

Notice on grid-connected Solar Photovoltaic System in Papua New Guinea

Papua New Guinea Power Limited

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1 Introduction¹

Explanatory note

Explanatory notes are provided throughout this Notice to improve ease of understanding. The explanatory notes have no legal status and the regular text of this Notice takes precedence.

1.1 Objective and scope of this Notice

- 1.1.1 The objective of this Notice is to facilitate the connection of Rooftop Solar PV Systems to the PNG Power's distribution networks, while also ensuring:
 - (a) That all customers are treated in an equitable manner;
 - (b) That technical performance of the PNG Power system in its steady state and transient operations is not compromised; and
 - (c) That PNG Power still recovers its reasonably efficient costs of providing electricity services, as per its Licence and Electricity Regulatory Contract with the Independent Consumer and Competitions Commission (ICCC).
- 1.1.2 The remainder of this Notice details the following:
 - (a) Types of solar PV connections allowed;
 - (b) Eligibility for Phase 1 of the Program
 - (c) Tariffs and other commercial terms;
 - (d) Installation and testing requirements; and
 - (e) Application and implementation procedures.

Explanatory note

Solar PV has the potential to reduce the cost of power supply in Papua New Guinea and reduce carbon emissions. By issuing this Notice, PNG Power intends to start allowing solar PV systems to connect to its grids through a customer's regular electricity connection, but only under certain

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conditions initially, so that the technical and commercial impacts on PNG Power's systems can be carefully managed.

1.2 Compliance with legislation and regulations

- 1.2.1 PNG Power has issued this Notice in its capacity as a licensed Distribution Network Operator and Retailer of electricity.
- 1.2.2 This Notice is in accordance with the following legislation and regulations:
 - (a) The Electricity Industry Act 2002, in particular Article 24d, which allows PNG Power, as a licensed undertaker, to carry out operations in the electricity supply industry;
 - (b) The Electricity Code, in particular Article 5i, which allows PNG Power to disconnect any customer that interferes with its distribution network or supply power to other customers;
 - (c) PNG Power's Regulatory Contract 2013-2018, in particular Article 2, which allows PNG Power to recover its allowed costs by charging tariffs to different customer types; and
 - (d) The ICCC (Amended) Act 2002.

1.3 Approval and future revisions

- 1.3.1 PNG Power's understanding is that ICCC does not need to grant explicit approval of this first phase of the Solar PV Program. Because ICCC considers that the activities proposed in this Notice fall within the conditions of PNG Power's licence and because the first phase will not have a material impact on the PNG Power's Electricity Regulatory Contract.
- 1.3.2 Future revisions or amendments to this Notice may be published from time to time and may require approval by ICCC.

1.4 Definition of terms

Term	Definition
AC	Alternate Current
ANSI	American National Standards Institute
AS/NZS	Standards Australia and Standards New Zealand
Capacity	The AC Capacity of the Solar PV Plant, expressed in kVA or kW. It is calculated as the sum of rated capacity of Inverters. For Rooftop Solar PV Systems, kW=kVA x PF and PF is assumed to equal 1.0

1.4.1 Definitions of the terms in this Notice are provided in the table below.

Term	Definition			
Certification Engineer	A person appointed by PNG Power to inspect and certify a Rooftop Solar PV System prior to grid interconnection			
Certified Solar Electricitian	A contractor that (1) carries a valid electrical contractor's or electrician's licence to carry out electrical installation and commissioning works and issued by PNG Power, and (2) is an accredited installer of the Clean Energy Council of Australia or holds an alternative accreditation that is deemed by PNG Power to be equivalent			
Customer	a person seeking the supply or sale of electricity to that person			
DC	Direct Current			
Grid-tied Inverter	An Inverter converts solar system generated DC electricity into AC electricity and equipped with anti-islanding feature along with applicable national and international standards for grid connectivity and protection of the overall system			
GSM	Global System for Mobile Communications			
HT	High Tension (also known as High Voltage)			
ICCC	Independent Consumer and Competitions Commission			
IEC	International Electrotechnical Commission			
IEEE	Institute of Electrical and Electronics Engineers, USA			
IEPNG	Institution of Engineers of Papua New Guinea			
Inverter	A machine/equipment that converts DC power to AC power			
IPP	Independent Power Producer			
Islanding	A possible mode of the grid-tied solar PV system attempting not to supply electricity or not to serve the customer's electrical equipment, while being connected to the PNG grid at the time of PNG grid outage/unavailability			
kV	kilo Volt			
kVA	kilo Volt-Ampere			
kW	kilo Watt (kW = kVA x PF)			
LT	Low Tension (also known as Low Voltage)			
MW	Mega Watt			
Maximum Demand	The maximum demand, expressed in either kVA or equivalent kW for that customer, as determined by a demand meter connected to that premises over any period of 12 consecutive months in the period of two years before the date of application. If the electricity has been supplied to the customer for a period of less than 24 months before the date of application, PNG Power shall take decision from case to case basis as per the information available with PNG Power and also the details provided by the customer			
Notice	This Notice on the Grid Connection of Rooftop Solar PV Systems			
Rooftop Solar PV System	A solar PV system, as defined in Sections 2.1 and 2.2			

Term	Definition	
PF	Power Factor. One of the electrical parameters representing AC power quality. It is defined as the ratio of real or active power to the apparent power in the circuit. For Rooftop Solar PV Systems, PF is assumed to equal 1.0.	
PNG	Papua New Guinea	
PNG Power	Papua New Guinea Power Limited	
Program	PNG Power's Rooftop Solar PV Program, as defined in this Notice	
PV	Photovoltaic technology	
Type Test	Tests conducted to determine directly or indirectly that a process, product, or service meets relevant technical standards and fulfills relevant requirements as per specification, contract or regulation	
VAR	Volt Ampere reactive (unit of measurement for reactive power)	

2 Types of solar connections allowed

2.1 Definition of Rooftop Solar PV Systems

- 2.1.1 Within its service area, Papua New Guinea Power Limited ('PNG Power') will allow and facilitate the connection and operation of Rooftop Solar PV Systems to its distribution networks, subject to the terms of this Notice.
- 2.1.2 A Rooftop Solar PV System is a solar photovoltaic (PV) based electricity generation system that is sited on a PNG Power customer's own premise, either mounted on a rooftop or on the ground. It has a grid-tied inverter and operates in parallel with the grid. At times when customer's demand is low and power generation from solar is more, then surplus electricity is exported to PNG Power's grid.
- 2.1.3 A Rooftop Solar PV System must be for a customer's self-consumption. The customer should plan his Rooftop Solar PV System in such a manner that, on average, no more than the customer's monthly energy requirement is delivered by the solar PV system.
- 2.1.4 No other type or variants of solar PV systems will be allowed to interconnect to PNG Power's grid under this Program.
- 2.1.5 For the avoidance of doubt, Rooftop Solar PV Systems cannot be connected to the PNG Power's transmission networks. Nor are they for the sale of electricity to PNG Power, to another licensee, or to another PNG Power customer.

This Notice deals with solar PV systems that remain connected to PNG Power's Grid. Changes in solar irradiation will impact on the real time operations of the grid. Rooftop Solar PV Systems therefore require specific types of inverters and electrical configuration.

This Notice does <u>not</u> deal with standalone solar PV systems, which are completely disconnected from PNG Power's grid. Such systems are to be dealt with separately but will require technical inspection and approval by PNG Power, under its functions as the electricity industry's technical regulator, as delegated by the Independent Consumer and Competitions Commission (ICCC).

PNG Power may introduce larger solar PV systems, which are dedicated to exporting energy to the grid, under separate arrangements. For example, as competitively-procured Independent Power Producers (IPPs) in accordance with PNG Power's power development plan.

2.2 Technical specification of Rooftop Solar PV Systems

2.2.1 A connection diagram for Rooftop Solar PV Systems is provided below. In the diagram, the position of the meter (M) and the voltage values are only indicative.



- 2.2.2 Rooftop Solar PV Systems should not directly distribute electricity within the customer premises either in DC or AC. The only connection of the solar PV system should be at the LT/HT switchgear near the energy meter, through a lockable AC isolation switch, in a location accessible by PNG Power's maintenance staff.
- 2.2.3 Rooftop Solar PV Systems must allow electricity to freely flow from the solar PV system to the grid, through the import-export meter, and vice versa. In other words, when the customer's equipment requires less than the power output of the solar PV system, electricity will freely flow through the meter to the grid. And 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.
- 2.2.4 Rooftop Solar PV Systems must include a lockable isolation switch that ensures physical isolation between the customer's electrical equipment, the PNG Power service line and the solar PV system. The lockable isolation switch should be near the PNG Power metering point and be easily accessible to PNG Power staff.

- 2.2.5 Rooftop Solar PV Systems must include an import-export meter that can facilitate net metering and net billing (even though net metering will not be allowed in the first phase), to the specifications advised by PNG Power during the installation process. Customers are advised to install another energy meter for recording output of the solar PV system.
- 2.2.6 Rooftop Solar PV Systems must include an on-line monitoring system, installed by the customer, which at the minimum should measure at five-minute intervals or shorter and store (a) AC terminal voltage (in V); (b) AC Current (in A), (c) AC power (in kW), (d) AC power (in kVA), and (e) power factor. This stored information must 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.

2.3 Solar equipment standards

- 2.3.1 All solar PV modules installed for Rooftop Solar PV Systems must meet standards IEC 61215, IEC 61853, IEC 61730, IEC 60364, IEC 60068, IEC 62716, IEC 62782, IEC 62759, IEC 61345, IEC 61701 latest available equivalent standards. The PV Modules should be Potential Induced Degradation free and tested as per IEC 62804.
- 2.3.2 All Inverter equipment installed for Rooftop Solar PV Systems must meet standards IEC 61000, IEC 61727 (2004 -12), IEC 61683, IEC 62109, IEC 62093, IEC 62910, IEC 60068, IEEE 519, IEEE 1547 2003 or latest available equivalent standards. Additionally, Inverters should have at least Type-II Surge Protection Device and short circuit protection at both DC and AC side.
- 2.3.3 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. The flash test result of all PV Modules must be made available.
- 2.3.4 String Combiner Box is optional for the Solar PV System with String Inverter. In case used, it must comply with standards IEC 61730, IEC 60664, UL-1741, IEC 529, UL-SU 6703, and EN 60715.
- 2.3.5 DC Cable has to be Cross Linked Polyolefin Type Cu cable of suitable voltage grade. Conductors shall be electrolytic grade high conductivity annealed tinned copper. Conductors shall be multi-stranded, smooth, uniform in quality and free from scale and other defects.
- 2.3.6 Alternatively, in the absence of a Type Test certificate, a laboratory test certificate may be submitted, from an accredited laboratory. These certificates should be submitted to the Certification Engineer, who will inspect the certificates and attach them to the commissioning test report.
- 2.3.7 The import-export meter must conform to the measurement standards provided in the table below.

#	Measurements	Compliance	
	Power Measurements	ANSI C12.20 Class 0.2 and IEC 62053-22 Class 0,2S	
1	Watt (active power)		
2	Volt-Amp (apparent power)		
3	Power Factor		
4	VAR (reactive power)		
	Inputs		
1	Voltage		
2	Current		
	Energy	ANGL C12 20 Class 0.2 and HEC (2052 22 Class 0.20	
1	Watt-hour (energy)	ANSI C12.20 Class 0.2 and IEC 62053-22 Class 0,25	
	Power Quality Measurements		
1	Power Frequency Trends		
2	Supply Voltage Variation		
3	Flicker Severity	WC (1000 4 20	
4	Voltage Unbalance	IEC 81000-4-30	
5	Voltage Total Harmonic Distortion		
6	Voltage Harmonics/Interharmonics		
7	Voltage Interruptions/dips/swells		
8	DC Injection		
	Conducted Emission	IEC (1000 4 20	
1	2kHz-150kHz Conducted Emissions	1EC 01000-4-50	

Type Tests are intended to verify compliance of the design of given equipment with the stated standard, where applicable, and the relevant product standard. Type Tests are performed on one single specified electrical equipment of one type and are intended to check the design characteristics. Type Tests usually relates to the first unit manufactured by a firm to a given specification. Any change in the bill of materials of the product will require further certification.

3 Eligibility for Phase 1 of the Program

3.1 Phase 1 of the Program

- 3.1.1 This Notice defines Phase 1 of PNG Power's Rooftop Solar PV Program.
- 3.1.2 PNG Power will approve applications for the connection of Rooftop Solar PV Systems on a first-come-first-served basis (subject to System Impact Check as mentioned in Clause 3.6.1), from the date on which the completed application is

received by PNG Power, so long as the application meets all the requirements specified in this Notice and does not exceed the cumulative capacity limit described in Section 3.5.

3.1.3 PNG Power will issue notices from time to time relating to subsequent phases of the Rooftop Solar PV Program after Phase 1 has been implemented and evaluated from technical, commercial, and economic perspectives.

Explanatory note

Phase 1 of the Program is intended to introduce solar PV systems in a manner that limits the technical and commercial impacts on PNG Power's system. PNG Power will monitor and evaluate the outcomes from Phase 1, including understanding the impact on load profiles, grid stability, and its revenues and costs. Phase 1 will also give PNG Power an opportunity to develop its solar PV expertise and improve forecasting of solar irradiation/generation.

The outcomes of Phase 1 will be used to prepare Phase 2 of the Rooftop Solar PV Program in approximately 18 to 24 months' time.

3.2 Eligible customers

3.2.1 Rooftop Solar PV Systems may only be connected if the customer has a Maximum Demand for electricity of at least 300kVA at the premises.

Explanatory note

By setting a requirement to have a Maximum Demand of at least 300 kVA, PNG Power is effectively limiting Phase 1 of the Program to large commercial and industrial customers.

This will limit the number of participants in Phase 1, thereby allowing PNG Power to closely monitor the performance of individual system and broaden its understanding of the grid integration of solar PV systems without being administratively overburdened.

The other reason for limiting Phase 1 to commercial and industrial customers is that most of their energy is typically required during the day-time, when the solar resource is available. Unlike smaller (residential) customers who typically require most of their energy in the evenings and early morning.

3.3 Eligible networks for connection

3.3.1 Rooftop Solar PV Systems may only be connected to PNG Power's Port Moresby distribution network.

Explanatory note

Port Moresby is PNG Power's network that is best able to cope with the intermittency of gridconnected solar PV and therefore provides the best environment for testing and understanding the impacts of grid integration of solar PV systems.

PNG Power recognises that solar PV systems have significant potential to reduce the cost of supply on PNG Power's other networks, given that sizeable portion of electricity is currently generated by

diesel engines. PNG Power intends to make other grids eligible in future phases of the Program, if the technical and commercial impacts of increased solar penetration can be managed appropriately.

3.4 Individual system size limit

3.4.1 Rooftop Solar PV systems may only be connected if the Capacity of the individual solar PV system will not exceed the customer's Maximum Demand or 1,000 kW, whichever is smaller.

Explanatory note

Capping installation size at the customer's Maximum Demand helps ensure that the solar PV system is for self-consumption. The additional cap of 1,000 kW prevents a single large solar PV system from using up most of the cumulative capacity limit (below).

3.5 Cumulative capacity limit

3.5.1 Rooftop Solar PV systems may only be connected if the connection will not result in the total capacity of approved Rooftop Solar PV Systems exceeding 2MW, for that particular PNG Power distribution network. The total capacity excludes any installations for which approval has expired, as per Section 6.3.

Explanatory note

The cap on cumulative capacity limits the impacts of grid integration of solar PV systems. The limit is set here in cumulative MW capacity terms for ease of understanding and implementation. It currently translates to approximately 2% of peak load in the Port Moresby system.

PNG Power intends to increase the capacity limit in future phases of the Program, if the technical and commercial impacts of increased solar penetration can be managed appropriately.

3.6 System impact check

3.6.1 PNG Power may reject an application if it considers that the requested Rooftop Solar PV System will adversely affect the operation of its network, even if the application meets all the other requirements set out in this Notice.

The location of a customer – for example they may be connected to a feeder at the outer limits of the distribution network – may be such that installation of a solar PV system is likely to adversely affect the operation of PNG Power's network and the quality of power supply to other customers.

4 Tariffs and other commercial terms

4.1 Banking and crediting of exported energy

- 4.1.1 During Phase 1 of the Program, PNG Power will not credit or pay for any surplus energy from Rooftop Solar PV Systems that is exported to the grid.
- 4.1.2 At such a time that PNG Power allows crediting of or payment for exported energy, under future phases of the Program, any customers that installed Rooftop Solar PV Systems under Phase 1 will automatically be eligible for the same commercial terms during the eligibility period described in Section 4.4.

Explanatory note

During Phase 1 of the Program, PNG Power allows electricity to freely flow from the solar PV system to the grid. But PNG Power is not crediting this exported energy in any way. In other words, PNG Power is not allowing net metering or net billing during Phase 1.

PNG Power intends to introduce net metering or net billing in future phases of the Program, once the commercial impacts of solar PV systems are better understood. At such a time, any existing Rooftop Solar PV Systems will be automatically eligible for net metering or net billing from that point forward.

By requiring all Phase 1 Rooftop Solar PV Systems to include an import-export meter, they will be compatible with any future net metering or net billing mechanism.

Net metering is a billing mechanism that credits solar PV system owners for the electricity they export to the grid during some daylight hours, by offsetting it against their consumption from the grid during other hours. If exports exceed imports in any given month, that credit is carried forward to the next month (usually for up to 12 months before it is lost).

Net billing is a similar billing mechanism, but the key difference is that exported energy is credited at a different per kWh rate to imported energy and that those rates can vary by time. For example, exported energy may not be credited on a 1:1 basis against imported energy, and exported energy during a weekday may be credited at a higher rate than energy exported on a weekend.

4.2 Applicable tariffs

- 4.2.1 Connecting a Rooftop Solar PV System under this Program does not change a customer's tariff classification (General Supply or Industrial). Customers will continue to pay as per PNG Power's latest tariff schedule.
- 4.2.2 PNG Power may from time to time adjust both the level and structure of its electricity tariffs in accordance with its Regulatory Contract with ICCC.

In the near future, PNG Power intends to amend its tariff structure and tariff classifications to better reflect the costs of providing electricity services. This will include ensuring that it can fairly recover its capacity costs and accurately reflect the cost savings attributable to customers with solar PV generation.

It is therefore likely that PNG Power will introduce a demand charge for all large customers and/or customers with solar PV systems, as per the current Industrial tariff. A demand charge is payable based on peak or contract demand, independent of the net amount of energy consumed.

Any such tariff will be subject to the terms of PNG Power's Regulatory Contract with ICCC and subject to ICCC's approval.

4.3 Meter cost

- 4.3.1 The cost of purchasing and installing the import-export meter for the Rooftop Solar PV System must be borne by the customer.
- 4.3.2 PNG Power will notify the customer of the meter requirements and the associated approximate cost at the time an application to this Program is approved.
- 4.3.3 The cost of the meter will be payable following testing and certification, as described in Section 6.1. In some cases, PNG Power may require the customer to make the meter payment upfront.

4.4 Eligibility period

- 4.4.1 Once approved and commissioned, a customer may remain in the Program for a 10year period from the date of commissioning, subject to the other terms in this Notice.
- 4.4.2 At the end of the 10-year period, the customer may be required to reapply for inclusion in the Program depending on the policies prevailing at that time.

Explanatory note

By allowing customers to remain in this Program for 10 years once their solar PV system is approved and commissioned (and they continue meeting the other terms and conditions of this Notice), PNG Power intends to give customers certainty that the Program will not be discontinued after a short period.

5 Installation and testing

5.1 Installation of solar PV system

5.1.1 The electrical installation of the solar PV system should be conducted on behalf of the customer by Certified Solar Electrician.

- 5.1.2 Electrical wires and accessories used for electrical connections should conform to applicable AS/NZS standards and practices approved by PNG Power.
- 5.1.3 Electrical installation should conform to AS/NZS 3000 Wiring Rules and all other standards and practices approved by PNG Power.
- 5.1.4 The structural quality of the roof or other structure on which the Rooftop Solar PV System is to be mounted, and the installation itself, must be certified by an IEPNG certified structural engineer. Evidence of the certification must be provided to PNG Power at testing and certification.

5.2 Testing and certification

- 5.2.1 It is the responsibility of the customer to ensure that the installation abides by all the standards, practices and rules in PNG, including but not limited to standards listed above to ensure the project quality and performance.
- 5.2.2 As part of the pre-commissioning activity through Certified Solar Electrician, the customer must test the installation, declare it ready for commissioning and issue a certificate. The Certified Solar Electrician will then facilitate testing by the Certification Engineer appointed by PNG Power.
- 5.2.3 A Certification Engineer appointed by PNG Power will test the installation of the Rooftop Solar PV System for its compliance with Section 5.1 above and for compliance with all other practices and rules followed by PNG Power. This will include the following inspections and tests:
 - (a) Isolation arrangement;
 - (b) Loss of mains protection, to ensure the Inverter does not cause unintended islanding; and
 - (c) Power quality, including harmonic, DC injection, and flicker analysis.
- 5.2.4 For the avoidance of doubt, the Certification Engineer appointed by PNG Power will not test the solar equipment itself, as described in Section 2.3.
- 5.2.5 PNG Power will install the import-export meter once certification is complete and payment of the meter fee has been made, prior to commissioning of Rooftop Solar PV System.

6 Application and implementation procedures

6.1 Application and connection process

6.1.1 **Application:** A customer must first submit an application to PNG Power using the application form provided in Section 6.4 and pay the application fee.

- 6.1.2 **Processing of application:** Following receipt of the application and payment of the application fee, PNG Power will process the application and notify the applicant whether their application has been approved or not. The customer should purchase solar PV system equipment only after the application is approved. It is the customer's responsibility to ensure the equipment and the installation are compliant with this Notice.
- 6.1.3 **Installation**: Once PNG Power has notified a customer that their application has been approved, the customer has six months from that date to install their Rooftop Solar PV System, in accordance with Section 5.1 and the other requirements of this Notice, and to request testing and certification by PNG Power.
- 6.1.4 **Testing and certification**: Following a customer request for testing and certification, PNG Power will ensure that its appointed Certification Engineer conducts the test within two weeks of the customer's request. PNG Power may allow temporary connection to its grid for the purpose of testing.
- 6.1.5 **Meter installation and commissioning**: Once PNG Power has certified the installation, PNG Power will install the energy meter and commission the installation within one week. The customer can then operate their PV system.

6.2 Application fee

6.2.1 The application fee is 1,500 Kina, payable at the time of application. The fee is non-refundable.

6.3 Approval expiry

- 6.3.1 Upon PNG Power notifying a customer of the approval for a Rooftop Solar PV System under this Notice, the customer has a period of six months to install their Rooftop Solar PV System and to request testing and certification by PNG Power.
- 6.3.2 If commissioning is not completed within six months, excluding any delays attributable to PNG Power, the customer will no longer be eligible for connection, and must reapply for the Program.

6.4 Application form

Application for Installation of grid-connected Solar Photovoltaic System

- 1. Application number (to be completed by PNG Power upon receiving the application):
- 2. Date application submitted:
- 3. Name of customer as stated in the electricity account:
- 4. Customer's premises number and complete address:
- 5. Telephone numbers:
- 6. Email:
- 7. Electricity customer account no:
- 8. Maximum demand averaged over the past 12 months (kVA):
- 9. Rated capacity of the proposed solar PV system (on the alternating current side of the inverter) (kW):

10. Information to be submitted with the application (\Box) :

- □ Single-line diagram of the proposed installation
- □ Layout of proposed Solar PV System
- □ List of protective devices between the inverter output and the point of interconnection to the PNG Power grid, and their protection settings
- □ A tentative Bill of Material of proposed Solar PV System (includes name of component, component description, make, and quantity)

11. Certification by the customer (\Box) :

I attach the receipt number	dated	
for the payment of		Kina
as the fee for this application, to PNG Power.		

- □ I certify that the Rooftop Solar PV System will be located at the premises served by the electricity account stated above 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 PNG Power.
- □ I certify that the Rooftop Solar PV System shall be in compliance with all aspects of PNG Power's Notice on the Grid Connection of Rooftop Solar PV Systems, as published on the date of this application.

Signature:

Name (the customer):

Date: