PNG Power Pilot Rooftop Solar Program

Consultation Workshop

26 June 2018

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PNG Power's Pilot Rooftop Solar Program

Objectives and background

Scope of the program and types of connections

Technical aspects of rooftop solar PV system

Technical standards and application procedures

Future tariffs and net metering

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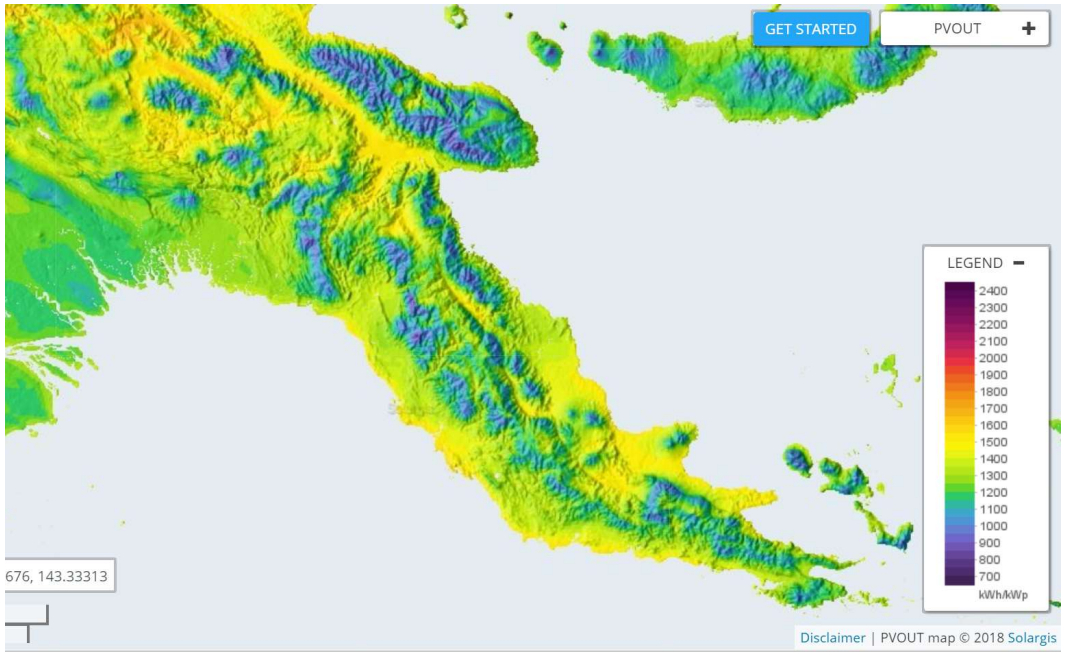
Solar has the potential to bring significant benefits to PNG

Key benefits

- Displace expensive diesel generation at peak hours
- Reduce network losses, because of proximity to load
- In the longer-term, reduce burden of generation and network investments
- Reduce carbon emissions

Solar potential in PNG

- Solar irradiance appears to be good, particularly on the coastal areas
- Works well alongside hydro storage



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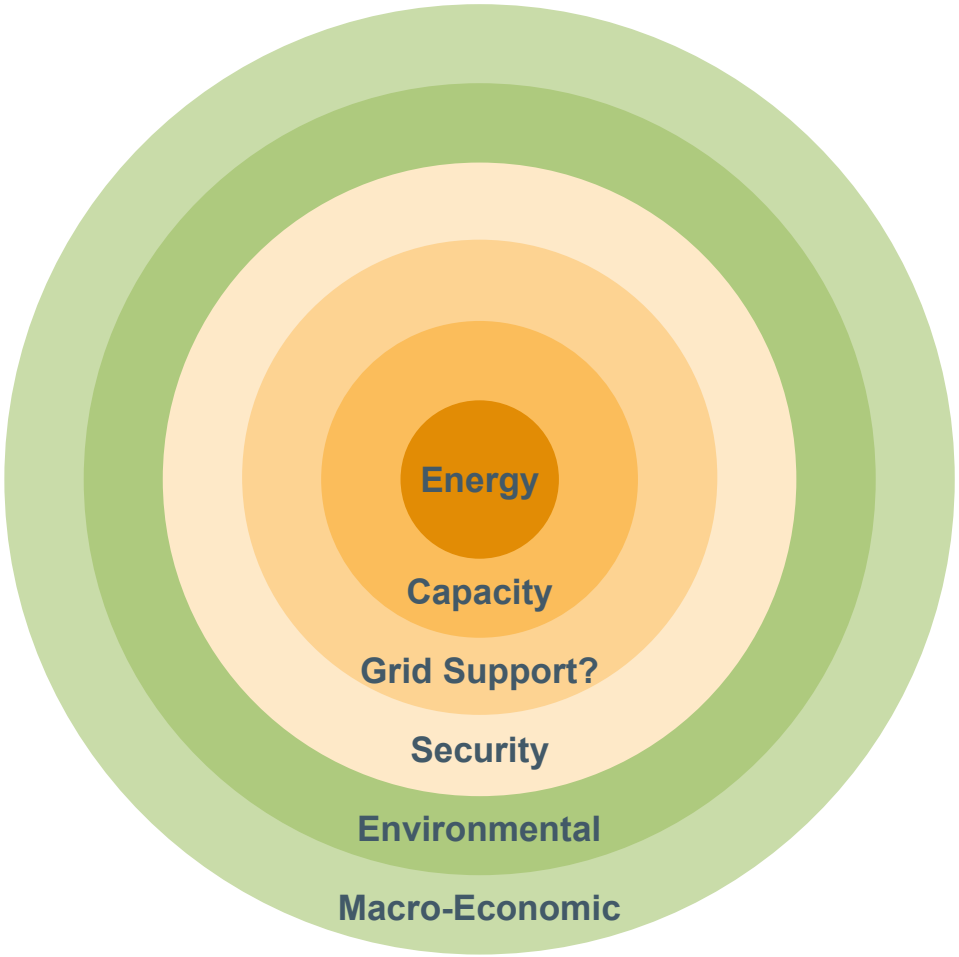
The potential benefits



FINANCIAL

ENERGY
- avoided fuel costs
- reduced system losses

CAPACITY
- avoided generation investment
- reduced network investment

GRID SUPPORT?
- unlikely but possible with advanced inverters

SECURITY
- diversification of supply services

SOCIAL (externalities)

ENVIRONMENTAL
- pollutants and carbon emissions
- land and water requirements

MACRO-ECONOMIC
- employment
- tax revenues

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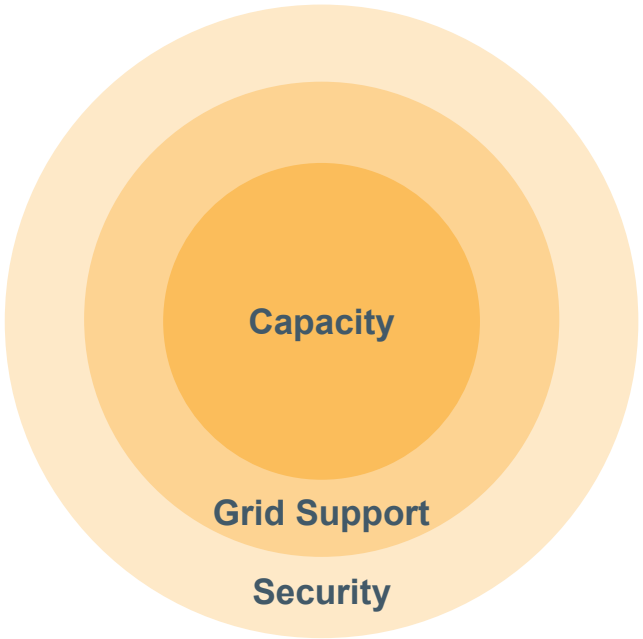
The potential costs



FINANCIAL

CAPACITY
- solar PV investment costs
- connection & grid reinforcement

GRID SUPPORT
- balancing (ramping & cycling)
- frequency response
- reactive power & voltage control
- forecasting (operating reserves)

SECURITY
- storage and back-up capacity

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Solar PV has already arrived in PNG and is going to get cheaper

- There is **strong interest among private sector developers** in installing rooftop solar PV
  - To reduce their cost of supply
  - As part of their corporate/social responsibility
- Several **large customers have already installed** rooftop solar PV systems
  - Including CPL (200kW), Air Niugini (100kW).
  - PNG Power staff have conducted some testing of these installations, but they are currently disconnected until the technical and commercial terms of connection are clearly defined by PNG Power.
- The technology is **here to stay**
  - Solar PV will continue to get cheaper (~20% per year)
  - Battery costs are currently too high to make standalone systems cost-competitive with the grid. But this may change over time.
  - Other Pacific Island countries have taken first steps to allow some rooftop solar PV (Vanuatu, Tonga)

Scope of the solar PV program

Small solar PV systems (usually installed on a rooftop)

For a customer's **self-consumption** (customer is a net importer from grid)

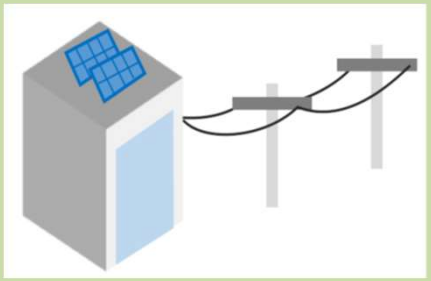
Synchronised to the grid (i.e. no battery storage). Grid act as a storage. Excess power can be exported and required power can be imported.

Larger solar PV systems (that are primarily for export to the grid), are procured separately as IPPs.

Isolated/Offgrid systems (that are not connected to the grid)

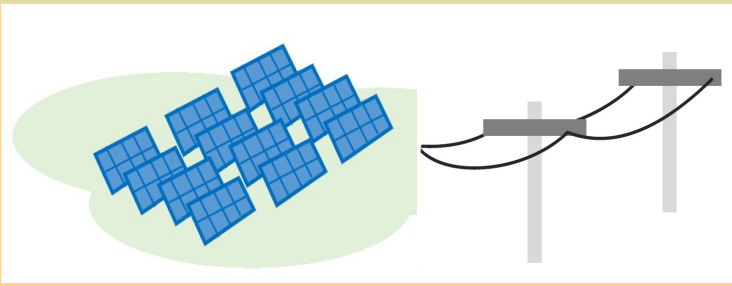
Rooftop business models

- Self-supply
- Net metering, net billing
- Buy all / sell all



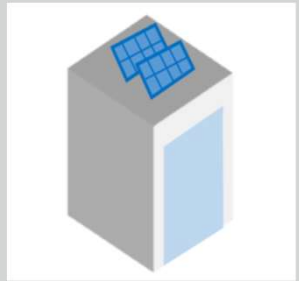
Sell to the utility

- Stand-alone
- Wheeling
- Embedded



Isolated/Offgrid systems

- SHS – leasing / purchase / utility
- Solar and hybrid mini-grids



Possible technical issues to be managed

Intermittency of solar PV

How well will PNG Power's existing grid copy with the inherent intermittency of solar? Solar irradiation levels are not yet well understood. It will take time to establish reliable forecasting models.

Too much solar would aggravate grid stability. Other customers could experience change in power quality.

Ensuring quality solar equipment

It is important that customers install high quality PV modules and inverters.

Poor quality inverters may lead to issues with harmonics, DC injection, reactive power, sensitivity to voltage and frequency, and even voltage collapse. Cheaper, low quality PV modules will degrade over shorter time and customers will lose faith in the technology.

Ensuring correct installations

There is limited knowledge and experience of solar PV systems in PNG.

If the system is not designed, installed and maintained correctly, it may cause issues within each solar PV system as well as PNG Power's grid.

Possible commercial issues to be managed

Recovery of capacity costs

PNG Power always has to provide standby capacity, including standby generation and network capacity. Even when a customer's solar PV is generating.

Under the current tariff structure, residential and commercial customers do not pay a capacity or fixed monthly charge.

Reflecting the variation in cost by time of day

PNG Power's cost of generation varies by the time of day and therefore so will the value of excess solar PV generation that feeds into the grid.

It is currently most expensive during the peak hours in the middle of the day, which, fortunately, largely coincides with peak solar PV.
Avoided costs could change in the future.

Fair treatment of customers

Some cross-subsidies exist, including between commercial and residential customers, and between urban and rural areas.

Should be careful to ensure that commercial customers do not reap the benefits of solar PV at the expense of residential customers.

Implementing a pilot program will allow PNG Power to carefully monitor and manage the technical and commercial impacts

Implement pilot phase

Only allow certain types of installations

Only allow installations in certain locations

Limit individual sizes of installations

Limits the total capacity of solar PV

Limit crediting of exports

Monitor and evaluate

Monitor impacts on grid stability

Monitor changes in load profiles of solar customers

Monitor commercial impacts of rooftop solar

Train PNG Power staff in testing and commissioning

Improve forecasting of solar irradiation/generation

Next phase of solar program

Adjust tariff structures

Increase capacity limits

Make scheme available to other customer types

Credit imports

Reinforce distribution networks

Implement solar grid support, active filtering etc.

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Initially, a cumulative capacity limit of 2MW

- PNG Power will approve **applications** for the connection of solar PV systems to its distribution networks **on a first-come-first-served basis**
- So long as the connection will not result in **the total capacity** of approved Net-Metered Solar PV Systems exceeding **2MW**

- Limits the impacts of new solar installations on the stability of PPL's network
- Set in terms of cumulative MW capacity terms for ease of understanding and implementation
- Currently translates to approximately 2% of peak load in the Port Moresby system

Initially, only commercial customers eligible

- The customer has a **maximum demand for electricity of at least 300kVA** at the premises
- The capacity will **not exceed the customer's maximum demand** or 1,000 kW, whichever is smaller

- Limits the number of participants, which allows PNG Power to closely monitor the performance of individual systems as well as grid
- Large commercial and industrial customers consume their electricity mostly during day-time when the solar resource is available, so exports to the grid will be minimal (unlike residential customers)

Initially, only connections to the Port Moresby grid allowed

- Solar PV systems may only be **connected to the Port Moresby distribution network**
- **Excludes** solar PV systems that are connected to the transmission network or for the **sale of electricity** to PNG Power or to another licensee

- Port Moresby is PNG Power's most stable network, so is best able to cope with the intermittency of grid-connected solar PV
- The potential value of solar is actually higher in other grids that rely on diesel generation during peak hours
- PNG Power may introduce larger solar PV systems, which are dedicated to exporting energy to the grid, under separate arrangements (e.g.) competitively-procured Independent Power Producers

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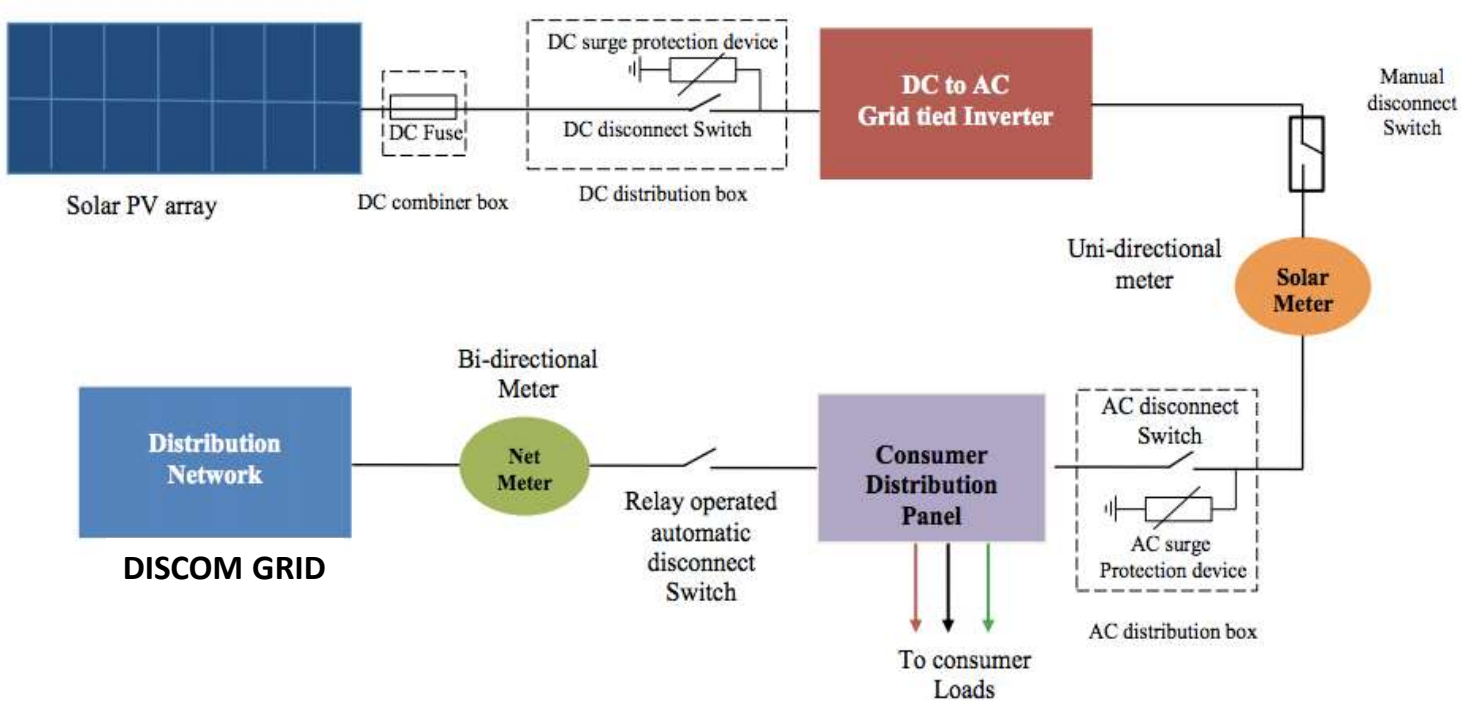
Technical Aspects of Rooftop Solar PV System

Rooftop Solar PV Systems might be implemented under Grid-Connected or Off-Grid Modes



The Key Technical Parameters to consider for implementing a Rooftop Solar Project are

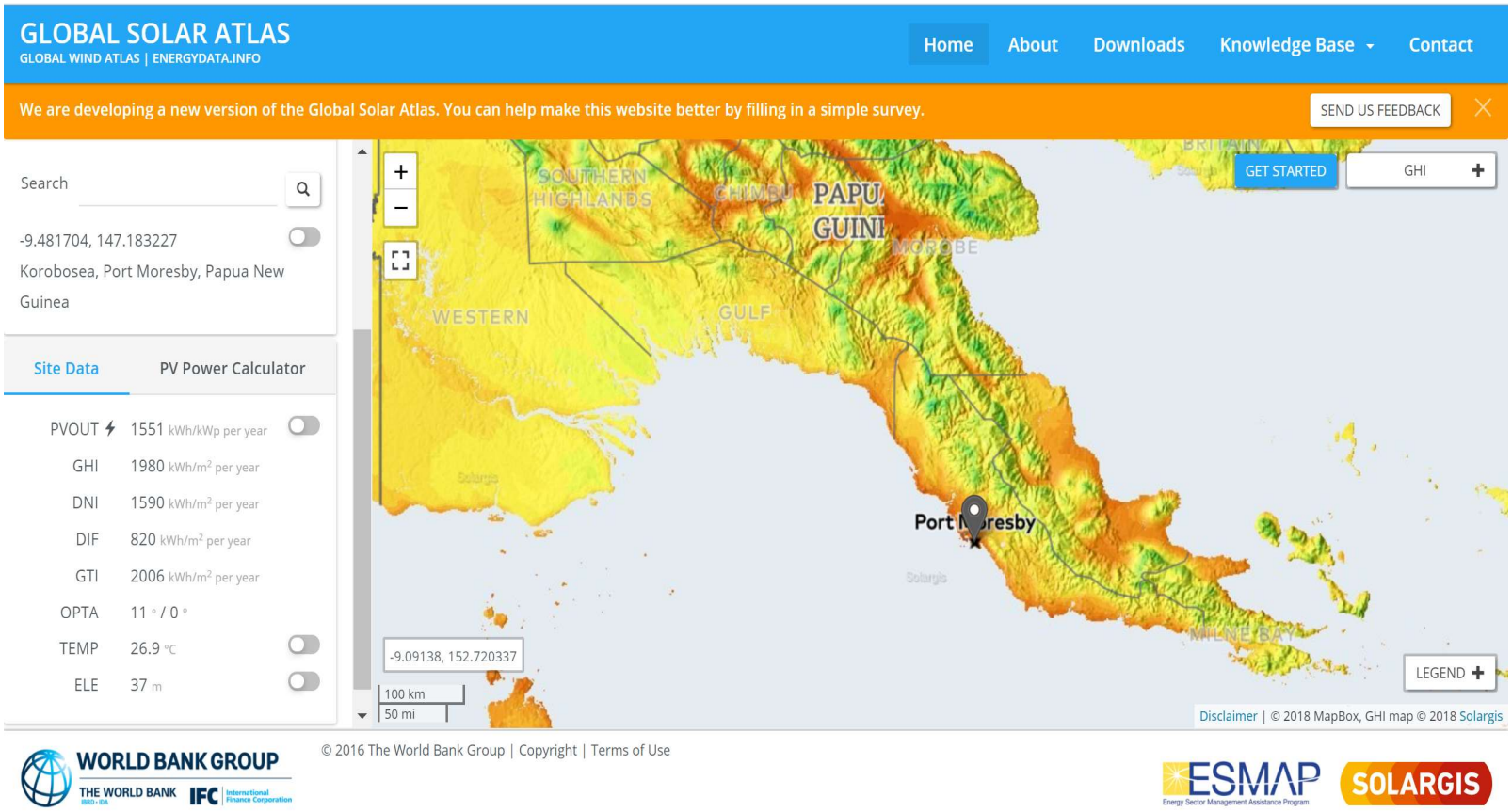
- Resource
- Potential
- Technology
-

Technical Aspects of Rooftop Solar PV System

Resource –

The resource assessment comprises Solar Radiation (GHI), Temperature and other meteorological parameters.

Potential locations of PNG receives annual GHI more than 1800 kWh/m^2 which makes if suitable for solar PV projects.



Source - http://globalsolaratlas.info

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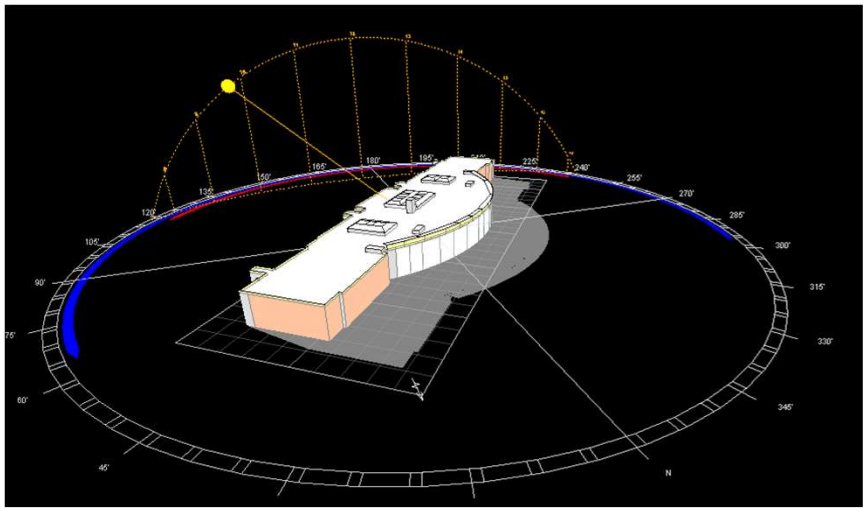
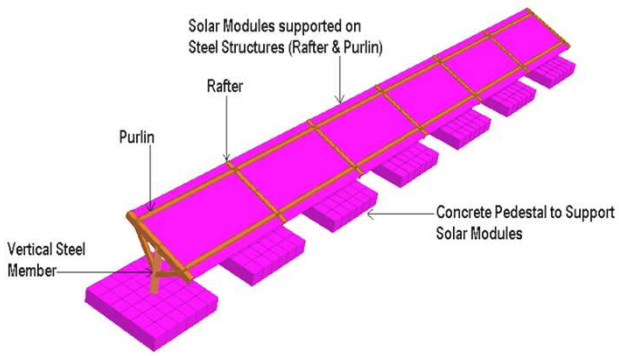
Technical Aspects of Rooftop Solar PV System

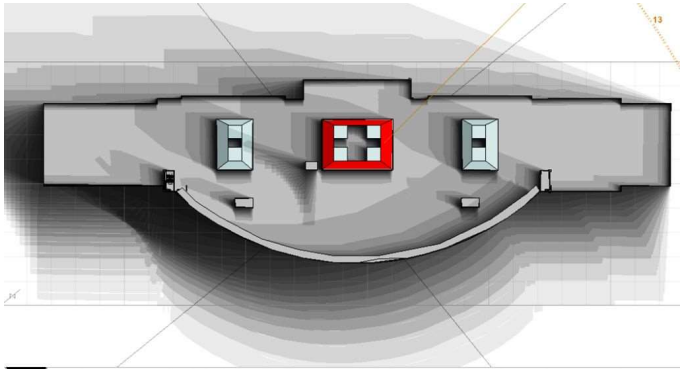
Potential –

The area requirement for rooftop solar PV is considered as **10-12 m^2** per kW capacity system.

- Availability of **Shadow Free** Rooftop Area
- Strength of the Building Structure
- High Usable Area







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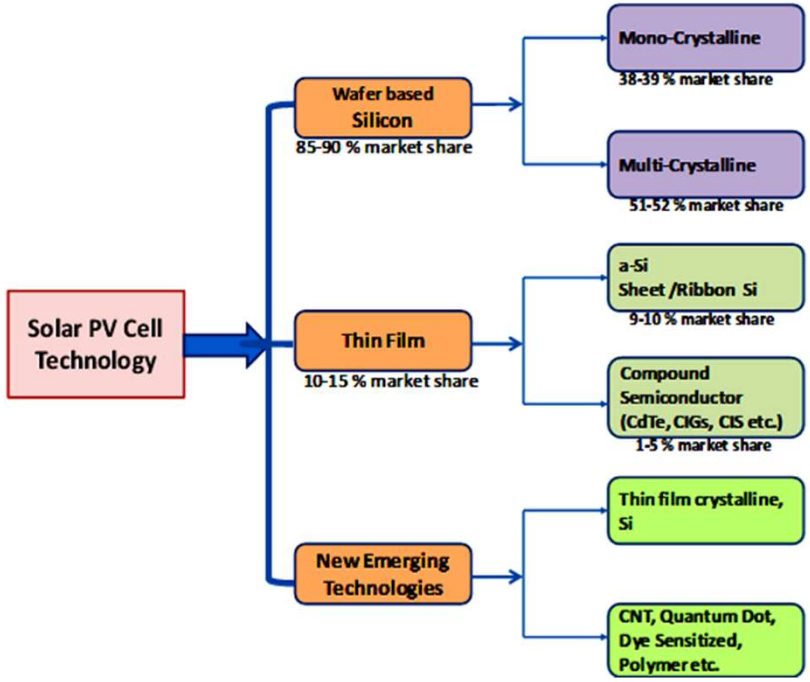
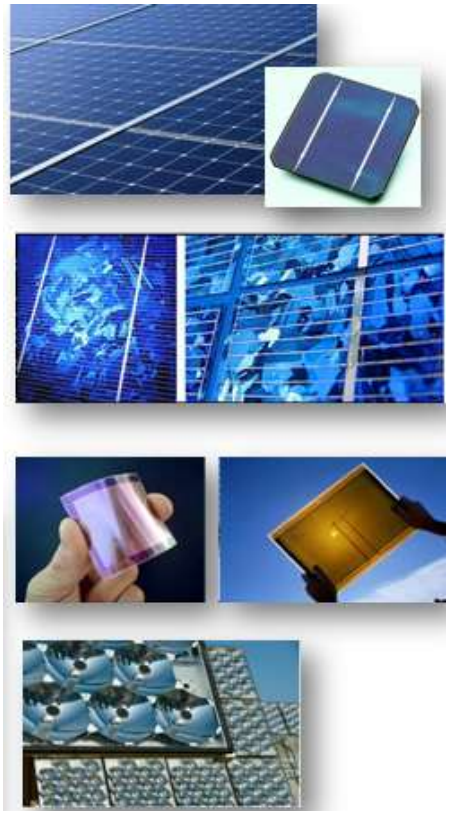
Technical Aspects of Rooftop Solar PV System

Technology

- Modules and Inverters are two major components of a typical Rooftop PV system.
- Crystalline solar PV technology is most accepted option in rooftop PV.
- Flexi type of solar PV modules are good to implement the project in lesser time.
- TIER-1 manufacturers are recommended for bankability of the projects.





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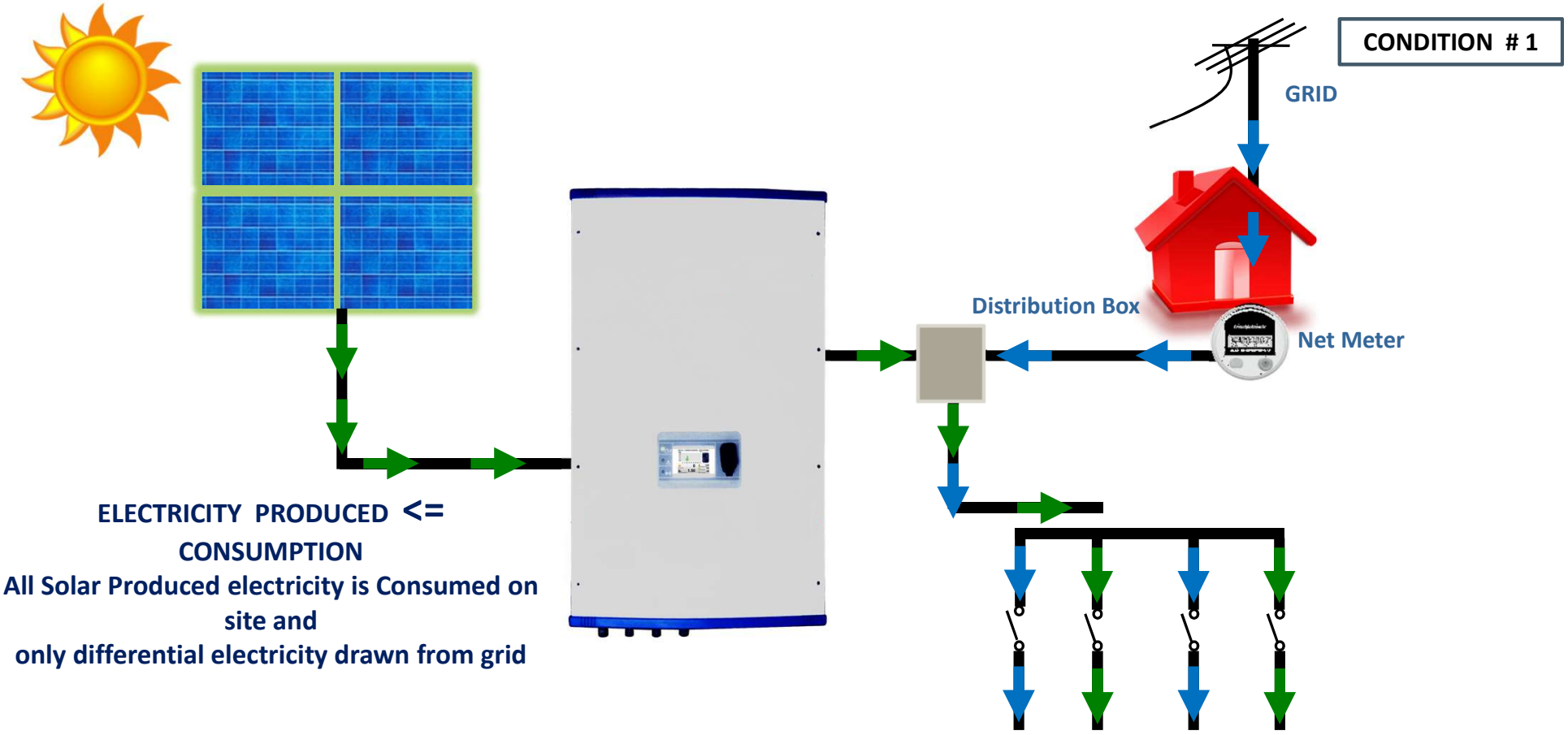
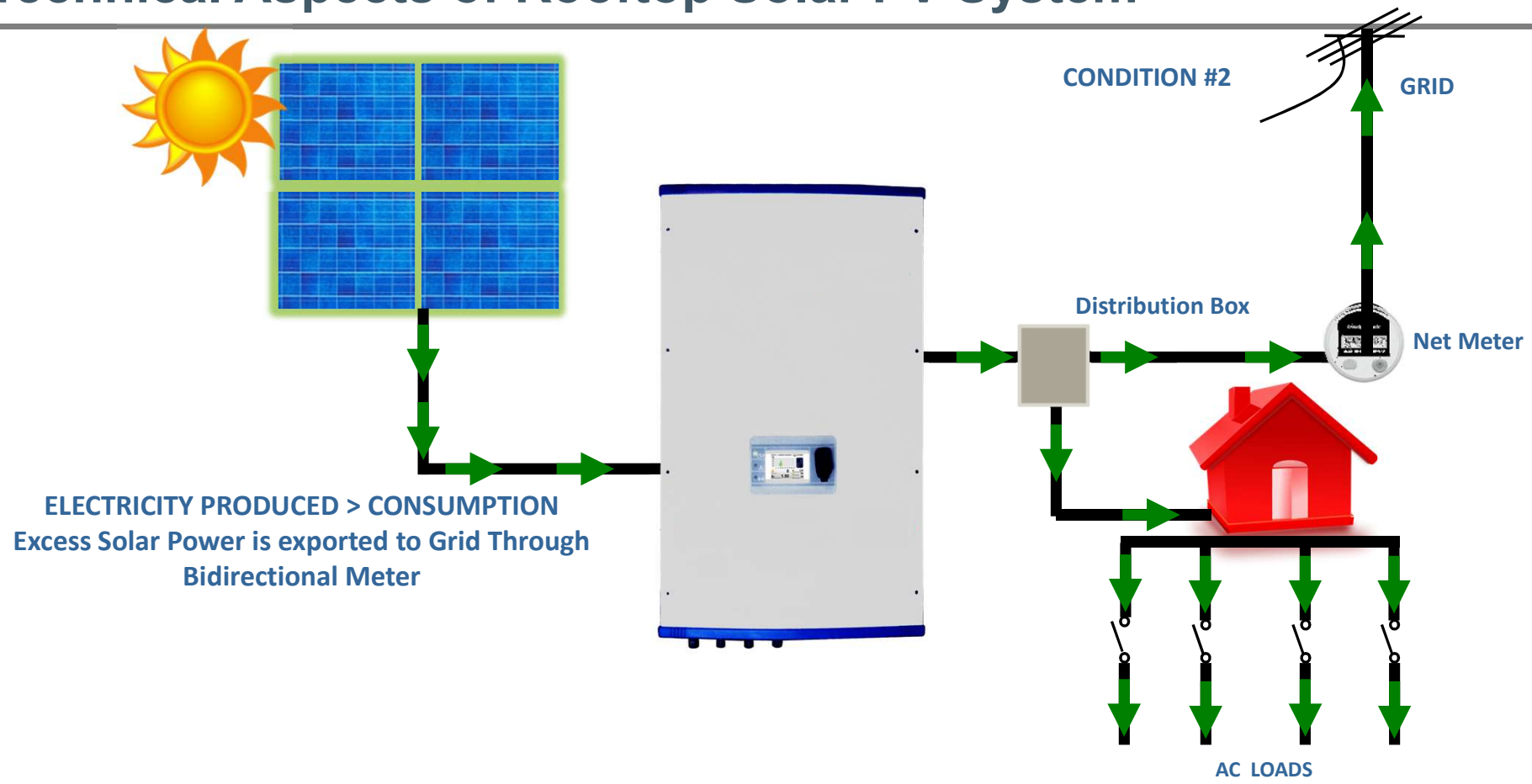
Technical Aspects of Rooftop Solar PV System



ELECTRICITY PRODUCED <=
CONSUMPTION
All Solar Produced electricity is Consumed on site and
only differential electricity drawn from grid

Technical Aspects of Rooftop Solar PV System



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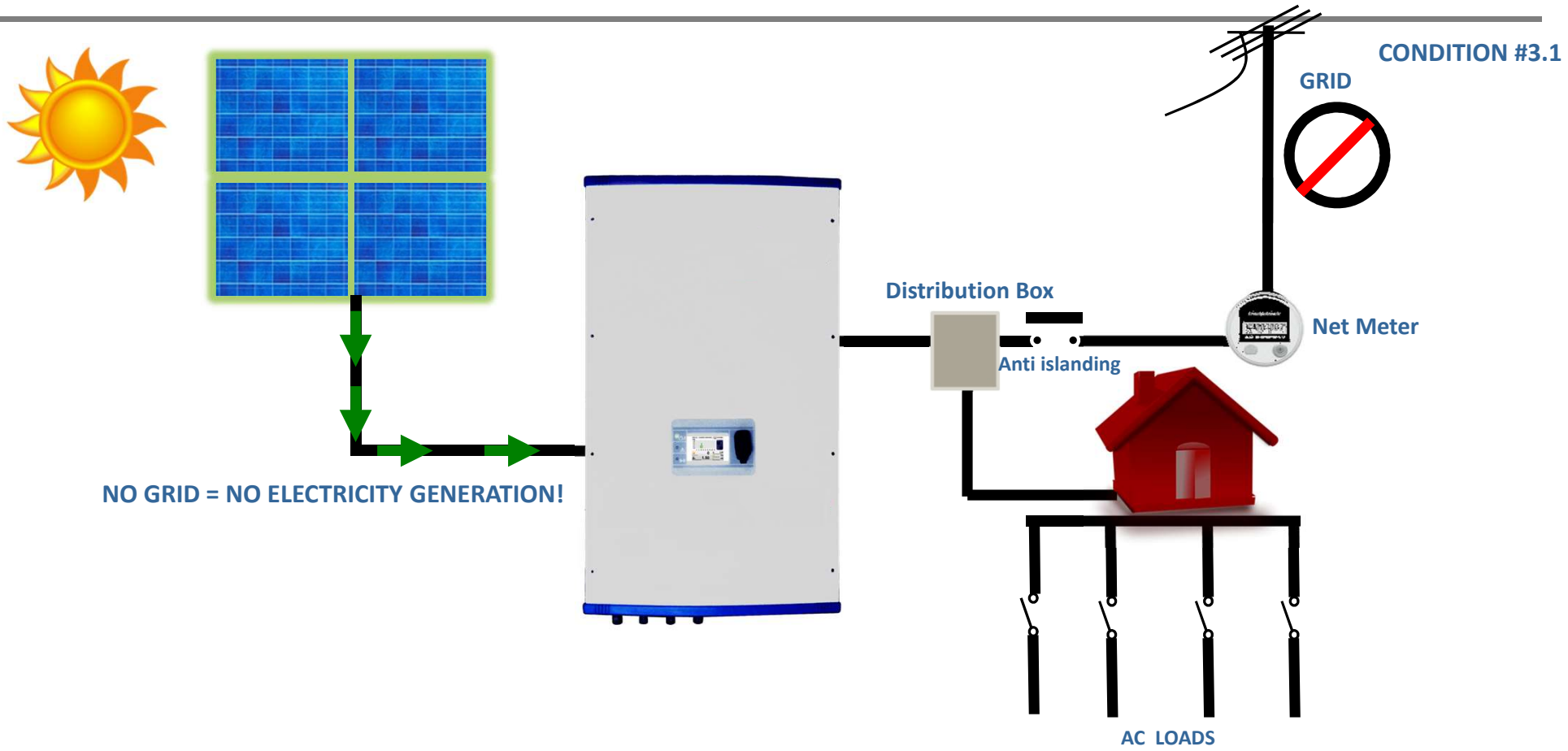

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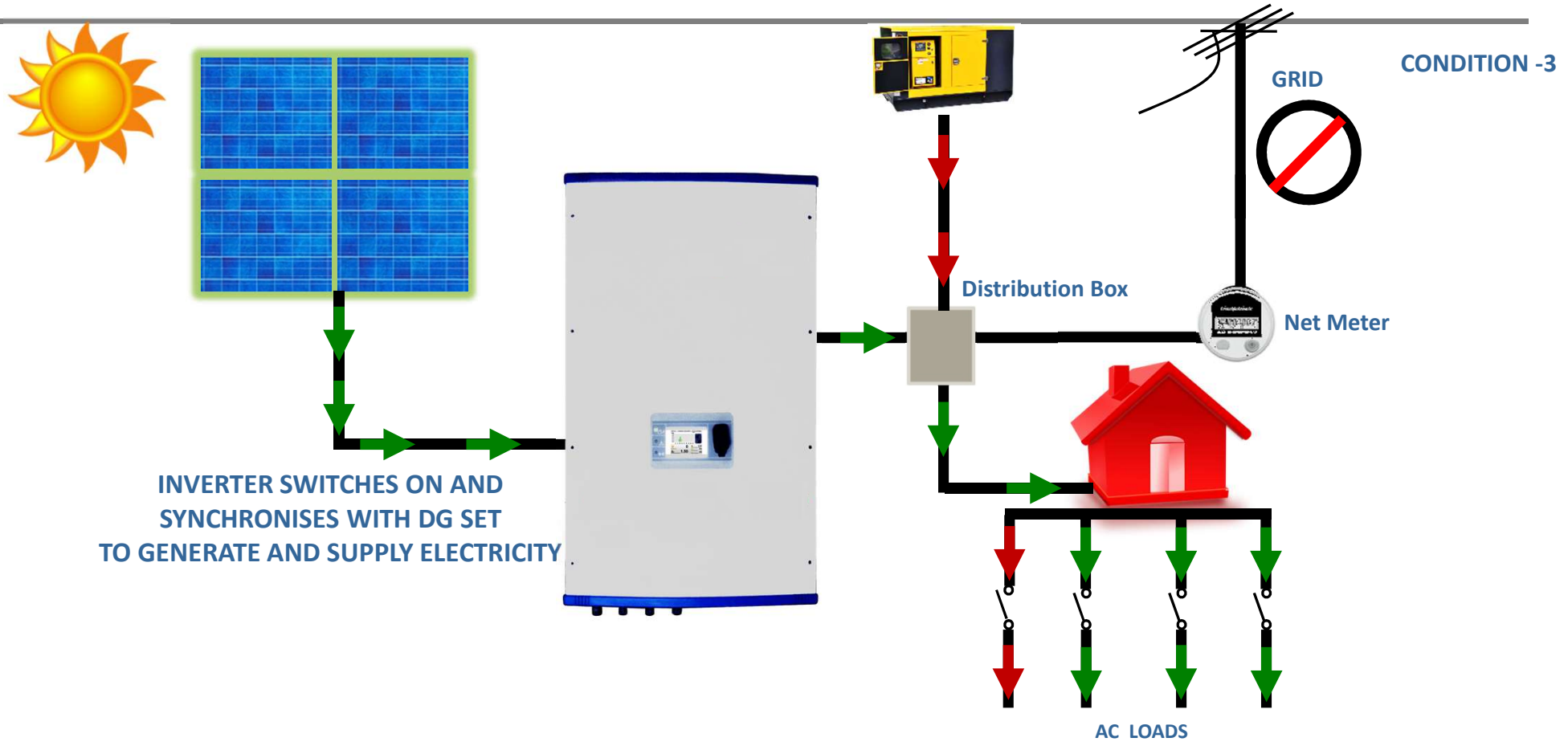
Technical Aspects of Rooftop Solar PV System



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Solar equipment standards

- **Solar PV modules** should conform to standards IEC 61215, IEC61646, IEC 61730 or equivalent
- All **Inverter equipment** installed for Net-Metered Solar PV Systems should meet IEC 61727 (2004 -12), IEC61683, IEC62109, IEEE 1547 – 2003 or latest available equivalent standards
- Minimum requirements for system documentation, commissioning tests and inspection as per IEC62446
- Conformity to standards for both solar PV modules and Inverter equipment should be fulfilled by **producing a Type Test certificate** from an accredited testing laboratory, provided to the customer by the manufacturer or the re-seller of such equipment
- In the absence of a Type Test certificate, a **laboratory test certificate** may be submitted, from an accredited laboratory

- IEC = International Electrotechnical Commission
- IEEE = Institution of Electrical and Electronic Engineers, USA
- Type Tests are intended to verify compliance of the design of given equipment with the stated standard, performed on one single specified electrical equipment of one type and are intended to check the design characteristics

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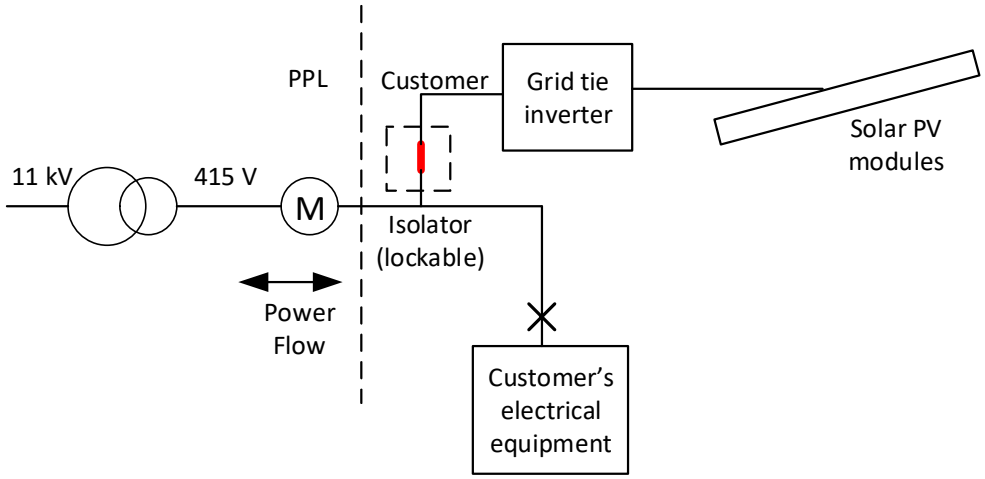
Eligible solar PV systems must operate in parallel with the grid

- Solar PV System with **grid-tied Inverter**, operating in parallel with the grid
- Should **not directly distribute electricity** within the customer premises either in DC or AC. The only connection should be at the LT/HT switchgear near the energy meter
- **Lockable AC isolation switch** should ensure physical isolation between the customer's electrical equipment, the PNG Power service line and the solar PV system



Solar PV system diagram

Position to the meter (M) and voltage values are indicative. Metering at 11kV or higher voltages, and connection of the solar PV system inverter at a different voltage is acceptable, within allowed voltages stated in the grid code and other regulatory documents

Must include an import-export meter that will enable net-metering

- Customer's existing energy meter replaced with an **import-export meter**. Customers are advised to install another energy meter for recording output of the solar PV system
- When the customer's equipment requires more power than the output of the solar PV system, electricity will **freely flow from the PNG Power grid to the customer**, through the import-export meter. And vice-versa
- The customer should plan his solar PV system in such a manner that **no more than the customer's monthly energy requirement is delivered** by the solar PV system

- PNG Power will install the new meter once certification of a new installation is complete, prior to commissioning
- PNG Power plans to introduce net metering in future phases, once the commercial impacts are better understand and tariffs have been calibrated accordingly
- Discussed later in this presentation

Installation of solar PV system

- The electrical installation of the solar PV system should be conducted by a **Licensed Electrician or a Licensed Electrical Contractor**
- **Electrical wires and accessories** used for electrical connections should conform to AS/NZS standards or equivalent
- **Electrical installation** should conform to AS/NZS 3000 Wiring Rules and all other standards and practices approved by PNG Power
- The connection of the solar PV system to the grid should be through an **isolator, installed within a lockable enclosure**, in a location accessible by PNG Power's maintenance staff

▶ May introduce such a requirement for future phases of this program once smaller customers are eligible

Monitoring system

- The customer will install an **on-line monitoring system** for the solar PV system, which in the minimum, should measure at five-minute intervals (or at shorter intervals) and store (a) AC terminal voltage, (b) AC power (in kW), (c) power factor
- This stored information will be **sent to PNG Power** at the end of each day, **through a GSM link**, for which the customer is required to install and pay any associated fees
- The information should also be **stored in the on-line monitoring system** for a period of at least one year, and, upon PNG Power's request to the customer, should be downloaded and provided to PNG Power

Testing and certification

- **Pre-commissioning customer testing**: Customer must use a Licensed Electrician or a Licensed Electrical Contractor (licensed by PNG Power) to test the installation, declare it ready for commissioning and issue a certificate
- **Inspection and certification**: The Licensed Electrician or the Licensed Electrical Contractor will facilitate the testing by the Certification Engineer appointed by PNG Power. Testing will include:
  - Isolation arrangement
  - Loss of mains protection, to ensure the Inverter does not cause unintended islanding
  - Power quality, including harmonic and flicker analysis.

- The Certification Engineer appointed by PNG Power will not test the solar equipment itself

Application process

1. **Application**: A customer must first submit an application to the PNG Power and pay the application fee. The application will be evaluated by PNG Power and approved or not
2. **Testing and certification**: Once the customer has installed a solar PV system the customer will request testing and certification. PNG Power will arrange for a appointed Certification Engineer to test and certify the installation within two weeks
3. **Commissioning**: Once PNG Power has certified the installation, PNG Power will install the energy meter (to be paid for by the customer), and then approve commissioning within two weeks

- Customer has six months to request testing and certification. If this six months is breached, the customer's approval is revoked and they must reapply

Simple two page application form

1. **Name of customer as stated in the electricity account:** _____

2. **Customer's premises number and complete address:**
_____
_____

3. **Telephone numbers:** _____ **Email:** _____

4. **Electricity customer account no:** _____

5. **Contract demand of the supply:** _____ **kVA** [should be higher than or equal to <300 kVA>]

6. **Maximum demand, averaged over the past 12 months:** _____ **kVA** [should be higher than 300 kVA]

7. **Rated capacity of the proposed solar PV system (on the alternating current side of the inverter):** _____ **kW** [should be lower than 1000 kW, on the AC output side of the Grid-tied Inverter]

8. **Information to be submitted with the application:**

(a) The single-line diagram of the proposed installation.

(b) The compliance certificate for the inverter.

(c) List of protective devices between the inverter output and the point of interconnection to the PPL grid, and their protection settings.

9. **Equipment supplier/installers details**

Name of Company: _____

Address: _____

Phone: _____

Name of the responsible person: _____

10. **Certification by the equipment supplier/installer:**

I certify the proposed solar PV system is compliant with the standards, guidelines and requirements stipulated in the notification.

Signature: _____

Name: _____

Date: _____

11. **Certification by the customer**

□ I attach the receipt number _____ dated _____ for the payment of _____Kina as the fee for this application, to PPL.

□ I certify that the solar PV system is required at the same premise where the electricity account is already provided, and that the power from solar PV system to be harnessed is within the property served by the existing electricity supply.

□I agree to install all the required equipment and to provide information whenever requested by PPL.

□ I certify that the solar PV system shall be in compliance with all aspects of PPL's *Notice on the Grid Connection of Solar PV Systems*, as published on the date of this application.

Signature: _____

Name: _____ [the customer]

Date: _____

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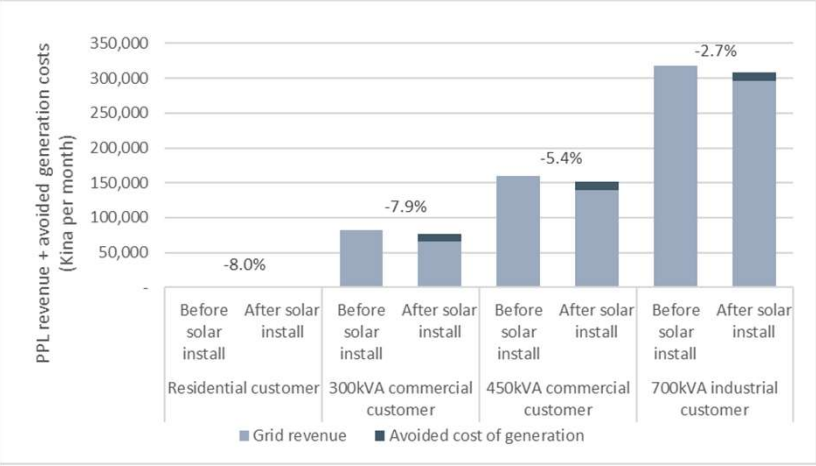
PNG Power's proposed tariff/commercial arrangements

During the pilot phase

- Solar customers will remain on their existing tariff (General Supply or Industrial)
- Electricity exported back to the grid will <u>not</u> be credited or paid for

Future phases

- Tariffs will be adjusted to better reflect costs (energy + capacity charge)
- Electricity exported back to the grid will be offset against consumption (net metering)



- Customers can remain in the scheme for 10 years
- PNG Power has the right to change tariffs at any time

Example analysis of commercial impacts on PNG Power

Putting it in context: solar is changing the game for utilities

The traditional reality: Customers must accept tariffs

- In vertically integrated systems, customers traditionally had no alternative supplier
- Customers therefore had no choice but to accept the tariffs set by the utility, regardless of the level or design

The new normal: Competition from solar

- Customers have the option of installing rooftop solar to supplement (or even substitute) grid supply
- Tariff design matters!

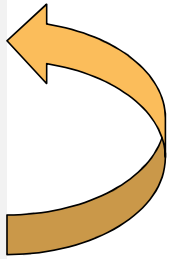
Set the energy charge (K/kWh) too high:
Customers may install lots of solar, the utility will not recover its capacity costs

Set the energy charge (K/kWh) too low:
Customers may not install solar at all, despite it being economically efficient

As solar uptake increases, cost-reflective tariffs become more important

If customers do not pay cost-reflective tariffs and significant numbers start installing solar:

- Customers will consume less from the grid and the **utility will no longer recover all of its capacity costs**
- Which forces the utility to further **increase tariffs to recover fixed costs** (from less total consumption)
- Which will **further encourage customers to install solar**



Downward spiral

This can easily be avoided by using two-part cost-reflective tariffs

What are cost-reflective two-part tariffs?

Energy charges (K/kWh)

- Used to recover the variable costs of additional electricity supply in each interval.

Demand charges (K/kW)

- Used to recover generation and network capacity costs. Should be based on demand (kW or kVA) at time of system peak, as this is the driver of investment needs.

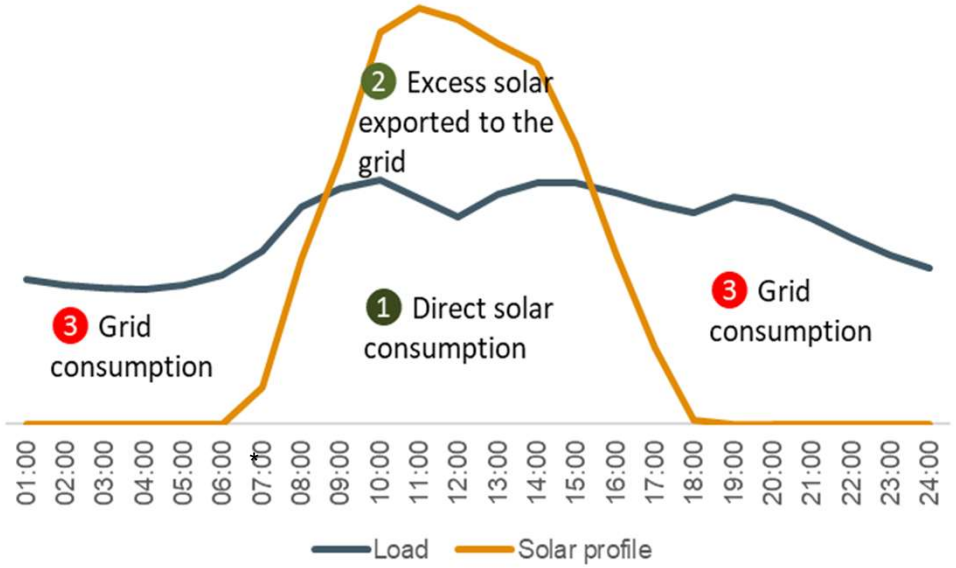
- This ensures that even if a customer consumes nothing from the grid, PNG Power will still recover its capacity/fixed costs.

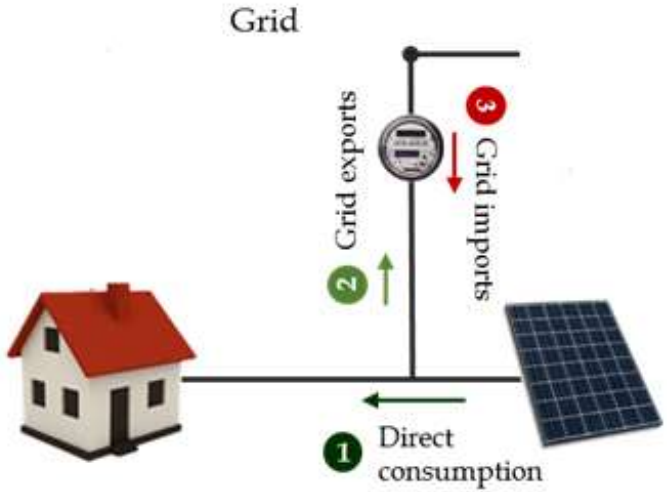
Are two-part tariffs really that difficult to implement?

Conventional arguments against two-part tariffs for residential customers:	But do these arguments still stand for rooftop solar?
▶ Too expensive to upgrade the meter ▶ May impact on affordability (customers have to pay something, regardless of the total amount of consumption) ▶ Difficult to understand the tariff	▶ Solar installation requires upgrading the meter anyway ▶ Affordability is likely not an issue for customers able to front the cost of installing solar and consumption levels are likely high ▶ Complex tariffs are a necessary consequence of maintaining two power supplies (grid + solar)

What is net metering?

- ‘Net metering’ refers to the billing mechanism for dealing with this exported power
- Exported power is ‘banked’ for a time and offset against future consumption from the grid. It is a kWh-for-kWh offset. Customers are never paid if they end up exporting more than they consume. Therefore, capacity of solar PV system has to be carefully decided considering power and energy requirement in the premise.



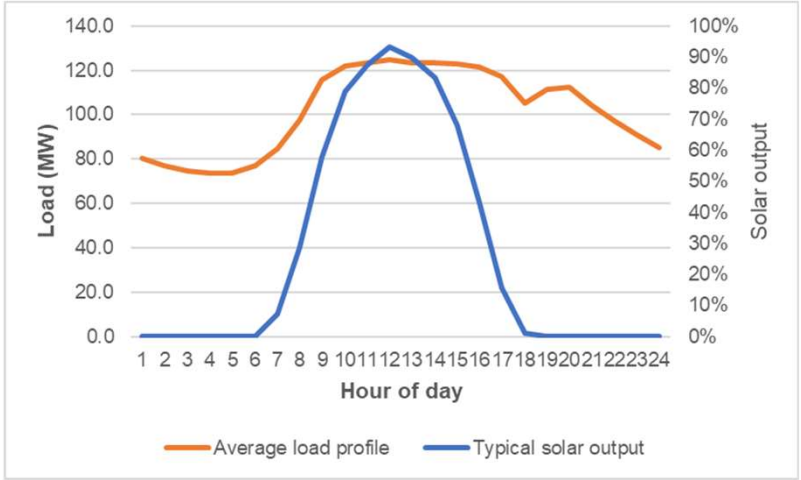


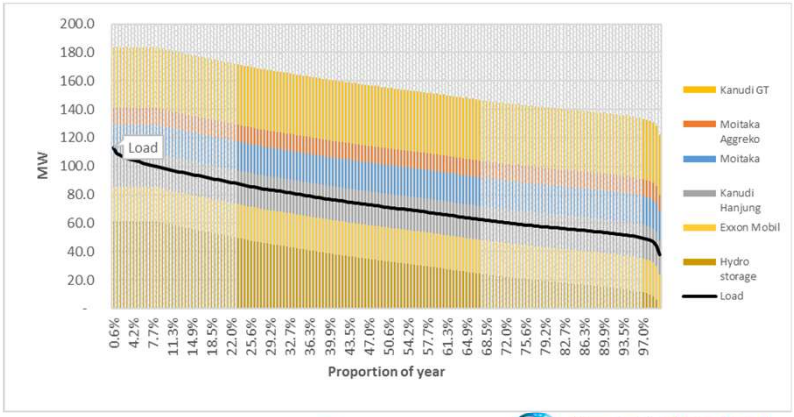
Net metering v net billing

	Net metering	Net billing
Metering	• Bi-directional or two meters	• Two meters
Energy sold	• Credited in kWh	• Paid in cash / off-set
Timing of sale	• End of period	• Instantaneous
Value of sales	• Fixed	• Can vary by time

Before revising tariffs and allowing net-metering, PNG Power will use the pilot to better understand the impacts of solar generation

- Solar output is largely highest during peak hours
- Peak hours are currently supplied by diesel generators, but this may not be the case in the future
- Will vary by PNG Power grid
- Avoided cost can be used to determine revenue impacts and revise tariffs accordingly





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