0 kW ac	-	
needs		Unlimite	ed load (grid)							
simulation n Productio	results n	Produ Performar	iced Energy ice Ratio PR	1135 1 70.73	8 kWh/ye %	ar Specific	prod.	1274 kWh/k	Wp/year	
ormalized productions (per Installed kWp): Nominal power 89.1 kWp Performance Rati							ince Ratio I	PR		
Le . Collection Lo	es (PV-array iossas)	D BS KVMARMARIAN		10	PR Perform	Inca Rallo 197/ Yrs 10.	707		, , , , , , , , , , , , , , , , , , , ,	
VI Produced use	ful energy proenter output	1:3 HO KAN MARKET		0.8-						
un Føb Jåer	Apr May Jun		Prodect	00- 02- 00-	Jan Feb Ma	a Agir Mey	an A	Aug Sage Cot	Nov Dec	
			Balances an	d main re	esults					
		Diffusion		01-1-1-1	0.157				1	
	Gioph		*C	GIODINC MAlbim?	GIODEIT	EArray	E_GIIG	PR		
January	89.4	44.6	11:37	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 64.2	21.48	162.1	152 2	11751	11327	0 784		
Aprii	167	1 66.4	26 71	172 1	161.3	12200	11762	0.767		
Мау	189.1	7 9/4	32 34	191 2	179.4	13173	12683	0.745		
June	190.5	5 99.5	32 14	189.8	178.2	13174	12686	0.750		
July	170.9	B 16.1.7	30.90	1714	160.3	12019	11592	0.759		
August	121.	100.3	26.00	174.5	163.3	12291	8458	0.544		
October	130	2 6.4.T	24.66	140.5	131.5	10075	9731	0 777		
November	96.9	46 ~	17.89	107.8	100.4	7906	7655	0.797		
December	85.9	4	13.28	97.7	90.6	7244	7019	0.806		
Year	1720.	1 8714	23.78	1801.3	1686.3	128641	113518	0.707		
Legends	GlobHor H	GlobHor Horizontal globa Circadiation				Effective Globa	il, corr. for l	AM and shadings		
-	DiffHor H	orizontal diffuse mas	hation		EArray	Effective energ	y at the outp	pul of the array		
	T Amb A	mbient Temperature			E_Grid	Energy injected	into gnd			
	Globinc G	ilobal incident or coll.	piane		PR	Performance R	atio			



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
- I. 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.