添付資料⑥

Chapter：Facility Planning Method (PV system for residential use)

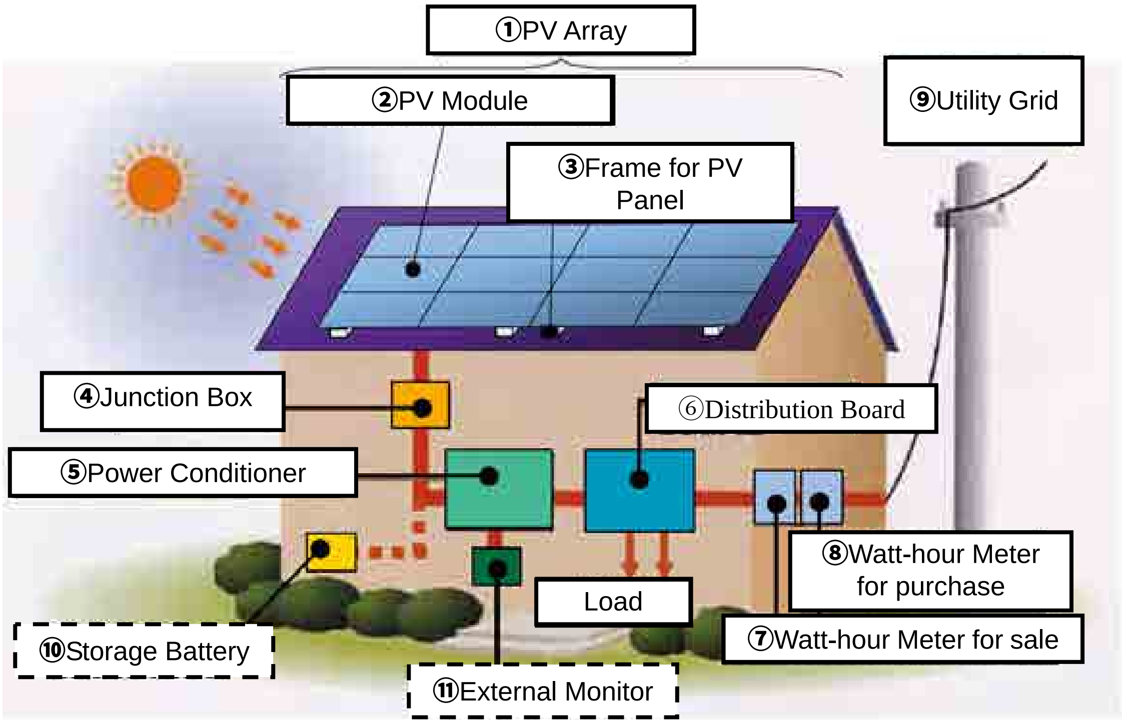
Text

Contents

Chapter 1 Basic knowledge of PV power systems for residential use

1. Definition of terms

Figure 1-1 shows a configuration of a general PV power system for residential use. Also, Table 1-1 shows terms of PV power system for residential use.



※In some cases, an external monitor and a storage battery may not be required.

※The distribution board and commercial power grid are existing equipment and facilities.

Figure 1-1 Configuration of PV power generation system for residential use

(Source: Japan Photovoltaic Energy Association “PV power generation system manual”)

Table1-1 Terms of PV power generation system for residential use

№	Component	Explanation
①	PV Array	・PV array is a cluster of solar cells made by connecting more than one module and mounted on the frame mechanically and electrically.
②	PV Module	・PV module is a panel to convert solar energy into electrical energy (Direct Current) directly.
③	Frame for PV panel	・It is a rack to mount PV module at specified tilt angle. ・Generally, most of the frames are made of steel or aluminum alloy. ・It may not be required for “Roof material type” module.
④	Junction Box	・To combine wires and output power from PV module into one. ・It includes a switch used at the inspection and maintenance of a PV panel, surge absorber, and blocking diode that prevent reverse current flow to PV panel. ・Some are integrated with power conditioning subsystem.
⑤	Power Conditioning Subsystem (PCS)	・It controls DC power generated by PV panel to maximize, and converts DC power into AC power. ・Usually, it includes Grid-connected Protective Equipment to prevent any impact on the distribution lines (commercial utility grid) from the utility company. ・Also, it has the isolated operation function, and some power conditioners can supply power to specific load when commercial utility grid has a power failure.
⑥	Distribution Board	・It distributes electric power to each electrical load in a building. ・It works as a connecting point between the output of power conditioner and the commercial utility grid. ・A circuit breaker exclusively for PV power system is required. (built-in or separate setting)
⑦	Watt-hour meter for sale	・This is to measure the amount of selling power (surplus power) for the system with reverse power flow to sell electricity to the utility company. The customer may need to bear the installation cost depending on utility companies. ・Since the watt-hour meter type is different depending on the type of the power purchase contract, it should be noted.
⑧	Watt-hour meter for purchasing	・This equipment is to measure the amount of purchase power (power demand) from the utility company. An existing watt-hour meter change to the watt-hour meter with reverse metering prevention device by the utility company.
⑨	Commercial utility grid	・It’s the commercial power system of the utility company. The single-phase three-wire system at 100/200V is for residential use
⑩	Storage Battery	・Storage battery can store the electric power in order to supply the power that the load demands when solar irradiation is weak, or the night time when it won’t generate power. Also, it can be used for the backup power supply in case of emergency.
⑪	External monitor	・It displays the amount of generated power, reduction effect of environmental load and so forth. The monitor may be standard equipment or optional equipment or unequipped depending on the manufacturers.

※⑩storage battery and ⑪external monitor will be installed if needed.

(Source: Japan Photovoltaic Energy Association “PV power generation system manual”)

2. The principle of PV cells

Nowadays, many solar cells are made by the crystalline silicon semiconductor. This subsection describes the principle of PV cells made by the crystalline silicon semiconductor. When the sunlight shines on the two kinds of different silicon semiconductor (n type and p type), the light energy will be absorbed in a solar cell and holes which are positive (+) and electrons which are negative (-) are generated. The hole is attracted to p type and the electron is attracted to n type, and if the load is connected to an electrode, a current will flow. Although it is called a battery, it won't be able to generate electricity without solar radiation, and the PV cell can not store electricity in itself.

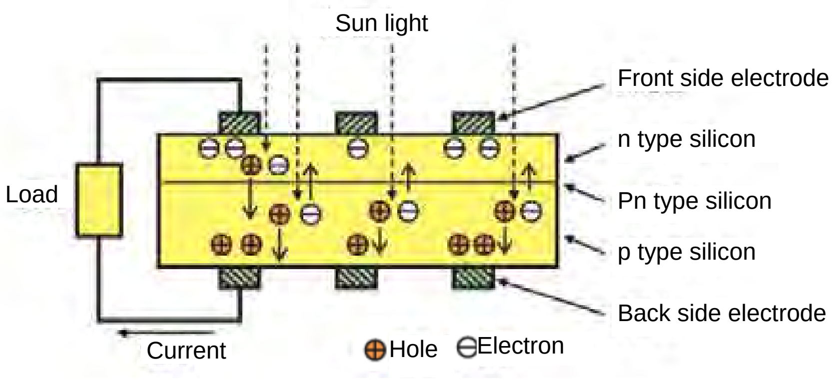


Figure 1-2 The power generation principle of PV cells (Source: NEDO "the manual for installation of a large-scale PV power generation system")

3. Type of PV panel

The manufacturing process and the characteristics of a PV cell are different depending on its material. The materials of the PV cell can be classified into silicon type, compound type and organic type like the figure 1-3. Also, the table 1-2 shows the characteristic and the application of each PV cell.

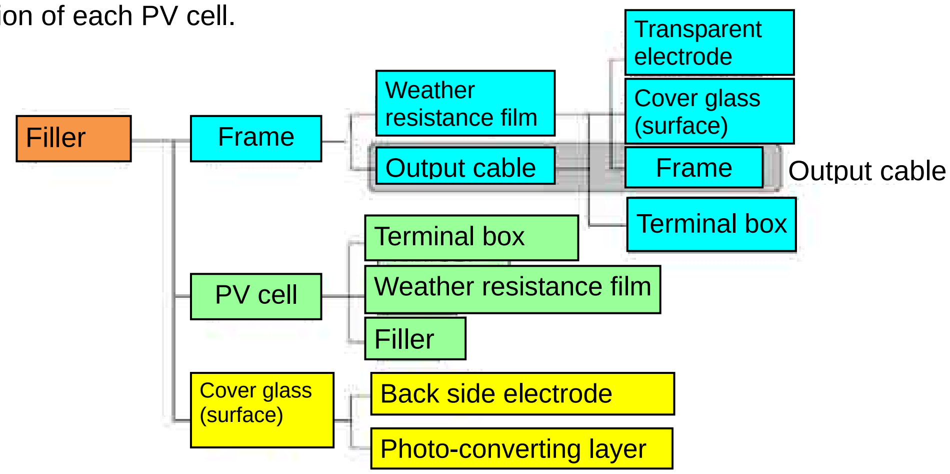


Figure 1-3 The type of PV cell (Source: NEDO "the manual for installation of a large-scale PV power generation system")

Table 1-2 The characteristics of each PV cell (Source: NEDO "the manual for installation of a large-scale PV power generation system")

Silicon	Monocrystal Silicon	A high purity monocrystalline silicon wafer is used, it has been used most for many years. The conversion efficiency is high and excellent in reliability. However, the amount of high-purity silicon usage is high and energy and cost required for production become high. At present, conversion efficiency of commercial module is about 15% to 19%.
	Polycrystal Silicon	This is the most popularly used PV cell now. It is PV cells that use polycrystalline silicon consist of small crystals. The module's conversion efficiency is lower than monocrystalline silicon. However, the energy required for production is less and it is excellent in energy budget, energy payback tune (EPBT), green house gas emission, and reduced cost. At present, conversion efficiency of the commercial module is about 13% to 16%.
	Thin-film Silicon	This type is getting popular due to the shortage of silicon materials. It is made by forming a very thin film, about 1/100 of crystalline silicon. An amorphous or microcrystalline is used. Although the efficiency is low, it is easy to mass-produce, and the strong point is to make a lightweight and flexible module. The conversion efficiency of the commercial module is about 6% to 11%.
	Heterojunction (HIT)	This PV cell is laminated with crystalline silicon and amorphous silicon. It is resources saving and a high conversion efficiency compared with regular crystalline silicones. Temperature performance is also good. The conversion efficiency of the commercial module is about 16% to 19%.
Compound	CI(G)S	This type is made from compound such as copper (Cu), indium (In), gallium (Ga), selenium (Se) and sulfur (S), instead of silicon. It is a resource saving, and the conversion efficiency can be the same as polycrystalline silicon. The mass productivity is good, so there is a big potential for cost savings. The conversion efficiency of the commercial module is about 9% to 11%.
	CdTe	This CdTe type uses cadmium that has toxicity, but the mass productivity is good and the production cost is low. Due to these advantages, this type is used in a large-scale of PV power plant in Europe and the U.S., and it has been promoting rapidly. The conversion efficiency of the commercial module is about 9% to 11%.
	Condenser	This type is mainly used for space applications. When it collects sunlight, it performs more than 40% conversion efficiency, so this is a ultra high performance PV cell. It has a very high production cost, but it is being studied for utilization in concentrating type system in countries and regions that have much direct sunlight.
Organic	Dye sensitizer	This is a new type of PV cell. Without using pn junction, dye adhering to titanium oxide absorbs light and emits electrons to generate. It is lightweight and colorable. Significant cost reduction is expected in future mass-production. The current challenge is its efficiency and durability. The development for practical utilization is in progress.
	Organic thin-film	This PV cell is currently under development, and it uses a semiconductor thin film contained in an organic substance. It can be made by just coating a film at room temperature, and also it can be colorful and lightweight.

Monocrystalline module

Polycrystalline module

Thin film silicon multi-junction module

CIS type module

Figure1-9 Samples of various PV module appearance

(Source: Japan Photovoltaic Energy Association “PV power generation system manual”)

4. Selection of PV panel

There are various types of a PV panels, so it is necessary to select on that is suitable for the place it will installed. Usually, the efficiency and the price are dominant factors in making a selection. However, it is necessary to take into consideration what factors are important based where it will be installed and for what purpose.

If obtaining as much electric power as possible in the installation area is emphasized, efficiency is an important factor, or if the priority is given to low cost, then take the price of the whole system including frame into consideration.

PV systemsfor residential use are usually installed on the roof, thus the roof-mount type or the roof material type of PV module is selected. There is an inclined roof style and a flat roof style in the roof-mount type, and the standard PV module is used for both types. In the roof material type, there is a roof integration style where PV modules are built into the roofing material, and a roof material style where PV modules function as a roofing material.

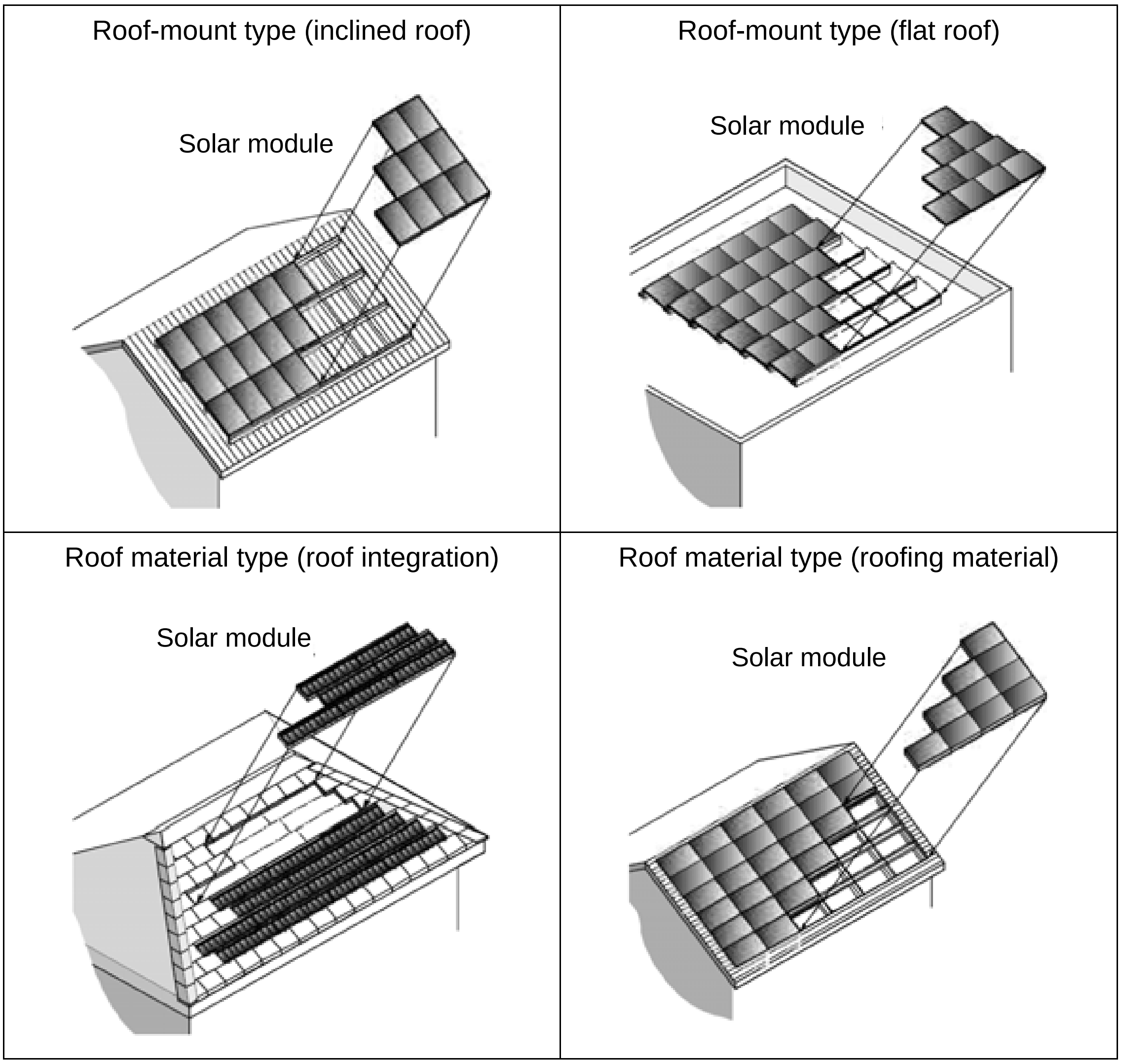


Figure1-10　Roof-mount type and roof material type of PV module

(Source: Japan Photovoltaic Energy Association “PV power generation system manual”)

5. The type and the composition of a PV power system

The type of a PV power system is roughly divided into two systems as shown in a figure1-12. It is a grid-connected system and a stand-alone system. The grid-connected system means a PV power system connects to the utility grid. When connecting the PV power system to the utility grid, it is necessary to discuss with the utility company. (Grid-interconnection discussion) The stand-alone system means a PV power system that is not connected to the utility grid, in isolated islands, or mountain areas.

The PV power system for residential use is one of the typical grid-connected PV power systems, and it consists of a PV array installed on the roof (including PV modules, frame, etc.), a Power conditioner installed in either indoor or outdoor (including inverter, utility interactive protection unit, etc.), and cables that connects them, and junction box, further an AC side switch (installed in a distribution board, etc.), a watt-hour meter (watt-hour meter for sell power) and so forth.

The mechanism of the PV power system for residential use is that the DC power that comes from a PV array is gathered into one wiring in a junction box, and converted into AC power in a power conditioner, and then supply electricity to home appliances through the distribution board. In addition, surplus power is reverse-transmitted to the utility company through the distribution board (sell power). On the other hand, in a case of the generating power shortage due to bad weather, or night time when the PV panel can not generate power, the electricity is supplied by the utility system of the power company (purchase power). Most of the PV power systems for residential use is at 3 to 5kW and commonly installed on the roof.

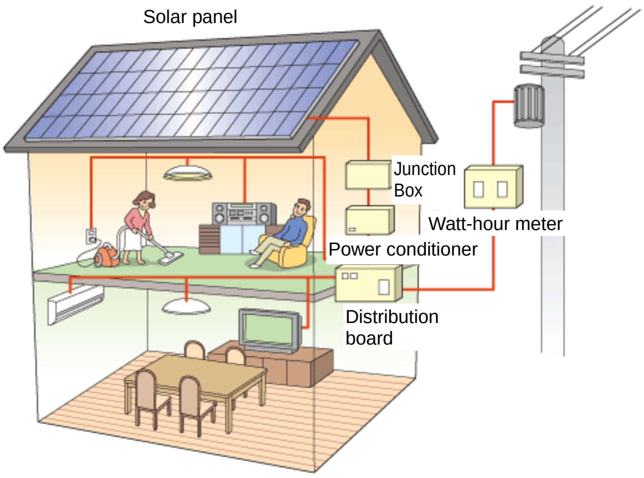


Figure1-11 PV power system for residential use

(Source: Japan Photovoltaic Energy Association website)

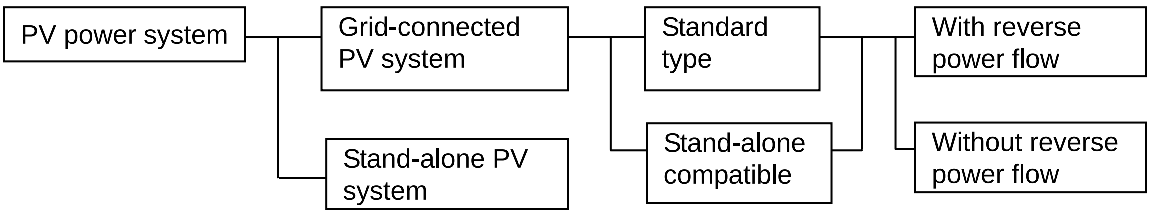
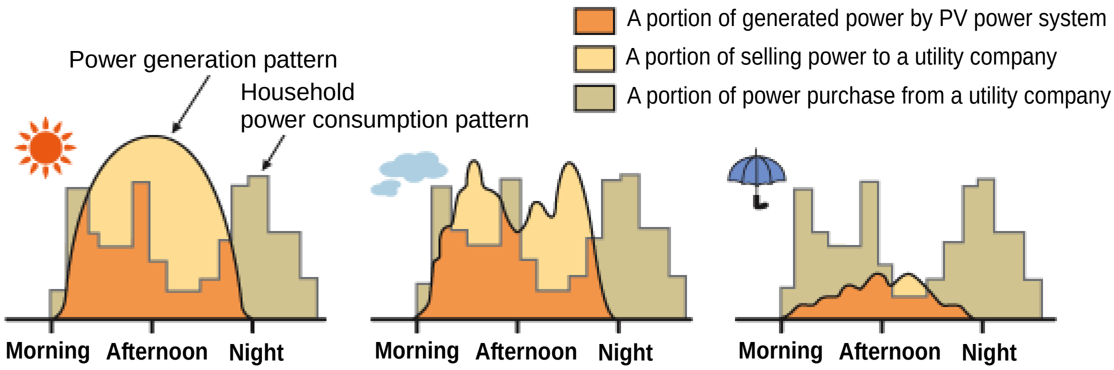


Figure1-12 PV power system type



(Clear day)
Electricity is generated in proportion to solar Irradiation. Electricity that is sold to a utility company, increases.

(Cloudy day)
Although depending on a cloudiness, changing of the power production amount is larger in the day.

(Rainy day)
A PV power system can generate power depending on the solar radiation in a rainy day, but the electricity that is bought from a utility company, increases.

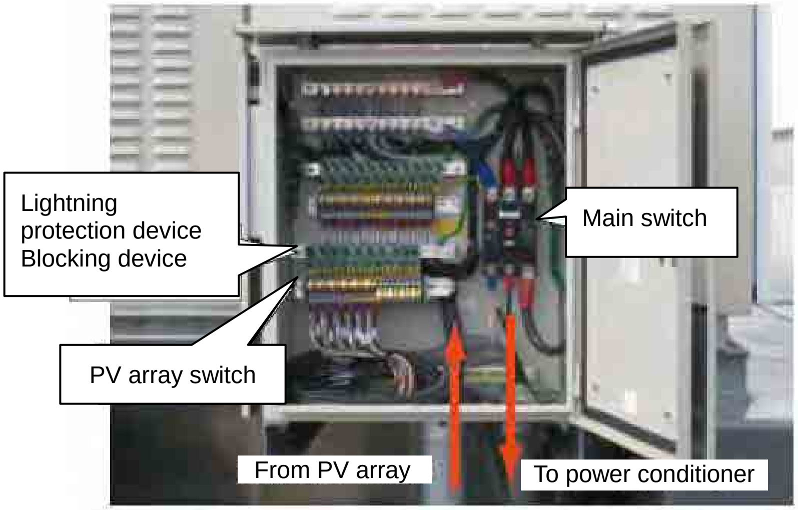
Figure1-13　Sell and purchase power pattern by the weather conditions
(clear / cloudy, / rainy day)
(Source: Japan Photovoltaic Energy Association website)

6.Peripheral devices

6.1 Junction Box

A junction box consolidates wiring from every block of the PV module into one, and transmits generated power to the power conditioner. There is a DC switch, a blocking device (prevents power from flowing to the PV array), a lightning protection device and so forth in the junction box.

The junction box also improves convenience of maintenance and inspection work by isolating circuits to make for easy inspection work and minimize the shut down area when a failure in the PV array occurs.



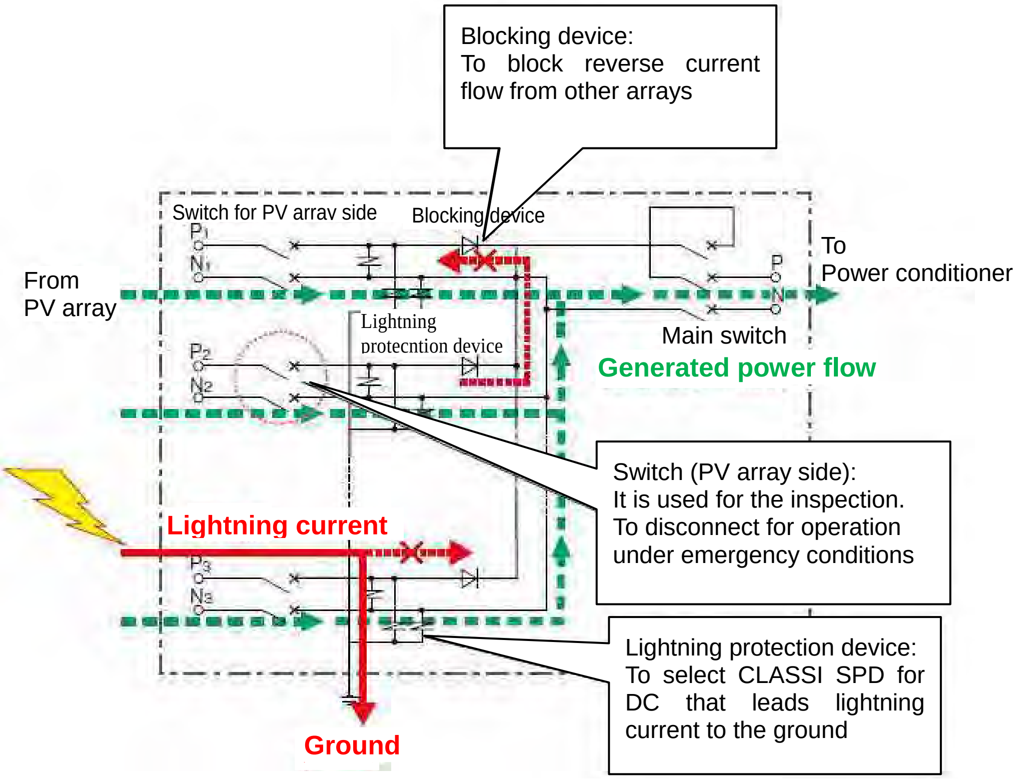


Figure 1-14 Functions and internal structure of a junction box

(Source: NEDO "For effective introduction of PV power system")

6.2 Power Conditioner

A power conditioner is an integrated equipment with an inverter which converts DC power into AC power, a control device, and a utility interactive protection unit. It converts DC power from PV array into the same AC power as a utility company, and supplies stable power to the load. Also, if power from PV array is greater than the load, reverse power flow is carried out to the wiring of a commercial power as surplus power.

Some power conditioners have an earth detector that is a function to prevent electric shock from the electricity flow from a utility company when a ground fault occurs on a PV module by the earthquake, thunderbolt, and so forth, and also have a stand-alone system that is a function to supply electric power generated according to the amount of solar radiation as an emergency power supply when a power failure occurs by a natural disaster and so forth.

A wall mounted type of PV power system for residential use is popular in Japan regardless of installation location at indoor or outdoor, and single-phase two-wire system is adopted.

Figure1-15　Power Conditioner for residential use

6.3 Distribution Board

A distribution board has a circuit breaker used for connecting the AC output of a power conditioner to the grid in the case of a grid-connected PV power system. Since the distribution board is already installed in the residence in many cases, it will be used if there is a suitable circuit breaker for the rated output current of a PV power system. If a circuit breaker for the PV power system cannot be installed in the existing distribution board, an additional distribution board should be arranged and desirable to set it up next to the existing one.

The circuit breaker for the PV power system should be a reversible type of earth leakage breaker. However, if it is already installed in the grid side on the existing distribution board, it should be fine.

Also, in a case of connecting to the grid with a single-phase three-wire system, if the maximum current may flow in a neutral conductor by unbalance load, it is necessary to install the circuit breaker (3P-3E) that can release over current to three poles at the network connection point.

6.4 Watt-hour meter

An integrating wattmeter is a measurement tool for commercial transaction to measure the amount of electric power reversed flow to the grid in a grid-connected PV system with reverse power flow, and calculate the electric power fee to sell to a utility company. Hence, it is necessary to use the watt-hour meter that has received official approval by the measurement law.

In addition, in order to perform separation measurement of reversed power flow only, the watt-hour meter with prevention device for reverse rotation is used. If installing a grid-connected PV power system having a reverse power flow, the conventional watt-meter to measure power purchasing from the utility company needs to be replaced with a meter which prevents reverse rotation, by the utility company.

The watt-hour meter for reverse power flow measurement should be installed adjacent to the watt-hour meter for power demand measurement installed by the utility company. The watt-hour meter is selected for outdoor type or indoor type and put it in a case with a window for outdoor installation.

The watt-hour meter for reverse power flow measurement connects consumer side as a power supply side that is the opposite way of the connection method for the watt-hour meter for power demand measurement.

The cost burden for the watt-hour meter for reverse power flow measurement in Japan, each utility company charges its installation cost to the customers (as of March 2011), but when making an appointment for a prior consultation with the utility company and so forth, it is recommended to check this matter as soon as possible.

7.Installation methods

7.1 Configurations and types of roofing and rooftop installation methods

The majority of photovoltaic power systems (either for residential or public / industry use) are installed on rooftops in Japan. This section refers to typical roofing on general residences.

Although the role of roofing is to prevent infiltration of rainfall, wind, and sunlight, both practicality and design are also desired. Various roofing materials are applied for different sizes, shapes, or types of buildings as well as the surrounding climate. Roofing geometry also varies depending on used materials, inclination, precipitation, wind direction, insolation of the installed area, or to comply with regulations in the location.

However, when installing solar modules on roofs, a proper installation must be done based on an understanding of the characteristics of each roof.

Common installation examples on buildings are frame deck mounts, in which modules are attached to the erected frame deck on a flat-topped roof, flush mounts which can be applied on the horizontal surface of a roof, and pitched mounts which utilize the angled surface of the roof. In deck rooftop installation, modules are mounted on a frame with a watertight foundation block. The positioning of the base frame and mounting method should be determined as a result of the structural study of the building frame during the preliminary designing stage. Flush mounts require small brackets and fixtures to mount on folded-plate roofs enabling it to be the most cost effective method. In any case of installation on an existing building, it is important to clearly understand the current condition of the building frame through drawings and site surveys. For pitched mounts, more built-in or integral building materials can be adopted for streamlining the mounting approach.

Table 1-3 shows characteristics of rooftop installation and special notes.

Table 1-3　Characteristics of rooftop installation and special notes

Frame deck mount	Flush mount	Built-in type
・Mount on base frame with use of standard modules ・Mount on base frame for folded-steel plate roof ・Study for structural safety and waterproof treatment is necessary	・Direct mount on building with use of standard modules ・Does not retain capability (fire/heat resistance/ water-resistant, etc) of attached building component ・Generation capacity and design functionality	・Energy creation materials (combined ability of power generation and building materials) ・Promotion of eco-friendliness with outstanding design and placement ・Structural safety and water resistance

7.2 Installation methods for PV arrays

① Deck roof installation (frame mount type)

It is often seen on flat-topped roofs with reinforced concrete and steel framed buildings. Since a certain angle towards the Sun is necessary to improve generation efficiency of solar modules (optimum angle differs with location), a base frame is required to which modules are attached, and sometimes concrete foundation work becomes necessary to install the frame itself. Special notes in deck roof installation are listed in table 1-4. Considerations on structural study, ensured water resistance, cost effectiveness and architectural appearance are important.

Table 1-4　Special notes on deck roof installation

・Verify and examine the strength of columns, beams, slab to determine the arrangement of water-proof foundation blocks. ・Structural binding is necessary to connect the water-proof foundation blocks and existing materials on existing buildings. ・Examine building structure and foundation when installing power conditioner, etc on rooftops. ・When work requires penetrating the waterproof layer, study to ensure water resistance. ・Inclination is often kept low to ease the impact of wind load on frames and structure. ・Ensure that there is adequate space and an access route for maintenance. ・Consider the arrangement of solar modules for a neat appearance.

Figure 1-16　Example of deck roof installation

② Pitched roof installation (direct mount type)

Span roofs, hipped roofs, sawtooth roofs, and pent roofs are examples of sloped roofing. Installation on sloped roofing should be well-arranged considering the landscape due to its high visibility from distant locations. A span roof is suited for plant type buildings because of its flexibility in selecting covering materials and structural types. Corrugated roofs have been adopted in spaces where plants are grown since olden days due to the ease of sunlight intake and good ventilation. Table 1-5 shows special notes for installation on sloped roof.

Table 1-5 Special notes in installation on sloped roof

- Prior study is required since installation direction is restricted based on the roof orientation
- Though facing towards the south is typically recommended, facing east or west is possible depending on the roof configuration
- Examine the structural fitting and water resistance along with roofing materials and bedding
- For sloped roofs on factory type buildings, secure a safe access route for maintenance
- Architectural design is necessary due to increased visibility compared to deck roof mounts
- Consider introducing newly available built-in roof type modules that are both water resistant and elaborately designed
- Consider well-aligned placement of electrical wiring for external appearance

Figure 1-17 Examples of pitched roof installation

③ Roofing material type (built-in material type)

Built-in type modules are developed to enable power generation while retaining architectural performance of roofs and walls, and they also easily allow for design and placement consideration. In some cases during new construction, materials that also function as roofs and walls can be cheaper than standard panels.

Advantages of such integrated modules include eliminating the need of a base structure by combining building materials and solar cells, in addition to lowering construction cost by conducting building construction and module installation at the same time. In particular, the effect on installation, cost, and surface design integration is higher during new construction, and incorporation into the architectural design can be relatively easy. Among the integral types, built-in roof development is more advanced than the others, and a variety of modules are available from many roofing manufacturers.

Figure 1-18　Examples of built-in module installation

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Chapter：Facility Planning Method (PV system for industrial use)

Text

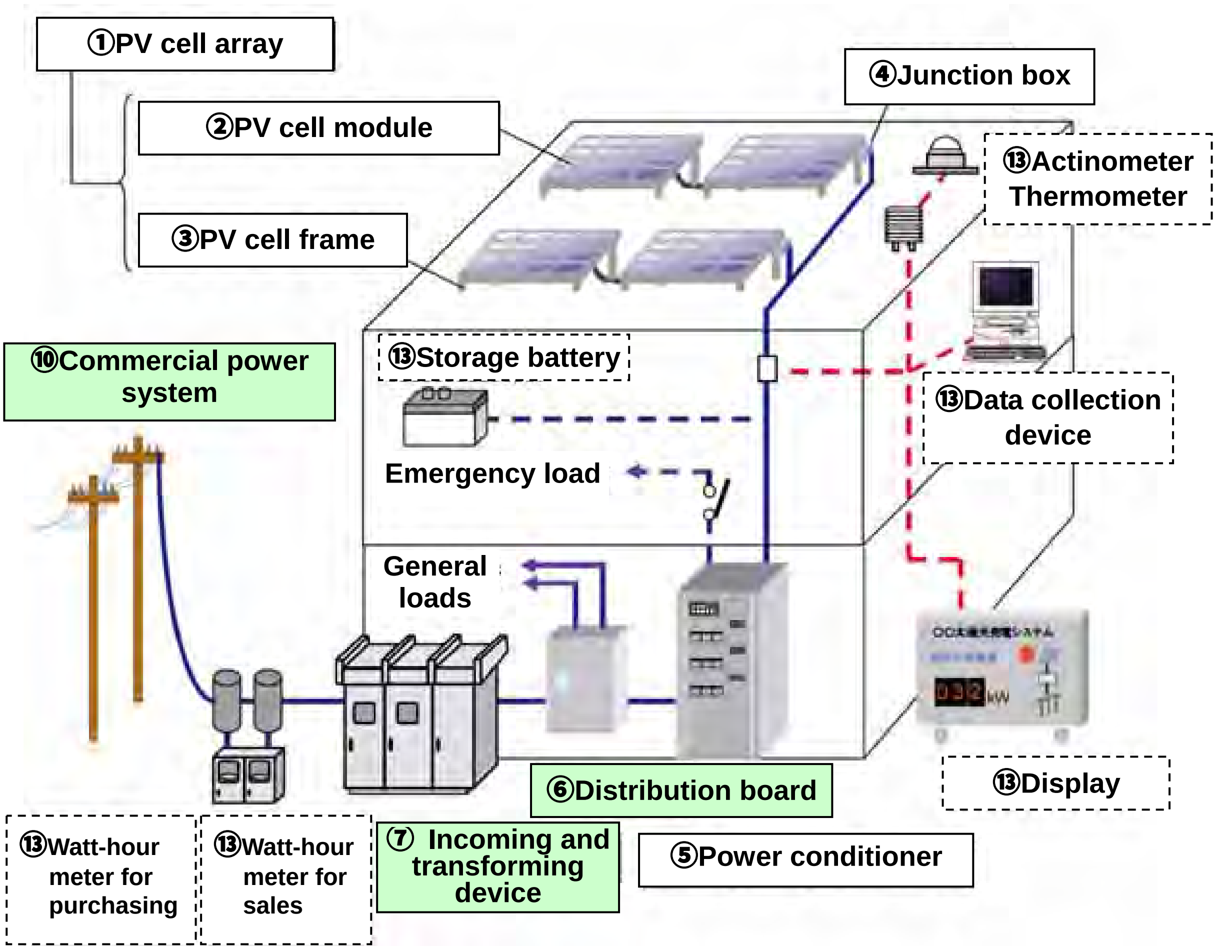
Contents

Chapter 1: Basic knowledge of industrial PV power systems

1. Definition of terms

Figure 1-1 is a typical system configuration of an industrial photovoltaic power system. Technical terms for this system are listed in table 1-1.

Generally, the output of a 3-phase 3-wire type power conditioner is more than 10kW, and the minimum capacity of this industrial PV power system is 10kW, which usually will only require a single power conditioner.



※ Interconnection can be done at low-voltage (directly interconnect at low-voltage without connecting incoming and transforming device, or deemed as low-voltage interconnection utilizing incoming and transforming device) or high-voltage.

※Distribution board, incoming and transforming equipment, and commercial power system are existing equipment.

※Data collection device, actinometer & thermometer, display device, and storage battery may not be required.

Figure 1-1 Industrial PV Power System Diagram
(Source: Japan Photovoltaic Energy Association, "*PV power system manual*")

Table1-1 Technical Terms for Industrial PV Power Systems

№	System Component	Description
①	PV cell array	・A group of PV cell modules connected mechanically and electrically on a frame
②	PV cell module	・A panel, which converts photovoltaic energy directly into electric energy (AC power)
③	PV cell frame	・Base frame used to mount PV cell modules at a certain angle ・Generally made of a steel or aluminum alloy ・Unnecessary when using building-integrated type modules
④	Junction box	・A box which contains all of the power cables from each string of PV cell modules ・Contains an embedded anti-reverse flow diode to prevent power from flowing back to the solar cell side in addition to a power switch and lightening protector for use during inspection and maintenance ・Often incorporated into the power conditioner
⑤	Power conditioner	・Provides control to maximize the generation of DC power from solar cells and also converts into AC power ・The interconnection protective device is normally equipped to prevent negative impact on the utility distribution system (commercial power system) ・Able to operate independently supplying power for specific loads even in the event of a power outage from the commercial source
⑥	Distribution board	・Distributes power for each electrical load in the building ・Interconnection point between the power conditioner output and the commercial power system ・Dedicated circuit breaker is necessary for the PV system
⑦	Incoming and transforming equipment	・Receives power from the commercial power system (6.6kv, etc) and converts it into lower voltage power (3-phase 3-wire 200V) or lighting power source (single-phase 3-wire 200/100V). ・Some low-voltage receiving points don't require these devices
⑧	Watt-hour meter for power sales	・Measures power sold back to the utility company (excess power) for systems wherein reverse flow is enabled. Some utility companies obligate consumers to provide such meters at their own cost ・The meter sometimes varies depending on the type of purchase agreement with the utility company
⑨	Watt-hour meter for power purchasing	・Measures purchased amount of power (demand consumption) from the utility company. The utility company should replace the conventional meter with one that has a reverse protection function
⑩	Commercial power system	・Commercial power system provided by the utility company. AC 3-phase 3-wire 6.6kv or 200v, etc
⑪	Data collection device	・A device used to collect and store data including power output, etc. Usually, an ordinary PC is used.
⑫	Actinometer, thermometer	・Devices used to measure insolation and ambient temperature
⑬	Display device	・Indicates power output, total energy production, radiation levels, etc for promotional purpose
⑭	Storage battery	・Allows the storage of electricity generated during the daytime and releases it at night or when there's trouble with the utility system. In that case, a controlling unit for charging / discharging and another junction box for the storage battery connection will be necessary.

※ ⑪ data collection device, ⑫ actinometer, thermometer, ⑬ Display device, and ⑭ storage battery are installed as necessary depending on the situation.

(Source: Japan Photovoltaic Energy Association, "*PV power system manual*")

2. Study of Interconnection Point

(1) Selecting an interconnection point

① Transmitting capacity

Electrical components located at the interconnecting building including primary feeders and a molded-case circuit breaker, etc must be able to accommodate the maximum generated capacity. Of course, breaking capacity of the circuit breaker, allowable carrying capacity of the upper feeder, and transformer capacity need to be verified and reinforced as necessary. Be sure to use a reversible earth leakage breaker for interconnection.

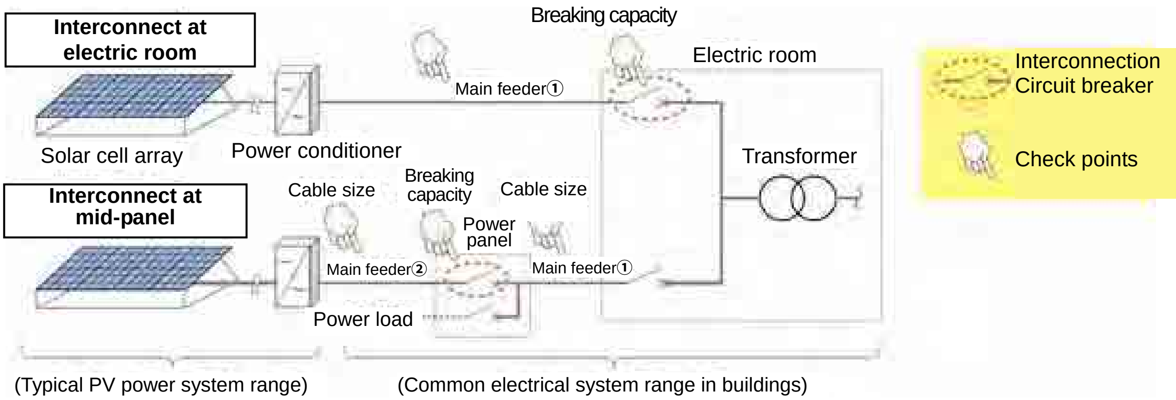


Figure 1-2　Capacity Check for Building Electrical System
(Source: NEDO "*Taiyokou Hatsuden no Kouka teki na dounyu no tameni*")

② Insusceptible to service work impacts

When setting an interconnection point in a building where electrical upgrading arises frequently, such as for tenant facilities, choose an interconnection point at the least influenced system since the power has to be shut down for all electrical work. Connections within an electrical room are generally considered to be less affected in such systems.

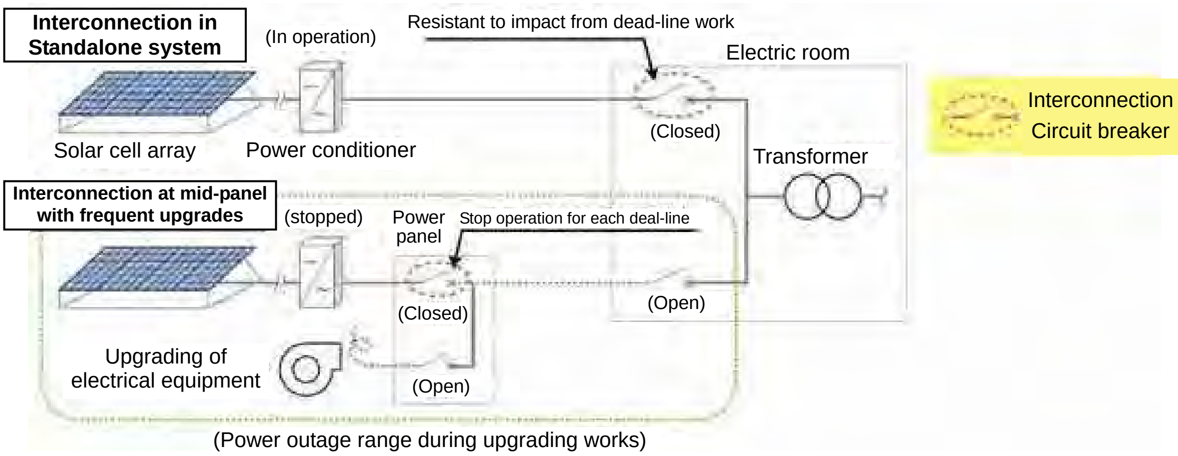


Figure 1-3　Examination of an Interconnection Point in a Building Electrical System
(Source: NEDO "*Taiyokou Hatsuden no Kouka teki na dounyu no tameni*")

(2) Necessary resources for the selection of an interconnecting point

The following materials need to be verified in order to define an interconnection point. Additionally, checking the actual site to verify its condition as stated in the materials and drawings is important.

● Single-line diagram for incoming and transforming equipment
  ・Verify if the necessary relaying device is equipped for interconnection protection
  ・Verify the type of transformer and voltage

● Feeding diagram / floor plan
  ・Verify interconnection point
  ・Primary feeding route, feasibility of additional wiring, grounding system

● Field validation
  ・Verify that the provided drawing is not outdated due to upgrades or modification (size of main feeder, the number of additional wiring connections, etc)

3. Adoption of small-scale power conditioner s(10kW)

The capacity of the power conditioner (output capacity and the number of units) is emphasized rather than the capacity of the solar cell array in industrial PV power systems.

In recent years, a large-scale power conditioner ranging from 500kW to 1MW has been developed and become available. Benefits of utilizing such a large-scale power conditioner are; lower unit cost per kW as well as higher conversion efficiency, etc. On the other hand, the utilization factor of the power system declines when failure occurs from long shutdown periods until system restoration or when the servicing cost by the manufacturer's engineer is not cheap. Therefore, constructing a system combining multiple smaller devices that are easily accessible, instead of a large-scale power conditioner, brings the following benefits; a risk averse way of lowering the utilization factor from failures (restore with backup devices), prompt recovery by local engineers, and system development with relatively low cost. Introduction benefits of the above mentioned system are considered high when adopted at isolated locations such as remote islands.

A power conditioner for an industrial PV power system is to be a 3-phase 3-wire model. The smallest capacity of the most commercially available 3-phase 3-wire power conditioner is 10kW. Since the 10kW power conditioner is a commercialized product, unit cost per kW is lower than that of the 50kW or 100kW type. Adoption of the 10kW power conditioner is also recommended for medium scale PV power systems due to the advantage in failure response.

In Okinawa, there are several existing power systems already incorporating generally available 10kW power conditioners and they are also in operation without any issues in multiple remote islands. Recently, such a small power conditioner (10kW) was also adopted in a mega solar system.

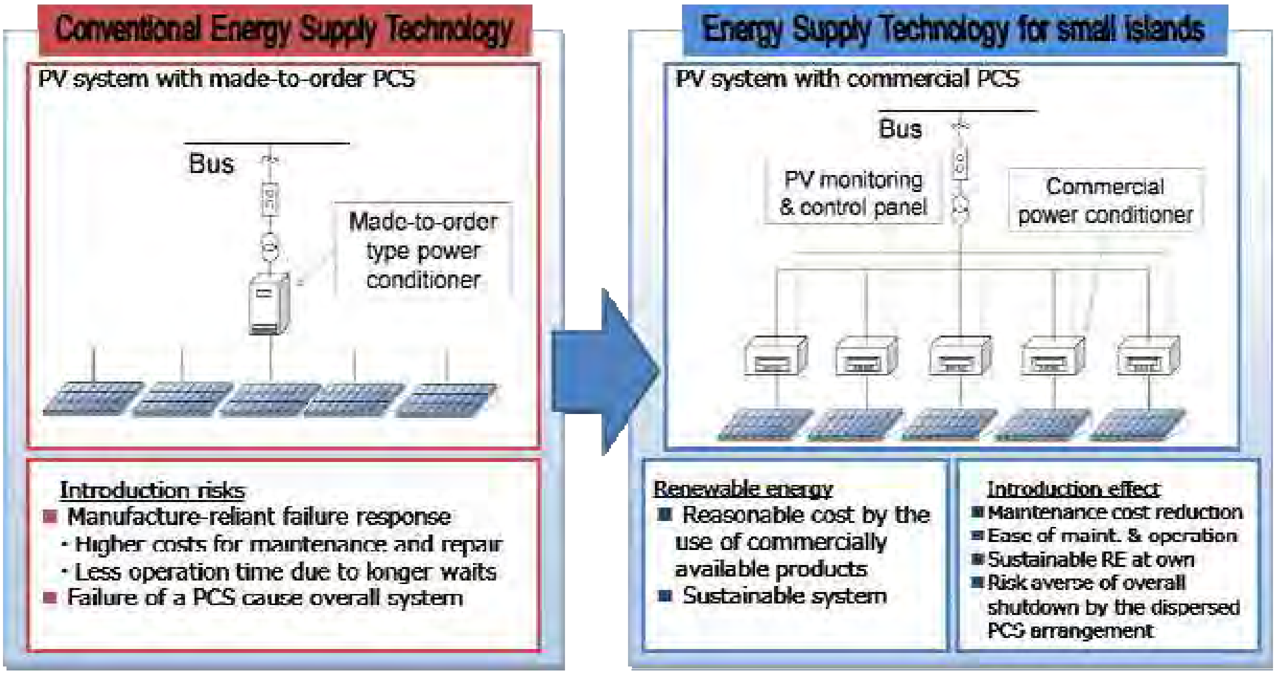


Figure 1-4 Example of System Configuration

Figure 1-5　Example of a PV System with Commercialized PCS in the Remote Islands of Okinawa

Power is sent by DC transmission between the PV cell array and the power conditioner and by AC transmission between power conditioner and the receiving point. Because the voltage becomes zero for each cycle in AC transmission, it’s easier to interrupt thus less risky to the human body. However, voltage in the DC transmission is constant, thus difficult to interrupt and more impact on human body when electrocuted.

For an outdoor type power conditioner’s (10kW) benefit, safety improves by installing it on an array and minimizing the distance of the DC transmission.

Chapter 2: Introduction Cases of Industrial PV Power Systems

1. Introduction example (Maximum Power Point Tracking)

The Clean Association of Tokyo 23 has installed a 50 kW PV power system on the roof of a molten slug storage facility in the Katsushika Incineration Plant as a response to the recycling society in 2007.

Considering the shading impact, module pitch is set for about 3 degrees, and the junction box is mounted on a wall in the lower level so that maintenance can be easily performed. Outdoor cables are contained in conduit pipes to avoid degradation from sun exposure (UV). Wiring flows indoors through a watertight pull box and a pigeon house with adequate waterproofing treatment. Indoor type power conditioners (10kW x 5 units) are located in a common hallway.

【System outline】

Facility name：Katsushika Incineration Plant – Molten slug storage facility

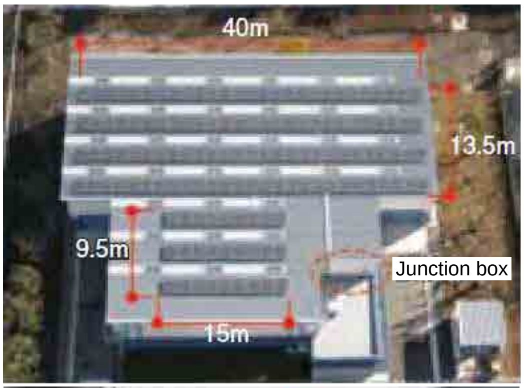
Generation capacity：50kW (186W x 270 panels)

Installation method：Flush mount

Power conditioner：10kW x 5 units

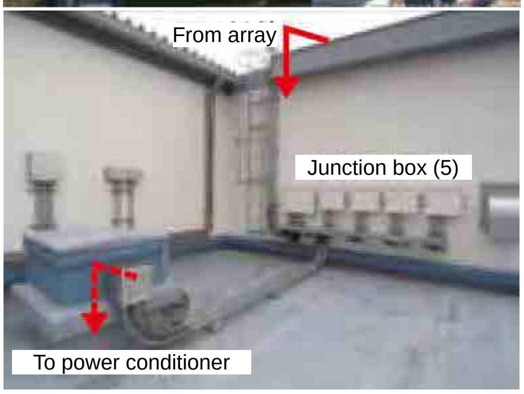
Interconnection point：Power panel within the building

Interconnected voltage：3φ - 200V

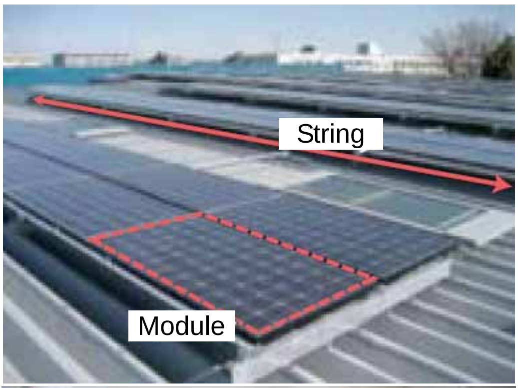


Skylight windows are situated between the arrays to allow for natural day lighting. There is adequate space available for a maintenance aisle, forming a total of approx. a 530 m^2 array area excluding the skylight space.

This makes an equation of 1kW ⇔ 10.6 m^2.

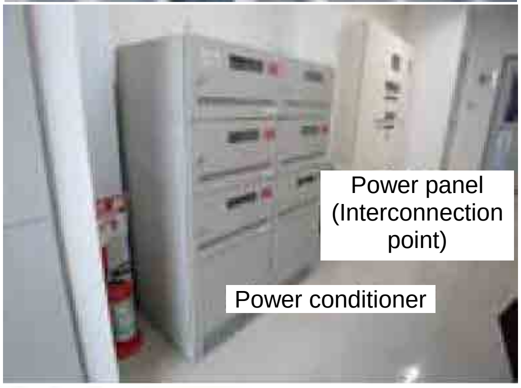


There are five 10kW junction boxes to match with the power conditioner configuration, and mounted at a location where the wiring distance from the arrays to indoors is minimized.



Nine (9) series' constitutes one (1) string, a total of six (6) strings are connected in parallel, and they are fed into a junction box.

186kW x 9 series x 6 in parallel =10.044 kW
Voltage: 37.1V x 9 series =333.9V



The power conditioner is constructed with five (5) 10 kW units, and converted AC is interconnected with a power panel, which is located right next to it to minimize the transmission loss.

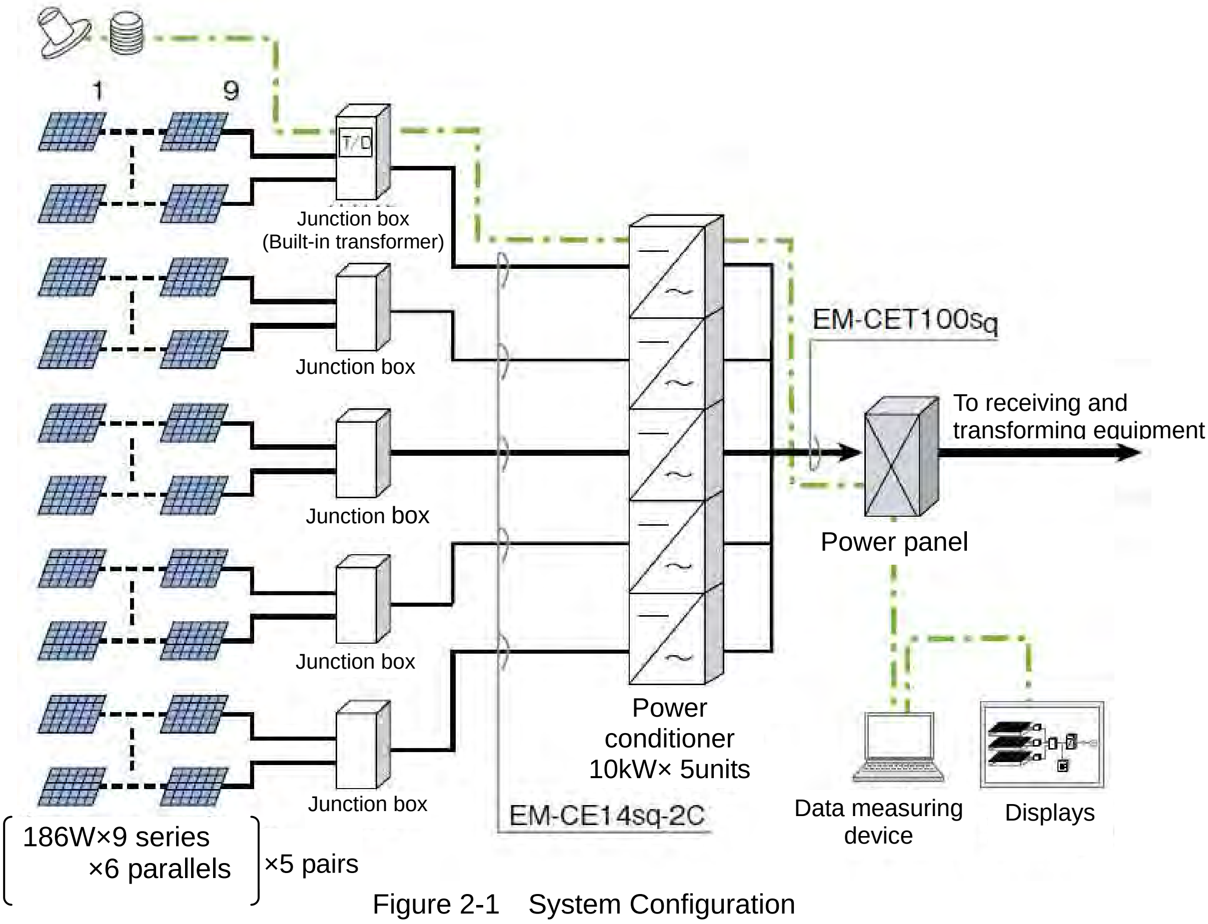


Figure 2-1 System Configuration

2. Introduction example (Peak cut)

Peak cut commands are sent to each power conditioner from a peak-cut controller, which receives monitored receiving power information. There are three (3) pairs of 100kW PV modules with 100kW power conditioner (300kW total), and a storage battery is directly connected to the DC side right before the power conditioner. By omitting a DC/DC converter, conversion loss of the device is eliminated. Those 3 pairs can be controlled independently as well.

One of the three pairs has an isolated operation function as being an emergency power source.

A nickel hydride battery is adopted for power storage, which can charge / discharge at 4 times faster than the common lead acid storage battery, and several peak cut operations can be executed in a day.

【System outline】

Facility name：Kawasaki Precision Machinery Company – Core parts plant

Generation capacity：300kW (200W x 1,508 panels)

Installation method：Flush mount

Power conditioner：100kW x 3 units

Interconnection point：Cubicle power panel

Interconnected voltage：3φ - 210V

Storage battery capacity：1.108 Ah / 276V

150kW PV panels are installed on the roof surface of two different buildings oriented at 180 degrees (total 300kW).
However, electrically they are divided into 3 sections.

Power information at receiving point is sent to the peak cut controller, and then it sends peak cut commands to each power conditioner

The nickel hydride battery, which is highly advanced compared to the lead acid battery, is adopted. The container shown in the left picture stores the storage battery.

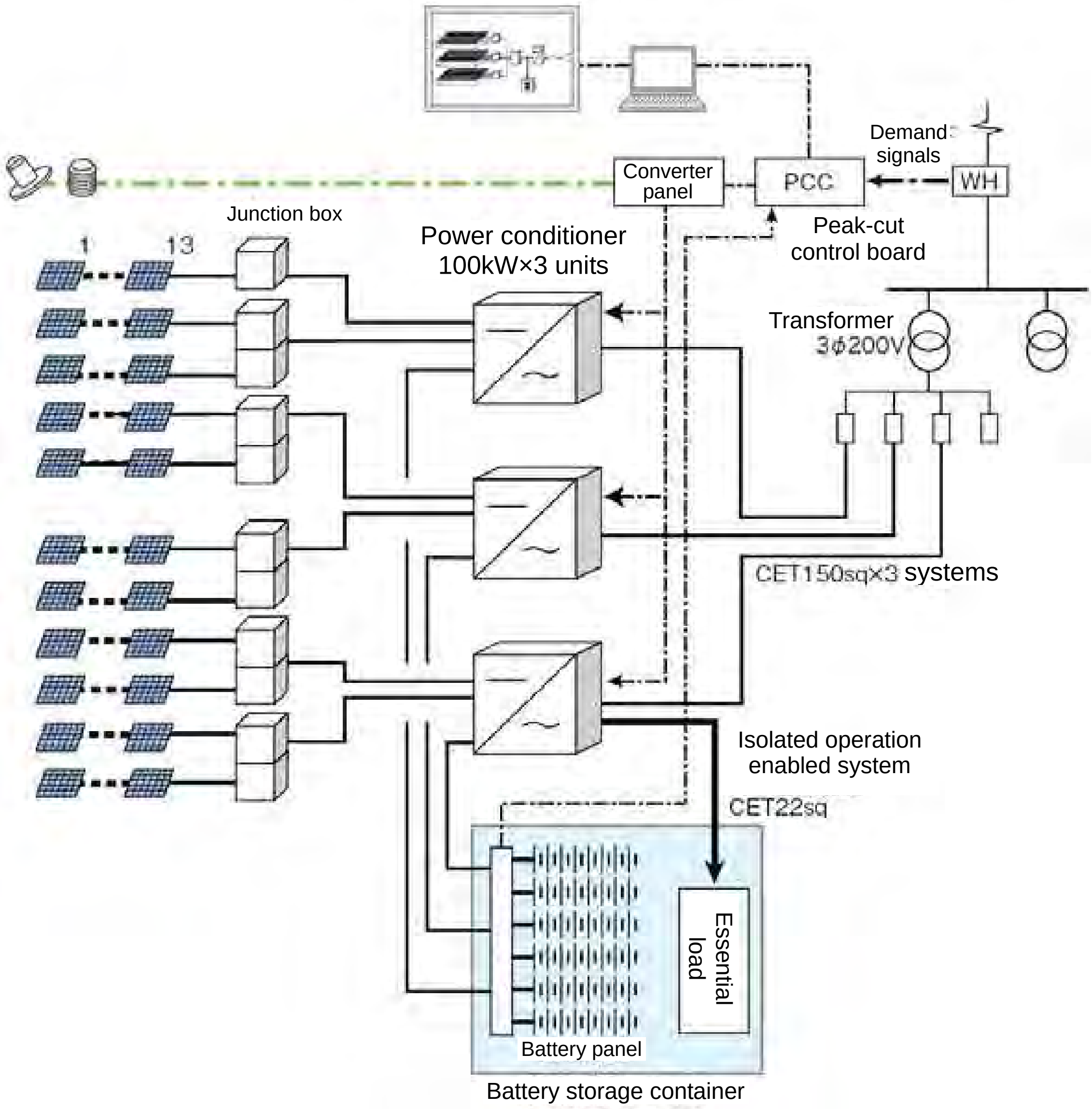


Figure 2-2 System Configuration

3. Introduction example (Emergency backup system)

This PV power system is interconnected with the utility system using maximum power point tracking, although it can be independent from the connected commercial power system and operate as an isolated power source once failure occurs with the utility system.

The output circuit for isolated operation of this system supplies power to a 1.5kW water pump through a backup source panel to supply water (water pump is normally powered by the commercial system). However, since there are no storage batteries installed in this system, it requires much more power from the PV system than the required amount to mobilize the water pump during emergencies.

【System outline】
Facility name：SHIN-YOSHA Corporation – Tama Sakai Plant
Generation capacity：50kW (167W x 300 panels)
Installation method：Flush mount
Power conditioner：50kW x 1
Interconnection point：Cubicle power panel
Interconnected voltage：3φ - 200V

Each 10kW string of the 50kW PV system is combined at the junction box and connected to the power conditioner.

Normally, the power conditioner executes ordinary interconnected operation, but it can be independent from the utility system and operate in isolation during emergencies.

The power conditioner is configured to supply power to a water pump through a backup source panel during emergency situations.

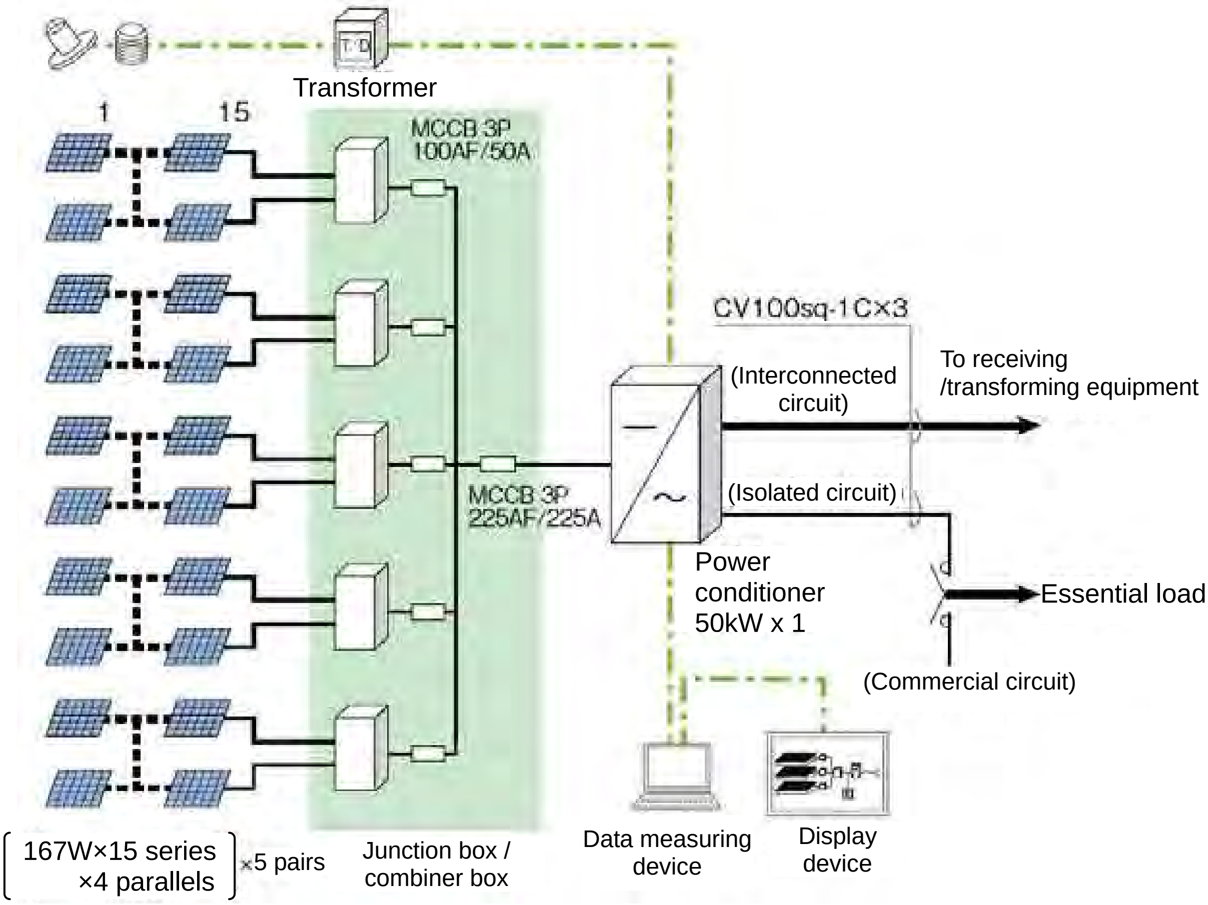


Figure 2-3 System Configuration

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Chapter：Facility Planning Method (Large-scale PV system)

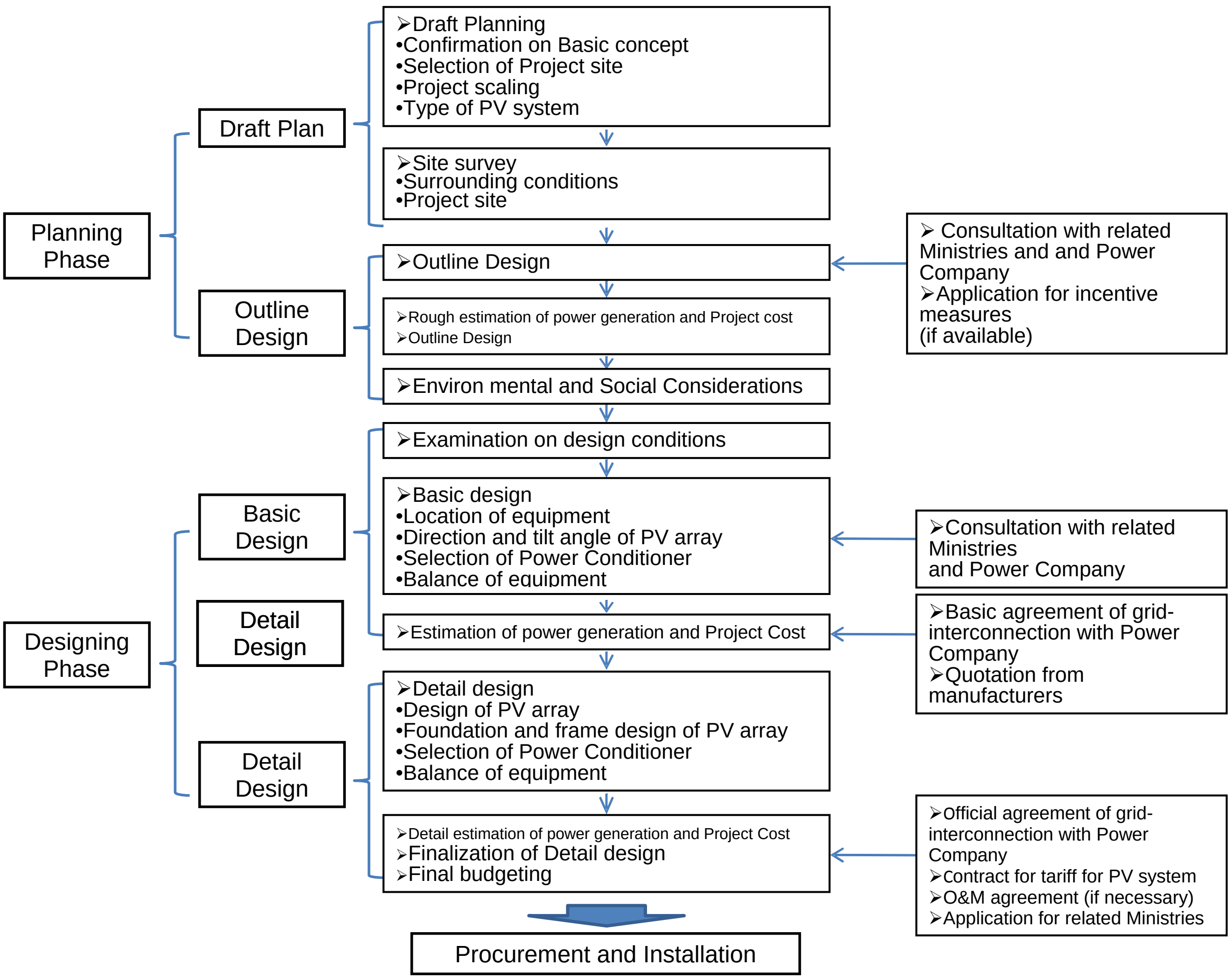
Text

Contents

Chapter 1 Plan and Design

1. Outline procedures for plan and design

As shown in Figure 1-1, procedures for planning and designing a grid-connected PV system consist mainly of planning, outline design, basic design, and detailed design. In the first phase, we define the basic concepts and purposes of introducing the system, select a site, and set up the type and scale of the system. In the next outline design phase, we have prior discussions with the concerned authorities and the power company and roughly plan PV system, electrical, and building facilities to be introduced. In countries that employ a promotion scheme for PV system (e.g. Feed-in tariff), it is necessary to ask the authorities concerned to show requirements for applying the scheme. In the basic design phase, we design the system (electrical and building facilities) according to a more concrete equipment layout plan and make basic design drawings. In the detailed design phase, we design the facilities in more detail and make drawings that allow equipment and material suppliers to make a quotation and construction plan. In addition, we shall estimate generated energy by the PV system and rough project costs in each step of the outline, basic, and detailed design phases in consideration of the schedule to make a budget for the client and to make an application to the concerned authorities for applicable incentive schemes.



(Source: JICA Senior Advisor)

Figure 1-1: Plan and design phase to introduce PV system

2. Technical requirements for grid-interconnection

① Power supply quality of Japan

Adverse effects on other customers must be prevented by securing the **reliability** of power supply (preventing the expansion of the interrupted area in case of a fault by protection coordination) and by securing **power quality** (voltage, frequency, harmonics, etc.).

In case of Japan, already various distributed generators have been added to the grid of power companies, especially generators which utilize renewable energies (PV, wind power, etc.), reflecting the growing consciousness on global environmental issues. In this situation, it is gradually becoming difficult for power companies to keep "the quality of power supply" as shown on Table 1-1.

Table 1-1: Requirements for power supply quality in Japan

Parameter	Specification
Normal voltage variation (low voltage) Instantaneous voltage drop	101 ± 6 V and 202 ± 20 V (Ordinance for Enforcement of Electricity Business Act, Article 44) 10% (Technical Guidelines for Grid Interconnection)
Frequency variation	±0.1 to ±0.3 Hz (different code of practices by electric power companies)
Harmonics	· 6.6kV distribution line: Total voltage distortion factor of 5% · Extra-high-voltage line: Total voltage distortion factor of 3% (Harmonics Suppression Guidelines)
Flicker (low voltage)	$\Delta V10 \leq 0.45$ V (Recent Trends in Arc Furnaces for Steel Production and Power Supply, No. 72 Technical Report (Part 2), The Institute of Electrical Engineers of Japan)

(Source: Standards and Codes in Japan)

In addition, safety of general public and operators for power company must be secured. Adverse effects on power supply facilities and the facilities of other customers must be prevented (prevention of islanding operation and reversed charge).

② Electrical mode and power factor

(a) Electrical mode

The electrical mode of generating facilities must be the same as that of the grid connected. For example, if the grid connected is three-phase three-wire type, the generating facilities must be also three-phase three-wire type. This is because the voltage and current imbalance may be caused by possible phase imbalance.

(b) Power factor

When there is no reverse power flow, power factor at power receiving point should be 85% or higher, in principle, in order to alleviate voltage drop. Leading power factor against the grid is not allowed. Power factor is calculated as a formula of real power divided by apparent power. Power factor against the grid means real power coming to the load is positive, and power factor against the generating facilities means real power coming out to the grid is positive.

③ Voltage deviation

What happens if voltage is not properly kept within regulated range? Following malfunctions are expected;

- If the voltage higher than proper level continues, the lifetime and insulation of various equipment including home appliances are negatively damaged.
- On the other hand, if the lower voltage continues, performance of equipment might be lowered or

discontinued.

- Instantaneous voltage drops may cause the loss of data in memories of PC, etc.

In case of Japan, quite a few numbers of small-scale residential PV systems are expected to be interconnected with low-voltage distribution lines in the near future. In order to avoid the voltage deviation, several measures will have to be taken. It is possible to adopt thicker conductors or bigger distribution transformers to up-grade distribution lines. However, those measures will be the last-resort as it will raise the total cost. Another method is to restrict power output during the period large amount of excess power is forecasted, such as Golden-Week (long public holiday in April and May) in Japan. But this means some part of real power output from PV system is not fully utilized. Also the customer with restricted PV output may claim that it is not fair to control his/her PV system because PV systems for other customers are still interconnected. In order to avoid such a situation, another solution is to control power factor or reactive power from the PV system. The followings are the detailed explanation of this method.

Figure 1-2 shows the example of the power system. The figure shows the voltage is kept within the proper regulation range both in case of light load and heavy load.
The distribution line voltage is regulated within the proper range by the tap of transformer in a distribution substation, for both light load and heavy load.

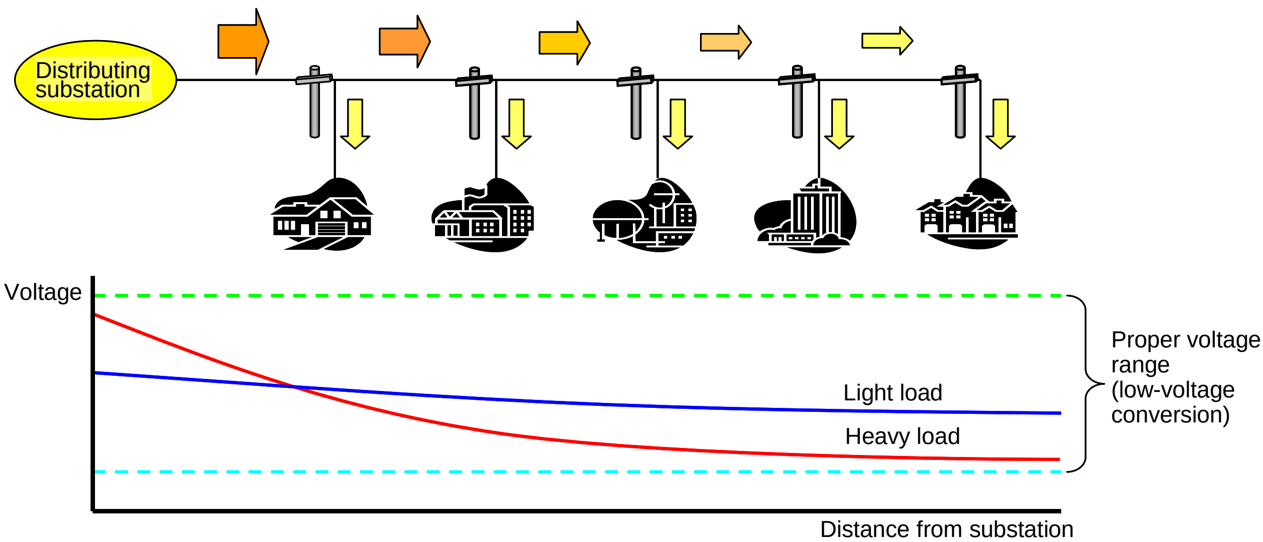


Figure 1-2: Before installing a grid-connected PV system

Figure 1-3 shows the voltage after installing a Grid-connected PV system. It shows if there is reverse power flow from the distributed generators to the grid, the grid voltage rises and may go beyond the proper voltage range at the light load condition.

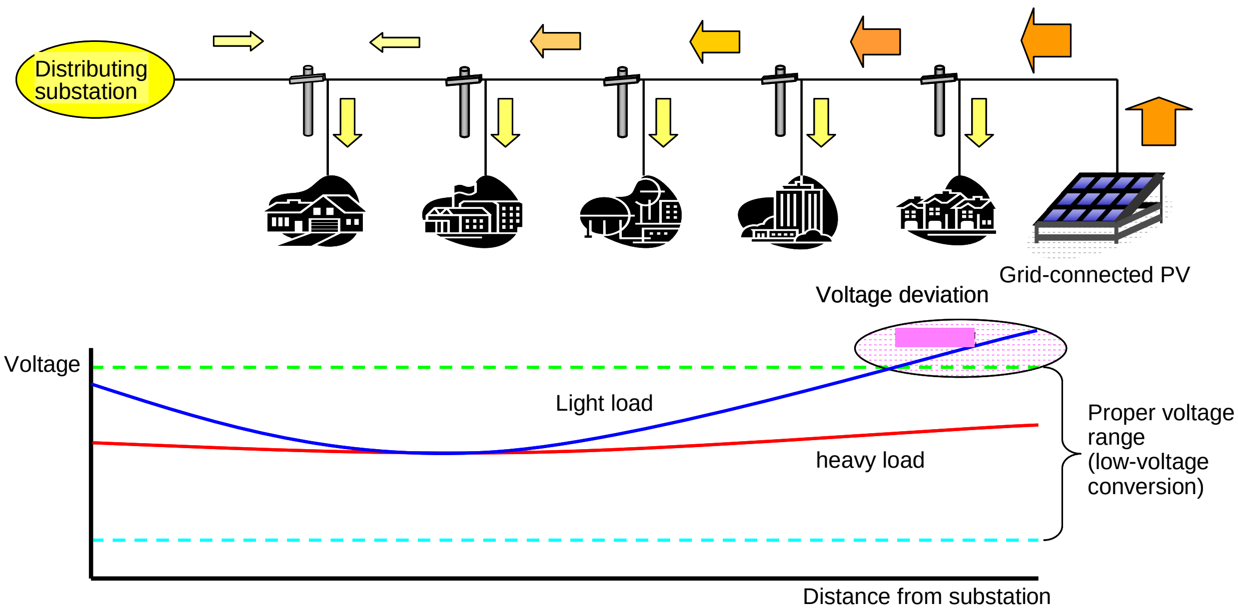


Figure 1-3: After installing a grid-connected PV system

Figure 1-4 shows the sample measure to suppress the voltage rise by a controlling power factor of distributed generators interconnected with the grid. If the power factor of a distributed generator is 1.0, deviation from proper voltage occurs. However, proper voltage can be kept by a controlling power factor of a distributed generator, as the power factor is shifted from 1.0 to 0.95 (leading power factor against the grid).

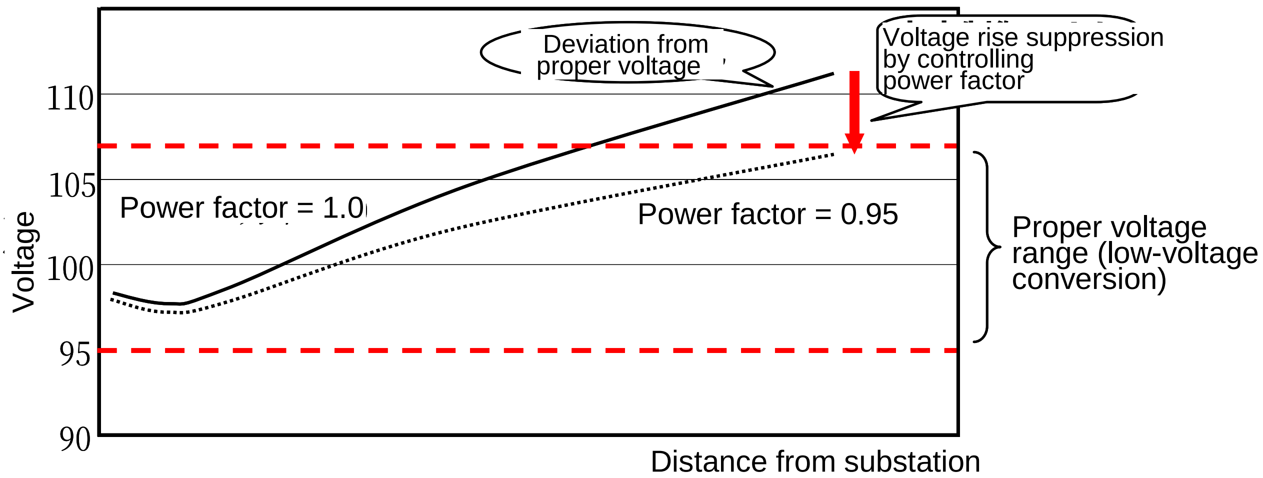


Figure 1-4: Suppression of voltage rise by controlling power factor

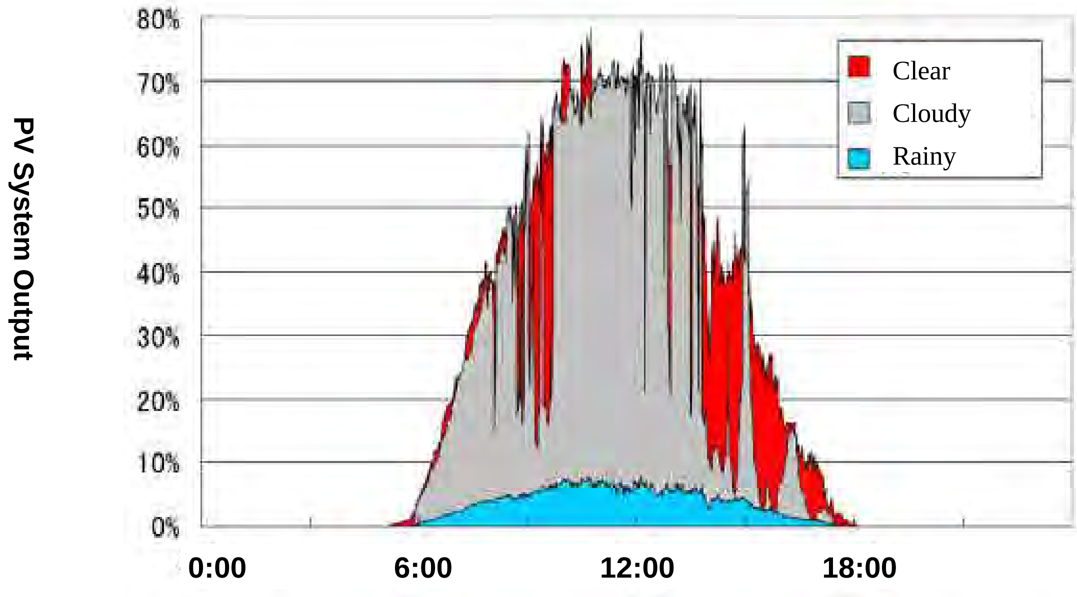
④ Frequency fluctuation

What happens if the frequency is not properly kept within regulated range? Following malfunctions are expected;

- Fluctuation of frequency results in the irregular motor rotation, which negatively affects manufactured products in assembly lines.
- Large fluctuation of frequency may generate resonance at rotating parts such as turbines of generators, which affects the lifetime of machinery.

- As the case may be, some generators cannot be synchronized as the stability of power system goes down. These generators will drop out from the synchronous operation of the power system. It brings about a further frequency drop, which causes the chain of drop out of generators and the whole grid may be stopped in the worst case scenario.

In general, the frequency of the power system is regulated by Governor Free operation of generators, Load Frequency Control (LFC), and Economic Load Dispatching control (EDC) in accordance with period of frequency fluctuation. However, the output of PV system changes rapidly depending on the weather conditions.



(Source: The Federation of Electric Power Company of Japan)

Figure 1-5: Fluctuation of PV system output

Therefore, in Japan and many European countries, appropriate technologies to control and regulate frequency is now under development and gradually deployed at sites. For example, the following measures are introduced.

- Introduction of variable-speed pumped-storage power station
  This system controls the rotation speed of the generator to change the pump turbine's velocity, resulting in changes in the pumping discharge. Therefore, it can precisely adjust the input power according to demand on the grid side even during pumping operation.
- Introduction of storage batteries
  As shown in Figure 1-6, the fluctuation of combined output to the grid side can be suppressed by introducing AC/DC converters and storage batteries.
- As a measure for increasing the amount of grid-interconnection of wind power, a request for interconnection based on the scheduled disconnection/output restriction method, in which disconnection or output restriction is done while the frequency regulation becomes difficult due to the light load condition.

In the future, we will need the method of estimating or grasping the output power of PV systems in accordance with weather forecasts, therefore, laboratories are now collecting PV output data.

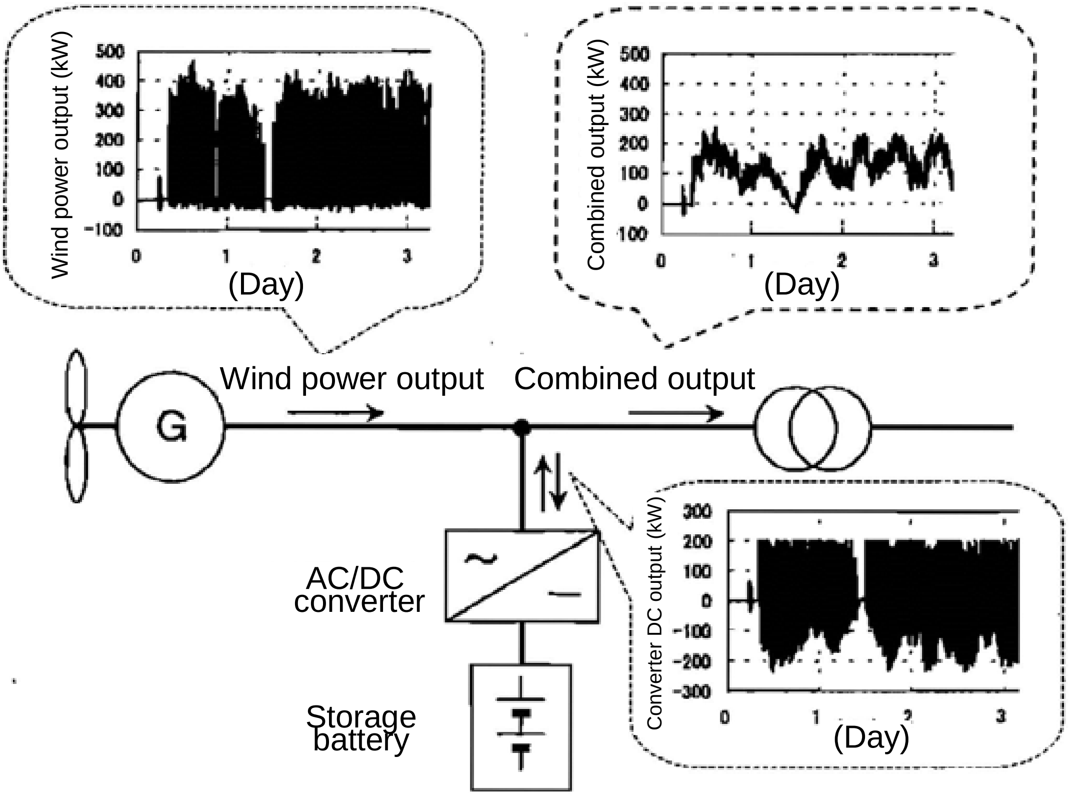


Figure 1-6: Suppression of output fluctuation by using storage battery

⑤ Harmonics

Harmonics are frequencies that have integral multiples of the fundamental frequency (50 Hz or 60 Hz). The inverter in the power conditioning system (PCS) has non-linear devices that generate harmonics. Therefore, we shall reduce their amplitude to levels regulated under concerned authorities and power company. Japan defines "Environmentally Targeted Levels of Harmonics," which show that the total voltage distortion factor shall be not more than 5% and 3% in 6.6kV distribution and extra-high-voltage transmission/distribution lines respectively. As a result, it is necessary to reduce the total current distortion factor of the PCS (harmonic generator) to less than 5% and the current distortion factor in each order to less than 3%. When selecting a PCS, we shall check whether it meets these requirements.

⑥ Protection coordination

When operating the grid-connected PV system, we shall detect any problem in the transmission/distribution line or PV system within a given period of time and stop the PCS to keep the grid safe. Japan, therefore, develops technical standards for electric facilities to define the obligation to install necessary protection devices (e.g. Protection relays and islanding prevention function). These protection devices are typically built in the PCS.

The basic concept of protection coordination to eliminate fault and minimize the area of power interruption is explained as below.

- Disconnect generating facilities with malfunction or fault to localize the affected area.

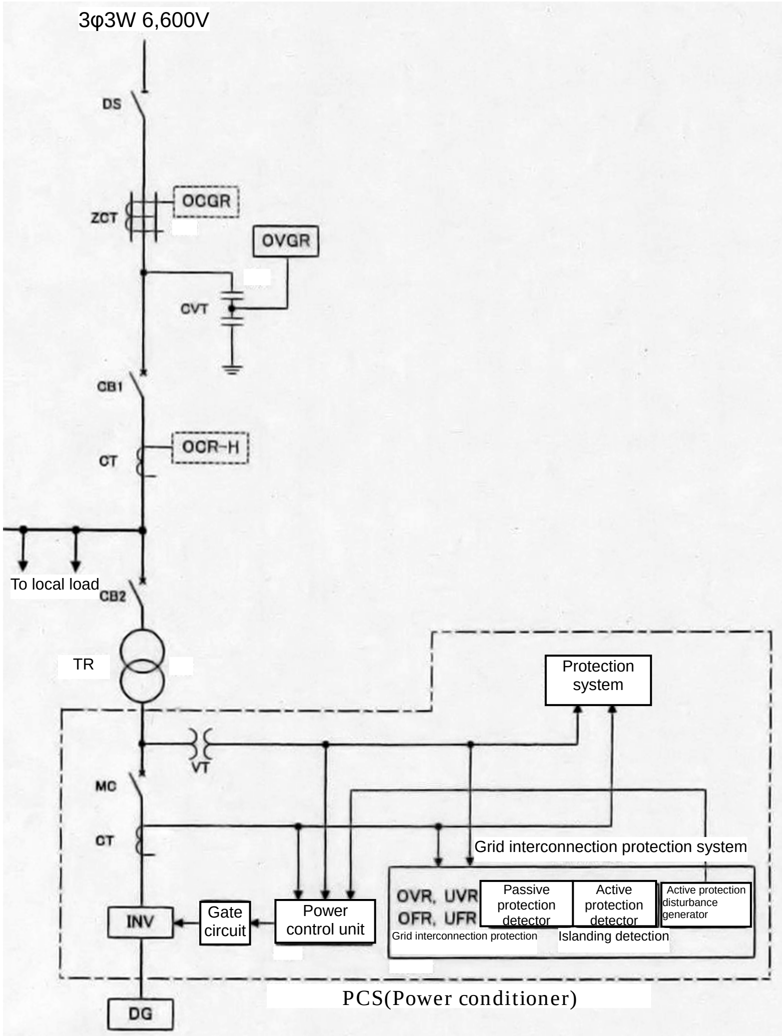
- Disconnect generating facilities when short-circuit or ground fault occurs at the grid.
- Disconnect generating facilities for power interruption caused by transmission line faults, etc. to prevent any islanding operation.
- Generating facilities are in a disconnected state at the time of grid reclosing.
- Avoid disconnection for a fault other than the grid connected by generating facilities.
- Keep operation or recover automatically from a momentary voltage drop of the grid.

The Japanese Grid-Interconnection Codes not only require protection from the following events but also define more detailed protection requirements in accordance with the voltage levels of grids to be connected and with or without the presence of a reverse power flow. It is recommended to have talks with the power company before selection of the type of protection relays to be actually installed and settings according to the country-specific grid configuration and grounding method.

Table 1-2: Basic sets of protection relays and scope of protection

<table>
<tr><th rowspan="2" colspan="2">Symbol</th><th rowspan="2">Protection</th><th rowspan="2">Faults to be prevented</th><th colspan="2">Example of setting range</th></tr>
<tr><th>Detection level</th><th>Detection time</th></tr>
<tr><td colspan="2">OCR-H</td><td>Overcurrent</td><td>Short circuit on premises</td><td>70% of minimum fault current of power receiving bus bar</td><td>Instantaneously</td></tr>
<tr><td colspan="2">OCGR</td><td>Grounding overcurrent</td><td>Ground fault on premises</td><td>The level at which no malfunction occurs due to transformer's rush current or on-site equipment's charge current</td><td>Coordinated time setting of ground-fault relay at the installation site and distribution substation</td></tr>
<tr><td colspan="2">OVGR</td><td>Grounding overvoltage</td><td>Ground fault on grid side</td><td>Equal to or less than level set in ground detection relay (OVGR) in distribution substation</td><td>Allowable time based on Type B grounding resistance of the grid</td></tr>
<tr><td colspan="2">OVR</td><td>Over voltage</td><td>Generator malfunction</td><td>110 to 120%</td><td>0.5 to 2 seconds</td></tr>
<tr><td colspan="2">UVR</td><td>Under voltage</td><td>Generator malfunction, Grid power interruption</td><td>80 to 90%</td><td>0.5 to 2 seconds</td></tr>
<tr><td colspan="2">UFR</td><td>Under frequency</td><td>Grid under frequency, Islanding operation</td><td>48.5 to 49.5 Hz
/58.2 to 59.4 Hz</td><td>0.5 to 2 seconds</td></tr>
<tr><td colspan="2">OFR</td><td>Over frequency</td><td>Grid over frequency, Islanding operation</td><td>50.5 to 51.5 Hz
/60.6 to 61.8 Hz</td><td>0.5 to 2 seconds</td></tr>
<tr><td rowspan="6">Islanding operation prevention</td><td rowspan="2">Passive</td><td>Voltage phase jump detection</td><td rowspan="6">Islanding operation detection</td><td>Phase change: ±3 to ±10°</td><td>Within 0.5 seconds</td></tr>
<tr><td>Frequency change rate</td><td>Frequency change: ±0.1 to ±0.3%</td><td>Within 0.5 seconds</td></tr>
<tr><td rowspan="4">Active</td><td>Frequency shift</td><td>Frequency bias: Several % of rating</td><td>0.5 to 1 seconds</td></tr>
<tr><td>Active power change</td><td>Active power: Several % of operating power</td><td>0.5 to 1 seconds</td></tr>
<tr><td>Reactive power change</td><td>Reactive power: Several % of operating power</td><td>0.5 to 1 seconds</td></tr>
<tr><td>Load change</td><td>Inserted resistance: Several % of rated power
Insertion time: Within 1 cycle</td><td>0.5 to 1 seconds</td></tr>
</table>

(Source: Grid-interconnection Code in Japan: JEAC 9701)



(Source: Grid-interconnection Code in Japan: JEAC 9701)

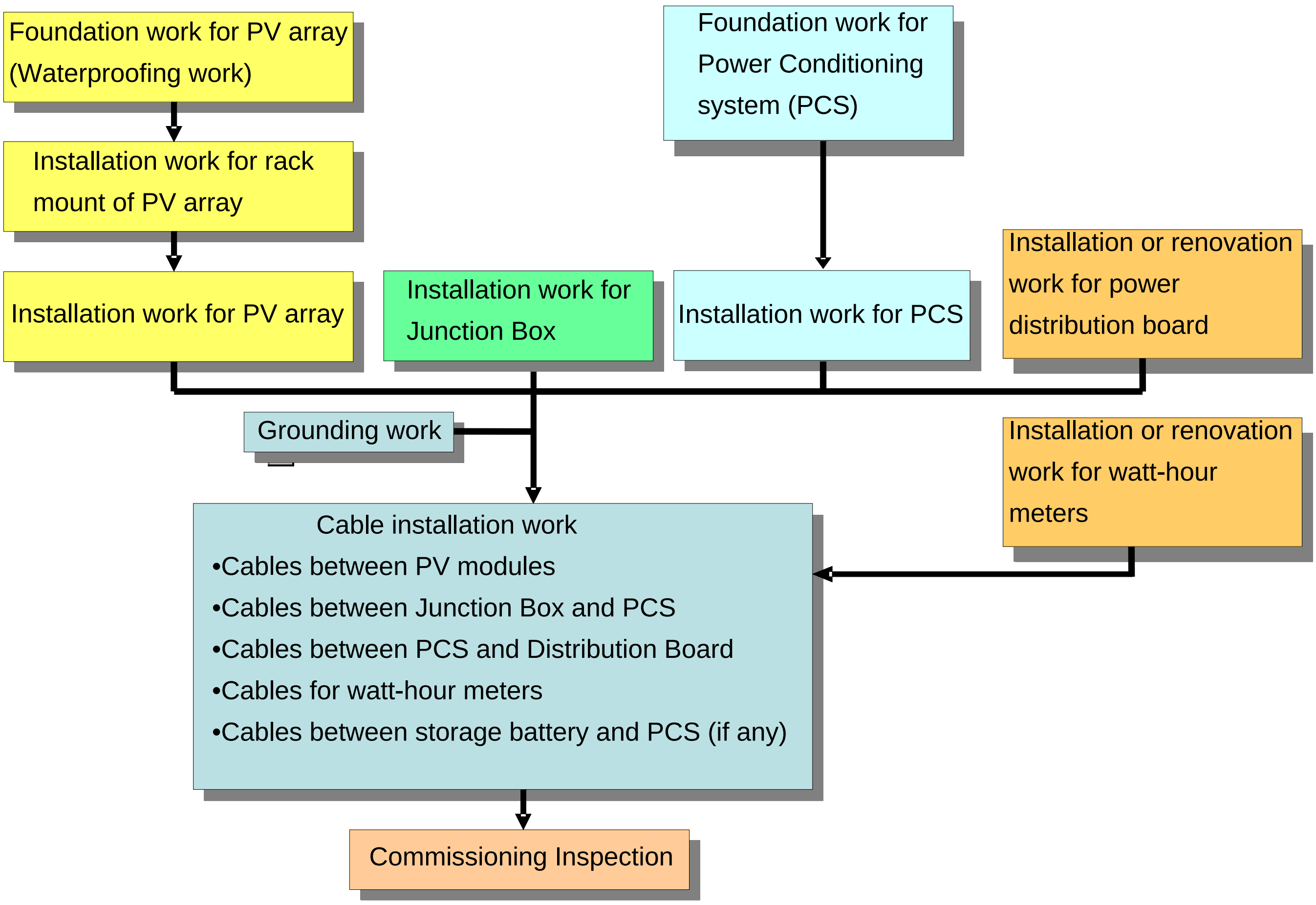
(Remark: with the reverse power flow, two or more prevention measures for islanding operation, without line voltage detector)

Figure 1-7: Sample protection scheme for interconnection with medium-voltage grid

Chapter 2 System Installation and Commissioning

1. Outline procedures for system installation and commissioning

The installation work of a grid-connected PV system consists mainly of six tasks: the foundation and installation work of the PV array, the foundation and installation of the power conditioning system (PCS), the installation work of the junction box, the installation or renovation work of the distribution board and watt-hour meter, cable installation work, and commissioning inspection. In addition, it is necessary to ground the steel racks, metal housings, and metal pipes to avoid a ground fault due to earth leakage. In Japan, necessary safety measures shall be taken in accordance with the Industrial Safety and Health Act and related laws. Unlike a general power generator, the PV cell generates power whenever it is exposed to sunlight, so we shall take special care not to be involved in an electric shock.



(Source: For effective performance of solar photovoltaic system, NEDO (modified by JICA Senior Advisor))

Figure 2-1: Procedures for system installation and commissioning

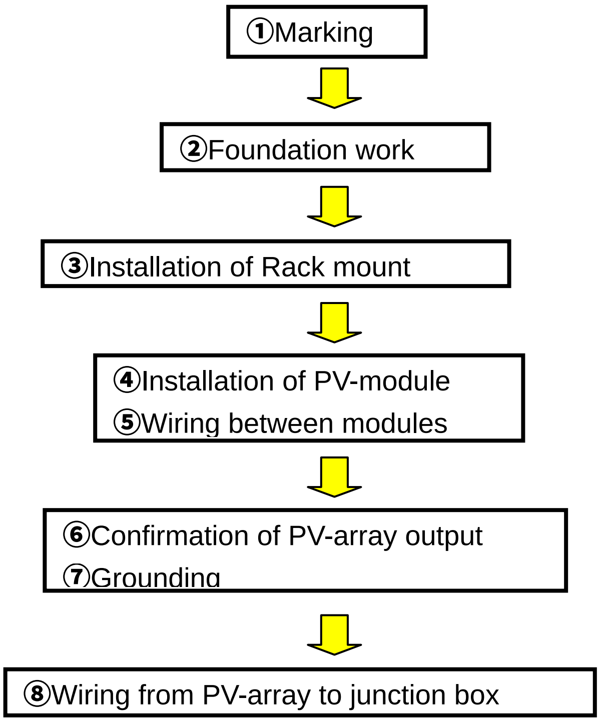
In Japan, the introduction of grid-connected PV systems is recently increasing rapidly. As a result, it is said that there are many low-quality installation works to be avoided. The responsible authority is now trying to introduce a qualification system for certifying that technicians who install PV systems in general houses have learned required skills for installation, maintenance, and inspection methods. In other developed and developing countries, the establishment of similar qualification systems is under way as a measure for increasing number of PV systems introduced.

2. Installation work for PV array

1) Standard procedure for installation work

Figure 2-1 shows detail procedures for installation work of PV array included in Figure 2-2. We assemble the rack on the foundation and then fix the PV modules to the rack with bolts and brackets to constitute the PV array. The carry-in and assembling work of steel frames for the rack requires a protection sheet to prevent them from coming into direct contact with a floor or the ground. In addition, to reduce the risk of theft and vandalism during installation, it is necessary to prepare an appropriate security system at a place where the PV modules are kept temporarily.

As an example, this subsection describes procedures for installing a ground-mounted PV array and precautions for each process.



(Source: Guidance for introduction of PV System, JPEA)

Figure 2-2: Procedures for installation work of PV array

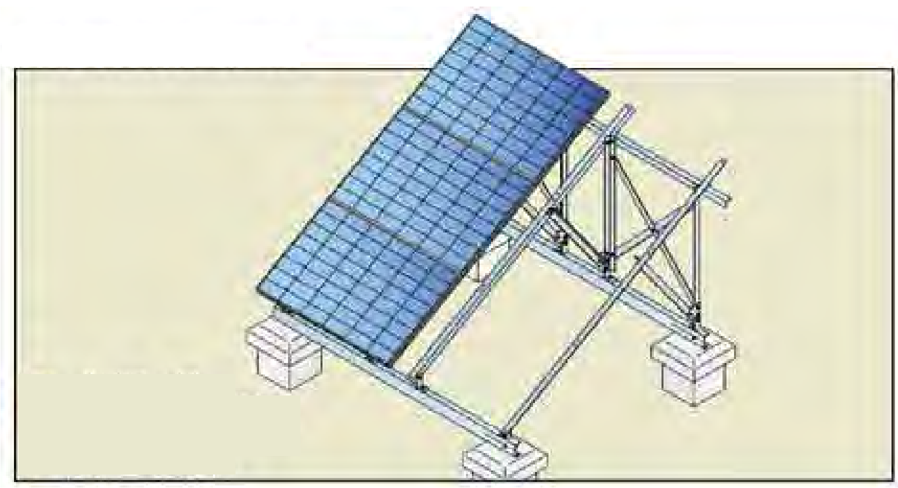


Figure 2-3 Installation of ground-mounted PV array

(i) Marking work

- Conduct marking work according to the design drawings including the layout of racks and modules and the manufacturer's construction manual.
- Note that it may be necessary to adjust the position of anchors at the site because it varies depending on the shapes of the roofing material and frame shape.

(ii) Foundation work

- Check the foundation pitch and shape

(iii) Rack installing work

- Temporarily put and fix racks on the ground according to the layout drawing.
- After the final fixation, check whether each joint is secured.

(iv) PV module installing work

- .Temporarily put and fix PV modules on the rack according to the layout drawing.
- .After the final fixation, check whether each module is fixed securely with bolts and nuts.
- Check the modules by appearance.

(v) Wiring between the PV modules

- .Connect cables while checking the polarities (+/-).
- <u>Take care not to receive an electric shock during wiring.</u>

(vi) Inspecting the PV array output

- .Use a tester to measure the open-circuit voltage of each string of the PV array.
- Check whether the measured voltage does not vary significantly between the strings.

(vii) Grounding work

- .Check where is grounded.
- Follow relevant laws to do grounding work.

(viii) Wiring from the PV array to the junction box

- .Check the wiring route from the PV array to the junction box in advance.

Chapter 3 Operation and Maintenance of Grid-Connected PV System

1. Operation and maintenance system

1.1 Selection of the organization in charge of operation and maintenance

If the grid-connected PV system exceeds a certain capacity, it shall be regarded as electrical facilities for utility, equivalent to power stations and substation owned by power companies. Therefore, it is highly recommended that the staff in charge of operation and maintenance have enough experience in operating and maintaining similar electrical facilities under both normal and emergency conditions. When the owner (e.g. hospital and school) that operates the project site has no engineer having similar experience, it shall make an operation and maintenance contract with an external organization like an electric power company having experience in operating and maintaining power stations. In addition, if the owner cannot handle all of the operation and maintenance works, it is necessary to consider outsourcing some of the works to the power company or private firms.

1.2 Checks on laws and regulations

When setting up a new organization that operates and maintains the PV system, regulations and laws enforced in the country shall be examined to check whether chief electrical engineers need to be appointed or safety code of practice are required, in accordance with existing regulations for the power generation. For example, we need to employ a chief electrical engineer if electrical facilities for private use are connected with a high-voltage distribution system in Japan. The chief electrical engineer is a qualified engineer who has a national license to supervise the safety during the construction, operation and maintenance of electrical facilities. Japanese safety codes require the entity to install electrical facilities for private use shall official submit following documents to the Ministry of Economy, Trade and Industry.

① duties and organizations of the personnel who manage the works relating to the construction, operation and maintenance of the facilities,
② safety education to be provided to the personnel who are involved in the construction, operation and maintenance of the facilities,
③ patrol, inspection, and examination for ensuring the safety of construction, operation and maintenance of the facilities,
④ operation or manipulation of facilities,
⑤ how to preserve the power station when the operation stops for a certain period,
⑥ measures against disasters or other emergency events,
⑦ records on the safety of the construction, operation and maintenance, and
⑧ a system for making legal voluntary inspections, and the preservation of records.

However, many developing countries have no regulations and/or standards concerning grid-connected PV systems as mentioned above. Accordingly, authorities concerned and power company shall be required to develop the realistic methods to apply and revise existing regulations and/or standards to the grid-connected PV system, according to the PV system capacity.

1.3 Organization necessary to the operation and maintenance

When the entity establishes the organization in charge of the operation and maintenance of power generation system, it is necessary to clearly define the purpose of the organization. Expected key purposes are shown below.

[Purposes of the system and organization of the operation and maintenance]

- To operate and maintain the power generation system in a sound and continuous manner.
- To keep the staff and neighbouring residents safe.

In order to fulfill the above purposes, the organization shall be required

- To employ technical staff in charge of the daily operation and maintenance.
- To set up required levels for operation and maintenance for each period in a day, and to build up a system suitable to them.
- To appoint groups which take action against a problem both during day time and night time.
- To establish liaison systems for normal and emergency cases.
- To examine the possibility of collaboration with other organizations in the company.
- To identify scope of works to be outsourced to utilities or private firms.
- To make education/training system and curriculum for the internal staff.

1.4 Operating and maintaining organization (example)

Table 3-1 shows an example of the organization that operates a PV system rated at about 1 MW or 10 MW. The PV system does not generate power during night, so the organization is set to be capable of supervising the system between the sunrise and sunset for every season. It is necessary to determine the number of maintenance technicians and operators as well as their technical levels in consideration of duties that the organization should address.

Table 3-1 Sample organization in charge of operating and maintaining a PV system

Post	Number of members		Duties	Working system	Necessary qualification, technical skills, and work volume
	~1MW	~10MW			
Manager	1	1	Final decision and order in operation and maintenance	Daytime work on weekdays. Call in emergency at night or on holiday.	Chief electrical engineer (when required in the country)
Operator	3	6	Operating and monitoring the system, daily patrol, and take measures against problems	2 shifts (e.g. 5:00 to 12:00 and 12:00 to 19:00 depending on season). 3 groups, each having 1 to 2 members (depending on scale). Note: Rotation including maintenance engineers is effective.	Engineers/Technicians who are familiar with basic principles of all facilities, and operating conditions and methods.
Maintenance staff	2	5	Planning and making regular inspection, and conducting technical maintenance and regular patrol	Daytime work on weekdays. Call in emergency at night or on holiday.	Engineers/Technicians who are familiar with basic principles of all facilities and maintaining work. Monthly patrol by group consisting of 2 members requires period between 1 and 2 MW/day.
Assistant worker	2	6	Assisting cleaning duties and work requiring no advanced expertise and assistance to regular patrol	Daytime work on weekdays. Call in emergency at night or on holiday.	Workload, number of members, and levels vary depending on system conditions, circumstances at site, and subcontracted work range. Sandy or dusty region requires the number of members that can clean all facilities in about a week.
Office worker	2	2	General affairs inside the station and communication with outside	Daytime work on weekdays. Call in emergency at night or on holiday.	
Total	10	20			

(Source: Shikoku Electric Power Company, Inc.)

1.5 Development of an operation and maintenance manual

Before preparing the organization such as above and staring operation and maintenance work, it is recommended to develop an operation and maintenance manual. The following shows the contents as an example.

① Facilities Name
② Operating Procedures
③ Basic Procedures for Proper Operation
④ Measures against Emergency
⑤ Organization
⑥ Inspection Tour and Maintenance
⑦ Safety
⑧ Training

The main purpose and important points of each chapter are shown below.

(1) Facilities Name

- To understand the operation and maintenance of PV system in terms of both the entire system and each component.
- Scope of the each term shall be explained clearly, with illustrations, photographs and so on.
- The application of each term is to be unified in the manual and the site
- The basic specification of the facility is to be described.

It is necessary to prepare several figures for general construction, components and facilities.

(2) Operating Procedures

- Procedure lists are to be prepared for each operating mode separately such as start-up and stop, and to be described entirely from the beginning to the end in one volume.
- Do not quote the procedure list of other modes partially.
- All procedures are to be described separately for each step.
- To be expressed in plain language so that even beginners can understand.
- Operations or items checking situation and numerical values are to be described separately in the order.
- It is desirable to use an illustration or a photograph for each step.
- The steps which tend to be misunderstood and operated in a wrong way are to be explained to draw special attention.

Some examples of mode from operation manual are as follows:

① Start-Up
② Stop operation (Normal shutdown)
(Operators are in the powerhouse)
③ Stop Operation (Emergency stop / Quick shutdown)
④ Basic operation procedures
In the case of voltage drop
⑤ Supervision work during operation

In the manual, the titles of modes are to be described clearly and operations or checking items are described individually.

(3) Basic Procedures for Proper Operation

It is important to show basic procedures for proper operation as follows:

- Normal operating conditions (targets)

- Skills to be acquired for operation

(4) Measures against Emergency

Measures against emergency which are supposed to happen frequently, are to be mentioned in advance. Those measures shall be explained in detail especially if there are some conditions such as climate to cause the fault. Concerning the equipment trouble, the troubleshooting method is to be described systematically.

Sample items are listed as follows:

① Operations in each season
② Measures against faults or blackouts
③ Measures against lightning stroke
④ Troubleshooting etc.

(5) Organization

Organizations for each condition including emergency case are to be decided in advance as follows:

- Operation organization
- Number of operators, shifts,
- In general and in case of an emergency
- Operation schedule
- Manager in charge
- Operation and maintenance works (incl. watering PV arrays, management of planned outages)
- Operating hours should be decided in consideration of the climate conditions.
- Procedures and flows for instructions
- Emergency action

(6) Inspection Tour and Maintenance

Operators should state system operation, patrol and maintenance method in the manual. Check items should be clearly stated.

The details of the patrol and maintenance should be stated after the “2. General concept of inspection tour and periodical inspection (maintenance)”.

(7) Safety

Operators should understand and be aware of the dangers during operation, inspection tour and maintenance of the system.

(8) Training

The organization shall build up its own education/training system and curriculum to prompt the operators and maintenance engineers to understand rules and technical principles for operating the power station, which engineers should know for each of their duties.

(9) Communication system

In case of an accident on the premises or grid side, the PV system owner shall build up a liaison system that allows for prompt exchange of information with the power company. The manual shall include contacts available around the clock, for example the contacts of the dispatch center operated by the power company, (including phone number for security communication, private and mobile phone numbers) as well as those of the manager and chief electrical engineer with whom operators or maintenance staff should contact first.

(10) Public awareness raising

In many cases, one of the purposes of a medium- to large-scale grid-connected PV system is to encourage and promote dissemination and awareness-raising of solar power generation among domestic and overseas leaders and general public. Therefore, it is recommended that the manual describes how to respond questions from visitors and to take a tour of the facility.

1.6 Budget for the operation and maintenance of the power station

Operating the power station continuously requires the profitable management from a long-term point of view. When estimating the project costs, we shall make an effective investment by precisely finding costs for the operation and maintenance.

(1) Budget for operating and maintaining the power station

The PV power station consumes no fuel, but the operation and maintenance as a whole requires costs for power generation, investments in communication and safety facilities, expenses for operating and maintaining them, and running costs for in-house power distribution, water consumption, and consumables for inspection and cleaning.

In addition, it is necessary to draw up a long-term financial plan for buying consumables, spares in case of failure, and maintenance tools that are necessary to the long-tem operation of the major facilities such as PCS.

The consumables include two types: one needs to be regularly exchanged and the other needs to be urgently procured to ensure the reliability of the operation when a fault occurs. Accordingly, a necessary number of the spares shall be kept in the consideration of the lead time. If there are consumables that will be difficult to procure after more than 20-years of operation, the spares shall be stocked in necessary quantities based on the mean time between failures (MTBF).

Table 3-2: Examples of spares

Spare	When	Reason and frequency	Quantity
PV modules	Failure occurs.	Module will be difficult to procure after more than 20 years of operation.	Quantity is derived from probability of damage due to thrown stone and failure in internal element and circuit, which vary depending on site conditions and module type. About 0.1% of the whole quantity for the moment. In consideration of damage conditions during 1 to 2 years after commissioning, it is necessary to consider early procurement based on failure rate.
DC Circuit Breakers for the termination of PV circuit	Abnormal event occurs.	If quick procurement is difficult upon failure, it has significant effect on operation.	1 unit for each kind
Fuse for PCS	Abnormal event occurs.	Failure rate may be high. Keeping spares is effective for the quick power restoration because on-site workers can take recovering action.	1 or more for each kind Note some PCS manufacturers don't allow the client to open the panel and change equipment inside the panel. Check your manufacturer first!
Condensers, Touch Panels, Batteries of touch panels, Fans for PCS	Replacement is necessary before life (5 to 10 years) or abnormal event occurs.	Failure rate may be high. In addition, regular inspection may show that component should be replaced. Periodical procurement is necessary according to life of each component.	
Circuit boards for PCS	Abnormal event occurs.	Circuit board has significant effect on operation and quick procurement is difficult.	
PCS (Whole equipment)	Abnormal event occurs.	If an engineer responsible for replacing parts judges that quick procurement is impossible for the site, a set of PCS shall be reserved to be replaced as a whole.	1 set Cool and secure storage space need to be prepared.

(Source: Shikoku Electric Power Company, Inc.)

Tables 3-3 and 3-4 show examples of testing devices necessary for regular inspection and taking measures against abnormal operation, and for maintenance works recommended to be prepared at site. The quantity of each device or tool can be derived from that of the facilities. The typical usage of the testing devices will be described later. They include expensive devices, therefore, we can lease them during inspection or ask the inspection vendor to procure them in consideration of the quantity of the facilities (to be checked), the financial state of the installer, and the necessary reliability of the system in question (the omission of checkpoints).

Table 3-3: Testing devices to be prepared

Items	quantity	necessity	main usage
Digital multi meter	1	◎	General measurement for circuit condition
Voltage detector	1	◎	
Clamp meter	1	◎	
Terminal boards & wire clips	1 set	◎	To make circuits for inspections
Insulation Resistance Tester (Megger)	1	◎	measurement for insulation condition of the circuit from PV to switching board
Grounding resistance tester	1	◎	measurement for circuit condition
I-V Curve tracer	1	○	Judgment of the condition of cells and the circuit
Infrared camera	1	△	Judgment of the condition of cells and wiring in modules
Current path detector	1	◎	Detection of disconnection wiring in modules

(Source: Shikoku Electric Power Company, Inc.)

Table 3-4: Maintenance tools to be prepared

Items	quantity (ex)		Specifications
Screwdriver (+ and -)	2	set	Screwdriver (+ and -)
Terminals board & wire clips	1	set	Terminals board & wire clips
Cutting nipper	2		Cutting nipper
Cutting Plier	2		Cutting Plier
Hammer	2		Hammer
Card tester	2		Card tester
Socket wrench	1	set	Socket wrench
Paint	2	cans	Paint
Anti-corrosive paint	2	cans	Anti-corrosive paint
Tool cabinet with door	1	unit	Tool cabinet with door

(Source: Shikoku Electric Power Company, Inc.)

1.7 Budget to manage the organization

In addition to costs for the facilities, we shall prepare a long-term financial plan for labor costs for the organization shown in Table 3-1, office construction/rental charges, and heat and lighting expenses.

2. General concept of inspection tour and periodical inspection (maintenance)

In general, “patrol” and “inspection” are required to maintain electrical facilities. In the patrol, we keep a record of the facilities in operation to determine whether conditions are good or not. In the inspection, we stop the system, replace components (if they can be exchanged only during a power interruption), make measurements, and inspect the inside to judge whether conditions are good or not. Both are very important.

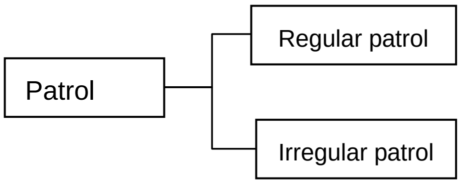
The checkpoints and frequencies should be determined on the viewpoints of the effective and efficient operation of the system, while they shall meet standards/regulations in the country and operator’s code of practice.

The maintenance work includes action against a possible failure, but it is necessary to take preventive measures to minimize the frequency of problems. The preventive measures are classified into two types: one is the method of controlling the implementation period according to the operating time and the number of elapsed years and the other is the way to check the conditions of the facilities through the items and values to be managed. If possible, maintaining the facilities according to their conditions generally tends to reduce the maintenance cost.

3. Daily inspection (inspection tour)

3.1 Inspection item

For the operation and maintenance of the PV system, it is required to conduct daily patrol taking preventive measures for faults, keep a record of the operation, detect any problem at an early stage, take a quick action against them, and monitor the performance of the system. Taking measurements and inspections while the facilities is under normal operation is called “patrol,” which is classified into two kinds: one is called “regular patrol” that should be conducted about once every month, and the other is called “irregular patrol” that should be conducted right after a heavy rain or earthquake that rarely occurs but has a significant effect on the facilities (Figure 3-1)



Type	Contents	Frequency
Regular Patrol	During Operation check the condition of all equipment to find failure.	Daily, monthly, etc.
Irregular Patrol	After heavy rainfall, earthquake or tsunami, operator should check the equipment condition.	Emergency case

(Source: “Basic concept of operation and maintenance”, NEDO textbook)

Figure 3-1: Type of patrol tour

Table 3-5 shows recommended checkpoints during the regular and irregular patrol.

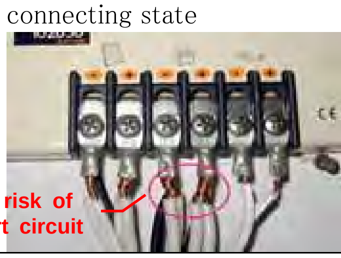
Table 3-5: Recommended checkpoints during patrol

<table>
<tr><th>Equip</th><th>Component</th><th>Checkpoint</th><th>Aging ctrl.</th><th>Component</th><th>Checkpoint</th><th>Aging ctrl.</th></tr>
<tr><td rowspan="3">PV array</td><td>Module</td><td>Damage, stain on surface, noise, bad odor, and mounting state

</td><td></td><td>External wiring</td><td>Damage and connecting state

</td><td></td></tr>
<tr><td>External wiring along rack</td><td>Rust, corrosion, break, damage to assembly, and connecting state
</td><td></td><td>Earth wire</td><td>Damage and connecting state
</td><td></td></tr>
<tr><td>Foundation</td><td>Damage and tilt

</td><td></td><td>Ground</td><td>Tall plants</td><td></td></tr>
<tr><td>Junction box</td><td>Housing</td><td>Rust, corrosion, break, and, mounting state
</td><td></td><td>Wiring</td><td>Damage, connecting state, bad odor, and burning mark

</td><td></td></tr>
<tr><td>PCS</td><td>Housing</td><td>Rust, corrosion, break, and, mounting state
</td><td></td><td>Wiring</td><td>Corrosion, damage, and connecting state

</td><td></td></tr>
</table>

Equip	Component	Checkpoint	Aging ctrl.	Component	Checkpoint	Aging ctrl.
	Conditions	Noise and bad odor		Protection relays	Check on operating state	
	Room temperature (present and peak values)	Check on specified range	Yes	Room humidity (present value)	Check on specified range	
	DC voltage (V)	Within total open-circuit voltage of modules 	Yes	Total generated energy (kWh)	Check on monitor	Yes
Distribution board (power receiving panel)	Conditions	Noise, bad odor, vibration, and break 		Output power (kW)	Below total capacity of PV modules. Irradiation data is used to evaluate power generation if available. 	Yes
Output board	AC voltage (V)	About design value	Yes	AC voltage (A)		Yes
	Total energy supplied to grid (kWh)	Check on watt-hour meter for selling to the power company 	Yes	In-house energy consumption (kWh)		Yes
Transformer and switch board for grid	Conditions	Noise, bad odor, vibration, break, and oil leak 		Oil tempera-ture (present value)	Check on specified range	Yes
	Oil level (present value)	Check on specified range		Conditions	Noise, bad odor, vibration, and break	

Equip	Component	Checkpoint	Aging ctrl.	Component	Checkpoint	Aging ctrl.
	Open/close counter	Check on specified range	Yes			
Yard of PV arrays	Irradiation (kW/m2)	Check on cleaning condition 	Yes	Tempera-ture (present, peak, and bottom values)	Check on cleaning condition 	Yes
	Humidity (present value)		Yes			
Security equipment	Outer fence	Installation condition, breakage or damage				
Circumstance	Possible shadow by structure	Growth of trees and newly constructed buildings		Dust generation	Ground and construction work around site	

(Source: Shikoku Electric Power Company, Inc.)

For monthly patrol, we shall develop a checklist as shown in Table 3-6 in order to prevent missing any checkpoint and to keep records.

Table 3-6: Checklist for regular monthly patrol (sample)

From:　　/　　/　　.
To:　　/　　/　　.

Records of Monthly Patrol

✓:Good　△:Caution　B:Bad　C:Cleaning　A:Adjustment　X:Exchange　L:Lubrication

	Date	／	／	／	／	／	／
	Name						
Items	Check Point						
General conditions at the yard							
Time							
Temperature (present)	(°C)						
Temperature (maximum)	(°C)						
Temperature (minimum)	(°C)						
Relative humidity　(present)	(%)						
PV　array 1							
Modules	Damage, Dust, Abnormal noise, Abnormal smell, Installation condition						
Wires	Damage, Looseness						
Frames	Rust, Corrosion, Damages,　Installation condition						
Grounding wires	Damage, Looseness						
Foundations	Damage, Slant						
Ground, surroundings	High plants and constructions, contamination						
PV　array 2							
Installed room							
Temperature (present)	(°C)						
Temperature (maximum)	(°C)						
Relative humidity　(present)	(%)						
General conditions	Dust, Security condition						
Incoming panels							
Generated Power　(present)	(kW)						
Generated Power (maximum)	(kW)						
Total energy sold to power company	(kWh)						
Irradiation　(present)	(kW/m2)						
Irradiation (maximum)	(kW/m2)						
General conditions	Abnormal noise, Abnormal smell, Installation condition						
Housing, Panels	Rust, Corrosion, Damages,						
Wires	Damage, Looseness						
Protection relay	Indications						
Power conditioner 1							
Input direct voltage	(V)						
Watt-Hour (accumulated)	(kWh)						
General conditions	Abnormal noise, Abnormal smell, Installation condition						
Housing, Panels	Rust, Corrosion, Damages,						
Wires	Damage, Looseness						
Protection relay	Indications						
Remarks							

(Source: Shikoku Electric Power Company, Inc.)

3.2 Evaluation of actual generated energy

This subsection describes how to evaluate the solar irradiation, output power, and energy that should be recorded regularly for aging control. Particularly, the irradiation should be measured at a frequency (shorter than one hour) that makes it possible to find the daily energy.

If there is data on the irradiation, we can compare it with the output power (kW) in the same period or with the energy (kWh) over a certain period. That is to say, we can continuously check if the calculated power derived from the recorded irradiation is consistent with the actual data measured monthly or annually (Table 3-8). The example below uses presumed parameters to make the calculation easy, while the measured values do not give absolute evaluation because they include errors that are difficult to quantify correctly. However, collecting the data for a long time right after commissioning allows us to grasp a relative degrading tendency and to detect a fault.

Table 3-7: Evaluation of recorded energy

How to find the energy matching degree E = Pr/Pc

Parameter	Unit	Variable	Value/calculation
Energy matching degree	1	E	=Pr/Pc
Energy (measured) per day	kWh/d	Pr	Measured value (kWh (daily record) or kW × hr)
Energy (calculated) per day	kWh/d	Pc	= Ir × p × n × K' × Kpt (variables are described below)
Inclined irradiation (measured) per day	$kWh/m^2/d$	Ir	Measured value (Horizontal irradiation should be converted to inclined one)
Rated capacity	kW	P	Rating (at 25°C and 1 kW/m^2)
Number of modules	piece	n	Recorded value
Basic design factor (crystal)	1	K'	0.756 (informative value, which should be replaced with measured one if available)
Basic design factor (amorphous)			0.693 (informative value, which should be replaced with measured one if available)
Temperature correction factor	1	Kpt	=1+α(Tcr−25)/100
Efficiency's temperature change factor (crystal)	1	α	-0.5% (informative value, which should be replaced with measured one if available)
Efficiency's temperature change factor (amorphous)			-0.2% (informative value, which should be replaced with measured one if available)
Module's weighted mean temperature	°C	Tcr	=T+ΔT
Mean temperature at daytime	°C	T	Announced value (which should be replaced with measured one if available)
Module's average temperature rise	K	ΔT	18.4 (informative value for rack-mount type, which should be replaced with measured one if available)

Where, the basic design factor is given by K' = Khd × Kpd × Kpm × Kpa × η pc.

Irradiation's annual change correction factor (informative value)	Khd	0.97
Chronological change correction factor (informative value for crystal type)	Kpd	0.95
Chronological change correction factor (informative value for amorphous type)	Kpd	0.87
Array's total load correction factor (informative value)	Kpm	0.94
Array's circuit correction factor (informative value)	Kpa	0.97
PCS effective efficiency (informative value)	η pc	0.90

Hence, the basic design factor (crystal) is 0.756 and
the basic design factor (amorphous) is 0.693.

(Source: Shikoku Electric Power Company, Inc.)

3.3 Example of log sheet for generated energy

Table 3-8 shows a proposed form for recording and evaluating the monthly energy data including the energy matching degree as mentioned above. Aging control with this form is helpful to evaluate the operating conditions of the facilities. Moreover, it makes further detailed evaluation possible by recording the energy generated, various operating quantities, and grid information hourly and daily.

Table 3-8: Collection of energy records

Record of Output energy
Year = 20XX
Record Capacity:Pi = XXX,XXX kW

Month	Number of days	Monthly Accumulated Watt-Hour energy (measured)	Maximum power (measured)	Station Service Power (measured)	Monthly Accumulated Irradiation energy (measured)	Monthly Accumulated Watt-Hour energy (calculated)	Coincidence of generated energy	Load Factor	Capacity Factor
	N	Pr (kWh)	Pmax(kW)	Ps (kWh)	Ir (kWh/m2)	Pc (kWh)	E = Pr/Pc	Fl=Pr/(N*24)/Pmax	Fc = Pr/(N*24)/Pi
Jan	31								
Feb	28								
Mar	31								
Apr	30								
May	31								
Jun	30								
Jul	31								
Aug	31								
Sep	30								
Oct	31								
Nov	30								
Dec	31								
Annual	365								

(Source: Shikoku Electric Power Company, Inc.)

4. Periodical inspection (maintenance)

Compared with the patrol, the inspection is made as long-term preventive measures to grasp the state of the PV system more precisely by stopping the operation regularly. The checkpoints and frequency of the inspection shall be defined in accordance with country-by-country and capacity-by-capacity standards for operating electrical facilities. The inspection is also classified into two types: one is called "regular inspection" that should be made in a legally specified cycle or in a necessary cycle from the viewpoints of the performance and durability of the facilities, and the other is called "irregular inspection" that should be made when a problem is found during patrol or an accident occurs suddenly due to disaster (Figure 3-2). In Japan, the frequency of regular inspections is defined as follows:

添付資料⑦

2015 年 1 月 21 日
有限会社 沖縄小堀電機

ソロモン諸島
沖縄県中小企業が有する島嶼地域向け系統連系型太陽光発電システム導入技術の普及・実証事業
最終報告

1．当社システムの特徴

当社の技術は、市販の小容量の PCS を多数台組み合わせるなどして、メーカーに依存せず自ら持続的に運用・維持管理が可能なシステムを構築する事である。従来の連系型 PV と比較した場合、当社の技術を活用したシステムでは以下のような利点がある。

・メンテナンスの迅速化
・設備利用率の向上
・メンテナンスコストの低減化

沖縄県の離島で、受注生産型の機器の復旧をメーカーに対応してもらう必要があるようなメーカー依存の体制の場合、遠隔地である本土からのメンテナンス員の派遣および部品発注に伴う「長期間のシステム停止」、「長期停止に伴う設備利用率の低下」、「多大なメンテナンスコストの発生」という問題があった。そこで、大型の受注生産品を用いるのではなく、図 1 に示すように小型の市販品 PCS を多数台組み合わせた安価なシステムを構築すれば、故障時に自ら対応することができるため迅速な復旧が可能となり、また、PCS 分散配置によるシステムの全停止リスクの回避が行なわれるため設備利用率の向上が期待できる。さらに、故障対応に要するコストも削減することが可能である。この技術は、システム設計に含まれる技術・ノウハウであるため、全体のスペックは設置条件により異なり、また、機器単体のスペック自体は従来のシステムと同様である。

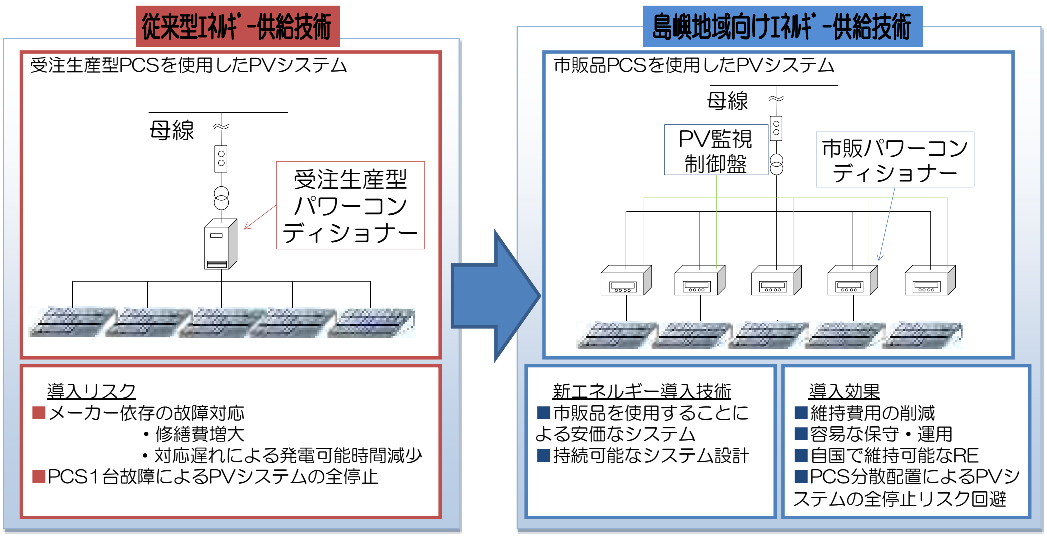


図 1　当社システムの特徴

メンテナンスが容易であることは、故障の復旧を現地にて施工することによる停止時間の低減を図ることができ、結果的に発電電力量の低下を防ぎ、採算性の向上に繋がる。ここでは従来型と当社型の 2 つのシステムを比較してその違いを示す。

2015 年 1 月 21 日
有限会社 沖縄小堀電機

1 つは従来型のシステム設計で 50kW の PCS を 1 台だけ備えているシステムであり、もう 1 つは当社のシステム設計で、10kW の PCS を 5 台備えているシステムとする。仮に同じ頻度でＰＣＳの故障が発生した場合、合計の発電電力量にどのような違いが発生するのか試算した。

表 1　50kW システムの仕様および条件例

	従来型システム	当社システム
PCS の台数	1 台	5 台
PCS の容量	50kW	10kW
発電電力量	1MWh／月	1MWh／月
PCS の修理期間	6 ヶ月間	1 ヶ月間
故障頻度※	1 回／年	1 回／年

※故障頻度は、試算結果が分りやすい設定としており、実際の頻度とは異なる。

従来型システムの PCS は故障するとシステム全体が停止するため、PCS の修理期間＝システムの停止期間となるが、当社システムの場合は、1 台の PCS が故障してもその他の 4 台は稼働するため、PCS の修理期間＝システムの 20%が停止している期間となる。

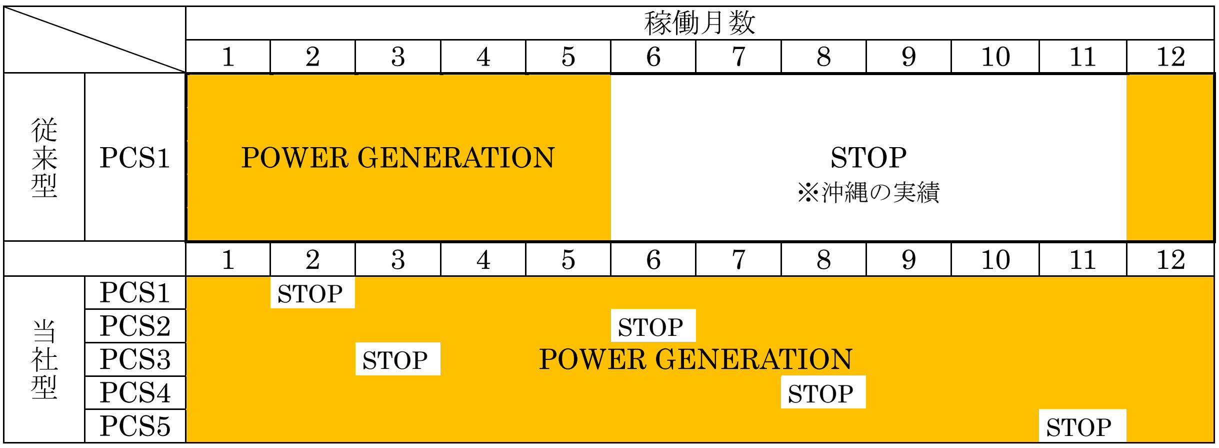


図 2　各システムの稼働状況のイメージ

従来型システム：[MWh/月]　×　(稼働期間　－　停止期間)[ヶ月間]　＝　[MWh]
1　×　(12 ヶ月　－　6 ヶ月)
1　×　(12－6)　= 6 [MWh]

当社システム：　[MWh/月]　×　(稼働期間　－　停止期間)[ヶ月間]　＝　[MWh]
1　×　(12 ヶ月　－　1 ヶ月×5 回×20%)
1　×　(12－1)　= 11 [MWh]

従来型システムが 6MWh/年であったのに対し、当社システムは 11MWh/年となった。
当然、多くの発電電力量を得れば、それだけ投資回収年収は短くなり採算性の良いシステムであるといえる。

・その他のメリット
一方で、今回採用した「薄膜シリコンハイブリッド太陽電池」は電気に変換できる光の波長(感

度帯域）が異なる二つのシリコン層を備えている。図 3 の青色の矢印で示されたアモルファスシリコン(a-Si)層が短波長側(青色光側)を吸収し、赤色の矢印で示された薄膜多結晶シリコン層が長波長側(赤色光側)の光を吸収するため、無駄がなくよりトータルに、効率的に電気に変換する。

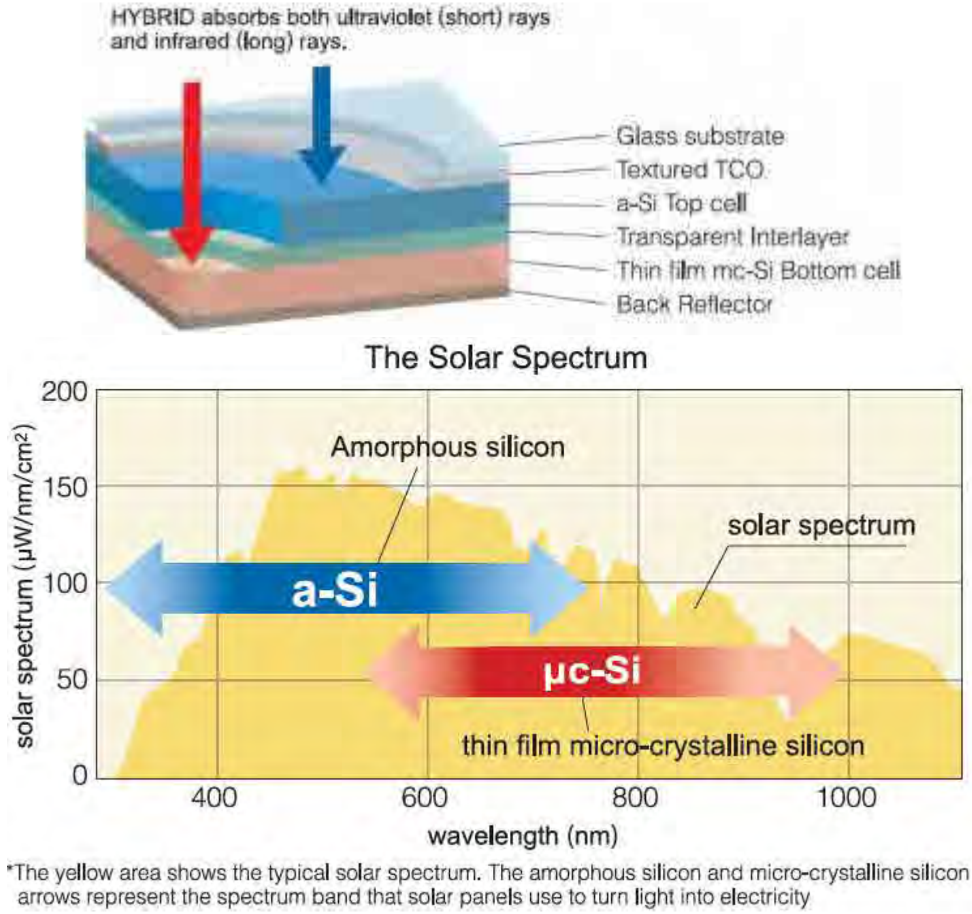


図 3　薄膜ハイブリッド太陽電池の構造と感度帯域

（出典：カタログ kaneka「HYBRID PV」）

また、「薄膜シリコンハイブリッド太陽電池」は、影の影響を受けにくい構造となってる。

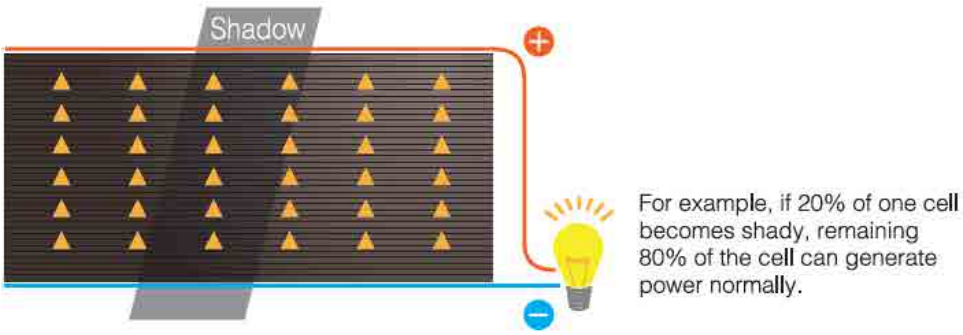


図 4　モジュールに対する影の影響のイメージ

（出典：カタログ kaneka「HYBRID PV」）

更に、低角度(5 度)のフラットで設置されており、架台のすみずみまで高密度での設置となっている。これにより、架台費の削減を行っている。

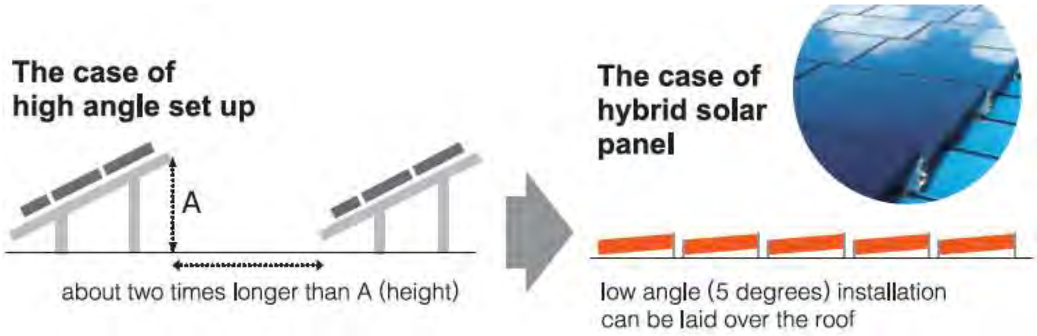


図5　太陽光発電モジュールの設置傾斜角の工夫

（出典：カタログ kaneka「HYBRID PV」）

薄膜シリコンハイブリッド型については、以下のメリットも挙げられる。

・コストが安く、大量生産が可能

・高温時でも発電効率が低下しにくい

薄膜シリコンハイブリッド型は非結晶シリコンであることから、高温時でも発電効率が低下しにくいという特性がある(図6)。よって、「ソ」国のような気温の高い地域(年間平均気温30.0℃「沖縄の平均気温23℃程度」)おいては、最適といえる。

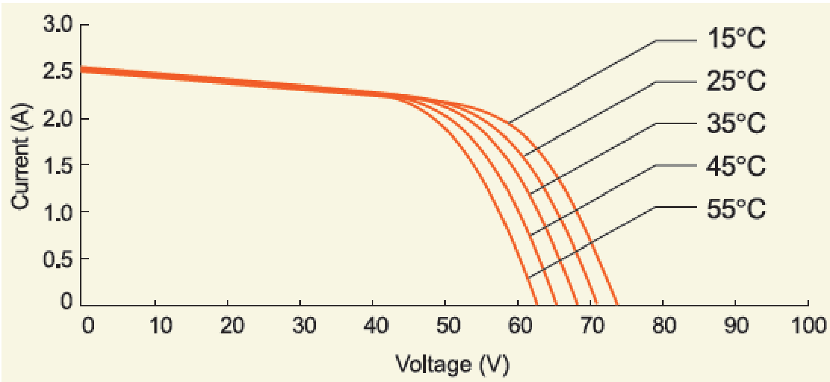


図6　薄膜ハイブリッド太陽電池の電圧・電流の特性(温度別)

（出典：カタログ kaneka「HYBRID PV」）

沖縄は台風の常襲地域であり、これまでの実績で培った強風・台風対策、塩害対策に係る経験と知見を活用することが可能であり、今回「ソ」国に設置されたシステムにもその技術は活かされている。

沖縄では過去にPVパネルが強風で飛ばされる事例も起きている。このため、PVパネルを固定する架台はこのような経験が活かされて設計されている(耐風速に有利な傾斜角5度設置工法など)。図7に沖縄における強風・台風対策が施された架台の事例を示す。

また、塩害についても溶融亜鉛メッキの実施、L型アングルの採用、その他防錆対策が取られた部材を用いる等、沖縄で培った経験と知見を活用することが可能である。

2015 年 1 月 21 日

有限会社 沖縄小堀電機

アレイサイドのカバーの様子

アルミレール施工の様子

図 7 沖縄における強風・台風対策が施された架台の事例

今回設置された 50kW のシステムでは、

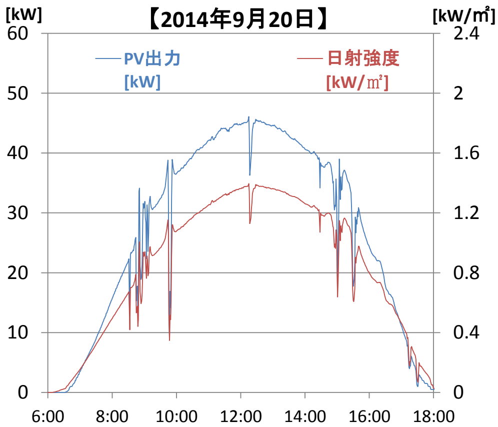
①感度帯域が広いので、太陽光を無駄なく効率的に電気に変換する

②高温時でも発電効率が低下しにくい

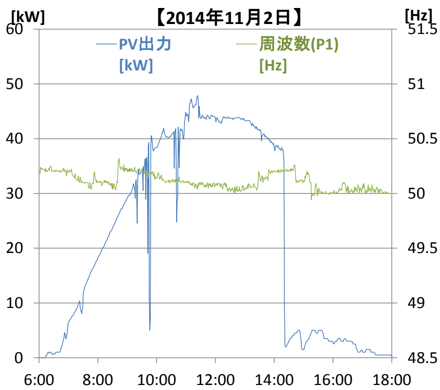
というメリットが、10 月と 11 月の発電電力量として記録されており、一般的な算出方法により試算された 63,000kWh/年を超える 74,000kWh/年の発電電力量が見込まれた。詳細は「３．発電電力量」に記載する。

２．発電状況

本事業では「ソ」国初となる系統連系型太陽光発電システム(以下：連系型 PV)の設置が行なわれ、当社の技術が「ソ」国においても有効であることが実証された。運転期間中の発電状況を図 8 に示す。また、9 月から 11 月末までの日毎の発電グラフを添付する。



発電出力と日射強度の比較



発電出力と周波数の比較

図 8　発電状況

図 8 の左の発電出力と日射強度の比較を見ると、日射強度を追従する形で出力が得られており、順調に稼働していることが確認できる。また、右の発電出力と周波数の比較を見ると、出力の急峻な変動が発生しても周波数にはほとんど影響はないことが確認できる。以上のことから、JET 認証の製品を使用した本システムが「ソ」国の電力系統においても有効に稼働していることが確認された。

３．発電電力量

次に、今回導入された 50kW のシステムにおける年間の発電電力量の予測を行う。

「ソ」国(ホニアラ)の日射量(水平面)は日本と比べ約 1.3 倍程度あり、PV の設置環境としては最適である。

表 2　月別平均日射量の比較(ホニアラと沖縄)

[kWh/m²・日]

平均日射	1 月	2 月	3 月	4 月	5 月	6 月	7 月	8 月	9 月	10 月	11 月	12 月	平均
「ソ」国 (ホニアラ)	5.25	4.99	5.05	4.91	4.39	4.19	4.12	4.67	5.21	5.67	5.64	5.35	4.95
日　本 (那覇)	2.41	2.77	3.33	4.18	4.52	4.93	5.71	5.25	4.71	3.91	2.94	2.51	3.94

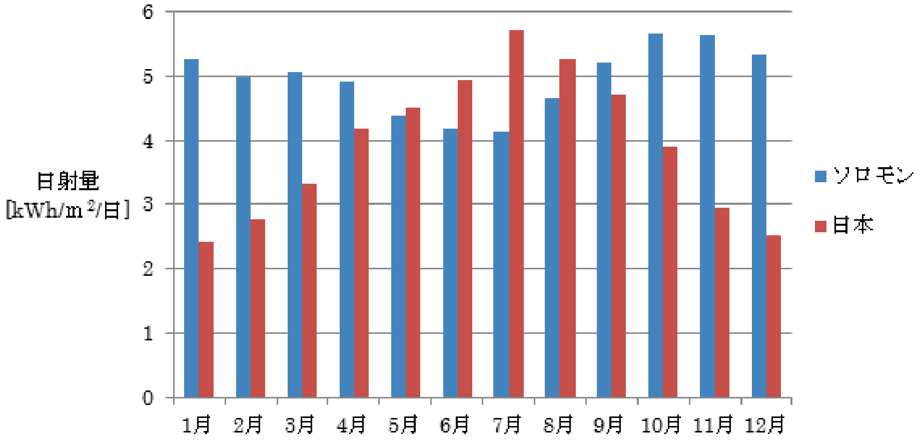


図 9　月別平均日射量の比較(ホニアラと沖縄)

この日射量データを元に以下の算出方法により年間の発電電力量を試算した。

年間の発電量　$E_P=(P_{AS}\cdot H_A\cdot K)/Gs=P_{AS}\cdot H_A\cdot K\times365$ 日

P_{AS}:太陽電池アレイ出力(kW)
H_A :設置場所、設置条件での日射量(kWh/m²・日)
K　:総合設計係数(0.65～0.8＝0.7 程度)
Gs:標準状態における日射強度(kW/m²)＝1kW/m²

■ソロモン:50kW の試算結果
発電量　$E_P=(P_{AS}\cdot H_A\cdot K)/Gs=P_{AS}\cdot H_A\cdot K\times365$ 日
＝50kW×4.95 kWh/m²・日×0.7×365 日＝63,236kWh
※沖縄での 50kW あたりの発電量:50,334kWh(ソロモンは沖縄の約 1.3 倍)

2014 年の 10 月、11 月分の発電電力量の実測データは、上記の試算値を超える値を示しており、仮に日射量当たりの発電電力量が年間を通して 10 月 11 月と同等であるとすると、年間発

電電力量は 74,458kWh になると見込まれた。この時、再生可能エネルギー導入率は、約 0.13%となる。(ホニアラの 2013 年の発電電力量： 約 57,000,000 kWh)

表 3　「ソ」国における 50kW PV システムの月別発電電力量(実績及び予測)

	1 月	2 月	3 月	4 月	5 月	6 月	7 月	8 月	9 月	10 月	11 月	12 月	合計
日射量 [kWh/m^2・日]	5.25	4.99	5.05	4.91	4.39	4.19	4.12	4.67	5.21	5.67	5.64	5.35	
発電電力量 [kWh] (実績及び予測)	6,526	6,203	6,278	6,104	5,457	5,209	5,122	5,805	6,477	7,616 ※	7,011 ※	6,651	74,458

※実績値。
実績以外の予測値は、11 月の 1.0 kWh/m²・日当たりの発電電力量(7,011÷5.64≒1243)を元に試算している。

4．燃料削減効果

「ソ」国の既設ディーゼル発電機を使用して、70,000kWh 発電した場合、燃料消費量と燃料コストを試算した。その結果を表 4 に示す。(74,458kWh/年が何等か要因で減少する可能性を考慮して、概算値 70,000 kWh/年にて試算した)

表 4　70,000kWh 発電に必要な燃料消費量とそのコスト

	ディーゼル発電機	太陽光発電設備
燃料消費量[※1] [ℓ]	16,000	0
燃料コスト[※2] [US$]	17,000	0

※1 燃料消費量は、SIEA から提供されたホニアラ電力系統の各ディーゼルユニットの燃料消費率の平均値を使用して試算した。
※2 燃料コストは、燃料消費量に SIEA から提供された燃料単価(8.26SI$)を乗じ、1SI$=14.48 円[※3]として試算。
※3 JICA 業務実施契約、業務委託契約における外貨換算レート表(2014 年 4 月～12 月、ソロモンドル)の平均値

次に、「ソ」国の PV 導入目標も踏まえ、以下の 2 つの規模の設備についてディーゼル発電用燃料の削減効果を検討した。

(A)　1.5MW(=1,500kW)：FS 調査[※]が終了し、設置計画が進められている設備容量

(B)　2.5MW(=2,500kW)：SIEA が現状の系統設備で連系可能とするＰＶの上限容量

※SIEA により実施された「LUNGGA SOLAR POWER STATION FEASIBILITY」のドラフト版

「ソ」国のエネルギー政策を示した報告書「SOLOMON ISLANDS NATIONAL ENERGY POLICY AND STRATEGIC PLAN VOLUME IV: RENEWABLE ENERGY STRATEGIES & INVESTMENT PLAN 2014」では、2012 年のホニアラの年間電力量は約 57,000MWh(=57,000,000kWh)となっており、また、ホニアラを含む都市部の最大電力需要見込みは以下の通り記載されている。

表 5 再生可能エネルギー導入目標(都市部(ホニアラ含む))

Technology	2015	2020	2030
最大電力需要見込み	—	18.7 MW※1	26.4 MW
年間発電電力量 予測値※2	—	72,000 MWh	100,000 MWh
Diesel	100%	50 %	10 %
Hydro	0%	41 %	50 %
Utility scale solar	0%	4 %	10 %
Geothermal	0%	0 %	25 %
Biomass/CNO	0%	5 %	5 %
Total	100%	100 %	100 %

※1 1MW=1,000kW なので、18.7MW=18,700kW、26.4MW=26,400kW
※2 発電電力量の増加率が需要見込みの増加率と同等であった場合の予測値
(参照: SOLOMON ISLANDS NATIONAL ENERGY POLICY AND STRATEGIC PLAN VOLUME IV: RENEWABLE ENERGY STRATEGIES & INVESTMENT PLAN 2014 より調査団作成)

表 5 の各 Technology の割合について報告書では明確な記載が見当たらないが、発電電力量に対する割合だと仮定した場合、今回の実証試験で得られた発電データから予測した 1.5MW の発電電力量は約 2,200MWh/年であり、2020 年の年間発電電力量の予測値の 3%にあたる。2.5MW まで PV を導入した場合でも、発電電力量は約 3,700MWh/年と増加する事が見込まれるが、2030 年のホニアラの年間発電電力量(予測値)の 3~4%にとどまり、「ソ」国政府が目標としている 2020 年の 4%、2030 年の 10%を達成するためには、更に多くの連系型 PV を設置する必要がある。
(ただし、いずれの場合も導入目標を達成するためには、変動抑制対策(蓄電池等)の必要性を事前に検討することが必須である。)

次に、経済的な比較を既設のディーゼル発電機と 1.5MW と 2.5MW の連系型 PV について行った。ここでは、PV と同じ発電電力量を、既設のディーゼル発電機で発電した場合の燃料消費量と燃料コストを試算した。

表 6 燃料消費量と燃料コストの比較(既設ディーゼルと PV)

<table>
<tr><td rowspan="2"></td><td colspan="2">2,200MWh の場合</td><td colspan="2">3,700MWh の場合</td></tr>
<tr><td>ディーゼル</td><td>PV</td><td>ディーゼル</td><td>PV</td></tr>
<tr><td>燃料消費量※1
[ℓ]</td><td>506,000</td><td>0</td><td>851,000</td><td>0</td></tr>
<tr><td>燃料コスト※2
[US$]</td><td>560,000</td><td>0</td><td>940,000</td><td>0</td></tr>
</table>

※1 燃料消費量は、SIEA から提供されたホニアラ電力系統の各ディーゼルユニットの燃料消費率の平均値(0.23ℓ/kWh)を使用して試算した。
※2 燃料コストは、燃料消費量に SIEA から提供された燃料単価(8.26SI$)を乗じ、1SI$=0.135US$※3 として試算。
※3 過去 1 年間(XE.com)の最小値 0.13040 と最大値 0.13991 を参考に中間値の 0.135US$/SI$とした

1.5MW の連系型 PV の年間発電電力量相当(2,200MWh)を発電するためには、560,000US$の燃料コストが必要となり、2.5MW の連系型 PV の年間発電電力量相当(3,700MWh)を発電するためには、

940,000US$の燃料コストが必要となることが見込まれた。

これは単純な試算であり、20年間に発生する故障や部品交換による設備停止は考慮されてないため、一概に上記の燃料コストがそのまま削減できるわけではないことを留意する必要がある。しかし、仮に20年間設備が順調に稼働した場合、燃料コストを数億～十数億円規模で削減することが予想出来る。

5．投資回収の事例

【発電事業者(SIEA)の場合】

このような燃料コストの削減によるPV設置コストの費用回収はSIEAのFS調査においても実施されている。FS調査を参考に、SIEAによって今回と同規模の日本製システムが日本の最も安価な市場価格帯で購入・設置された場合について、投資回収年数(概算)を試算した。試算した結果を表7、表8に示す。

※ JICA業務実施契約、業務委託契約における外貨換算レート表(2014年4～2015年1月、US$)の平均値、1US$=107.32円として試算。

表7　50kWPVシステムの投資回収年数の試算の条件

システム容量	50	kW
想定年間発電量	74,000	kWh／年
イニシャルコスト※1	312,000	US$
メンテナンスコスト※2	84,000	US$／20年
合計コスト	396,000	US$
燃料コスト※3	1.27	US$/ℓ
発電機効率※3	3.58	kWh/ℓ
発電コスト※3	0.355	US$/kWh

※1 日本のFIT制度の調達価格等算定委員会（第13回）の資料を参考に2610US＄/kW※4と設定。
※2 日本のFIT制度の調達価格等算定委員会（第13回）の資料を参考に83.86US＄/kW/年※4と設定。
※3 SIEAにより実施された「LUNGGA SOLAR POWER STATION FEASIBILITY」のドラフト版を参考に設定
※4 JICA 業務実施契約、業務委託契約における外貨換算レート表(2014 年 4～2015 年 1 月、US$)の平均値、1US$=107.32円として試算。

表 8　50kWPV システムの投資回収年数(概算参考値)

	総発電量 [kWh/年]※1	削減効果 [US＄/年]	投資回収額※2 [US＄]
設置時点	0	0	-396,000
1 年目	74,000	26,251	-369,749
2 年目	73,778	26,173	-343,576
3 年目	73,557	26,094	-317,482
4 年目	73,336	26,016	-291,466
5 年目	73,116	25,938	-265,528
6 年目	72,897	25,860	-239,668
7 年目	72,678	25,782	-213,886
8 年目	72,460	25,705	-188,181
9 年目	72,243	25,628	-162,553
10 年目	72,026	25,551	-137,002
11 年目	71,810	25,474	-111,527
12 年目	71,594	25,398	-86,129
13 年目	71,380	25,322	-60,808
14 年目	71,165	25,246	-35,562
15 年目	70,952	25,170	-10,392
16 年目	70,739	25,095	14,703
17 年目	70,527	25,019	39,722
18 年目	70,315	24,944	64,666
19 年目	70,104	24,869	89,536
20 年目	69,894	24,795	114,331

※1 総発電量はパネルの発電保証の値を年 0.3%ずつ低下させて計算している。
※2 表 7 の合計コストを投資回収額として設定している。

試算の結果、日本のシステムをそのまま採用しても SIEA が PV システムを設置し事業を行えば、投資回収が 16 年程度で行えることが考えられた。しかし、日本のシステムよりも安価な海外製の PV モジュールを使用する事で採算性は更に向上すると予想されるため、国内外の各メーカーと調整や機器仕様の確認を行いながら、当社のより良いシステムの構築を検討していく必要がある。

他方で、このような試算をより確実なものとするためには、長期間に渡り安定して発電するという品質が求められる。そのためには、塩害対策や防じん・防水対策が十分に施されており、台風などの強風にも耐え得る実績を持つ当社システムの導入が望ましい(1．当社システムの特徴 参照)。

【需要家(SIEA 以外の公共機関、民間企業)の場合】

一方で、SIEA 以外の公共機関や民間企業が連系型 PV を導入した場合を想定して、今回導入されたシステムにおいて投資回収年数(概算)を試算した。

本システムは設備費、輸送費、建設コストに加えメンテナンスコスト(予想)を踏まえると、概ね 460,000US$※であり、これを基に試算した結果を表 9、表 10 に示す。

※ JICA 業務実施契約、業務委託契約における外貨換算レート表(2014 年 4～2015 年 1 月、US$)の平均値、1US$=107.32 円として試算。

2015 年 1 月 21 日
有限会社 沖縄小堀電機

表 9　50kWPV システムの投資回収年数の試算の条件

システム容量	50	kW
想定年間発電量	74,000	kWh／年
イニシャルコスト※1	418,000	US$
メンテナンスコスト※2	42,000	US$／10 年
合計コスト	460,000	US$
電気料金※3	0.905	US$/kWh

※1 本事業の実績を参考に設定。カーポート用の架台含む。
※2 日本の FIT 制度の調達価格等算定委員会（第 13 回）の資料を参考に 83.86US＄/kW/年と設定。
※3 2014 年の 3 種類の電気料金メニューの平均値(約 6.7SI$/kWh)を参考に設定。

表 10　50kWPV システムの投資回収年数(概算参考値)

	総発電量 [kWh/年]※1	削減効果 [US＄/年]	投資回収額※2 [US＄]
設置時点	0	0	-460,000
1 年目	74,000	66,970	-393,030
2 年目	73,778	66,769	-326,261
3 年目	73,557	66,569	-259,692
4 年目	73,336	66,369	-193,323
5 年目	73,116	66,170	-127,153
6 年目	72,897	65,971	-61,182
7 年目	72,678	65,774	4,592
8 年目	72,460	65,576	70,168
9 年目	72,243	65,379	135,548
10 年目	72,026	65,183	200,731

※1 総発電量はパネルの発電保証の値を年 0.3%ずつ低下させて計算している。
※2 表 9 の合計コストを投資回収額として設定している。

このような単純な試算では、順調に稼働すれば 7 年で投資回収が見込めるほど、「ソ」国は PV 設置に最適な地域と言える。しかし、Daily Standby charge を適用すると結果は異なる。この制度はシステムの定格出力と契約している電気料金メニューにより負担金が異なる仕組みとなっており、仮に 50kW の定格出力で電気料金が 0.905US＄/kWh の場合、以下の通りとなる。

表 11　50kW PV システムの Daily Standby charge

Act rep [%]	kW rating in Times	Inverter Rating [kW]	Rates-Tariff [US$/kWh]	Daily Standby Charge [US$]
50%	4.4	4	0.905	7.964
50%	4.4	50	0.905	99.55

年間の支払額：99.55　×　365　≒　36,336　US$/年

この Daily Standby charge を踏まえると結果は逆転してしまい、10 年間で投資回収は出来

ない(表 12)。

表 12　50kWPV システムの投資回収年数(概算参考値)

	総発電量 [kWh/年]※1	削減効果 [US＄/年]	投資回収額※2 [US＄]
設置時点	0	0	-460,000
1 年目	74,000	30,634	-429,366
2 年目	73,778	30,433	-398,932
3 年目	73,557	30,233	-368,699
4 年目	73,336	30,033	-338,666
5 年目	73,116	29,834	-308,832
6 年目	72,897	29,636	-279,196
7 年目	72,678	29,438	-249,758
8 年目	72,460	29,240	-220,518
9 年目	72,243	29,044	-191,474
10 年目	72,026	28,848	-162,627

※1 総発電量はパネルの発電保証の値を年 0.3%ずつ低下させて計算している。
※2 表 9 の合計コストを投資回収額として設定している。

このような試算からも Daily Standby Charge の影響より民間の PV 普及拡大が鈍化することは容易に想像され、結果として「ソ」国の政策である再エネの促進の妨げになる可能性が考えられる。

2015年1月21日
有限会社 沖縄小堀電機

６．提言

「ソ」国のエネルギー政策を示した報告書「SOLOMON ISLANDS NATIONAL ENERGY POLICY AND STRATEGIC PLAN VOLUME IV: RENEWABLE ENERGY STRATEGIES & INVESTMENT PLAN 2014」では、2020年には4%、2030年には10%のPV普及を目指すことが記載されている。

また、発電時に化石燃料を使用しないPVの普及拡大は、世界的な環境問題を解決するために各国が取り組んでいるCO_2排出量の削減にも寄与する。

さらに、PVの普及拡大により、ディーゼル発電機の燃料が削減された場合、将来的に「ソ」国の電気料金の低減等に繋がる可能性が有り、これはPVの導入が「ソ」国の経済の発展に寄与できる可能性が大きいことを意味している。経済の発展は当然電力需要の拡大と共にあり、SIEAも同様に発展することと思われる。

本報告で示した通り、当社のシステムは「ソ」国のPV普及目標やSIEAの燃料削減等に寄与できる。

しかし、SIEA以外の政府機関や民間企業も率先してPV設置のために資金を投入するためには、より柔軟な制度が検討され、全てのPV導入希望者とって有益な仕組みをが出来ることが必要である。

そのためにMMEREやSIEA等を含む「ソ」国の電力関係者には、導入支援措置などを検討することが望まれる。また、有効性が確認された当社の技術・製品を含む、様々なPV製品が「ソ」国で活用されるためにも以下の2点が検討・実施されることが必要条件である。

【1】オーストラリア規格取得義務に対する緩和措置の設定

MMEREやSIEA等の電力供給関係者には、「ソ」国で設置可能なPV機器をオーストラリア規格品に限定しないための緩和措置を検討することが望まれる。なぜなら、本事業で導入しているPV機器は、オーストラリア規格は取得していないもののJET認証を取得おり、順調に稼働しているからである。今後の稼働状況も含めて検討が必要ではあるが、今後も設置を認められるべきである。緩和措置の例として、

「オーストラリア規格で求められる品質がその他の規格・認証の取得過程で全て確認された場合は設置を認める」、

「実績のある製品については設置を認める」、

「AS規格と同等の試験成績書を提出する」

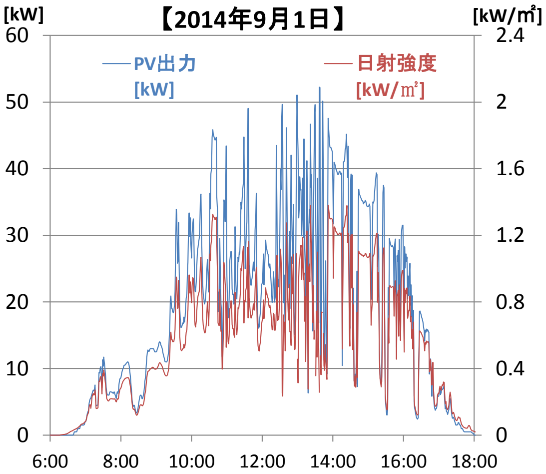
等が考えられる。

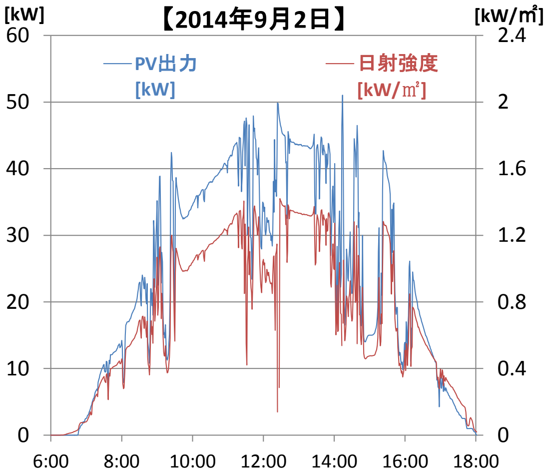
オーストラリア規格品に限定しないことで、PV機器をより多くの選択肢から選ぶことができ、よりニーズに応じた価格帯のシステムが構成できる等のメリットが得られる。

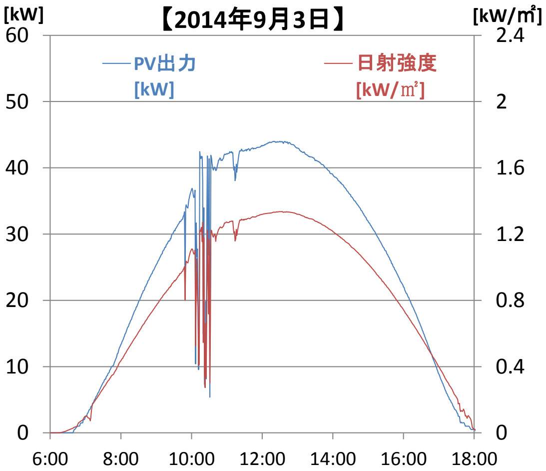
【2】太陽光発電導入促進のための支援制度の設定

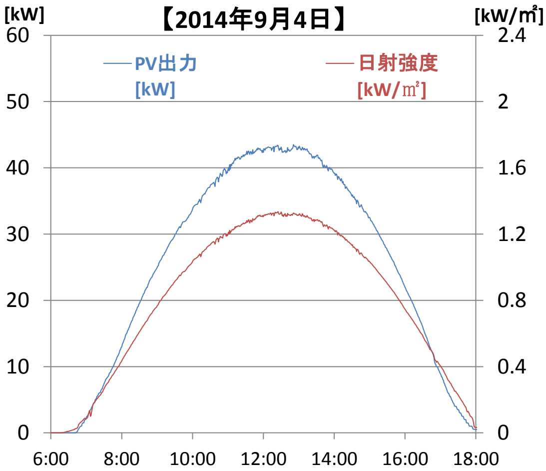
「ソ」国では他国のようにFIT制度がなく、PV設置に関する支援制度も整っていない。一方でDaily Standby Chargeなどの負担金が発生するため、PV設置を希望する者にとって、環境が良いとは言い難い状況にある。MMEREやSIEAを含む「ソ」国の電力供給関係者が協力して協議し、PV導入促進のために、イニシャルコストの一部負担等の支援制度を設定することが望まれる。

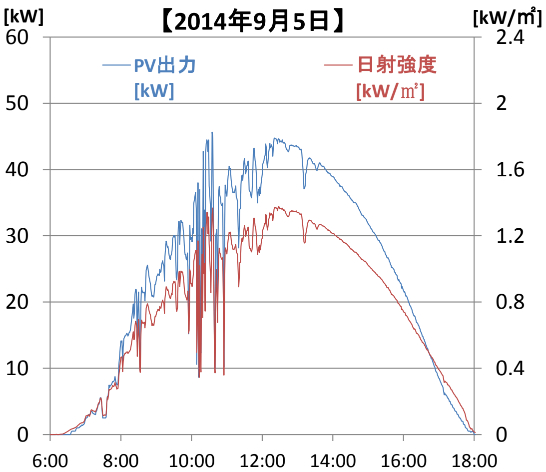
添付資料
太陽光発電データ

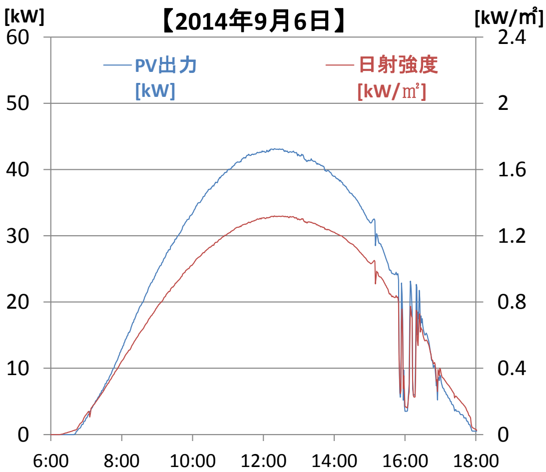




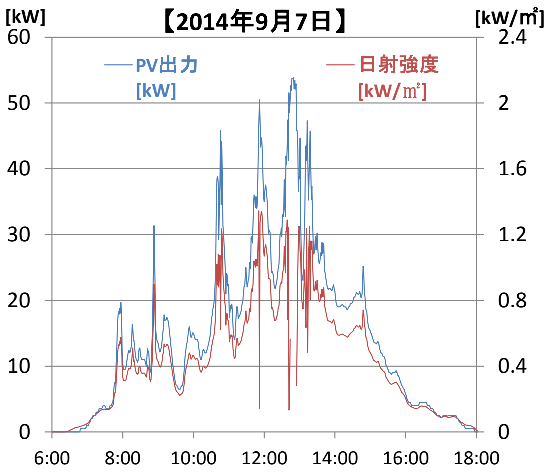


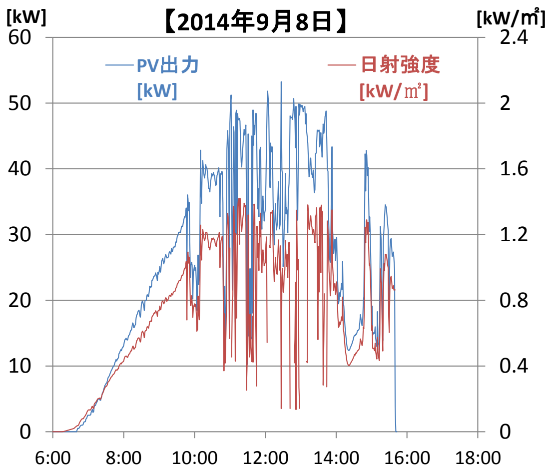


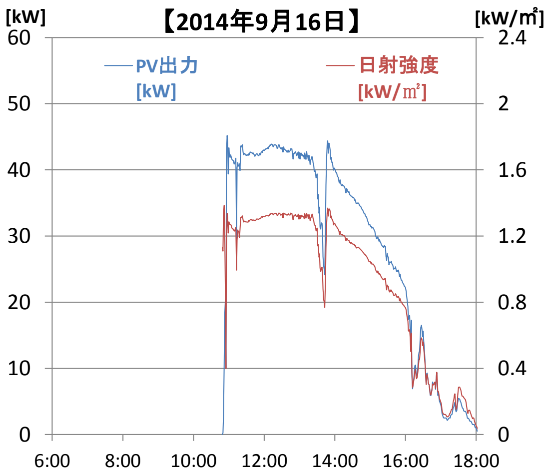


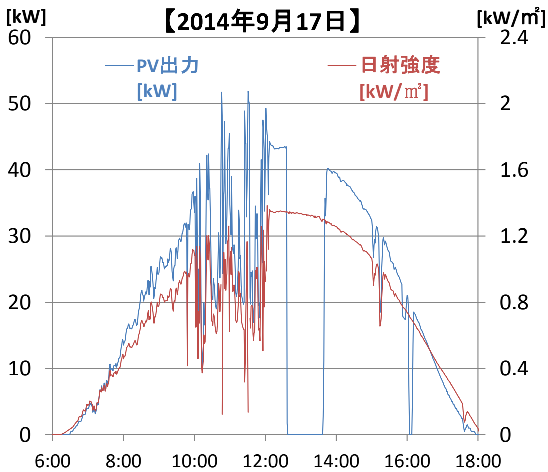


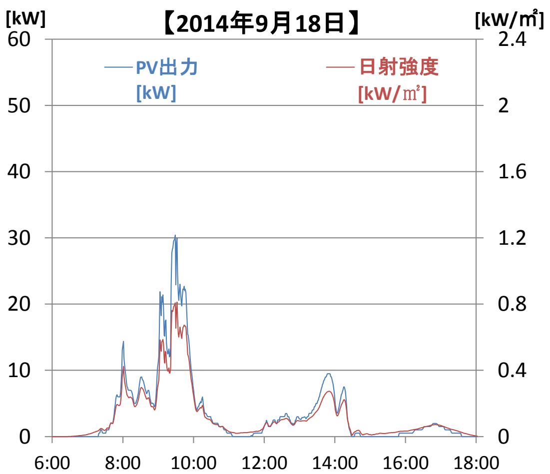
※9 月 1 日から 9 月 8 日は試運転期間

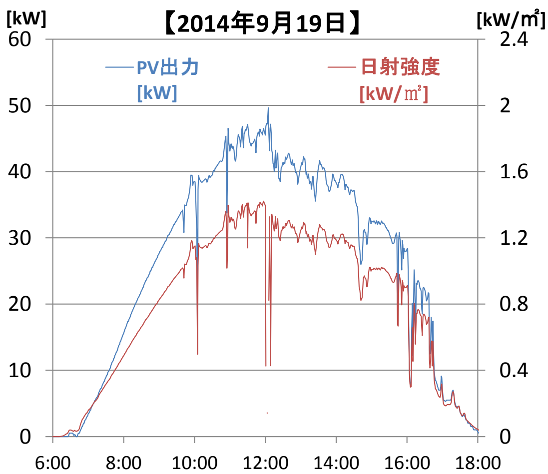












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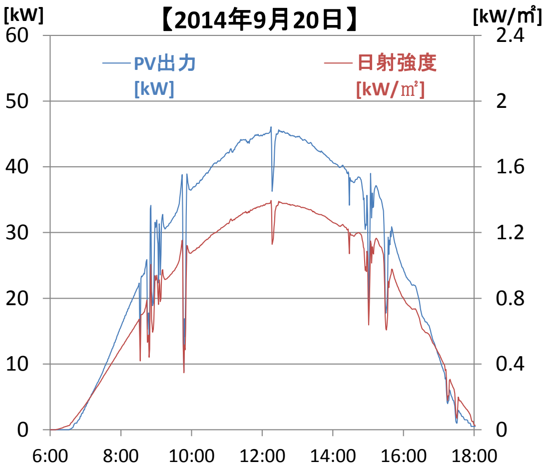
※9 月 16 日から系統連系開始、翌 17 日は実地研修に伴い、PCS 一時停止(13 時前から 1 時間弱)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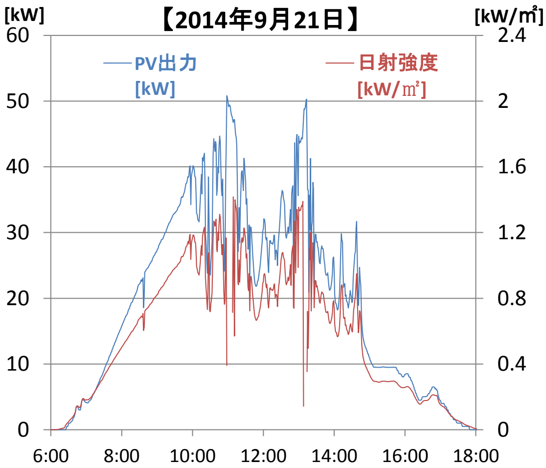
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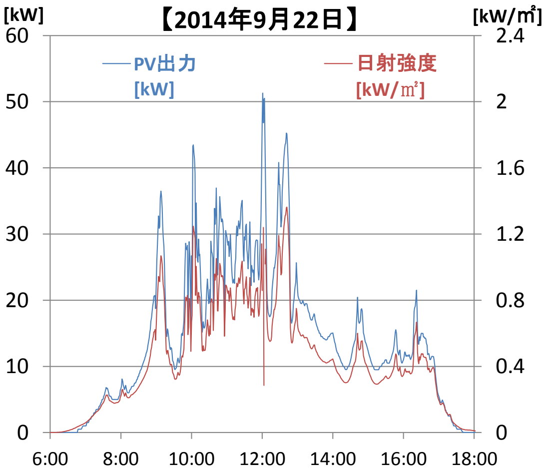
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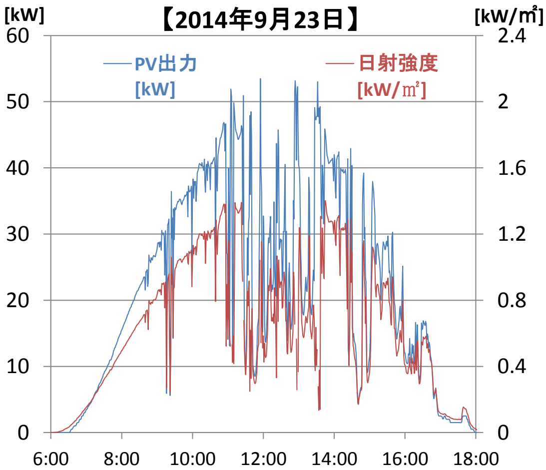
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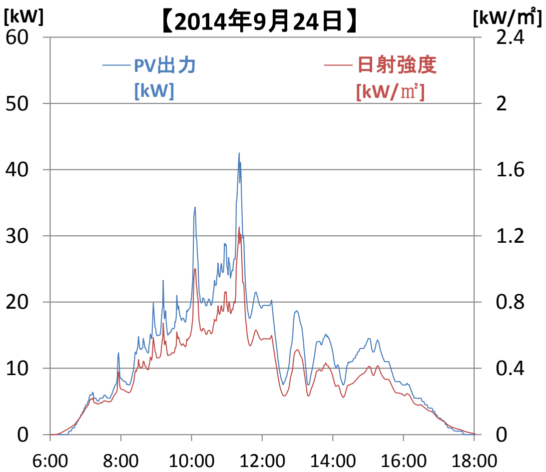
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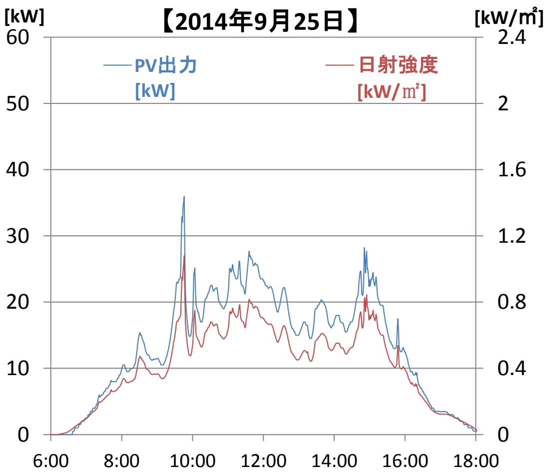
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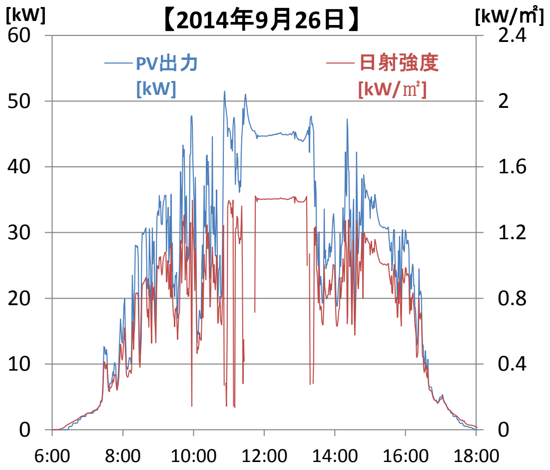
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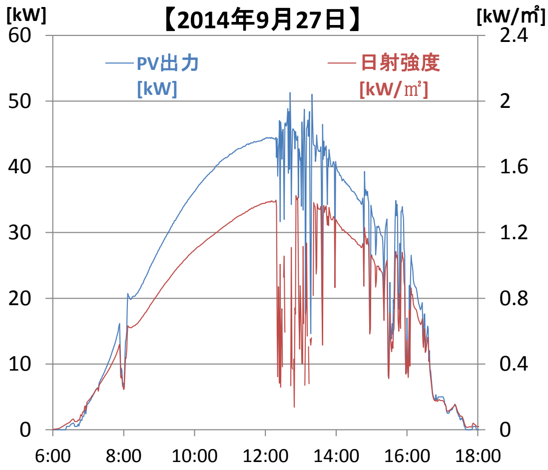
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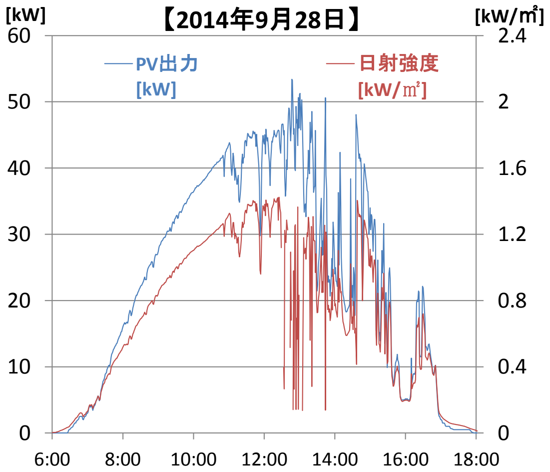
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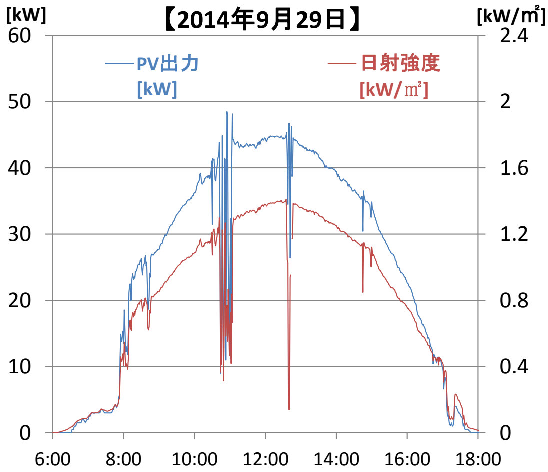
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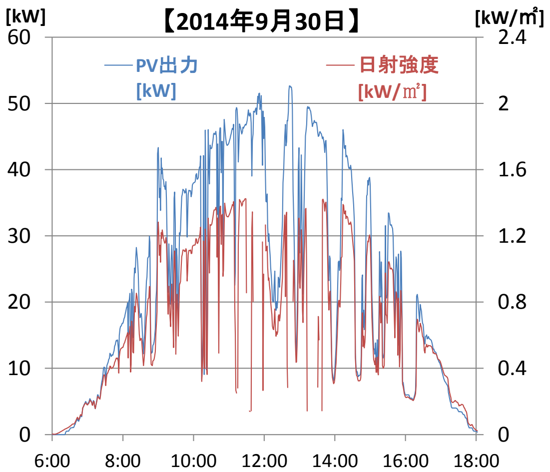
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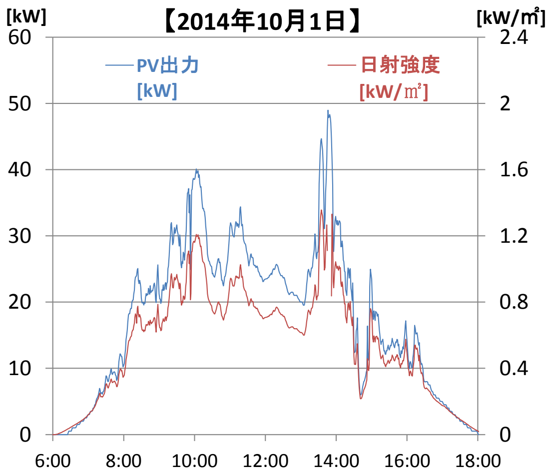
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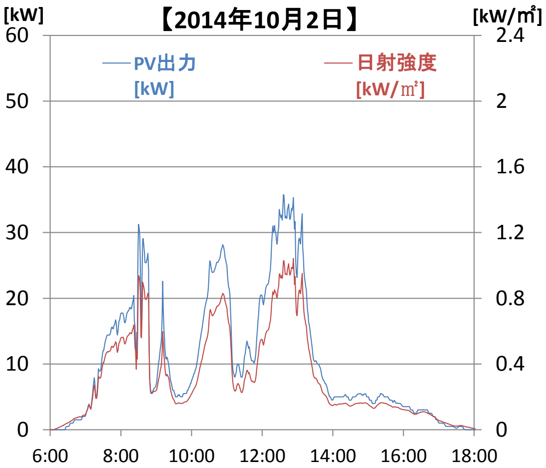
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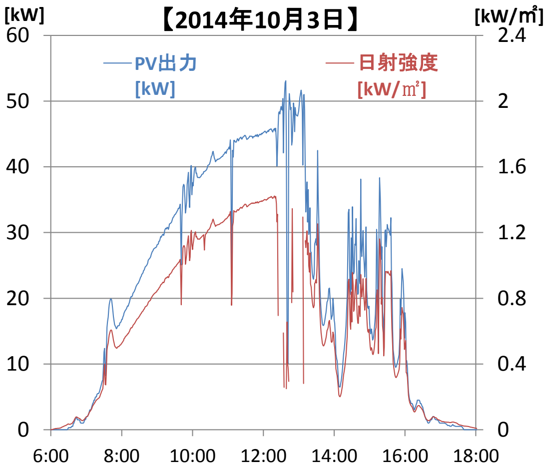
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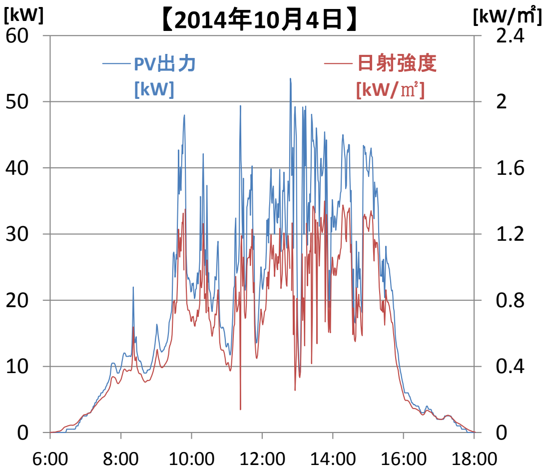
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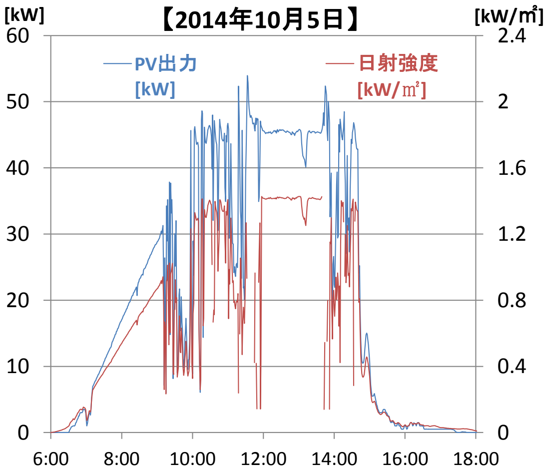
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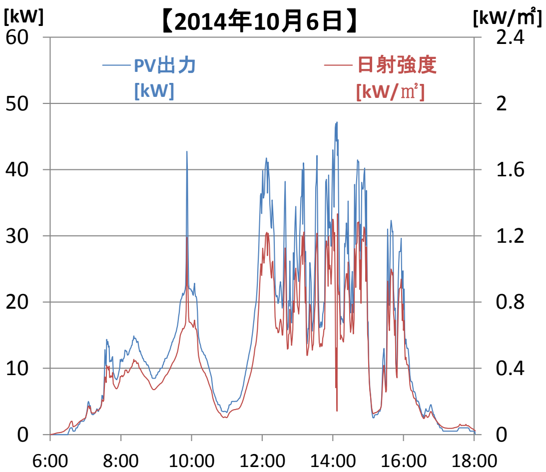
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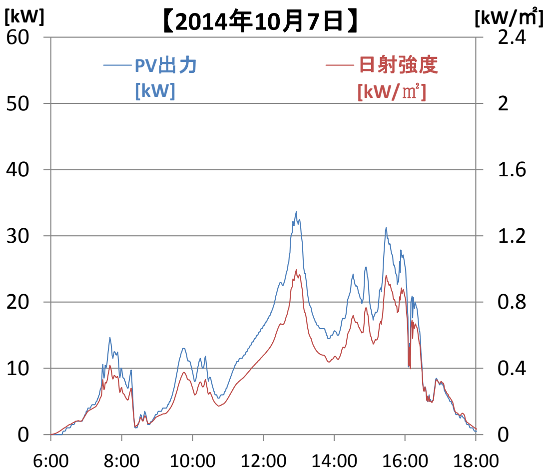
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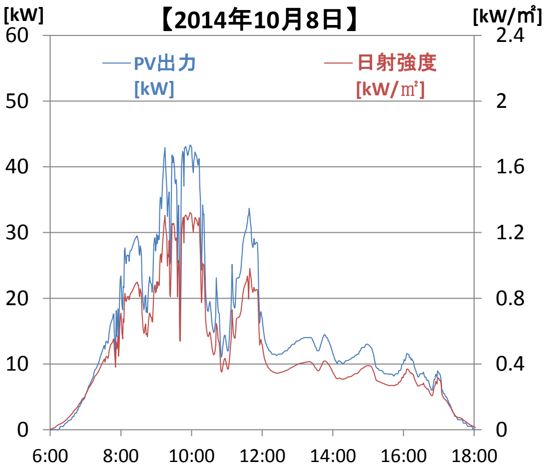
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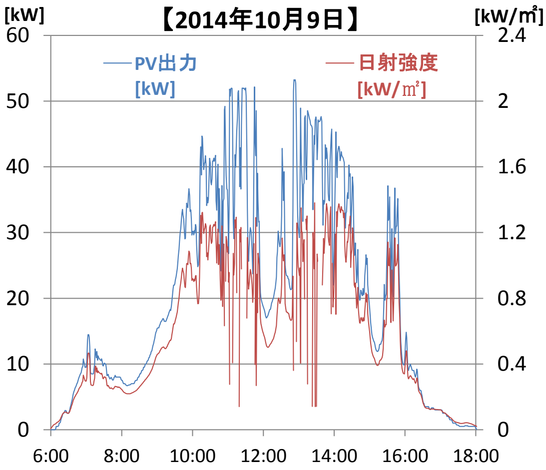
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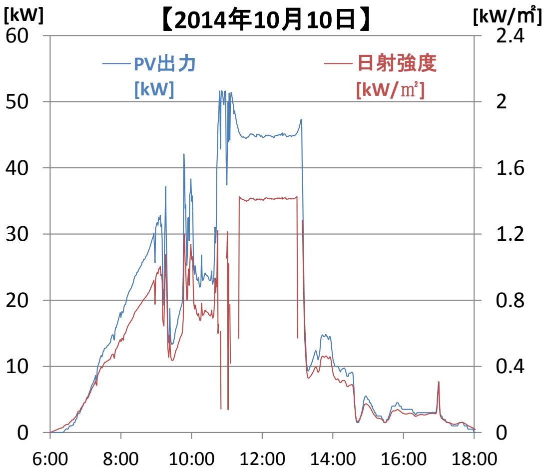
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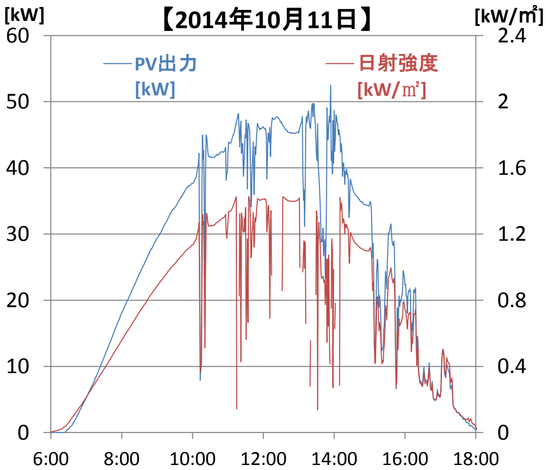
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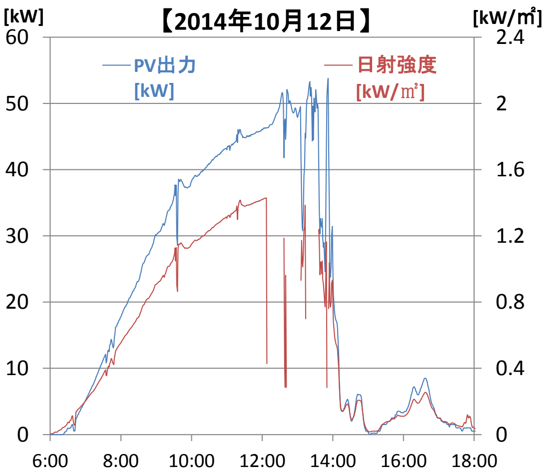
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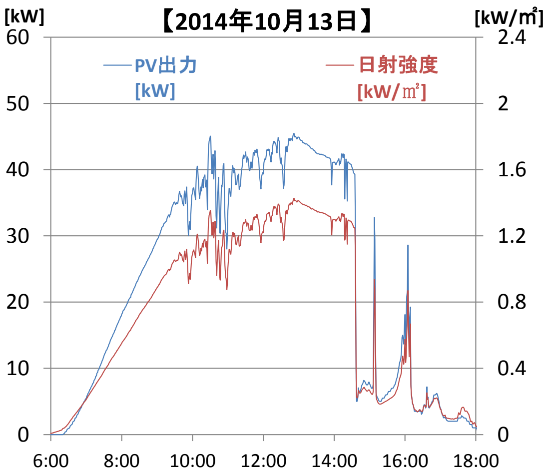
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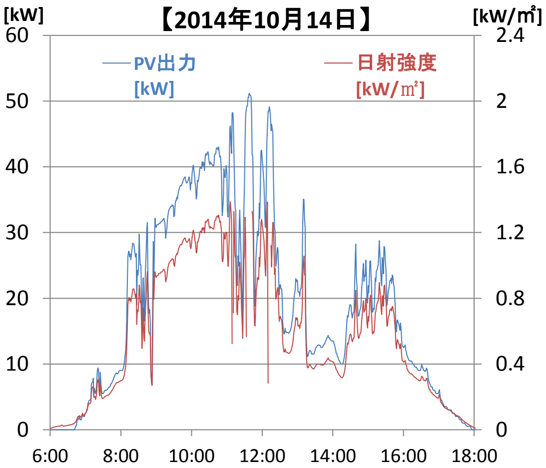
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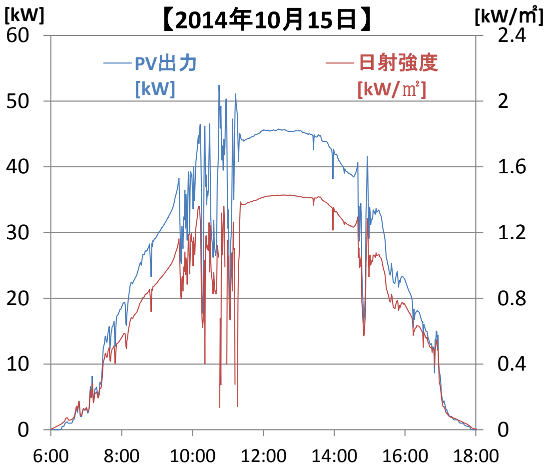
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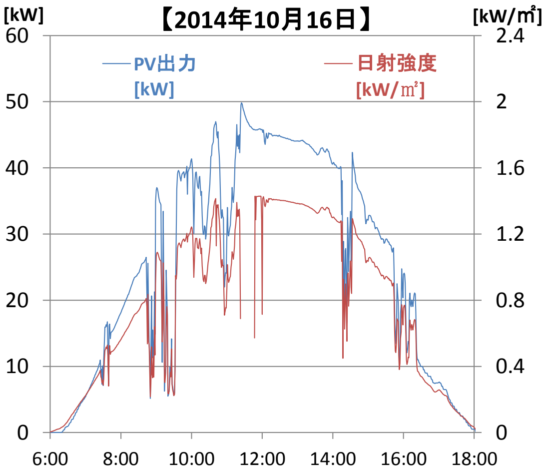
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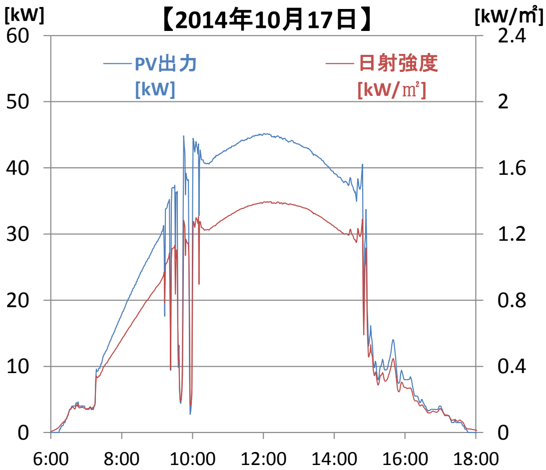
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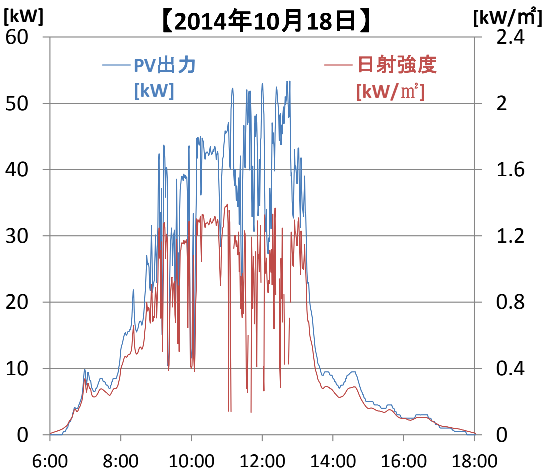
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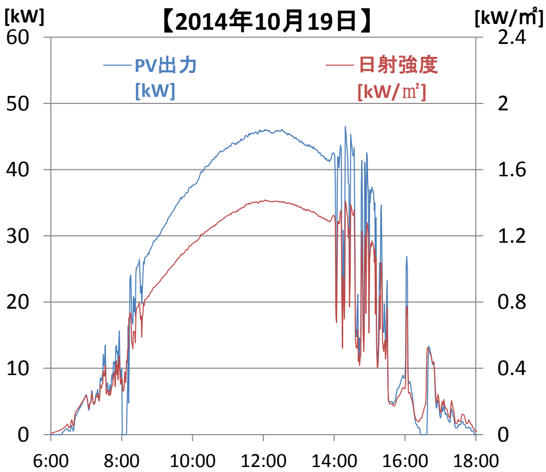
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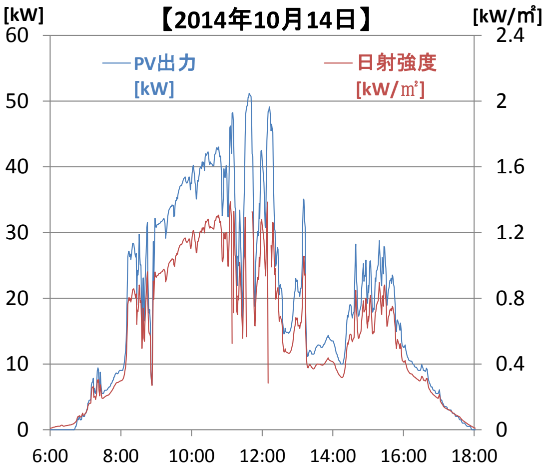
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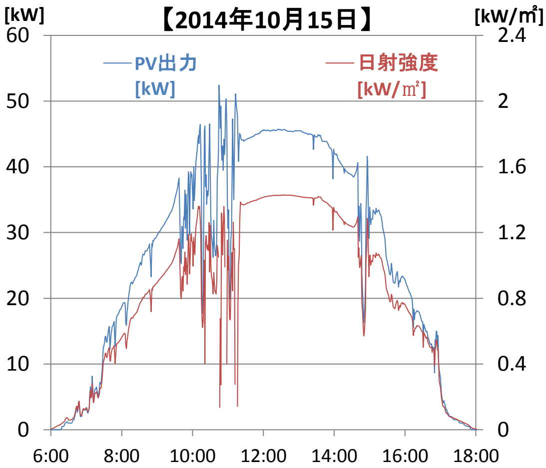
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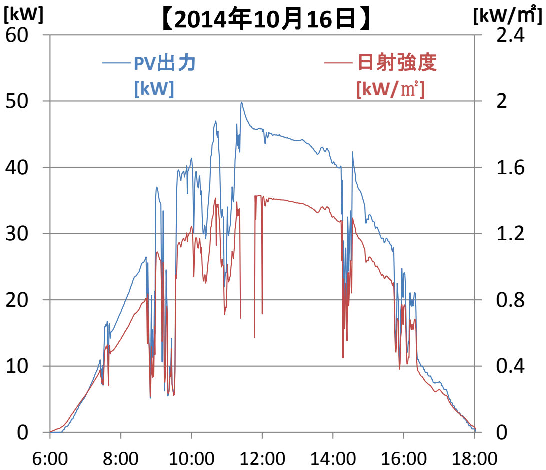
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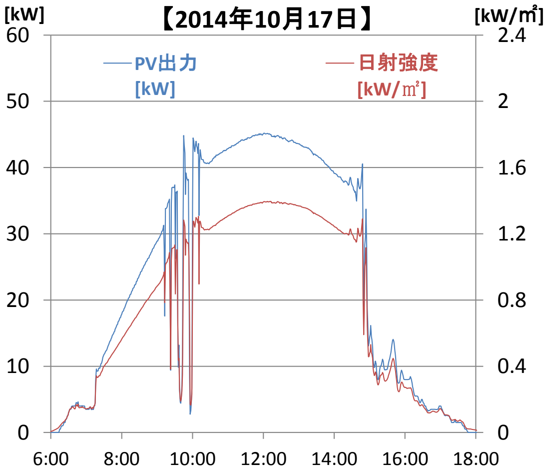
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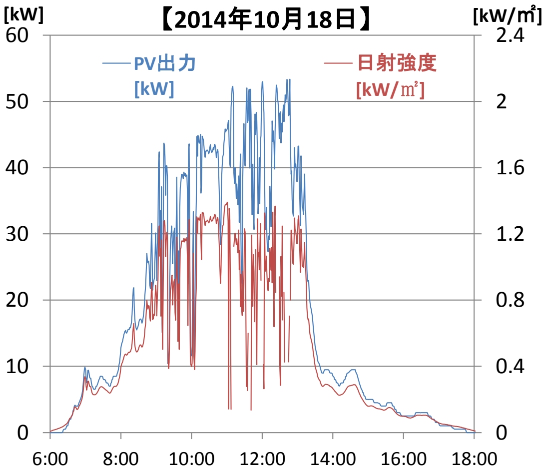
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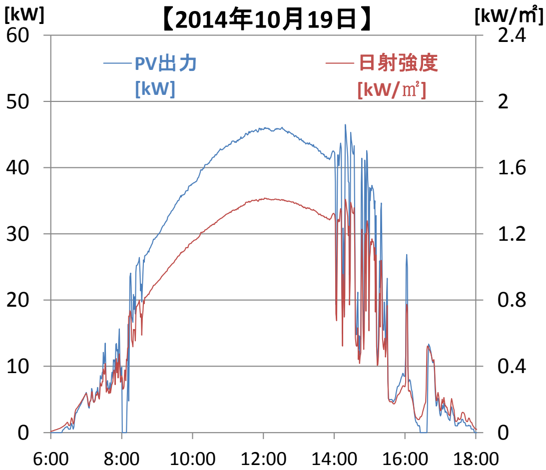
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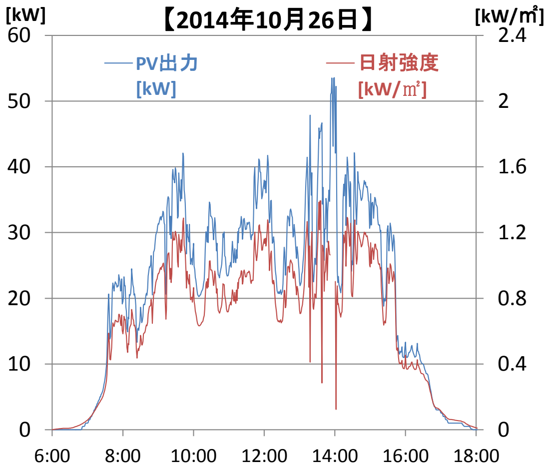
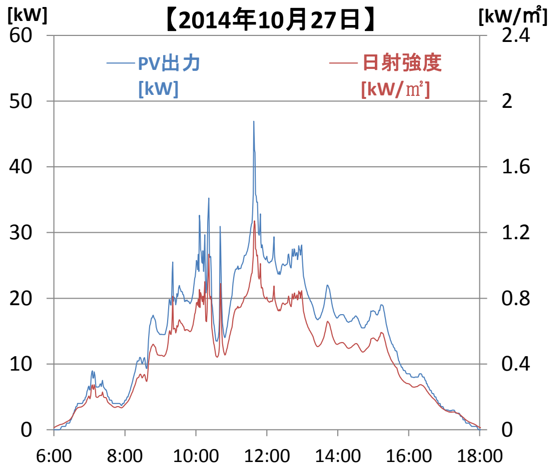
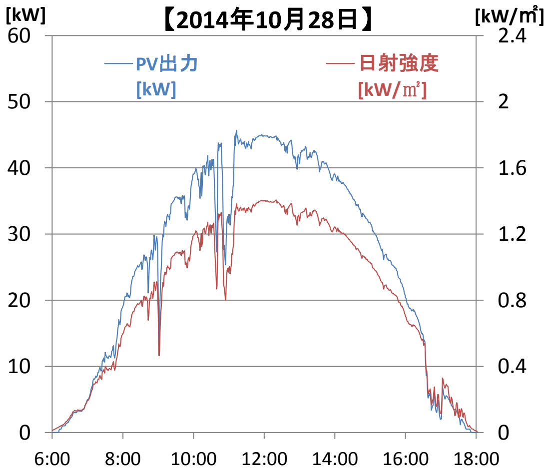
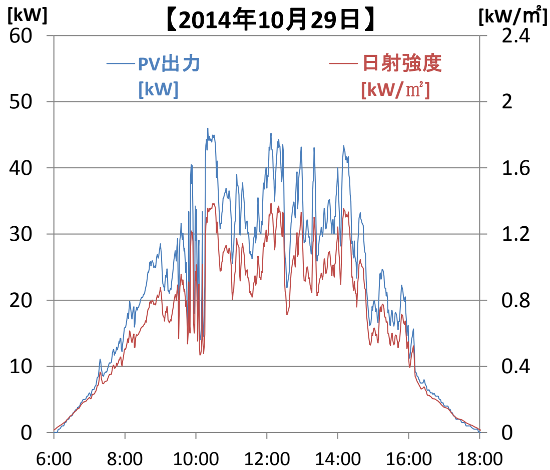
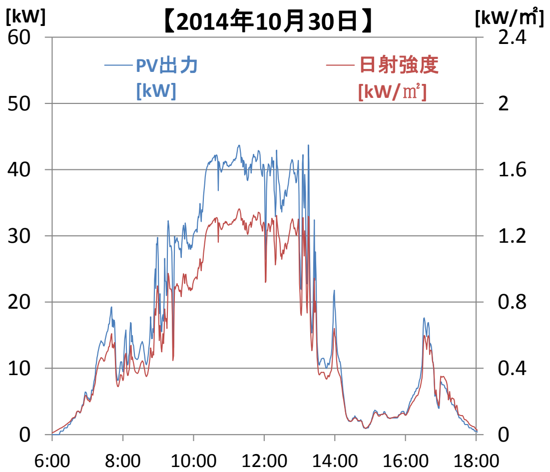
添付資料
太陽光発電データ

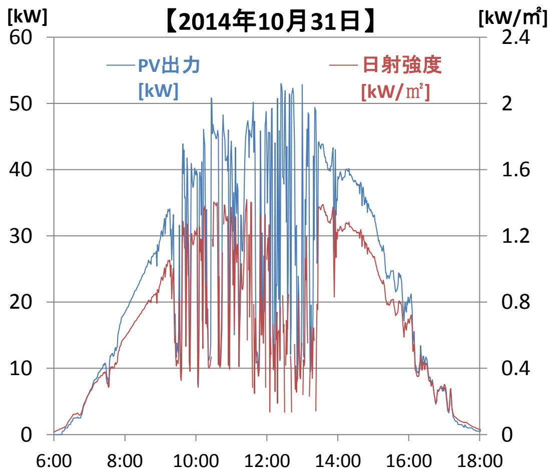


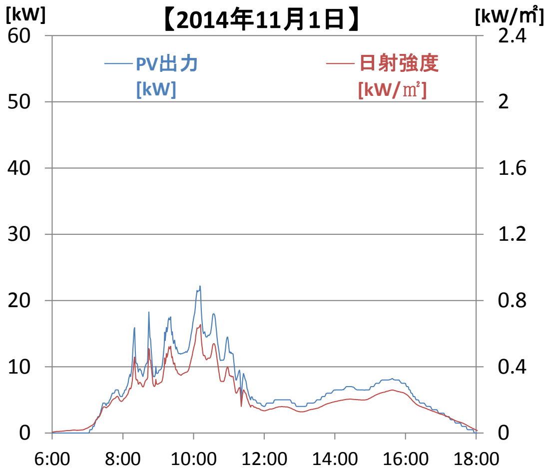








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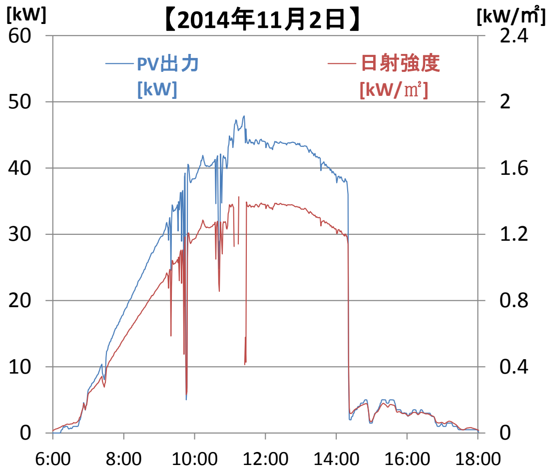
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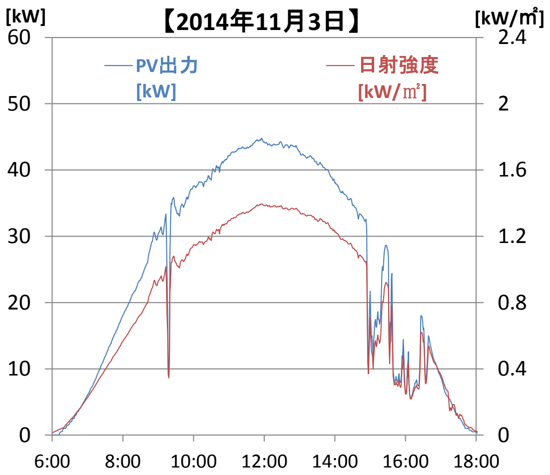
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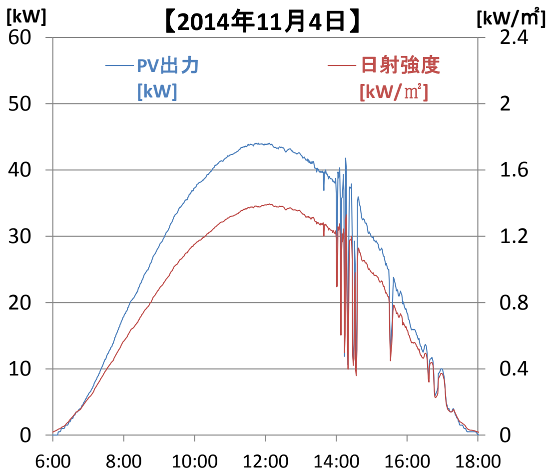
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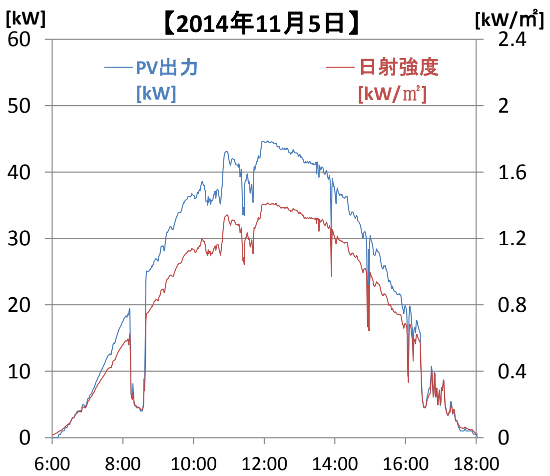
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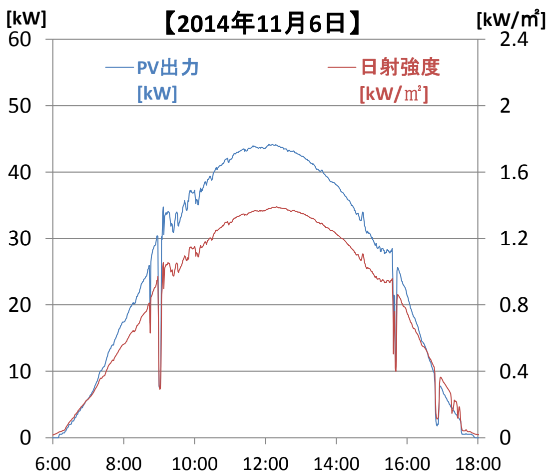
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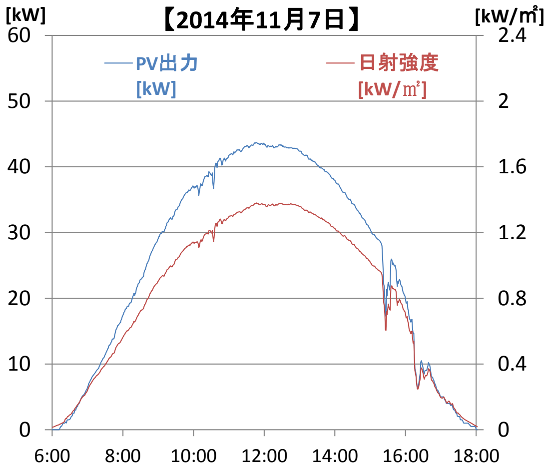
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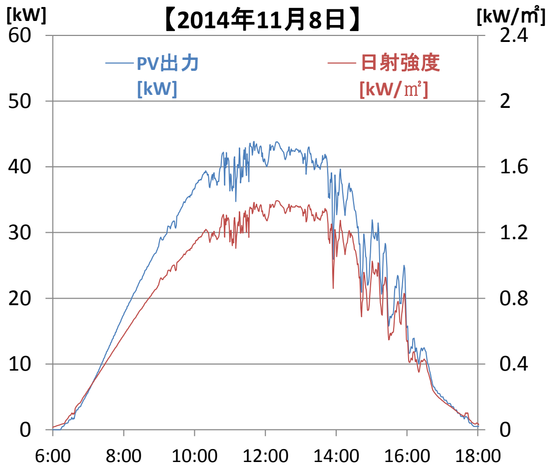
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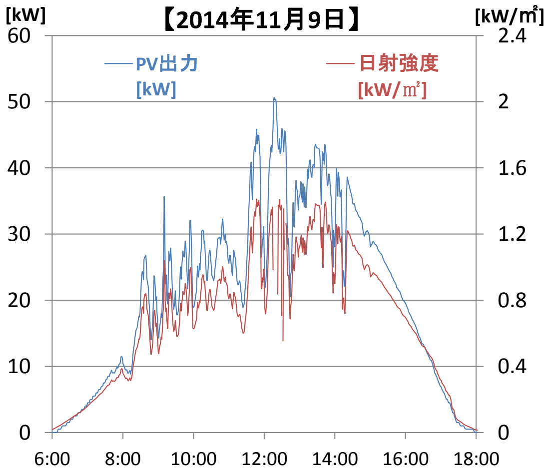
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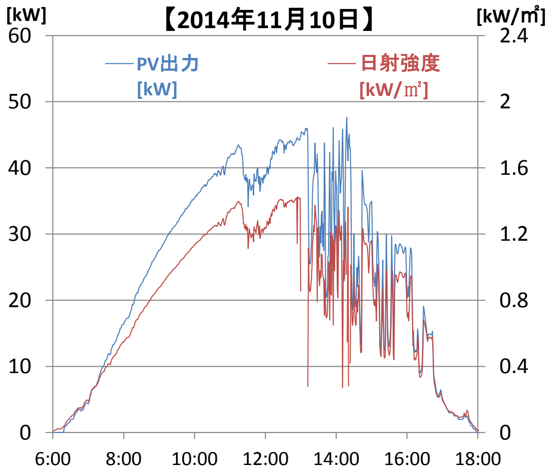
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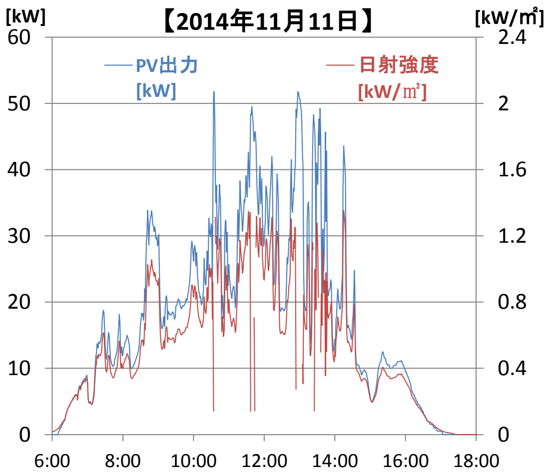
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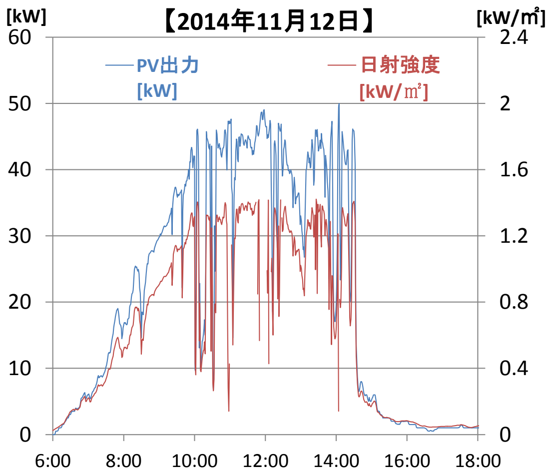
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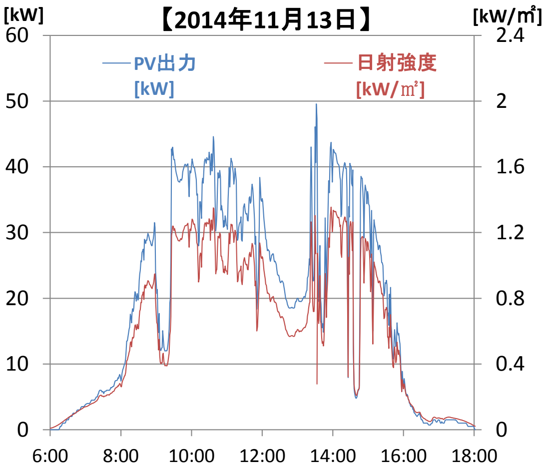
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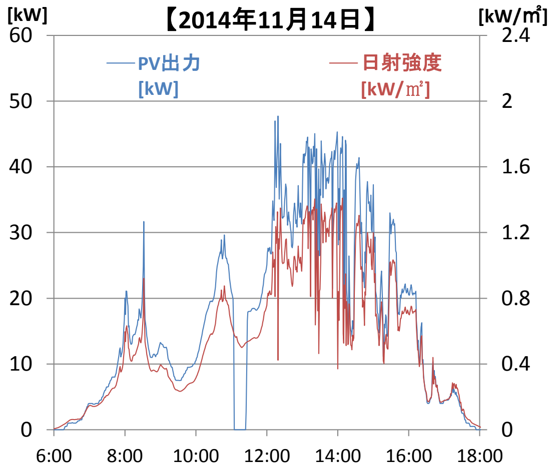
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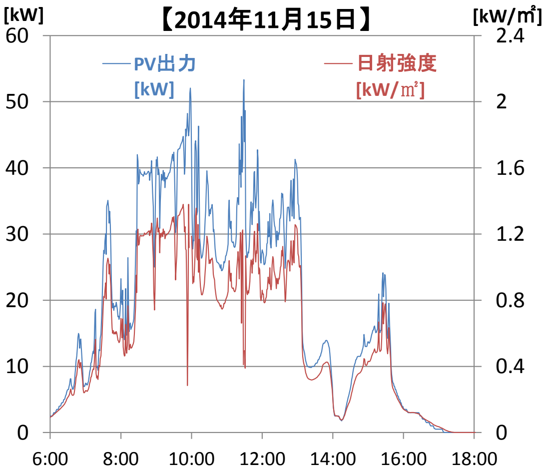
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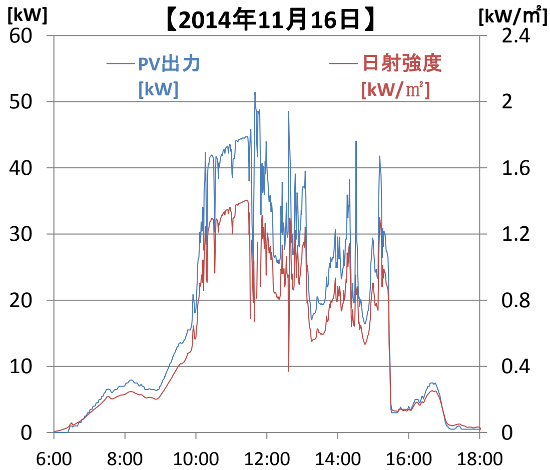
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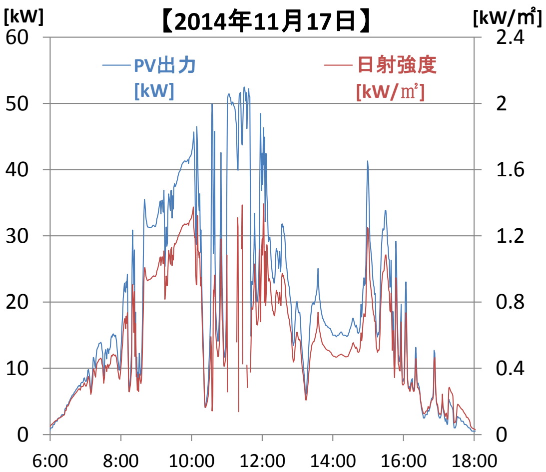
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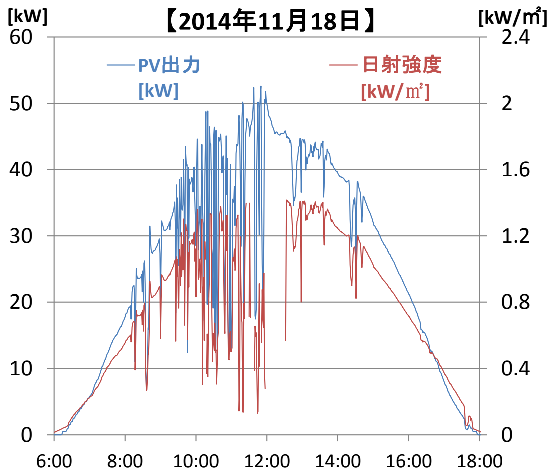
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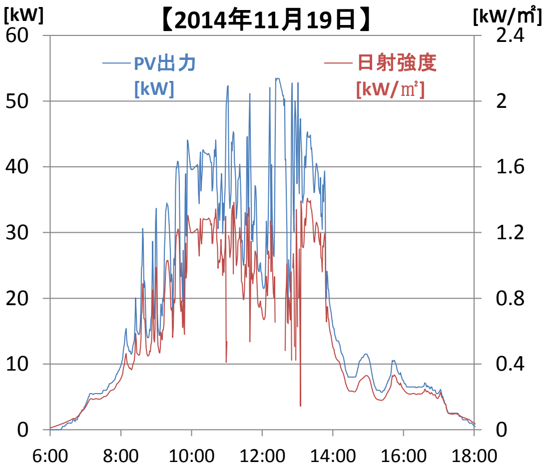
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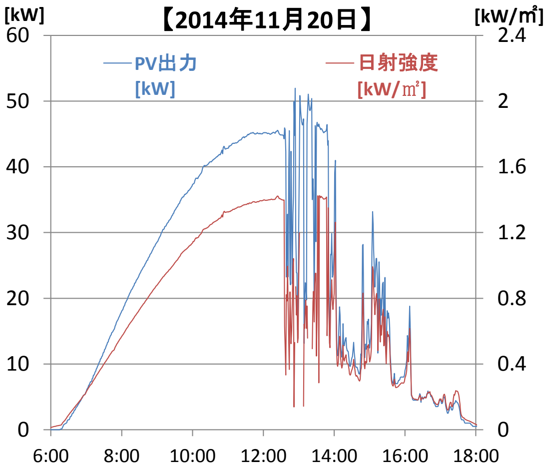
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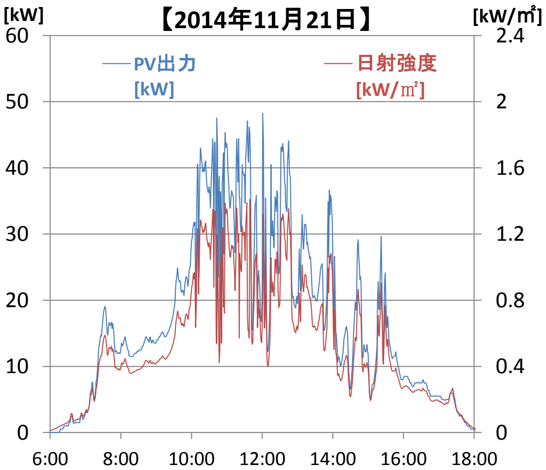
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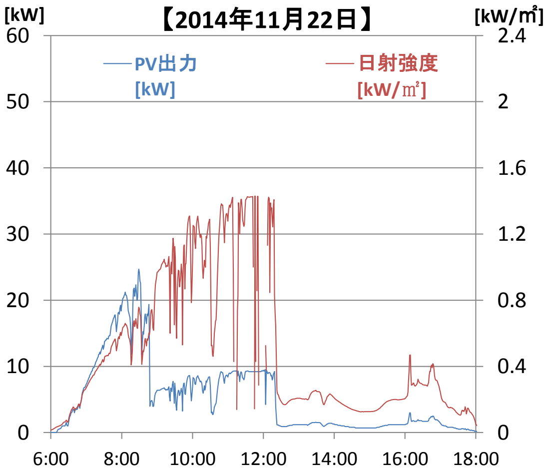
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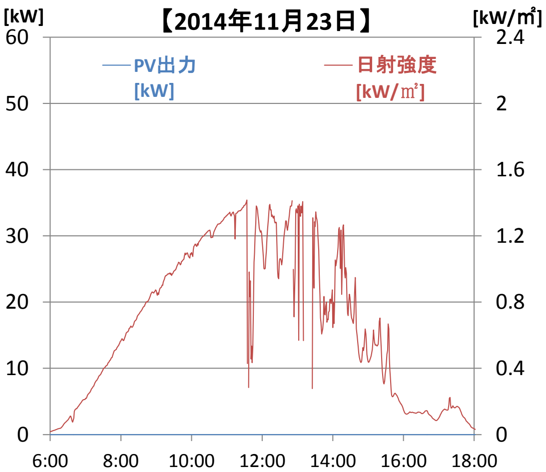
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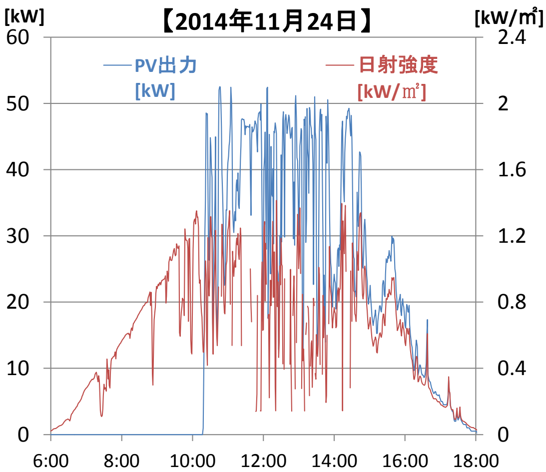
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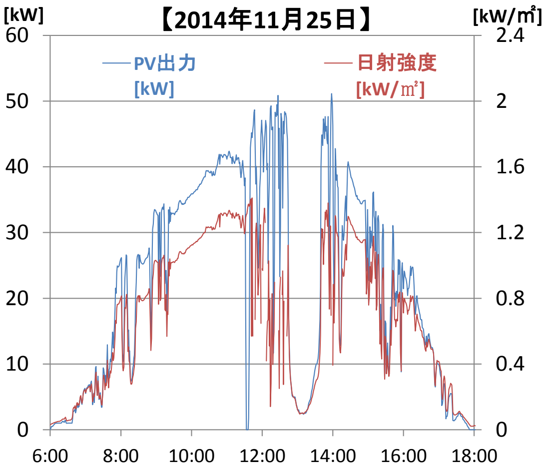
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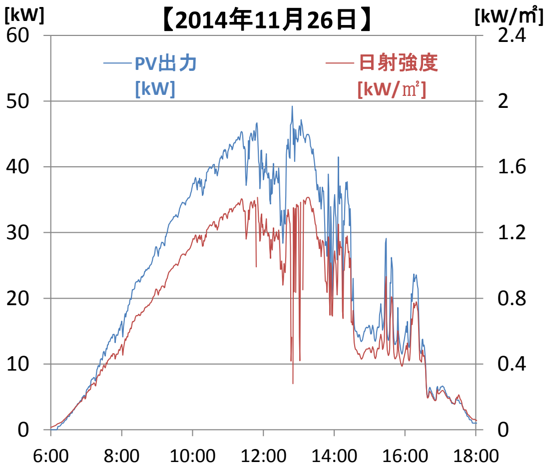
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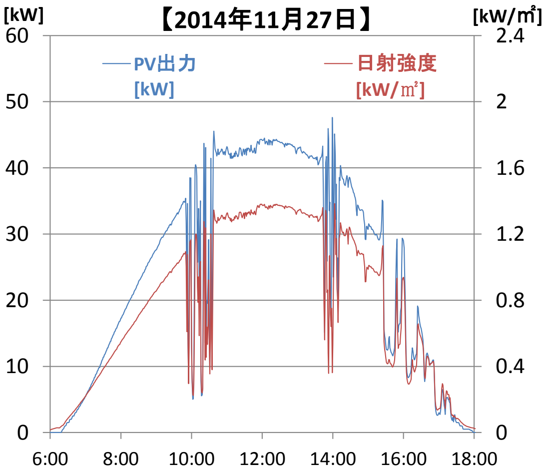
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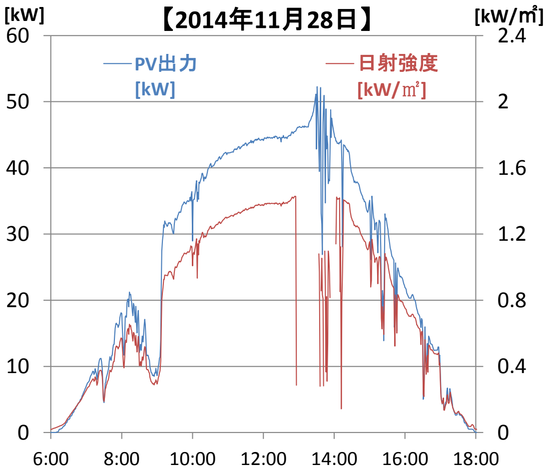
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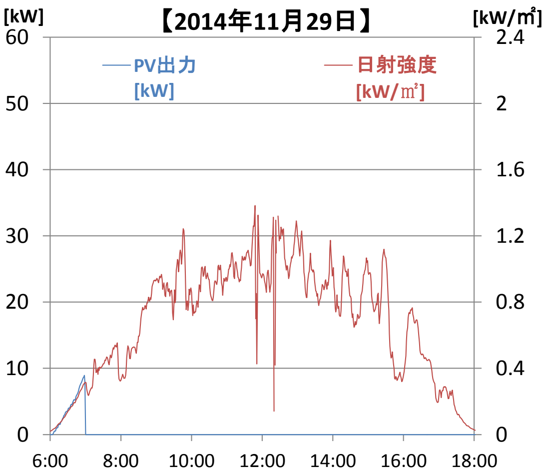
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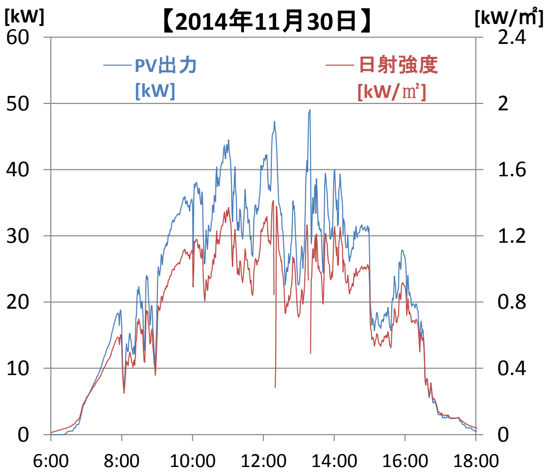
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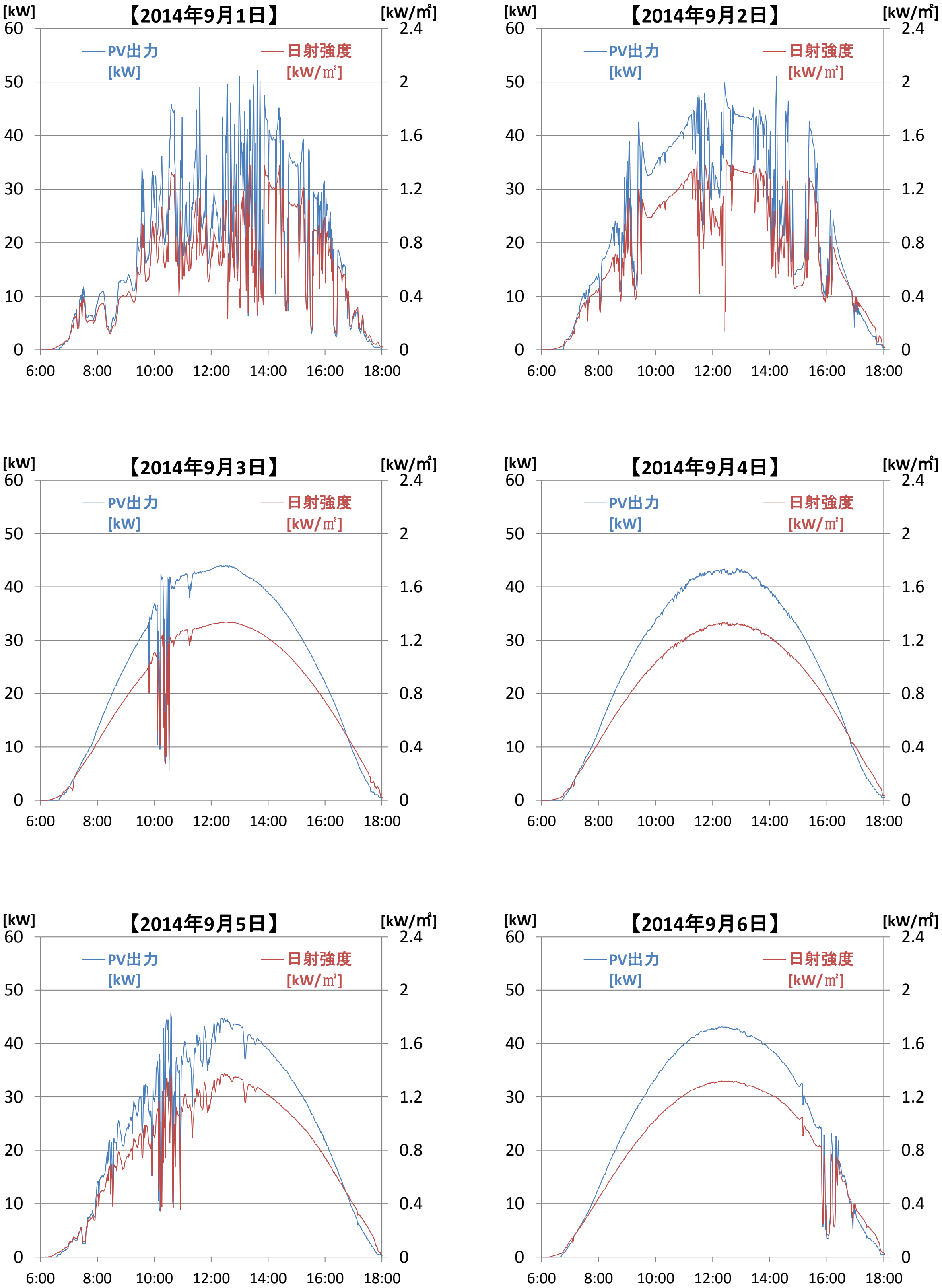
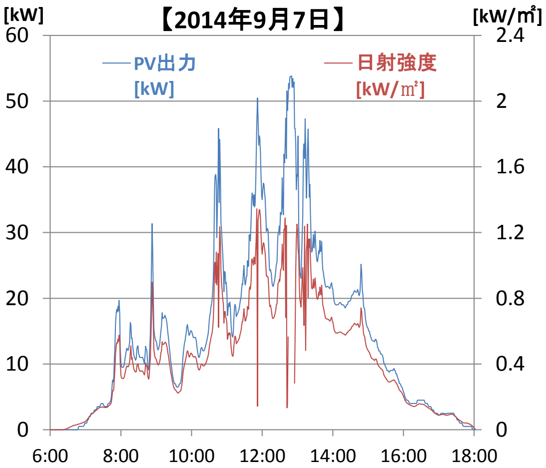
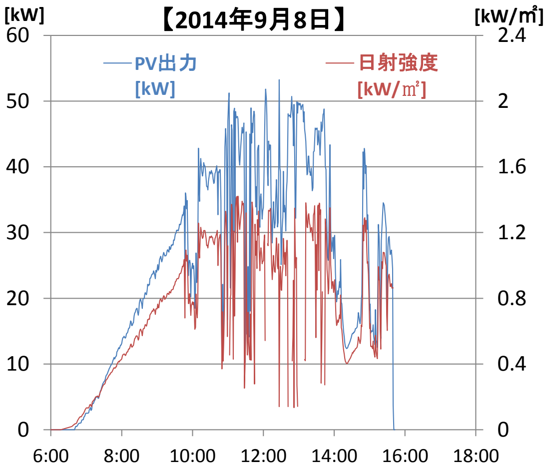
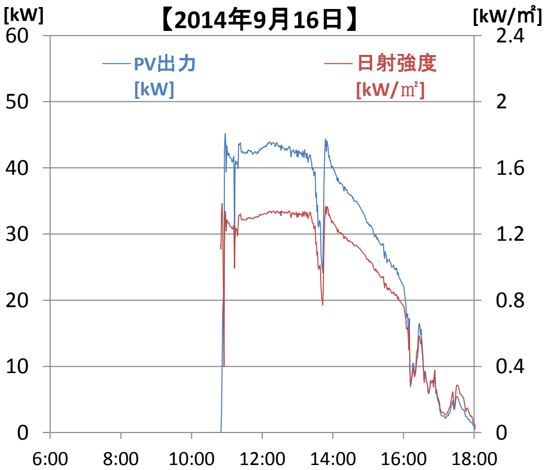
添付資料⑧

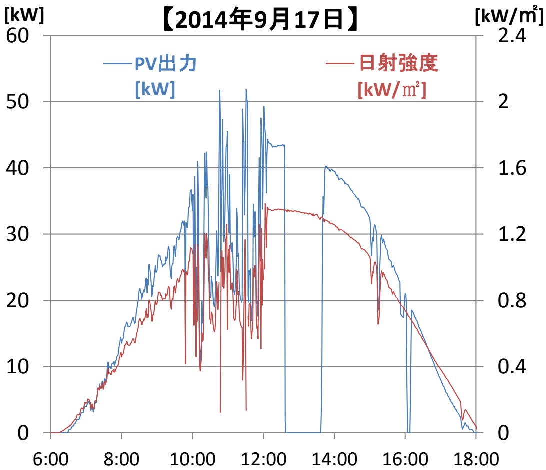


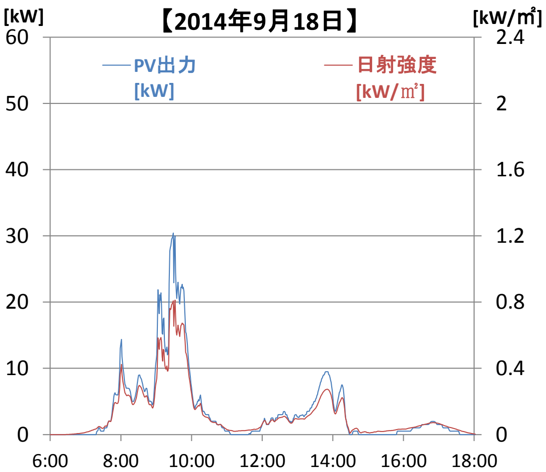
※9 月 1 日から 9 月 8 日は試運転期間

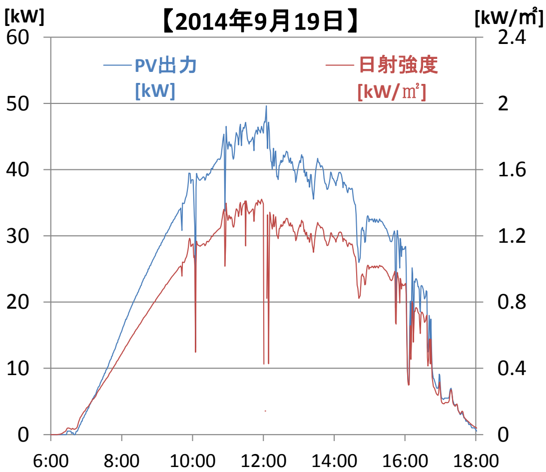






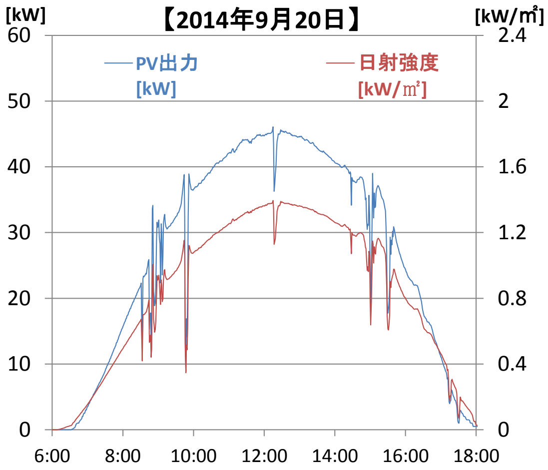






※9 月 1 日から 9 月 8 日は試運転期間

※9 月 16 日から系統連系開始、翌 17 日は実地研修に伴い、PCS 一時停止(13 時前から 1 時間弱)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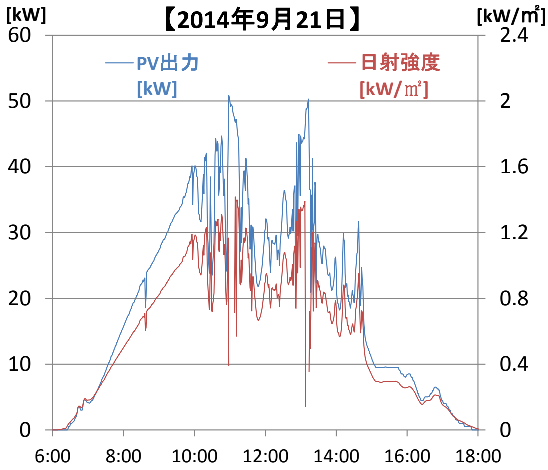
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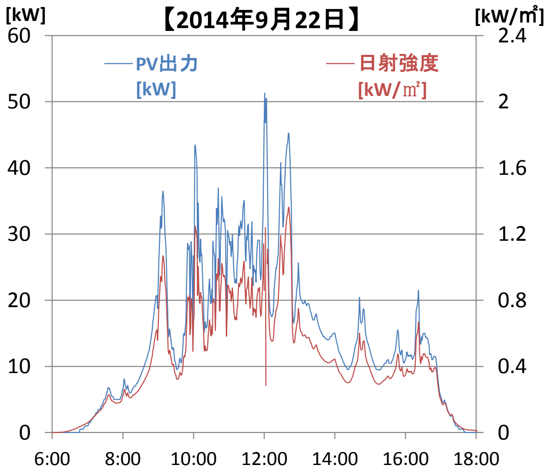
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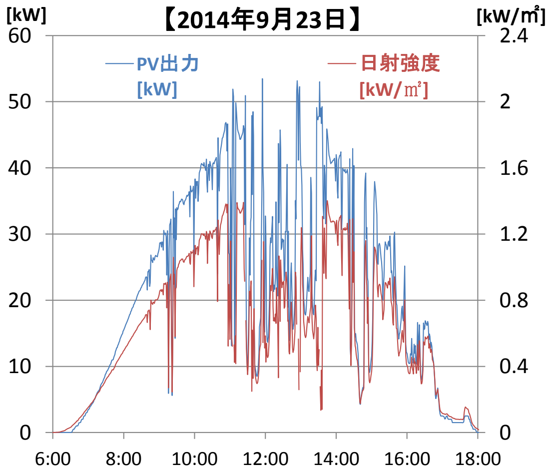
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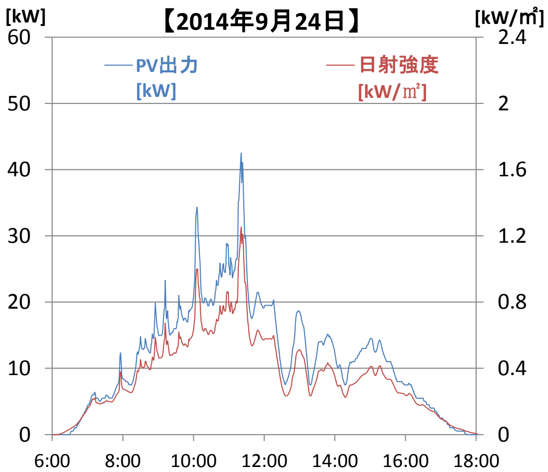
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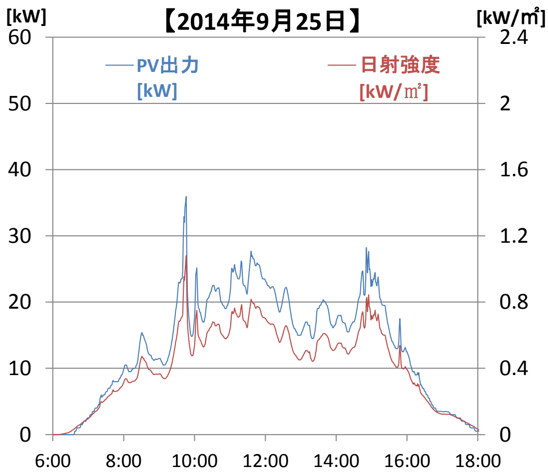
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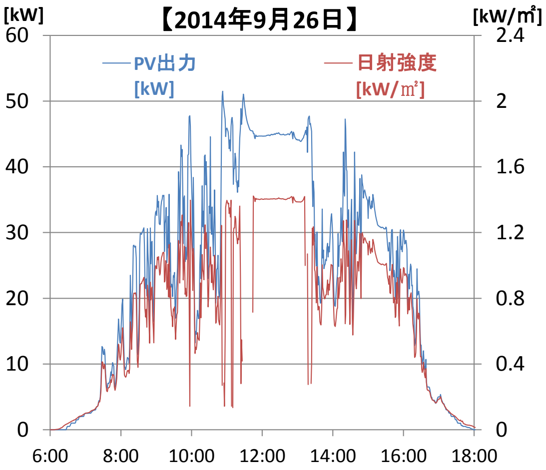
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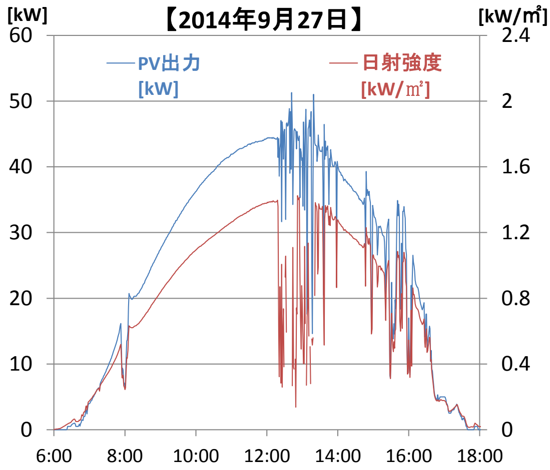
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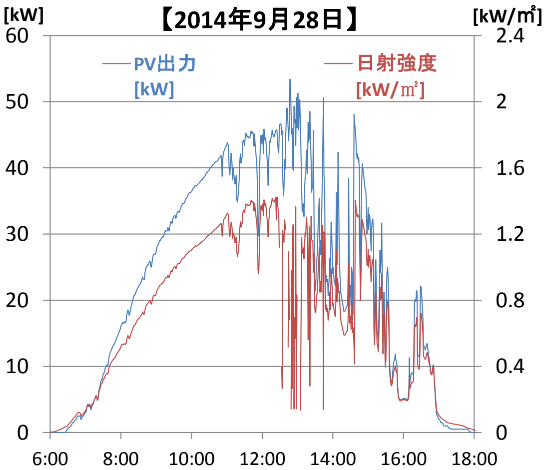
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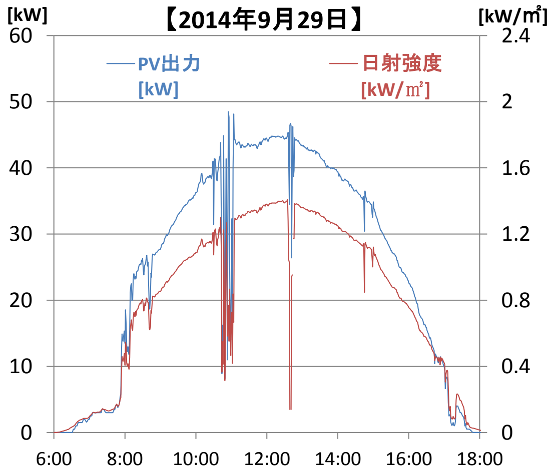
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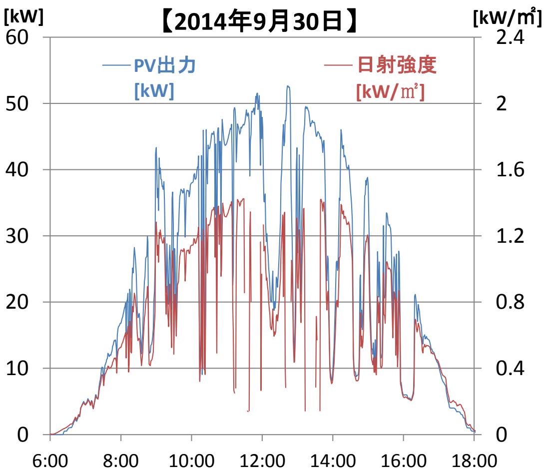
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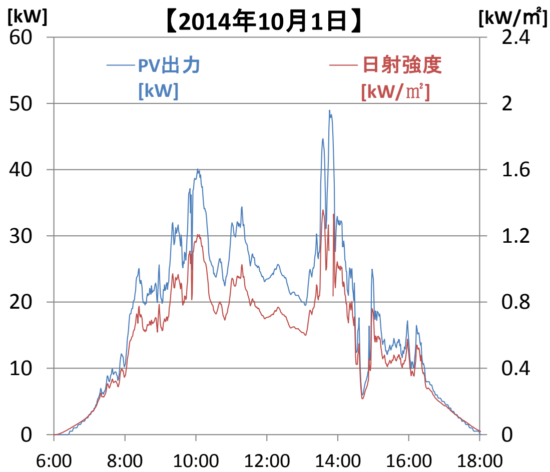
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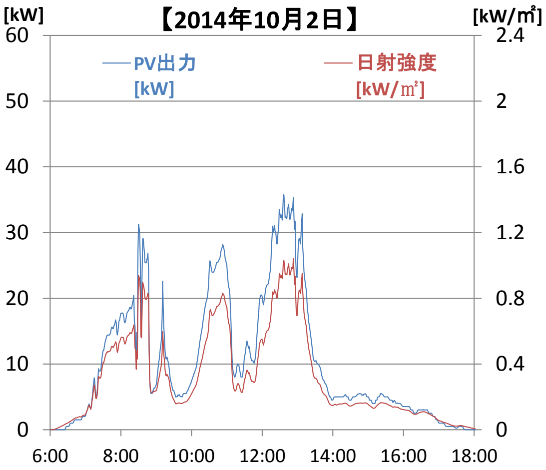
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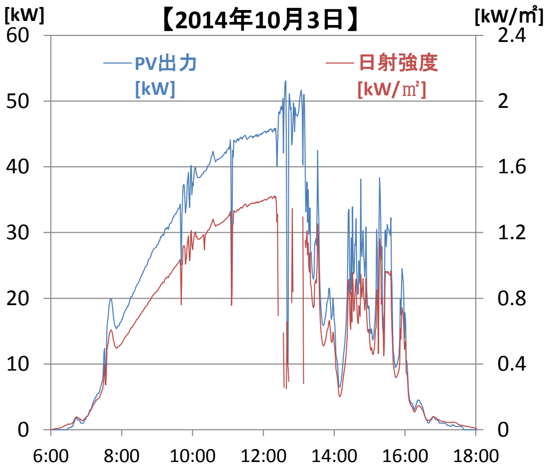
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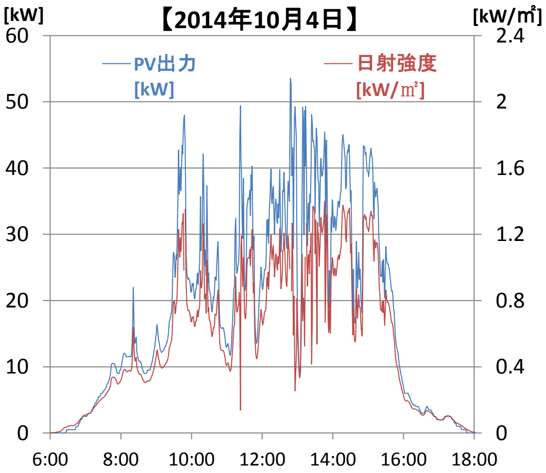
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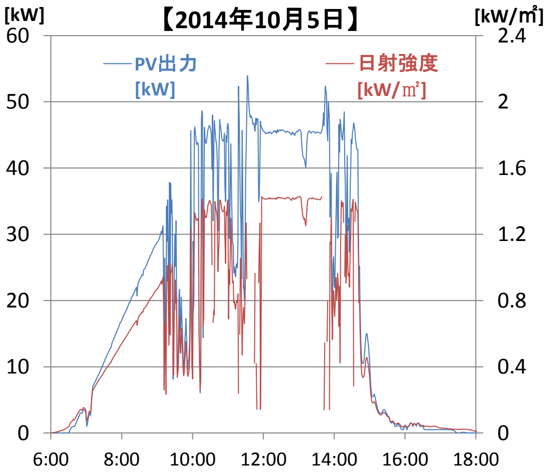
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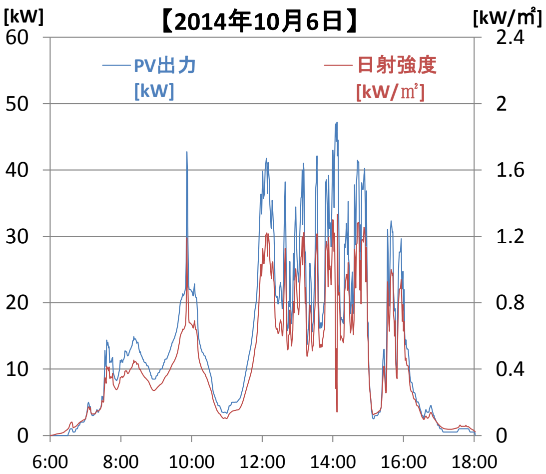
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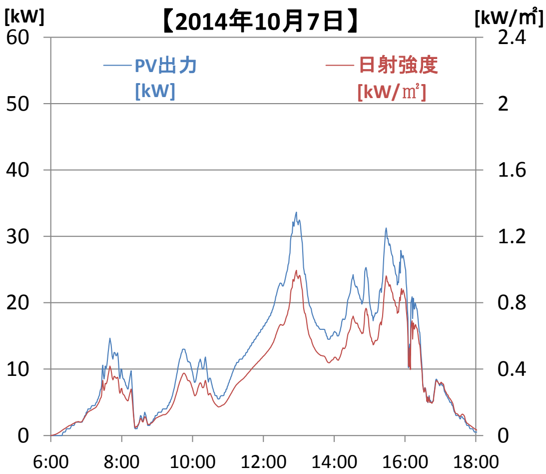
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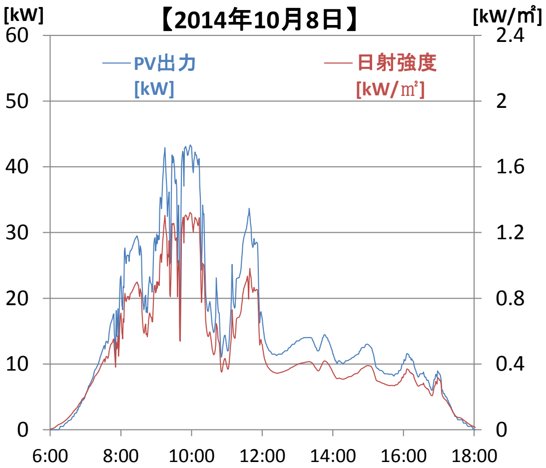
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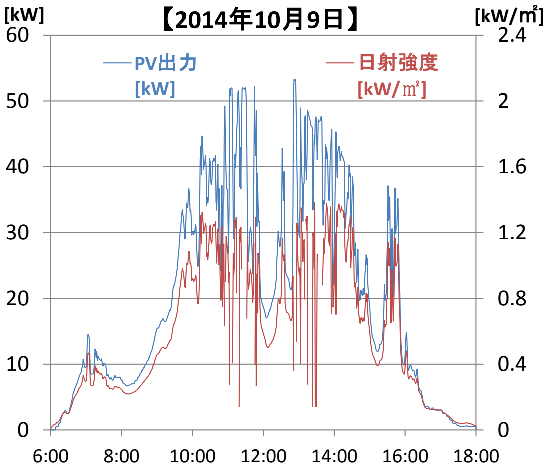
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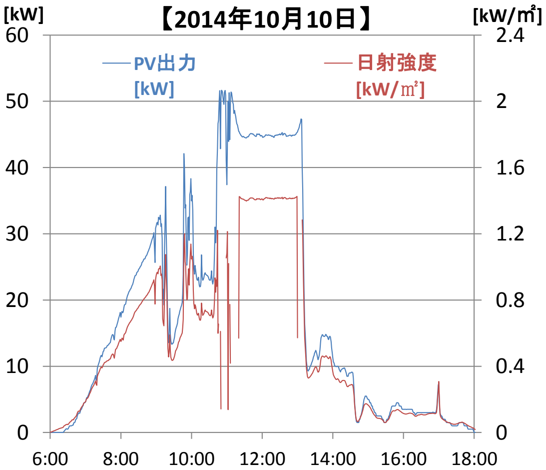
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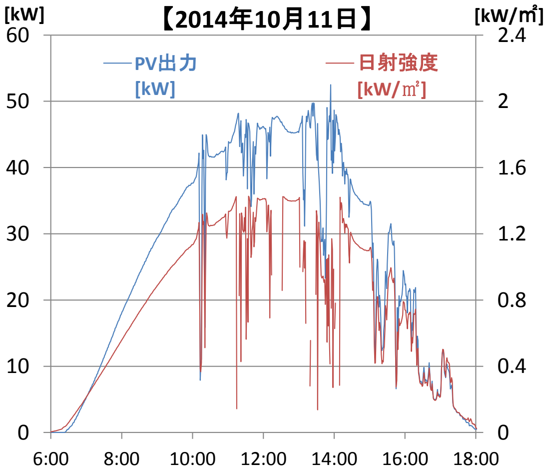
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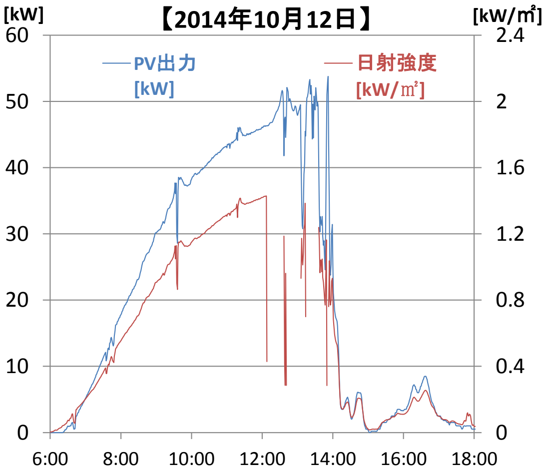
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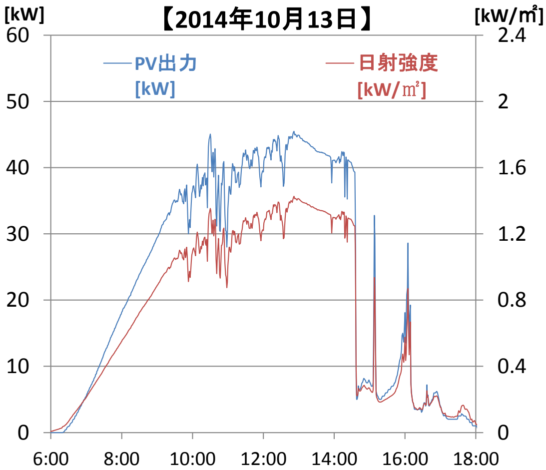
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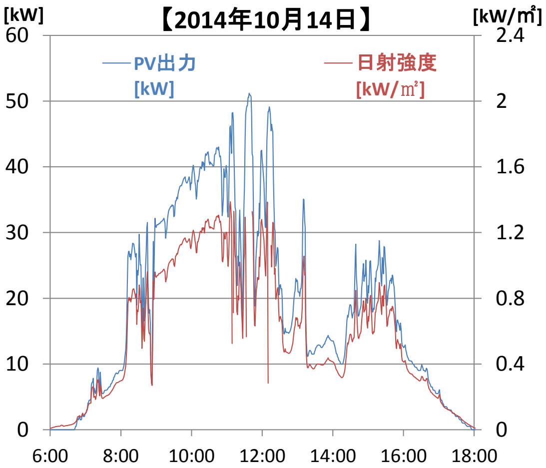
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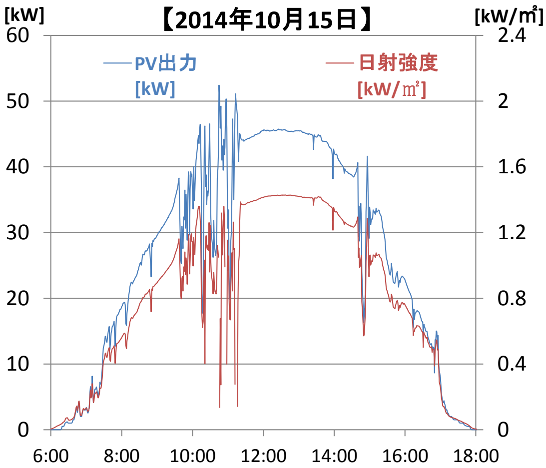
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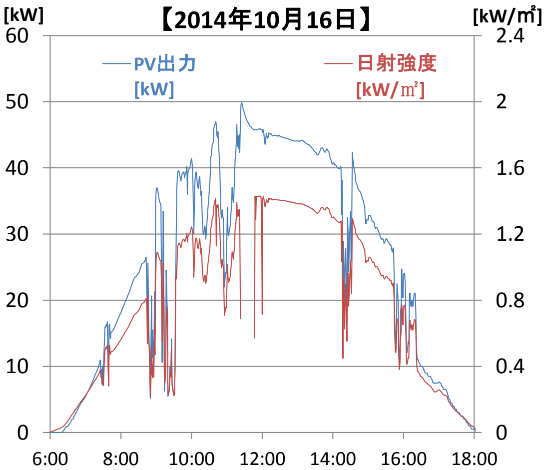
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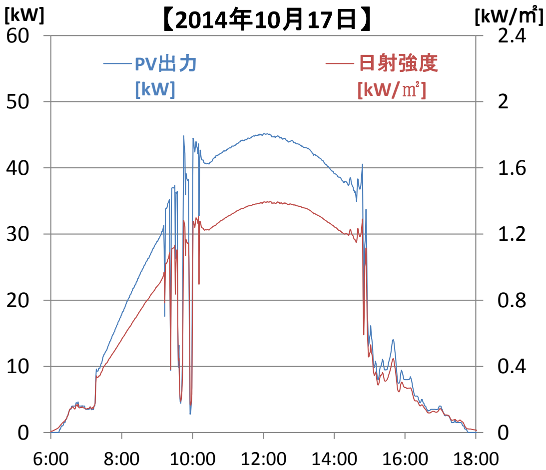
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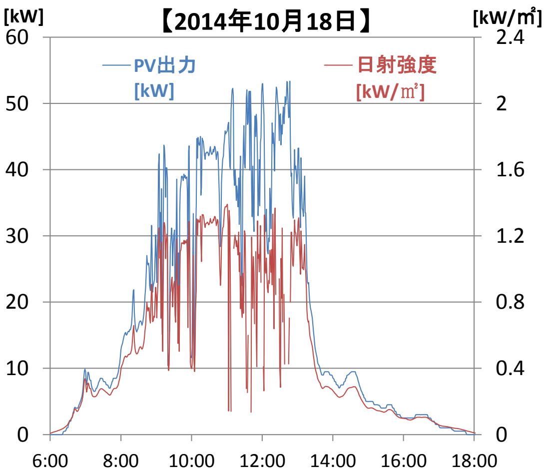
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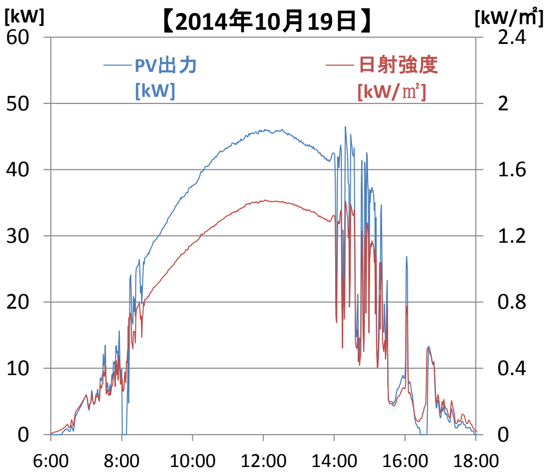
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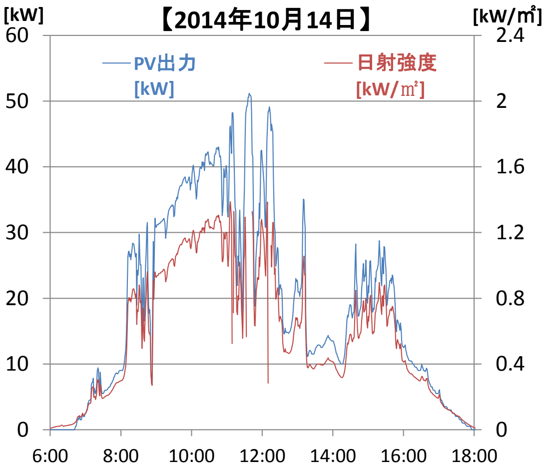
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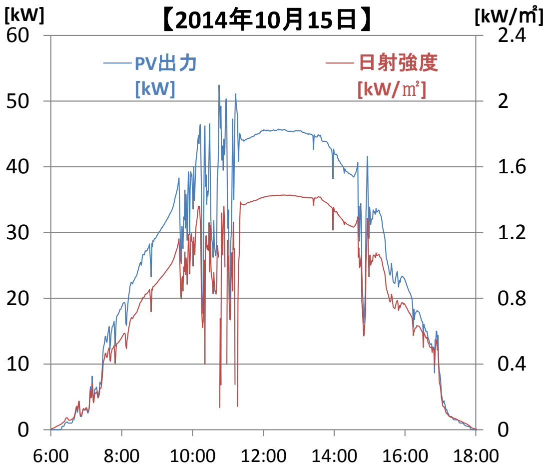
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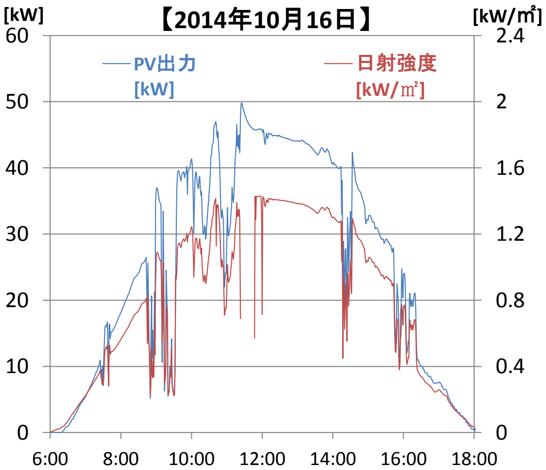
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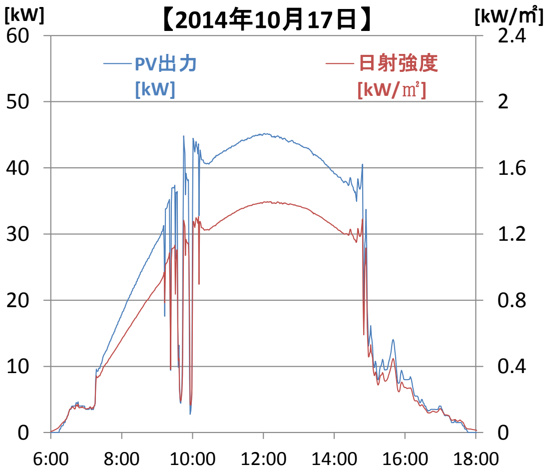
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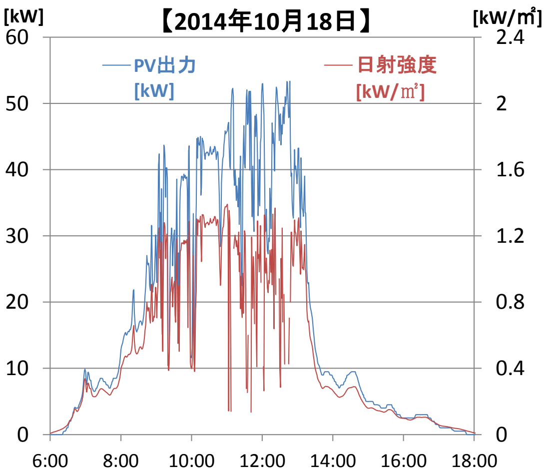
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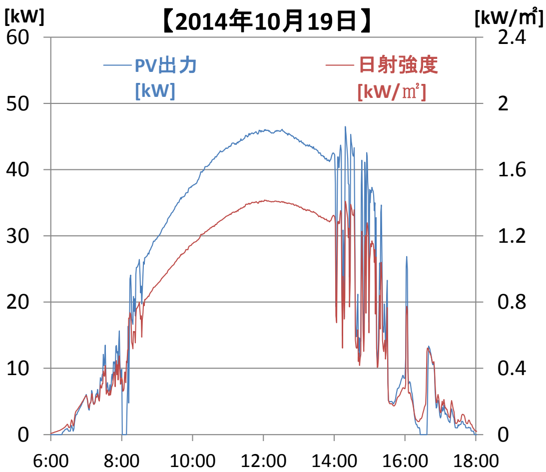
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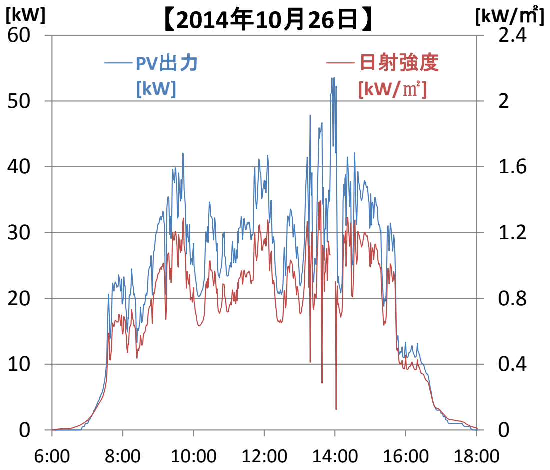
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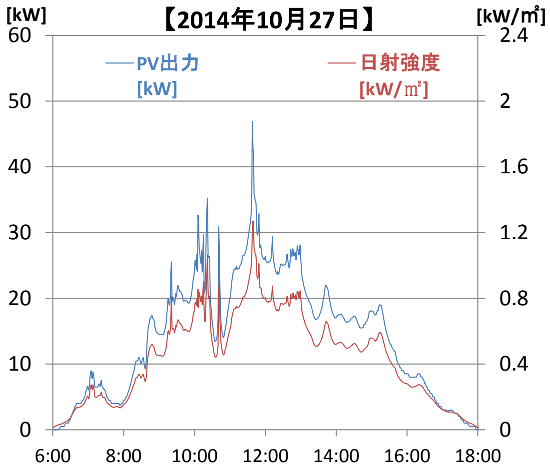
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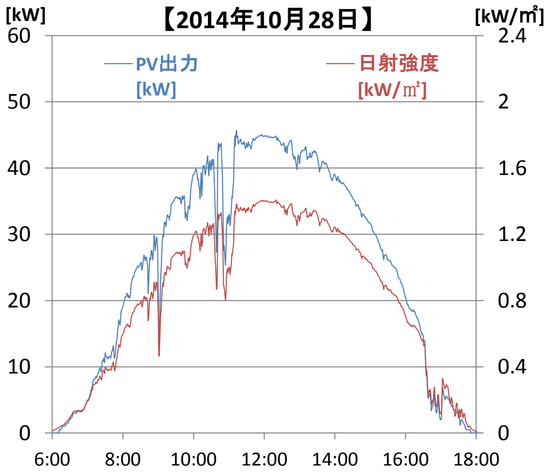
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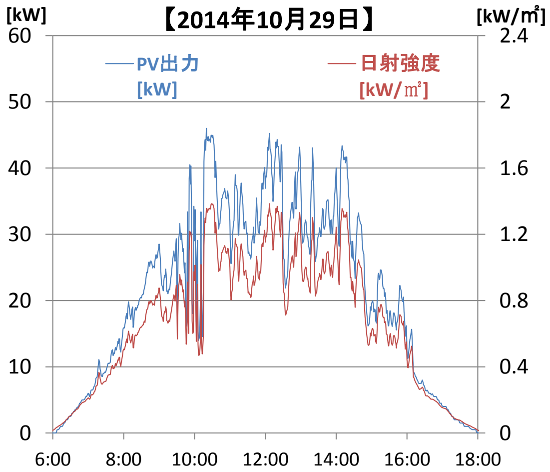
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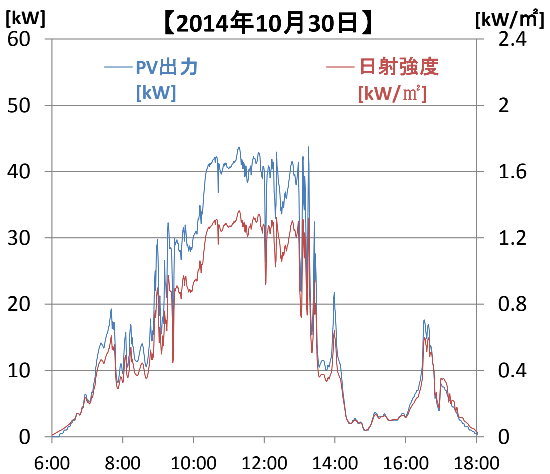
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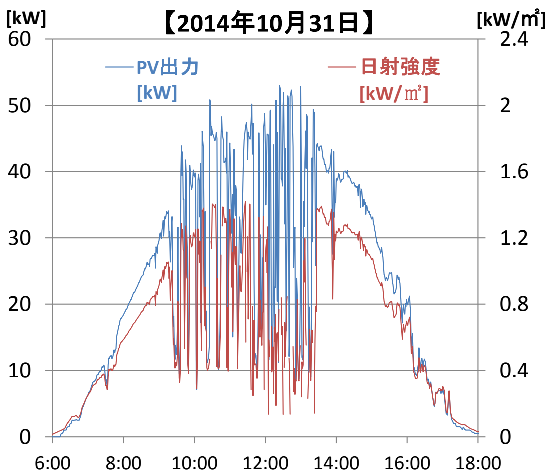
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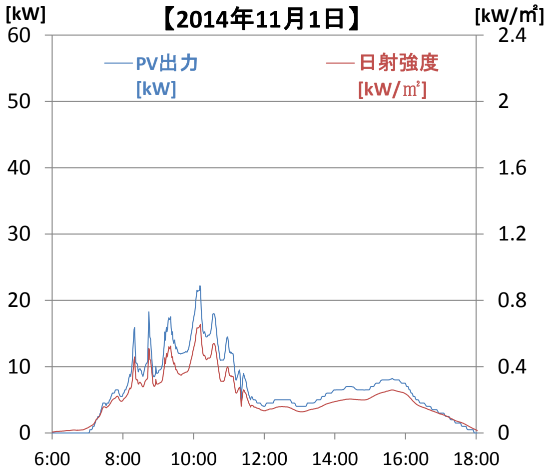
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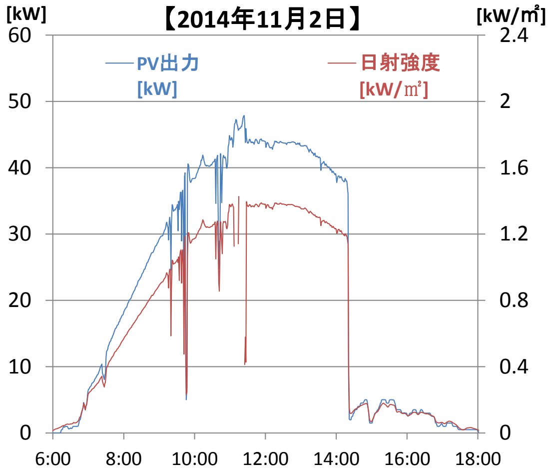
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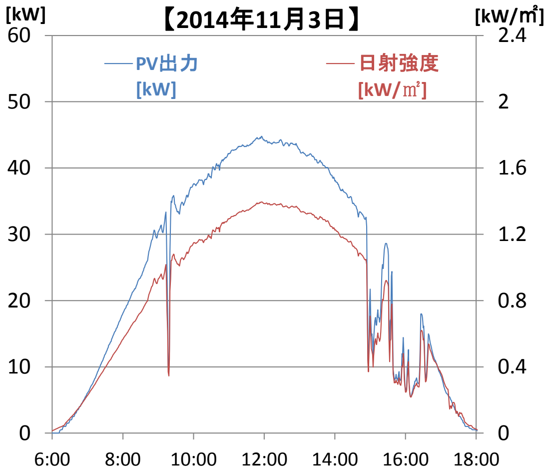
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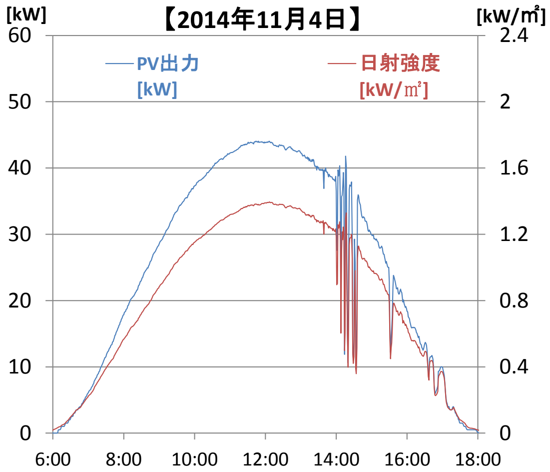
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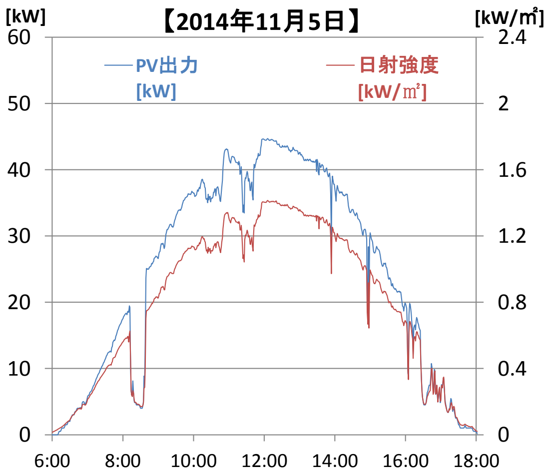
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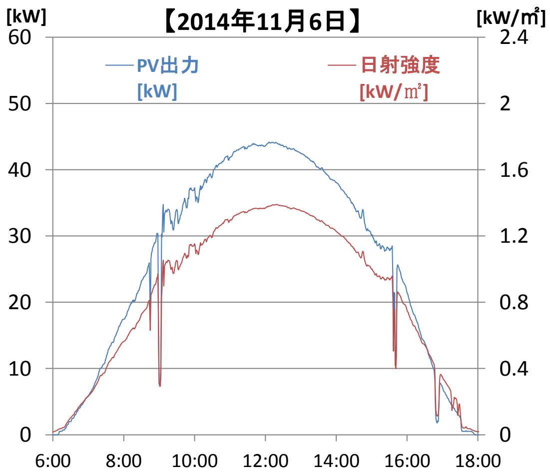
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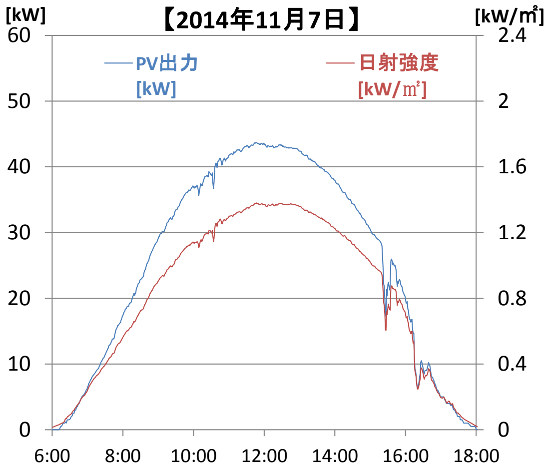
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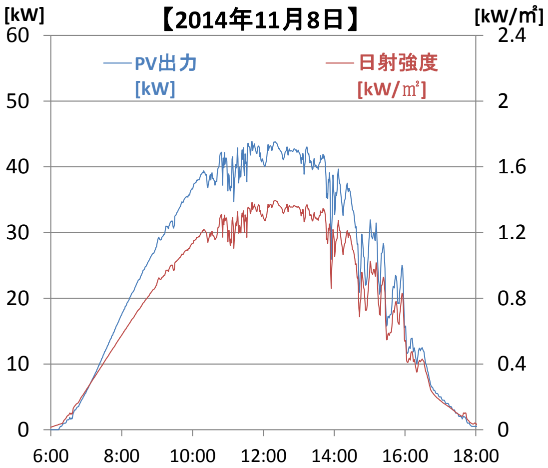
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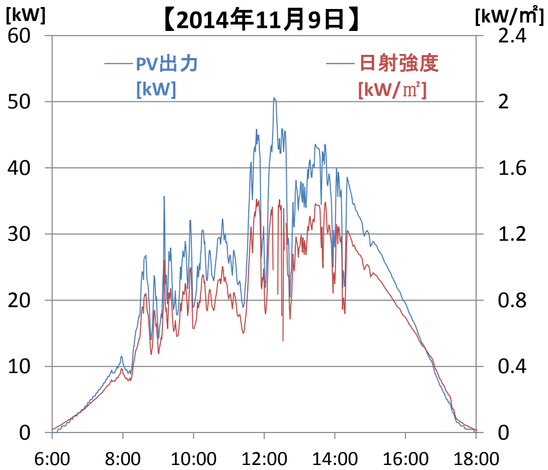
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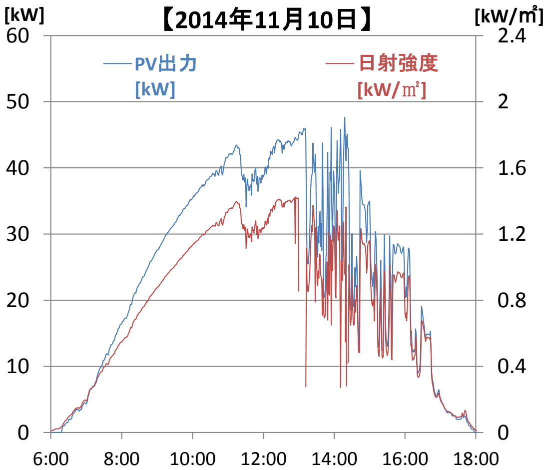
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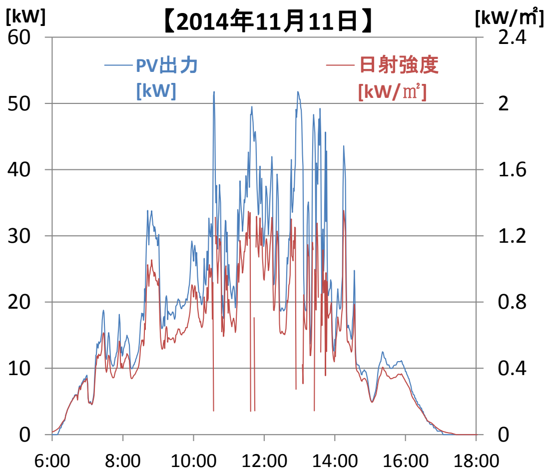
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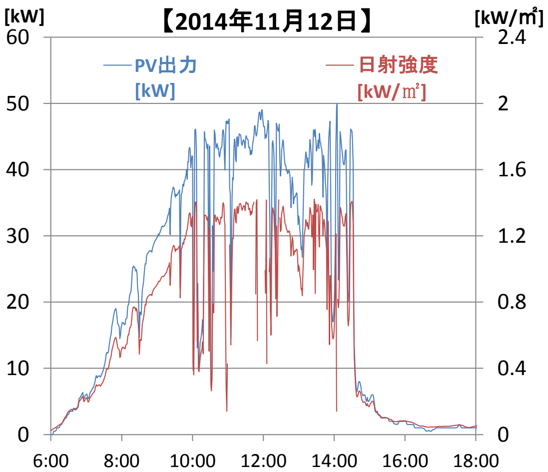
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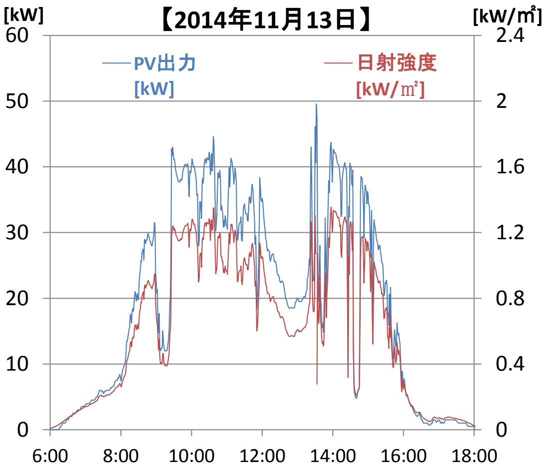
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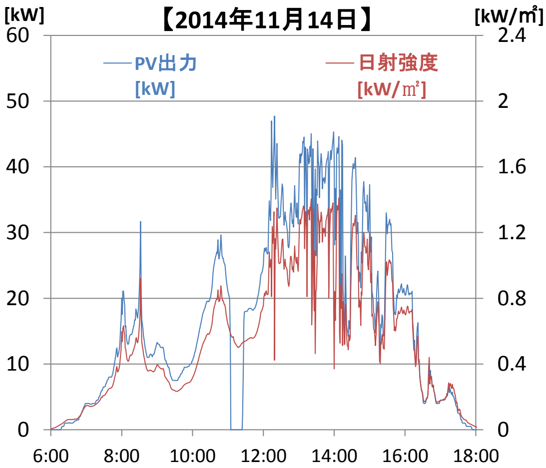
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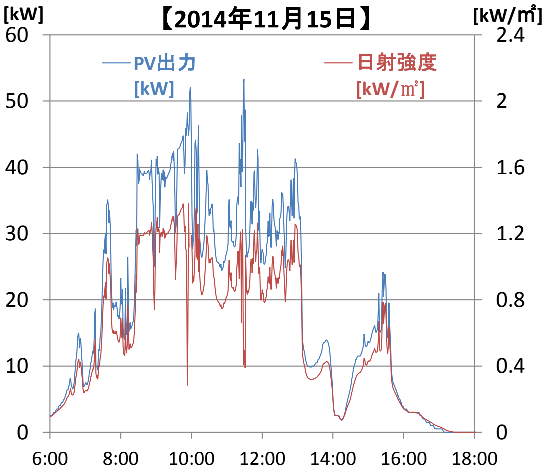
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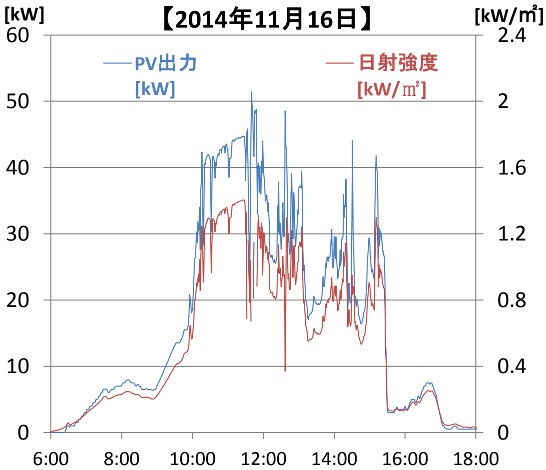
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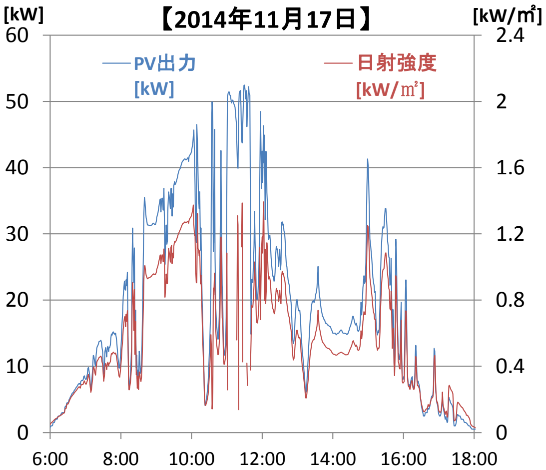
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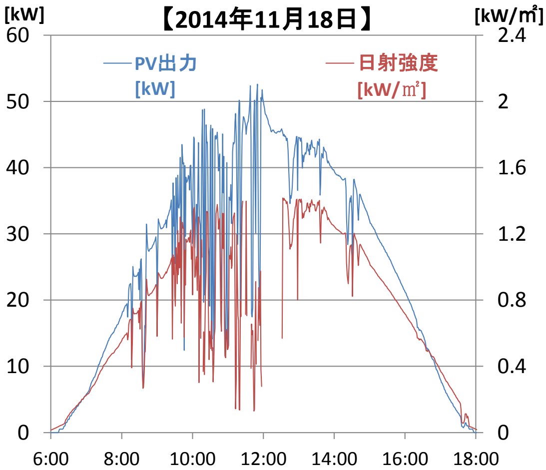
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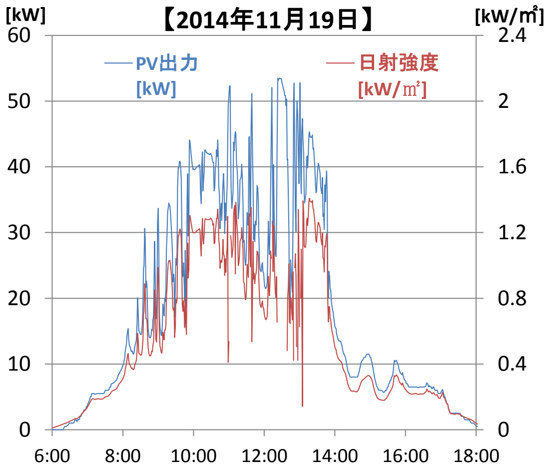
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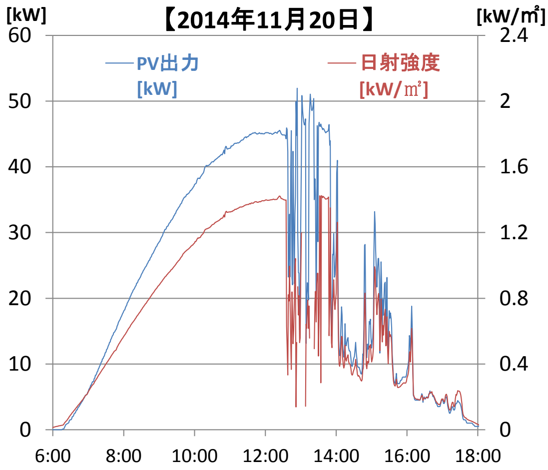
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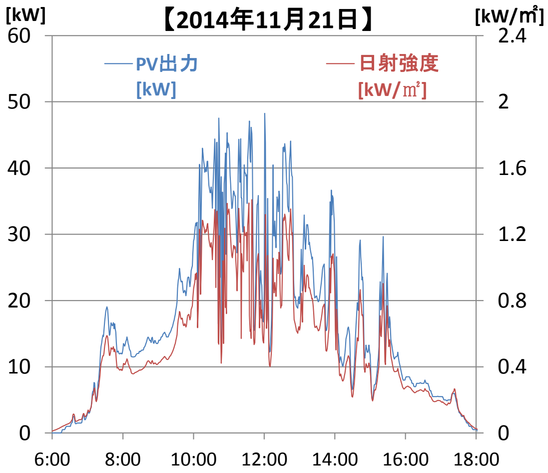
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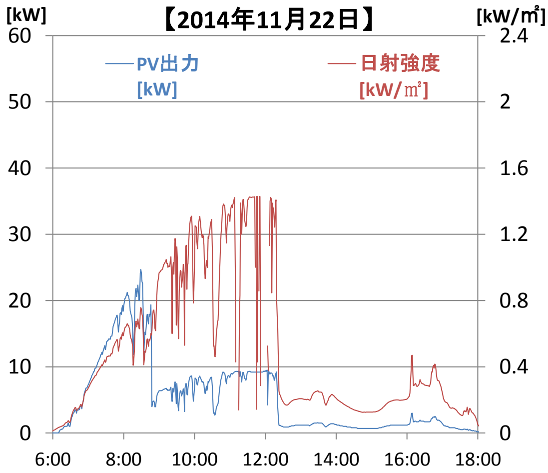
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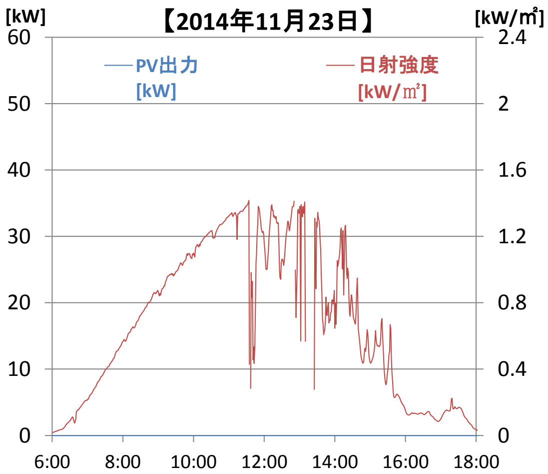
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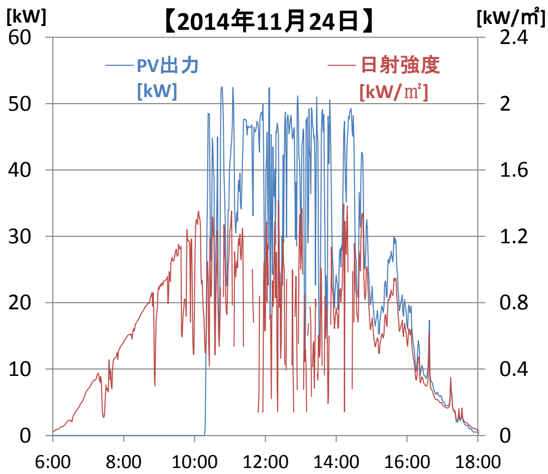
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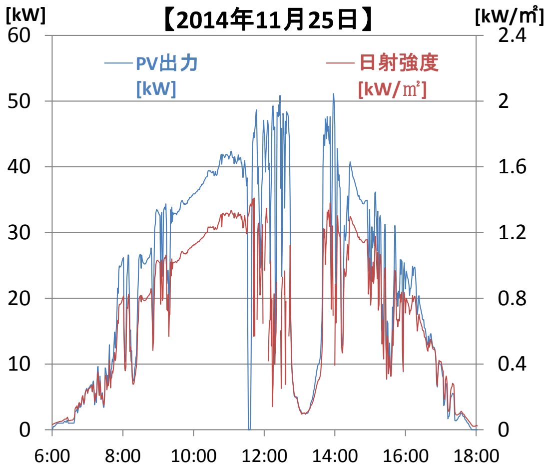
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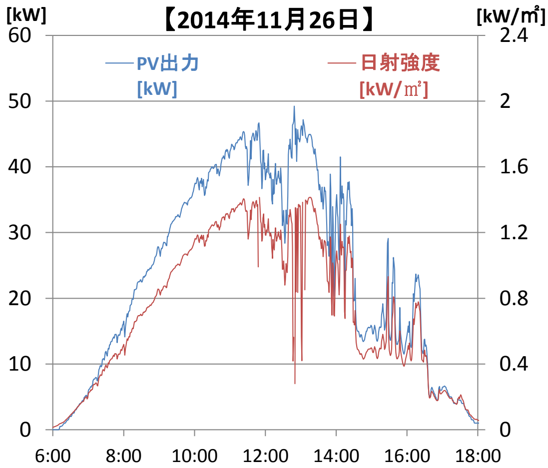
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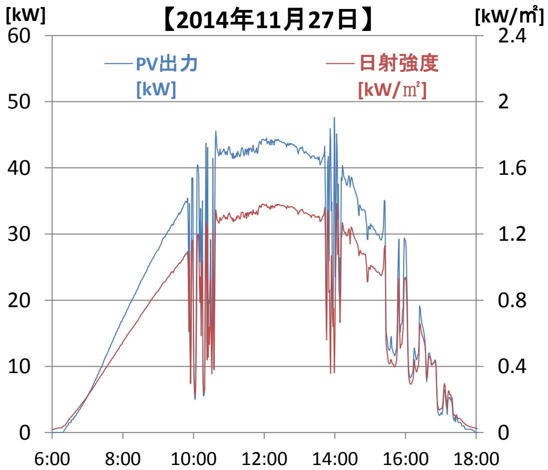
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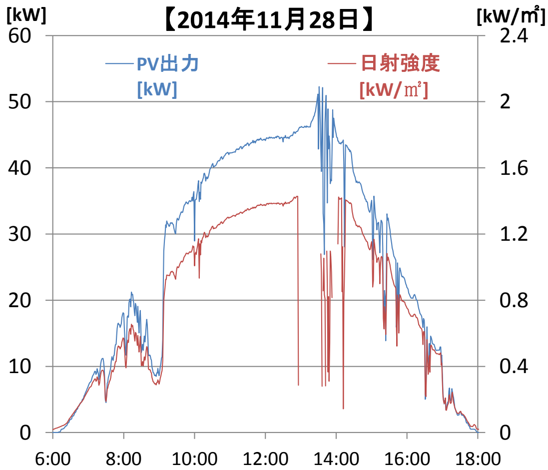
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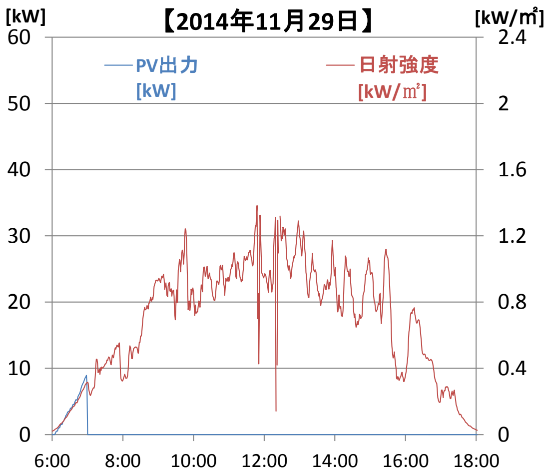
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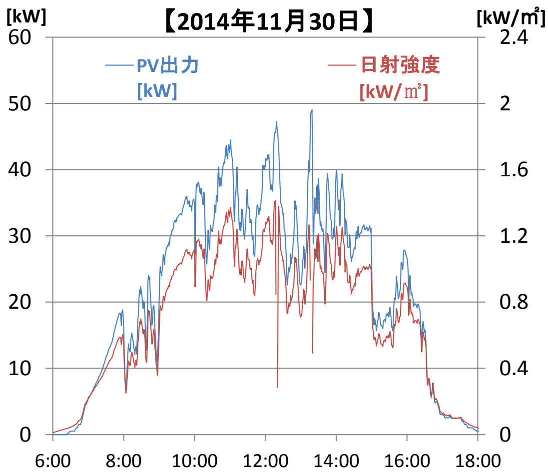
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Solomon Islands Electricity Authority

Solar System Connection Manual

Policies, Processes and Forms

This manual is intended for the guidance of SIEA's Customer Service and Engineering personnel who are involved in receiving, considering and approving the connection of solar systems to the SIEA grid.

Contents

Solomon Islands Electricity Authority

Solar PV Arrangements

Technical Arrangements for Grid Connection of Photovoltaic Systems via Inverters

This document explains the technical requirements to connect a photovoltaic (PV) inverter system to the supply system (the grid) of the Solomon Islands Electricity Authority (SIEA).

Contents

1 Introduction
This document explains the technical requirements to connect a photovoltaic (PV) inverter system to the supply system (the grid) of the Solomon Islands Electricity Authority (herein referred to as SIEA).

The PV inverter system will usually consist of a photovoltaic array on the roof of the building and a suitable grid-connect inverter connected to the metering box. This arrangement allows solar energy to be supplied to meet the customer's installation load and be backed up by the SIEA electricity grid at night and during bad weather.

The guidelines are broken into the following sections:

- Section 2: Describes the situations this document applies to.
- Section 3: Lists the technical requirements that must be satisfied as part of the installation and ongoing operation of the PV inverter system.
- Section 4: Gives information on the metering arrangements.

This document is to be read in conjunction with the following document:

- SIEA, draft 2013, "*Electricity Connection and Metering Manual*", www.siea.com.sb, in particular Chapter 10: *METERING ARRANGEMENTS FOR INVERTER ENERGY SYSTEMS CONNECTED TO THE DISTRIBUTION NETWORK*.

Other related documents are:

- *Photovoltaic Inverter Network Connection Agreement* draft 2013
- *Going Solar? The process of installing a photovoltaic (PV) system in your home*

2 Scope
These technical requirements are limited to the following situations:

- Inverter energy systems that have a continuous rating of no more than 10kVA for single-phase systems or 30kVA for three-phase systems.
- Connections to the SIEA grid only.
- Systems without battery storage, although these can be considered for special applications.

3 Installation Requirements
This section details the technical requirements to connect a photovoltaic inverter system to the SIEA grid.

3.1 General
These requirements are valid for the following network voltages and maximum power generation capacities (continuous rating):

Voltage	Maximum Capacity
230V single-phase	10kVA
400 V three-phase	30kVA

Higher rated installations may be allowed, but will require a special agreement with SIEA.

3.2 Australian Standards

These requirements pertain to SIEA specific matters. The installation should as a minimum comply with Australian Standards AS3000, AS4777 and AS5033 and all other relevant Australian Standards and Solomon Islands statutory requirements. Installations are exempted from complying with these standards only where stated (for example some clauses of AS4777.1).

The inverter to be used shall be of a model that has passed testing in accordance with the Australian Standard AS4777 guidelines. For a list of approved inverters see the website of the Australian Clean Energy Council, and follow the link to the 'Approved PV Inverters' (www.cleanenergycouncil.org.au)

3.3 Safety

In the event of loss of network supply, the PV inverter system shall be designed to disconnect from the network via its on-board protection systems. Under certain undesirable circumstances, it is possible that PV Inverter systems could continue to provide energy to the network, resulting in a hazardous situation. This situation is known as "islanding" and the Australian Standards are designed to prevent this from occurring.

3.3.1 Applicable Equipment

The permission to operate the installation is restricted to the equipment listed on the application form and approved by SIEA. The installation shall not have settings changed from those approved, or be upgraded, or be replaced, or be modified or be tampered with in any way. Systems found to be operating in such a manner will be disconnected from the grid until the matter is resolved.

Should it be necessary to change any parameter of the equipment as installed and contracted, SIEA shall be notified for re-approval. Subsequently SIEA will determine whether a new application is required.

3.3.2 Competent Designer

The PV Inverter system must be designed or approved by a person competent in this field prior to lodging an application with SIEA. For a list of approved designers/suppliers, see the website of the Australian Clean Energy Council (www.cleanenergycouncil.org.au)

3.3.3 Operating Personnel - Operation and Maintenance

The customer is responsible for the operation and maintenance of the PV inverter system. Adequately qualified and licensed persons must carry out all work.

The customer shall maintain the PV Inverter system to Australian Standard AS5033 and AS4777. Equipment directly involved with protecting and controlling the connection to the electricity system must be maintained to the equipment manufacturer's specification or the installer’s recommendation.

3.3.4 Installation and Inspections

Installations may be routinely inspected by SIEA once construction is completed.

An SI licensed electrician/electrical contractor shall carry out all installation and maintenance work.

3.3.5 Logbooks

For safety reasons all customers are required to maintain a logbook detailing inspections and operating activities. This log is an important document and it must be kept in a secure place (typically in the meter box) and be available for inspection by SIEA staff.

Further, any change/modifications done in the PV system will need a Certificate of Compliance. An example of logbook pages is shown below.

INVERTER	**Make/Model:**	**Serial No.**	**Rating: W**
Service provider		**Service details**	**Date**

PV PANELS	**Make/Model:**	**Serial No.**	**Rating: W**
Service provider		**Service details**	**Date**

3.4 Signage

Care must be taken to label switchboards and relevant equipment as per the Australian Standards.

3.4.1 Signage for Type 1 Connections

Main switchboard and distribution board(s).

Quantity: 1
Lettering height:
"WARNING" 8mm
Other text 4mm
Colour: Red, white letters
Size: 120 x 60 mm

WARNING
DUAL SUPPLY
ISOLATE NORMAL SUPPLY TO THIS SWITCHBOARD AND "*SOLAR*" SUPPLY AT MAIN METER BOX BEFORE WORKING ON THIS SWITCHBOARD

Main meter box where the private generation plant is connected.

Quantity: 1
Lettering height:
"WARNING" 8mm
other text 4mm
Colour: Red, white letters
Size: 120 x 60 mm

WARNING
DUAL SUPPLY
ISOLATE BOTH SERVICE FUSES AND "*SOLAR*" SUPPLY BEFORE WORKING ON THIS METER BOX

3.4.2 Signage for Type 2 Connections

Consumer switchboard or distribution boards connected to Solar Meter Box where private generation plant is connected.

Quantity: 1
Lettering height:
"WARNING" 8mm
other text 4mm
Colour: Red, white letters
Size: 120 x 60 mm

WARNING
DUAL SUPPLY
ISOLATE BOTH NORMAL AND *SOLAR*
SUPPLIES BEFORE WORKING ON THIS
SWITCHBOARD

Main switchboard and distribution board(s) upstream of distribution board connected to Solar Meter Box where the private generation plant is connected.

Quantity: 1
Lettering height:
"WARNING" 8mm
other text 4mm
Colour: Red, white letters
Size: 120 x 60 mm

WARNING
DUAL SUPPLY
ISOLATE BOTH NORMAL AND *SOLAR*
SUPPLIES BEFORE WORKING ON THIS
SWITCHBOARD

Solar meter box where the private generation is connected.

Quantity: 1
Lettering height:
"WARNING" 8mm
other text 4mm
Colour: Red, white letters
Size: 120 x 60 mm

WARNING
DUAL SUPPLY
ISOLATE BOTH NORMAL AND "*SOLAR*"
SUPPLIES BEFORE WORKING ON THIS
METER BOX

Main Meter Box

Quantity: 1
Lettering height:
"WARNING" 8mm
other text 4mm
Colour: Red, white letters
Size: 120 x 60 mm

WARNING
DUAL SUPPLY
ISOLATE BOTH SERVICE FUSES TO
THIS METER BOX AND *SOLAR* SUPPLY
AT *SOLAR* METER BOX BEFORE
WORKING ON THIS METER BOX

3.5 Protection Arrangements and Settings

SIEA requires protection equipment to achieve the following safety objectives:

- to disconnect the inverter from the SIEA system in the event of loss of SIEA supply to the installation; and
- to prevent the inverter from back-energising a de-energised SIEA circuit.

The protection arrangements should be as per AS4777 guidelines. The following specific voltage and frequency settings must be programmed into the inverter. **Note** These settings may need to be changed in "off the shelf" inverters.

For a single-phase system:

- Maximum voltage trip point will be 255V phase to neutral;
- Minimum voltage trip point will be 210V phase to neutral;
- FreqMAX will be 54Hz; and
- FreqMIN will be 46Hz.

For a three-phase system:

- Maximum voltage trip point will be 440V phase to phase;
- Minimum voltage trip point will be 370V phase to phase;
- FreqMAX will be 54Hz; and
- FreqMIN will be 46Hz.

In addition to any protection integrated into the inverter design, short circuit and/or over-current protection must be provided by fuses or circuit breakers. This back up over-current protection function can be provided by the metering fuses or by a circuit breaker located at the connection point of the inverter within the meter box.

All protection settings shall be such that satisfactory coordination is achieved with SIEA's protective system for the network.

In certain circumstances, SIEA may require the new exported energy to be limited to a specified amount. Any such limit will be advised to the Customer before a Network Connection Agreement is signed.

3.6 Surge Protection

The SIEA supply system may experience surges during such storms and at other times. The inverter contains many electronic parts and is directly connected to the SIEA supply system and may not be able to cope successfully with the surges. The inverter is also directly connected to the PV panels. Being usually mounted on top of the roof, these are directly exposed to the elements and storms and provide an alternative path for surges.

It is the customer's responsibility to include sufficient surge protection for the PV Inverter system. In case of failure of the PV Inverter system, SIEA shall not be liable in any way.

4 Network Connection Types and Metering Arrangements

This section details the types of connection arrangement which enable SIEA to meter the net electrical energy that SIEA supplies to the customer. Billing arrangements are detailed in the Network Connection Agreement.

The customer will meet the cost of installing the additional metering and any modifications to the existing metering arrangement. The meters will remain the property of SIEA.

The customer's licensed contractor will complete the wiring for the meter. When the work is complete and certified, SIEA will install and commission the meter and connect the PV system to the SIEA Grid.

Replacement of an existing Meter Panel containing Asbestos:

For all PV installations, if the existing meter panel contains asbestos, the panel must be replaced with a meter panel without asbestos before any work on the panel.

Replacement of the Meter Panel:

There may not be enough space on the existing meter panel for the additional meter. In this case, the customer shall provide and meet the cost of an additional meter box or relocation of fuses/circuit breakers within the existing meter box to accommodate the new meter.

4.1 Standard (Type 1) scenario

In this scenario, the inverter generation cable is connected at the existing meter box. All energy consumed from the grid at the premises will be metered by an import-only meter and billed to the customer under the applicable tariff(s). It is only any 'excess' energy will be exported to the SIEA grid. This energy will be metered, but will NOT be paid for by SIEA. This is a "*net metering*' scheme as shown in Figure 1.

This dual element (dual register) meter must be installed before any grid connection is made with a new PV array.

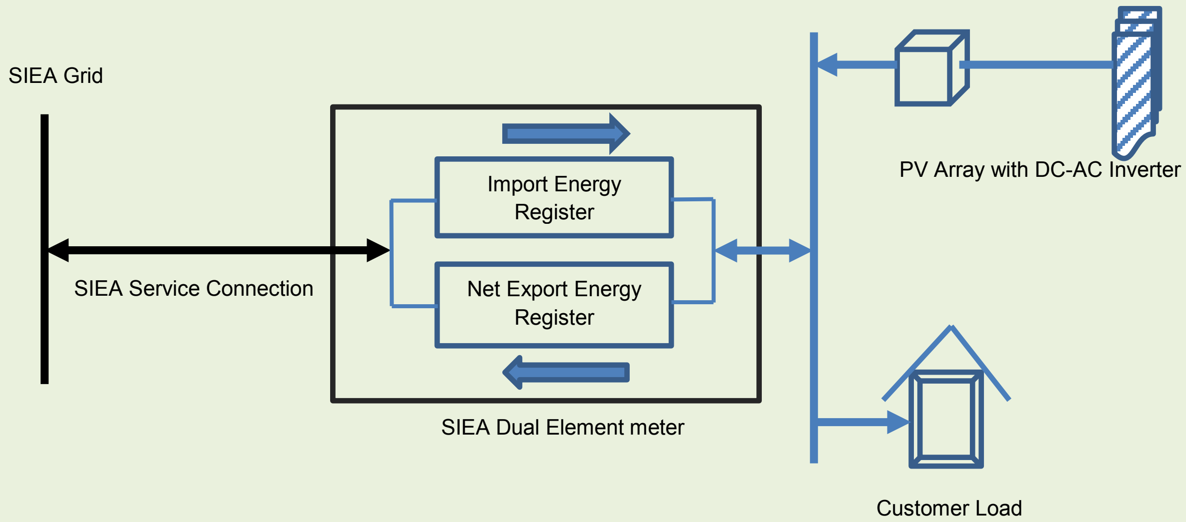


Figure 1 - Schematic Type 1 Single-Phase Metering; Dual-Element Meter

4.1.1 Single-phase customers with single phase PV

The customer must make a provision for installation of a single-phase, bottom-connect, dual-element meter; element 1 for energy consumed from the grid and element 2 for net energy supplied back into the SIEA grid.

4.1.2 three-phase customers with single-phase or three-phase PV

The customer must make provision for installation of a dual register three-phase, bottom connect meter for “energy supplied from the grid” metering and for “net energy exported” metering.

If the existing metering arrangement consists of three single-phase meters, they will be replaced by a single dual register three-phase meter (upgrade) with one element for the “energy supplied from the grid” metering, and one element for the “net energy exported” metering.

Connection Essentials for Designers/Installers

With the increasing popularity of solar photovoltaic (PV) systems, SIEA is keen to work closely with the solar PV industry to manage impacts to customers and SIEA's network. As an installer or electrical contractor in the solar PV industry, you play an important role in guiding our customers through the purchase, installation and connection process.

Lodging an application to connect a solar PV system

All Inverter Energy Systems (IES) systems **must be approved by SIEA before installation**. We ask that you ensure your customers are aware of this requirement.

To begin, you'll need to submit a completed *Application for network Connection of a grid-connected solar array* form to SIEA. However, if you're planning to install a solar PV system larger than 5kW in size, you'll need to make your enquiries directly with SIEA engineering.

Please ensure you submit the fully filled-in form to SIEA. Incorrect forms will not be considered and a new application will be required. Installers submitting applications on behalf of customers must ensure they have the customer's consent or the application will not be considered.

Assessing applications

SIEA will conduct a preliminary evaluation of the application based on the size of inverter and the nature of the local network serving the premises. A technical assessment will be required to check for any potential adverse impacts to the network, the customer's premises, or their neighbours' premises.

SIEA may require up to five weeks to technically assessing applications for systems that require connection to the Honiara network or to an outstation network. Ask SIEA for the *Outline of Solar Assessment criteria* document. Find out more from SIEA's *Outline of Technical Assessment Criteria* document.

Approving, downsizing or declining applications

Applications may be downsized or declined if:

- The transformer serving the premises is too small to support the volume of electricity that could be generated by the system
- The connection is a relatively long distance away from the transformer, which may cause significant voltage fluctuations
- There are already a number of solar PV system connections that share the same transformer. This may even be the case if there is only one other solar PV system.

If the application is downsized or declined, customers can re-apply for an inverter up to a maximum size we advise, withdraw their application or explore alternative options to:

- Install a small-scale system with an inverter of a lower capacity
- Upgrade the number of phases to the premises to accommodate the desired inverter size
- Pay for an upgrade to the network to accommodate the inverter originally requested.

If no adverse impacts are identified, SIEA will approve the solar PV system connection and send the customer two copies of an IES Network Agreement. For details on the terms and conditions of connecting to the SIEA network under this agreement, look at the *Solar Network Agreement* form.

Installing and connecting solar PV systems

Once the application has been approved and the customer has returned the IES Agreement, you can proceed to install the customer's solar PV system.

As an installer, you are responsible for ensuring the system and equipment installed at the customer's premises complies with:

- Australian Standard AS/NZS 3000:2007 - SAA Wiring Rules;
- Australian Standard AS/NZS 4777:2005 Grid Connection of Energy Systems;

  Note*:* Voltage ranges in inverters are generally factory-set to AS4777 standards. However, SIEA requires a narrower voltage range of 225V to 255V (240V +/-6%). Inverters must be set to this range in order to comply with the terms of the SIEA IES Network Agreement.

- Any other applicable Australian Standards, current as at the date of installation; and
- The relevant requirements of the *SIEA Electricity Connection and Metering Manual.*

If the customer has been approved to install a three-phase inverter system, then the output power must be distributed evenly across the three phases (unless indicated otherwise). Accordingly, if approved for a two-phase inverter system, the output power must be distributed evenly across two phases (unless indicated otherwise).

After connection, you'll need to submit Form A to SIEA requesting a meter change.

Resolving non-compliance

If SIEA receives a Form A for a system we have not approved, we will contact the customer to arrange completion of an application and conduct an assessment of the application before the connection can be approved and an appropriate meter installed.

If the inverter installed is of a different capacity to what has been approved in the application, SIEA may not be able to install the required meter. If a different inverter is required, please check with us to ensure the inverter is compliant with the customer's IES Network Agreement.

Non-compliance with SIEA's requirements may generate a Fault Notice to the customer to rectify any issues, and the new meter may not be installed. In addition, if SIEA deems the electrical installation to have a major defect, a Fault Notice will be raised and the premises may be disconnected. A Fault Notice may also be raised for minor defects. If we identify any adverse impacts to the network, the system may need to be disconnected until alternative solutions are explored. In some cases, the connection application may be declined.

Solar PV Connection Process

Solar PV systems, along with wind and hydro systems for example, are collectively referred to as Inverter Energy Systems (IES). When connected to the network, these systems can supply your power needs, and feed electricity back onto the grid.

Follow these simple steps to purchasing and connecting your solar PV system:

1. Choose the right system for your needs

If you're looking to install a solar PV system at your home, you'll need to contact a supplier to find a system that suits your needs.

2. Lodge an application to connect your system

Before having your solar PV system installed, you will need to secure approval from SIEA for your system to be installed and connected to the grid.

To begin, you'll need to submit an *Application for Network Connection of an Inverter Energy System* to SIEA.

This application process only applies to systems under 10kW in size. Applications for systems larger than 30kW must be made through SIEA directly

While the application is usually made by your system retailer or installer, as the electricity account holder you must provide your consent. Forms must be completed in full as relevant. Incomplete forms may be rejected.

3. Assess application

SIEA will conduct a preliminary evaluation of your application based on the size of inverter and the nature of the local network serving the premises. A technical assessment may be required to check for any potential adverse impacts to the network, your premises, or your neighbours' premises.

SIEA may require up to five weeks to technically assessing applications for systems that require connection to an SIEA isolated generation system in Honiara or in a remote area or community.

Find out more about SIEA's assessment on *Outline of Solar Assessment Criteria*.

4. Approve, downsize or decline application

SIEA will downsize or decline an application if it presents risks to the network or to individual premises. In some areas, even a small number of solar PV systems in the same area or a single large system could impact on the local electricity network.

Find out more about your options if your system application is downsized or declined.

If no adverse impacts are identified SIEA will approve the connection of your solar PV system and issue two copies of an *IES Network Agreement*. For details on the terms and conditions of connecting to the SIEA network under this agreement, view a sample IES Network Agreement.

This agreement outlines the terms and conditions for the connection of the solar PV system to the SIEA distribution network. It is a legally binding agreement between SIEA and the electricity account holder/s. Please read the terms and conditions carefully and seek legal advice where necessary.

You will need to sign both copies of the IES Agreement front page and return one to SIEA. You will then be free to arrange installation.

5. Install and connect the solar PV system

Once you have returned your IES Agreement, your system can be installed, and connected to the grid by an electrical contractor. Most installers are also electrical contractors.

SIEA strongly encourages the use of an installer accredited with the Australian Clean Energy Council or equivalent.

6. Request to connect electricity meter

Your installer or electrical contractor will notify SIEA of the new solar PV system connection and lodge a request for an appropriate electricity meter to be installed at your premises.

SIEA will endeavour to install new meters as quickly as possible. However, there may be delays in installing new meters in some areas.

7. Install electricity meter

To complete the process, SIEA will inspect your new solar PV system connection and install the appropriate electricity meter.

This meter allows SIEA to measure how much electricity you draw in from the grid and how much your solar PV system exports into the grid. **NOTE**: SIEA does not purchase any exported energy.

Your electricity meter will not measure the total amount of electricity generated by your solar PV system.

SIEA will then alter your Electricity Account as per the Network Agreement.

Application for Grid Connection of Solar Array

This form is to be completed and delivered to SIEA Head Office at Ranadi.
NOTE: All fields in Parts 1, 2 and 3 must be completed. Incomplete forms may be rejected.

PART 1: APPLICANT	
Name: *(As per electricity account – individual/s or company*	
Contact Person: *(if different to above)*	**Phone No:**
Address of proposed generation system:	**Postal address:** *(write 'as on left' if relevant)*
Email address:	
Registered Plan No: *(Found on rates notice)*	**Lot No:** *(found on rates notice)*
Upgrading existing approved system: ☐ No ☐ Yes, panels only ☐Yes, panels and inverter	
Is this a revised application for these premises? ☐ No ☐ Yes	

PART 2A: SYSTEM SALES CONSULTANT	
Name:	**Business name:**
Postal address:	
Email address:	**Phone No:**
PART 2B: ELECTRICAL CONTRACTOR/INSTALLER *(if different entities, list electrical contractor only)*	
Name:	**Phone No:**
Email address:	**Electrical Contractor No:**

PART 3 SYSTEM CHARACTERISTICS		
Type: ☐ Solar		
PV array/generator rated output (kW):	**Inverter rated AC power (kW):**	
Inverter brand:	**Inverter series:**	**Inverter model:**
No of phases of applicant's connection: ☐ Single ☐ Two ☐ Three ☐ Unsure		
Other aspects of applicant's electricity service of potential relevance to technical assessment, *e.g. length and size of consumer and service mains, approximate distance to nearest transformer, etc.:*		

NOTES:
1. Network approval must be obtained before installation.
2. Inverter maximum voltage trip point must be set to 255V (single phase) or 440V (three phase). Failure to adhere may lead to disconnection of the inverter energy system.
3. If the proposed inverter is not on the list of inverters compliant with AS4777: Grid Connection of Energy Systems Using Inverters published at www.solaraccreditation.com.au, compliance evidence must be supplied with this application.

All Applicants' signatures:

____

PART 4 INSPECTION DETAILS (TO BE COMPLETED BY SIEA)		
System compliant: ☐ Yes ☐ No	**Examination report Fault Notice No:**	**Connection Date:**
Name of SIEA assessment officer: *(print)*	**Signature:**	

PART 5: STANDBY CHARGE FEE

The amount of this standby charge will be calculated in terms of the Electricity Act. The relevant extract is shown in Appendix 1. The key calculation is that of estimating the "value of electricity that would have been consumed had the standby plant not been operated".

SIEA will then apply a charge based on up to 50% of this estimate. The value of electricity that needs to be calculated under the Regulation will be based on an estimation of the daily output from a modern solar system, and then relating this to the rating of the solar system. The expected kWh power production from a solar PV array in the high tropics can be expected to be 4.4 times the kW rating of the system (*Australian Clean Energy Council for Darwin City).* The kW rating of a solar system is defined by the kW rating of the inverter, so the kWh output can be estimated as 4.4 times the kW rating of the inverter.

As an example for a 4kW solar system, SIEA would then apply a daily standby charge:
Daily Standby Charge = 50% of [$4.4 x (4kW inverter rating) x (SIEA Domestic or Commercial Tariff)]

Connection Type	Act req 50%	kW rating in Times	Inverter Rating (kW)	Rates- Tariff	Daily Standby Charge=
Domestic Customer	50%	4.4	4	6.4685	$56.92
Commercial Customer	50%	4.4	4	6.9530	$61.19
Industrial Customer	50%	4.4	4	6.7719	$59.59

PART 6: AUTHORISATION FOR THIRD PARTY TO LIAISE WITH SIEA

If you wish to authorise any representative of your system sales company or your electrical contractor/installer (one of the parties listed on this form), to liaise on your behalf with SIEA during the course of the Solar Grid Connect System application and connection process, please complete this section.

Your authorisation will allow that person to:

- Contact SIEA to enquire, and be provided with information, regarding the status of your application and/or meter installation.

However, SIEA will at no time divulge any personal or account information to this third party. That party will not Receive copies of correspondence sent to you. Only basic information related to the Solar Grid Connect System application and approval will be released to the person or company listed below. The first page of this Application and the Solar Grid Connect System Network Agreement Forms applicants receive must still be signed by the electricity account holder/s.

I/We (all applicants listed as electricity account holder/s) ____

hereby provide permission for (name, if you wish to specify a single person) ____________________________

of (company) ____

To liaise with SIEA on my/our behalf with regard to my/our Solar Grid Connect System application and connection. I/We understand that once the new meter is installed; or upon advising SIEA in writing of a change of system sales company or electrical contractor/installer; or upon withdrawal, in writing, of this application, this permission ceases immediately.

Signed (all applicants) ____

Date ____ / ____ / ____

Privacy Notice
SIEA is collecting your personal information on this form for the purpose of assessing your Application for Network Connection of Solar Grid Connect System (IES). If you do not provide all of the information requested we will not be able to assess your application. Your personal information will not be disclosed to third parties unless you consent or it is authorised or required by law.

Inverter Energy System Network Agreement Form

Deliver to SIEA at its Head Office Ranadi when signed by all account holders	
CUSTOMER DETAILS	
Name: *(Electricity account holder – individual or company)* *("you" or "your")*	
Postal address:	
Address of proposed generation system: *(Write 'As above' if relevant)*	
Type: ☐ **Solar**	
Contact person: *(If different to name above)*	
Email address:	
Phone No: **Fax No:** **Mobile:**	
Registered Plan No: *(Found on rates notice)*	
Lot No: *(Found on rates notice)*	
SIEA DETAILS	
Name: *("we", "our" or "us")*	
Postal address:	
Contact person:	
Email address:	
Phone No: **Fax No: :** **Mobile:**	
GENERAL DETAILS	
Start date – The date the IES is installed at your Premises and capable of exporting energy to the Network. **Expiry date –** When this Agreement is terminated under clause 4. **IES Exported Energy –** You must ensure that the IES meets the following requirements: • Inverter rated output _______________kW • The maximum voltage variation measured at the point of connection to the Network will be: 240V+/- 6%	
ACCEPTANCE BY THE CUSTOMER	
Executed by the Customer (or an authorised representative if the Customer is a company).	
PRINT NAME	**POSITION** *(COMPANIES ONLY)*
SIGNATURE	**DATE**
ACCEPTANCE BY SIEA	
Executed for and on behalf of SIEA by its authorised representative.	
SIGNATURE	**DATE**
PRINT NAME	**POSITION**

1 PARTIES

This contract is between:

(a) SIEA (in this contract referred to as “we”, “our” or “us”); and
(b) you, the customer to whom this contract is expressed to apply (in this contract referred to as “you” or “your”).

2 DEFINITIONS AND INTERPRETATION

The definitions of capitalised terms are given in Schedule 1 of this Agreement

3 DO THESE TERMS AND CONDITIONS APPLY TO YOU?

This agreement applies to you if an IES is installed at your Premises that can, at times, result in electrical energy being exported to our Supply Network.
This Agreement applies in addition to the Connection Contract between you and us. Nothing in this Agreement affects your or our rights and obligations under the Connection Contract between you and us.

4 WHAT IS THE TERM OF THIS CONTRACT?

This Agreement takes effect from:

(a) if you install the IES, the date the IES is installed at your Premises and becomes capable of exporting energy to our Supply Network; or
(b) if you move into Premises where an IES is installed and is capable of exporting energy to our Supply Network, the date you move into the Premises.

This Agreement may be terminated:

(a) at any time at your request, by notifying us that the IES is no longer connected at the Premises;
(b) at the time that the Connection Contract between you and us, or your contract with your Electricity Retailer is terminated; or
(c) by us at any time if you fail to comply with the terms and condition of this Agreement or if you fail to remedy any situation where the IES represents a hazard or risk to our Supply Network, our officers and agents or the general public.

Where a breach of this Agreement is considered by us to be capable of being remedied, we may allow a reasonable amount of time for you to take measures necessary to eliminate, to our satisfaction, the matters identified.

If this Agreement is terminated, you must ensure that the IES is no longer capable of exporting energy to our Supply Network.

5 CONDITIONS FOR IES EXPORTING ENERGY TO OUR SUPPLY NETWORK

5.1 Consent for exportation of energy to our Supply Network

We consent to allow the connection of an IES at your Premises that is capable of exporting energy at times to our Supply Network on and subject to the terms of this Agreement.

5.2 Conditions of Consent

Our consent under this Agreement is at all times conditional upon:

(a) the IES complying with the “Technical Conditions for the Connection of Small Scale Photovoltaic Inverter Energy Systems” (Schedule 2);
(b) the IES complying with all relevant Australian Standards and Regulations; and
(c) you complying with the terms and conditions of this Agreement.

5.3 Discretion to specify additional conditions

We retain a right in our discretion to specify additional requirements for an IES system. In exercising our discretion we will consider the conditions of the specific network that the IES is connected to.

5.4 Design, Installation and Testing

You must:

(a) engage an Accredited Installer (full or provisional) for design and installation of the IES as specified on the Clean Energy Council website: **www.cleanenergycouncil.org.au** under 'Accreditation'; and

(b) consent to us, our officers and agents entering the Premises at any reasonable time and date to test the IES for the purpose of establishing that the IES and the installation complies with this Agreement.

You acknowledge that we are not responsible for ensuring that you comply with the relevant standards.

5.5 Operating Procedure

You must comply with any request from us for the IES to be taken off-line and disconnected for operational reasons or for planned maintenance.

In the event that our Supply Network is unable to accept energy generated by you for any reason, no compensation will be payable by us.

5.6 Request to cease energy export

We may request that you cease to export energy to our Supply Network if:

(a) exportation would result in a breach of technical or safety requirements under the Act, the Electrical Safety Act or this Agreement;

(b) exportation would unreasonably interfere with the connection or Supply of electricity to other users of the network;

(c) it is required to do so under any applicable law.

Such a request to cease exporting energy will be in writing to the customer. Other than for safety requirements, you are required to comply with this request within three business days. Where a safety risk is determined, you must comply with the request immediately. If you do not action such a request within the appropriate timeframe, we may disconnect you pursuant to our rights under the Connection Contract between you and us.

This clause does not alter any rights or obligations for disconnection of the premises under the Electricity Act. For the avoidance of doubt, we have rights and/or obligations for disconnection under the Electricity Act regulations.

6 METERING

You acknowledge that electricity metering relevant to the IES at the Premises is owned by us, will be installed in compliance with the "DNSP Metering Manual", and will be operated by us. We will have the discretion to determine the meter type.

You must supply us with safe access to allow us to install, test, maintain or remove the meter installation of the IES.

You consent to us, our officers and agents entering the Premises for the purposes of installing, testing, reading, maintaining or removing the meter installation.

7 SAFETY

You must:

(a) install and maintain the IES and associated equipment in safe working order at all times and in accordance with the requirements of this Agreement;
(b) have an IES isolation procedure displayed prominently and effectively secured at the main switchboard and keep a copy of the IES operations manual in or near the main switchboard at all times;
(c) comply with our reasonable directions in order to secure the safety and stable parallel operation of our Supply Network and the IES; and
(a) comply with the requirements of the Electricity Act, the Safety at Work Act, and Electricity Regulations for the installation, inspection, operation and maintenance of the IES.

8 MAINTENANCE

You must:

(b) ensure the IES is inspected and maintained in accordance with the manufacturer's recommendations by an appropriately qualified person;
(c) where there are no manufacturer's recommendations, ensure inspection and condition based maintenance is performed by an appropriately qualified person;
(d) provide, at our request, the results of any inspections carried out in accordance with the requirements of this Agreement; and
(a) ensure that any component of the IES replaced during maintenance is compliant with the requirements of this Agreement.

9 YOUR OBLIGATIONS

In return for our consent to export energy to our Supply Network, you agree to:

(b) pay all of our costs associated with any system reinforcement, system modification, additional protection and control equipment required to accommodate the IES;
(c) not mislead or deceive us in relation to any information provided;
(d) undertake, if necessary, any changes to the wiring at the Premises necessary for the installation of our metering equipment;
(e) advise us of any proposed material operational changes of the IES, including the installation of any additional IES;
(f) obtain our prior consent in writing to any material increase in capacity of the IES prior to any such increase;
(e) maintain the IES in accordance with Section 8 of this Agreement;
(g) advise any subsequent occupant of the Premises of the existence of this Agreement and the requirement for the new occupant to enter into a new Agreement with us; and
(h) consent to us, our officers and agents entering the Premises at any reasonable time and date to test or inspect the IES for the purpose of establishing that the IES and the installation complies with this Agreement; and

10 ASSIGNMENT

You may not assign your rights or novate your obligations under this Agreement without the prior written consent of us, which will not be unreasonably withheld.

SCHEDULE 1

GENERAL TERMS AND CONDITIONS

1 DEFINITIONS AND INTERPRETATION

1.1 Definitions

In this Agreement:

"**Accredited Installer**" means a person who has demonstrated their competence to design and install renewable energy systems and holds appropriate accreditation as acknowledgement of their competence.
"**Act**" means the Electricity Act.
"**Agreement**" means this Inverter Energy System Network Agreement.
"**Connection Contract**" has the meaning given in the Act.
"**Customer**" refers to the person (or persons) residing at the Premises where IES is installed.
"**Electrical Safety Act**" means the Electricity Act.
"**Electricity Industry Code**" means any Electricity Industry Codes made under the Act.
"**Electricity Regulations**" means the Electricity Regulations.
"**Export**" or "**Exported energy**" means the quantity of energy generated by the IES equipment and delivered to our Supply Network.
"**Inverter**" means a device that uses semiconductor devices to transfer power between a DC source or load and an AC source or load.
"**IES**" means an Inverter Energy System and represents a system comprising one or more inverters together with one or more energy sources (which may include batteries for energy storage), controls and one or more grid protection devices. In the context of this document, the energy source shall be a Photovoltaic Array.
"**Negotiated Connection Contract**" has the meaning given to that term in Electricity Act.
"**Photovoltaic Array**" or "**PV**" means an electrically integrated assembly of PV modules, and other necessary components, to form a DC power supply unit. A PV array may consist of a single PV module, a single PV string, or several parallel-connected strings, or several parallel-connected PV sub-arrays and their associated electrical components.
"**Premises**" means the premises (as that term is defined in the Act), at which you propose to install the IES.
"**Standard Connection Contract**" has the meaning given to that term in the Electricity Act.
"**Supply**" means the supply of electricity from our Supply Network to the Premises.
"**Supply Network**" has the meaning given to that term in the Electricity Act.
"**WHS Act**" means the Safety At Work Act.

1.2 Interpretation

In this Agreement, unless the contrary intention appears:

(a) headings are for ease of reference only and do not affect the meaning of this Agreement;
(b) the singular includes the plural and vice versa, words importing a gender include other genders and words and expressions importing natural persons include partnerships, bodies corporate, associations, governments and governmental and local authorities and agencies;
(c) other grammatical forms of defined words or expressions have corresponding meanings;
(d) a reference to a clause, paragraph, schedule or annexure is a reference to a clause or paragraph of or schedule or annexure to this Agreement and a reference to this Agreement includes its recitals and any schedules and annexures;

(e) a reference to a document or agreement, including this Agreement includes a reference to that document or agreement as novated, altered or replaced from time to time; and

(f) a reference to a party includes its executors, administrators, successors and permitted assigns.

2 GENERAL PROVISIONS

2.1 Inconsistency between clauses and schedules
If there is any inconsistency between a clause of this Agreement and the Schedules to this Agreement, then the clause of the Agreement will prevail.

2.2 Relationship with Connection Contract
This Agreement does not change the conditions of the Standard Connection Contract or Negotiated Connection Contract (whichever is applicable).

2.3 Effect of this Agreement
This Agreement covers the exporting of energy to our Supply Network only and does not relieve you of any obligations at law or the requirements of another authority in relation to the installation, operation or maintenance of the IES.

2.4 Joint and Several Liability
If you are more than one person:

(a) an obligation of those persons is joint and several; and
(b) a right of those persons is held by each of them severally.

2.5 Liability for Damage
You acknowledge that we will not be liable for any loss, damage or injury suffered or claimed by you or any other person that may occur or be attributable to the installation and operation of the IES at the Premises.

The parties acknowledge that you are responsible for any insurance costs associated with your obligations or possible liability under this Agreement.

SCHEDULE 2

TECHNICAL CONDITIONS FOR THE CONNECTION OF SMALL SCALE PHOTOVOLTAIC INVERTER ENERGY SYSTEMS

1 INTRODUCTION

The technical conditions hereafter refer to the mandatory requirements for the IES.

2 SCOPE

This Agreement covers installations up to a maximum of 30 kVA (3-phase) or 10 kVA (single phase) that may export electrical energy to our Supply Network regardless of the length of time that parallel operation would normally occur.

3 DESIGN AND INSTALLATION

The design and installation of the IES must comply with:

(a) AS 4777 – Grid Connection of Energy Systems via Inverters, Parts 1, 2 and 3;
(b) AS/NZS 3000 – SAA Wiring Rules;
(c) AS/NZS 3008 – Electrical installations—Selection of cables;
(d) AS/NZS 5033 - Installation of Photovoltaic (PV) Arrays;
(e) all other applicable Australian Standards/Codes of Practice, current as at the date of installation;
(f) the Technical Conditions as set out in this document;
(g) the SIEA Metering and Connection Manual.

4 METERING

The metering of the IES must:

(a) comply with the requirements of the Electricity Connection and Metering Manual; and
(b) be located adjacent to the existing revenue metering for the Premises.

5 GRID PROTECTION REQUIREMENTS

The IES output voltage, frequency and waveform must match that of our Supply Network such that any distortion of these parameters shall be within acceptable limits. There shall be no significant reduction in quality of Supply to other network users or risk of damage to apparatus belonging to other network users or us.

The Inverter protection elements must comply with AS 4777.3 “Grid Connection of Energy Systems via Inverters Part 3: Grid Protection Requirements” to ensure the following requirements are met:

(a) disconnection of the Inverter from our Supply Network in the event of a loss of Supply;
(b) to ensure the Inverter is operating within acceptable operating parameters;
(c) to prevent the Inverter from energising a de-energised circuit.

Passive protection arrangements shall comply with AS 4777.3 “Grid Connection of Energy Systems via Inverters Part 3: Grid Protection Requirements”.

In addition, the following specific voltage and frequency settings shall be programmed into the Inverter:

(a) Voltage: Maximum voltage trip point (Vmax) shall be 255V for a single phase system or 440V for a three phase system.
(b) Frequency:
    i. Minimum frequency trip point (Fmin) shall be 48Hz
    ii. Maximum frequency trip point (Fmax) shall be 52Hz

If voltage and/or frequency fall outside the set limits, the IES must be automatically disconnected from the Network. Reconnection procedure shall comply with AS 4777.3 “Grid Connection of Energy Systems via Inverters Part 3: Grid Protection Requirements.

Without limiting our discretion in Clause 5.3 of this Agreement, the IES must have any additional functionality specified by us regarding variable voltage and Volt-Amperes Reactive controls in accordance with the particular network conditions relevant to the IES.

6 IES TESTING

Upon completion of the installation of the IES, we may conduct a test of the IES equipment at a mutually agreed time and date for the purpose of establishing that the IES complies with this Agreement.
The test will consist of:

(a) disconnection of the Premises from the Supply Network;
(b) reconnection of the Premises to the Supply Network; and
(c) inspection and such testing of the IES as we consider necessary for compliance with this Agreement.

7 TYPE/CAPACITY CONSTRAINTS

At some locations, technical requirements may limit the type or capacity of IES that may be installed. Where required by us, you shall pay for any technical studies required to ensure the suitability of the IES interaction under normal and fault conditions. These studies shall be undertaken to our satisfaction regarding technical content. Should the studies require the Supply Network to be reinforced or modified you will be required to bear the costs associated with this work.

Standards for Grid-Connected Photovoltaic (PV) Arrays

Area		Title	Outline
Installation	AS/NZ 5033:2012	Installation and safety requirements for photovoltaic (PV) arrays	Sets out general installation and safety requirements for photovoltaic (PV) arrays, including DC array wiring, electrical protection devices, switching and earthing up to but not including energy storage devices, power conversion equipment or loads. The safety requirements of this Standard are critically dependent on the inverters associated with PV arrays complying with the requirements of IEC 62109-1 and IEC 62109-2 and all power conditioning equipment complying with IEC 62109 series standards. PV arrays of less than 240 W and less than 50 V open circuit voltage at Standard Test Condition (STC) are not covered by this Standard.
Installation	AS4777.1:2005	Grid connection of energy systems via inverters - Installation requirements	Specifies requirements for the installation of inverter energy systems with ratings up to 10 kVA for single-phase systems, or 30 kVA for three-phase systems, onto the low-voltage electricity distribution network (grid).
Inverter Req'ts	AS4777.2:2005	Grid connection of energy systems via inverters - Inverter requirements	Specifies requirements for inverters with ratings of up to 10 kVA for single-phase systems, or 30 kVA for three-phase systems, and intended for connection to the low-voltage electricity distribution network (grid).
Grid Protection Req'ts	AS4077.3:2005	Grid connection of energy systems via inverters - Grid protection requirements	Specifies grid protection requirements for inverter energy systems with ratings up to 10 kVA for single-phase or 30 kVA for three-phase, systems and intended for connection to the low-voltage electricity distribution network (grid).
General Wiring Standards	AS/NZS3000:2007/Amdt 2:2012	Electrical installations	Known as the Australian/New Zealand Wiring Rules

Outline of Solar Assessment Criteria

All applications to connect a solar PV system to an SIEA network require a technical assessment to be undertaken. This is because SIEA has an obligation to operate, maintain (including repair and replace as necessary), and protect its supply network to ensure the adequate, economic, reliable and safe connection and supply of electricity to its customers.

These assessments can also help customers avoid over-investing in systems that are too large to operate effectively at their point in the network.

Why applications need to be technically assessed

Solar PV systems have the potential to compromise the efficiency of the electricity network and cause voltage levels to fall outside the statutory ranges.

An inverter that is too large will trip off when the voltage rises above the set limit, and the system will not generate or export to the grid until the voltage comes back into an acceptable range.

Assessment thresholds

SIEA will undertake technical assessments of any application (regardless of rating) to connect to its Honiara network, or to any of the outstation networks.

SIEA reserves the right to assess any application and to change these thresholds at any time.

The technical assessment process

Our assessment process considers both the size of the inverter, the number of electrical phases of the premises, and the attributes of the local network servicing the premises.

The assessment references information including:

- The Registered Plan (RP) number and Lot number of the premises
- The capacity of the solar PV system inverter
- The capacity of the distribution transformer and local network that supply the premises
- The total capacity of solar PV systems already connected to the same transformer.

Assessment exclusions

The assessment does not consider:

- The condition of the household wiring.
- The number of solar PV panels that are planned for installation. The assessment only considers the size of the inverter.

- The amount of electricity that is typically used by the occupants of the premises during the day.

Installation and commissioning

General

These check lists are to be filled out for each installation.

> **WARNING:** Where short circuit currents are required, follow AS/NZS 5033 Appendix D for the steps that shall be undertaken to measure the short circuit current safely.
>
> **NOTE:** Some projects require that short circuit currents are recorded as part of the contractual commissioning; otherwise a record of the actual operating current of each string is sufficient. This could be done by using the meter on the inverter or by using a clamp meter when the system is operational.

Insulation resistance measurement

> **WARNING:** PV array dc circuits are live during daylight and, unlike a conventional ac circuit, cannot be isolated before performing this test. Follow AS/NZS 5033 Appendix D4 for the steps that shall be undertaken to measure the insulation resistance safely.

Installation and commissioning sample

See

Appendix 1 **Checks and Certification**

Appendix 2 **Signage**

Appendix 3 **Insulation**

Appendix 1 Checks and Certification

INSTALLATION DETAILS			
Address of installation:			
PV module manufacturer and model number:			
Number of modules in series in a string:		Number of strings in parallel in PV array:	
Inverter manufacturer and model number:			
Number of inverters:		Number of MPPTs:	
PV ARRAY			
PV array tilt	………………………°	PV array orientation	…………………°
Array frame is certified to AS1170.2 for installation location	**Yes / No**	Array frame is installed to manufacturer's instructions	**Yes / No**
No galvanically dissimilar metals are in contact with the array frames or supports	**Yes / No**	Roof penetrations are suitably sealed and weatherproofed	**Yes / No**
PV wiring losses are less than 3% at the maximum current output of the array	**Yes / No**	Where PV array comprises multiple strings, string protection has been provided	**Yes / No**
Wiring is protected from mechanical damage and is appropriately supported	**Yes / No**	Weatherproof PV array isolator mounted adjacent to the array	**Yes / No**
LV DC and AC INSTALLATION			
All low voltage wiring has been installed by a licensed electrical tradesperson	**Yes / No**	All wiring has been tested and approved by qualified electrical tradesperson	**Yes / No**
INVERTER			
PV array isolator mounted adjacent to the inverter	**Yes / No** (Rating: …………..Vdc, …………….Adc)	Isolator is mounted on output of the inverter (where required)	**Yes / No**
Lockable AC circuit breaker mounted within the switchboard to act as the inverter main switch for the PV/inverter system	**Yes / No** (Rating ………….. A)	Inverter is installed as per manufacturer's specification	**Yes / No**
Inverter ceases supplying power within two seconds of a loss of AC mains	**Yes / No**	Inverter does not resume supplying power until mains have been present for more than 60 seconds.	**Yes / No**

CONTINUITY CHECK		
Circuit checked (record a description of the circuit checked in this column)	______________________________	Yes / No
Continuity of all string, sub-array and array cables		Yes / No
Continuity of all earth connections (including module frame)		Yes / No

SYSTEM CHECK

WARNING:

· IF A STRING IS REVERSED AND CONNECTED TO OTHERS, FIRE MAY RESULT.

· IF POLARITY IS REVERSED AT THE INVERTER DAMAGE MAY OCCUR TO THE INVERTER.

	Polarity	Voltage	Short Circuit Current	Operating Current
String 1		V	A	A
String 2		V	A	A
String 3		V	A	A
String 4		V	A	A
Sub-arrays where required		V	A	A
PV array at PV array switch-disconnector		V	A	A
Irradiance at time of recording the current			W/m2	W/m2

INSULATION RESISTANCE MEASUREMENTS
(see table 12.3.1 for minimum values of insulation resistance)

Array positive to earth	MΩ
Array negative to earth	MΩ

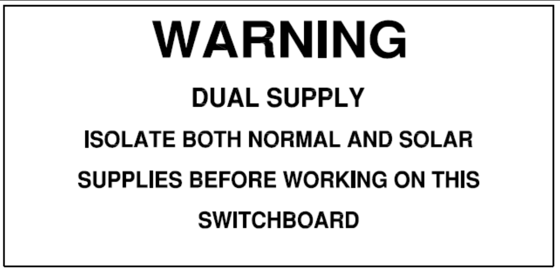
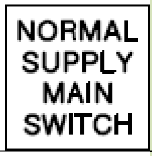
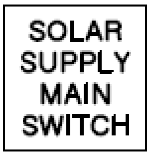
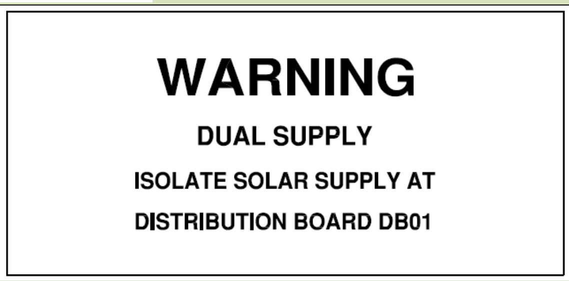
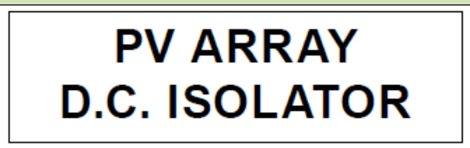
INSTALLER INFORMATION

CEC Accredited installer's name:			
CEC Accreditation number:			

<u>I verify that the above system has been installed to all relevant standards</u>

Signed:		Date:	
CEC Accredited Designer's name:			
Licensed electrician's name: (where applicable, e.g. LV work)			
Electrician's licence number:			
Signed:		Date:	

Appendix 2 Signage

SIGNAGE (AS4777)		
	On switchboard to which inverter is directly connected	**Yes / No**
	is permanently fixed at the main switch	**Yes / No**
	is permanently fixed at the solar main switch	**Yes / No**
	If the solar system is connected to a distribution board then the following sign is located on main switchboard and all intermediate distribution boards	**Yes / No**
	Where the inverter is not adjacent to the main switchboard, location information is provided	**Yes / No**
SIGNAGE (AS/NZS 5033)		
	Is permanently fixed on array junction boxes (black on yellow)	**Yes / No**
 	Fire emergency information is permanently fixed on the main switchboard and/or meter box (if not installed together)	**Yes / No**
	PV DC isolation is clearly identified	**Yes / No**

	Is placed adjacent to the inverter when multiple isolation/ disconnection devices are used that are not ganged together	**Yes / No**
SOLAR	Exterior surface of wiring enclosures labelled 'SOLAR'	**Yes / No**
Shutdown procedure is permanently fixed at inverter and/or on main switchboard	Any other signage as required by the local electricity distributor	**Yes / No**

Appendix 3 Insulation

Minimum insulation resistance

System voltage (Vdc x1.25)	Test Voltage	Minimum insulation resistance MΩ
<120	250	0.5
120-500	500	1
>500	1000	1

Downsized or Declined Applications

If your application is downsized or declined, SIEA can assist you with further advice and options. The term downsized, means that while SIEA cannot approve the size of inverter you originally applied for, you are able to re-apply for an inverter up to a maximum size we advise or to explore one of the other options presented.

Reasons to downsize or decline an application

Applications may be downsized or declined if:

- The transformer serving the premises is too small to support the volume of electricity that could be generated by the system.
- The connection is a relatively long distance away from the transformer, which may cause significant voltage fluctuations or cause voltage levels to fall outside the statutory ranges.
- There are already a number of solar PV system connections that share the same transformer. This may even be the case if there is only one other connected solar PV system.

Alternative options

SIEA supports renewable energy and will work with you to explore alternative options including:

- **Installing a small-scale system with an inverter of a lower capacity.** SIEA will advise the maximum capacity that can be re-applied for at the premises to ensure effective operation of the system and to protect the electricity supply in the local area. Customers will need to lodge an updated application form.
- **Exploring the option of upgrading the number of electrical phases of the premises to accommodate the desired inverter size.**
- **Paying for an upgrade to the network to accommodate the inverter originally requested**. SIEA allows individual customers to pay for upgrades to the network, where those upgrades are for the benefit of an individual premise. To obtain a quote from SIEA for the necessary upgrades, please contact SIEA. Fees may apply to lodge an application, but will be credited against the total cost of the upgrade if you choose to proceed.
- **Withdrawing application.** Customers may choose not to install a system, in which case they should contact SIEA to withdraw the application.

Assessment Tests for Parallel Embedded Generation via Inverters

NETWORK TESTS

SIEA will initially assess all proposals for connection of inverter energy systems based on the following five network criteria being met:

Test 1 - 11kV Feeder Penetration Test for HV Voltage Regulation
That the addition of the proposed inverter system will not cause the total installed PV capacity on the 11kV feeder to exceed 15% of the 50% minimum feeder load (50% of the assumed minimum daytime load), such that the feeder does not enter export mode back to the 11kV zone substation bus.

Test 2 - Transformer Penetration Test for LV Voltage Regulation
That the addition of the proposed inverter system will not cause the total installed PV capacity off a **shared** transformer to exceed 25% of the transformer nameplate rating, reducing the probability of the transformer entering net export mode back onto the 11kV feeder.

Test 3 - Maximum Single Phase Inverter Test (Unbalance)
That the maximum single phase inverter size does not exceed 10% of the transformer nameplate rating (single phase transformers), or 8% of the nameplate rating (three phase transformers). This test is not applicable to three phase balanced inverters.

Test 4 - 11kV Feeder Voltage Fluctuation & Distortion Test
That the ratio S_i / S_{schv} is ≤0.1%

Where: S_i Three phase inverter rating (kVA)
S_{schv} Three phase fault level at point of common coupling – 11kV (kVA)

(To minimise voltage disturbance to customers on same 11kV network.)

Test 5 - LV Feeder Voltage Regulation, Fluctuation & Distortion Test
That the ratio S_i / S_{sclv} is ≤ 1.0%

Where: S_i Three phase inverter rating (kVA)
S_{sclv} Three phase fault level at point of common coupling – LV (kVA)

(To minimise voltage disturbance to customers on same low voltage network.)

GENERATION TESTS

SIEA will then assess all proposals for connection of inverter energy systems based on the following criteria:

Test 1 – Minimum Generator Load Test
Minimum load test to ensure that no diesel engine operates at less than 40% of its nameplate loading while any solar system is operating.

Test 2 – Stability Test
Stability test to ensure that the sum total of solar inverter ratings connected to a system does not exceed 15% of the ratings of the diesel engines that are operating while any solar systems are operating. This test will be assessed at (G-1) operating conditions i.e. with the highest rating diesel engine out of service.

ASSESSMENT

Each application for connection of a solar PV array will be assessed against EACH of these criteria, and must pass ALL tests satisfactorily before approval.

Consideration can be given to reducing the approved inverter rating in marginal cases. See *Downsized or Declined Applications*.

Guide to buying household solar panels (photovoltaic panels)

Solar power systems are now an affordable option for households looking to reduce their power bills and generate their own electricity. There is an increasing number of products and suppliers on the market, most of which will be able to be connected to the Solomon Islands grid.

SIEA follows the Australian/ New Zealand standards for connection of solar panels to its electricity grid. This is to ensure the safety of its staff and customers, as well as ensuring that customers can be comfortable with their investments.

This guide is intended to provide an introduction to solar PV systems so you are better equipped to make choices about a product that is right for you.

Towards the back of this guide there are a series of questions you can ask your installer, and the Solomon Islands Electricity Authority (SIEA) to ensure you have all the information you need to make smart decisions.

This guide is only intended for people who will be connecting their system to the SIEA electricity grid.

Contents

Installation checklist

A Step-by-Step Process to having your Solar PV System installed:

1. You conduct your own research into the benefits of having a solar PV system installed. In particular, you should ensure that you understand what will happen to your meter, your electricity tariff and your electricity bill before you agree to have a PV system installed.

2. You contact several Designers/Installers to arrange for a quote. They should preferably be CEC-accredited Designers/Installers. A list of Australian ones can be found at *solaraccreditation.com.au*

3. By asking informed questions, (see '*Questions to ask your Designer/Installer*'), you then select a Designer/Installer.

4. The Designer/Installer designs a PV system to meet your requirements (see '*What does the Design and Specification of my Solar PV System involve?*')

5. You, or your Designer/Installer, complete the connection and approval process for SIEA. See SIEA document: '*Solar PV Connection Process'*.

6. The Designer/Installer completes the installation of your solar PV system

7. The Designer/Installer contacts SIEA to arrange for your new meter to be installed (see '*Questions to ask SIEA'* below).

8. SIEA installs your new meter.

9. Your solar PV system is now ready to produce electricity.

10. SIEA will conduct a safety inspection of your solar PV system.

How does solar PV work?

Solar Photovoltaic (PV) panels are generally fitted on the roof in a northerly direction and at an angle to maximise the amount of sunlight that hits the panels.

Solar PV panels on the roofs of homes and businesses generate clean electricity by converting the energy from sunlight. This conversion takes place within modules of specially fabricated materials that make up the solar panels. It is a straightforward process that requires no moving parts. Solar panels are then connected to the mains power supply through a device called an inverter.

Solar panels have been installed on the rooftops of houses and other buildings countries such as Australia since the 1970s. Currently there are many solar panel systems safely and reliably delivering electricity to households and businesses across Australia.

Grid-connected solar PV systems

Most suburban homes in Honiara are connected to the electricity grid, which uses alternating current electricity (AC). However the electricity generated by solar panels is direct current

(DC). That means grid-connected (GC) solar PV systems need an inverter to transform the DC electricity into AC electricity that is suitable for ordinary household needs. Houses with solar systems use solar power first before sourcing electricity from the grid.

When the panels are not producing any electricity at night or producing at reduced levels during cloudy days, electricity is supplied from the existing SIEA electricity grid (back-up). The grid also supplies the heavier currents needed to start electric motors etc even when the solar panels are in use.

How much power do they generate?

The output of a solar PV system depends on its size. The most common household systems are either 1 kilowatt (kW) or 1.5 kilowatts, although some property owners have installed systems of up to 10 kilowatts.

A Darwin house (at similar latitude to Honiara) consumes around 18 kilowatt hours (kWh) per day so a 1-2kW system displaces an average of 25-40% of your average electricity bill. Solar panels produce more energy in summer than they do in winter.

Average Daily Production					
Location	**1 kW system**	**1.5 kW system**	**2.0 kW system**	**3.0 kW system**	**4.0 kW system**
Darwin	4.4 kWh	6.6 kWh	8.8 kWh	13.2 kWh	17.6 kWh

How much do solar panels cost?

The cost of solar panels has continued to reduce with an increased diversity in the panels, inverters and suppliers on the market.

You need to ensure that having a grid-connected PV system makes sense for you by meeting your needs at a sensible price.

It is important to understand on what you want from your solar PV system. Are you after a system that will partially offset your energy consumption for 5-10 years before requiring a system upgrade? Or do you want a system that will completely offset your household's electricity use for the next 25 years? Like buying a second-hand car as opposed to a brand-new sports car, these two solar PV systems are both sound investments depending on your needs, but will vary significantly in price.

The price of your solar PV system can also be affected by variables including:

- Location
- Number of panels
- Orientation of panels
- Type of panels
- Type of inverter
- System design and configuration
- Shipping costs for equipment and parts
- Structural engineering, architectural, and other professional services (for commercial systems)
- Contractor installation costs
- Removal of trees or other shading
- Type of roofing (for example, tiled or tin)
- Height of roof
- Site preparation needs (for example, condition of roof or ground)

Australian Standards

It is important you ask your accredited installer to provide proof that your panels meet Australian standards.

The Clean Energy Council has a frequently updated list of all solar panel and inverter models that meet Australian standards. To see the list, https://www.solaraccreditation.com.au/solar-products/inverters/approved-inverters.html

Solar PV systems must also comply with The CEC Design and Installation Guidelines.

Warranties and Guarantees

Solar PV panels generally come with a performance warranty that can last up to 25 years and a guarantee lasting five to ten years. Additionally, panel material warranties and workmanship guarantees generally span 5-10 years.

It is important to know who is providing the warranty – the manufacturer or the importer. In the absence of a manufacturer, the importer is responsible for the warranty. However, if the importer changes their business name or sells their business, their warranty obligations towards you cease. Ask your installer who is providing the warranty.

A system manual that provides operation, maintenance and safety information should be provided by your installer. This must also include a system energy output (kWh) estimate. It is important to ensure you obtain written confirmation of statements made by your installer, including performance claims, guarantees and warranties. Documentation will be essential if you need to make warranty or insurance claims.

What Solomon Islands government schemes are in place to lower the cost of purchasing a solar PV system?

There are currently NO government assistance schemes in the Solomon Islands for the installation and operation of solar PV arrays

Renewable Energy Certificates

The Solomon Islands does NOT have a Renewable Energy Certificate Scheme.

Feed-in tariffs

SIEA does NOT purchase excess energy from a domestic or commercial photovoltaic system.

Standby Charges

SIEA DOES apply a daily standby charge for the operation of solar PV arrays that are connected to its network. This is 50% of the power that is generated by the array and consumed internally by the customer. The power generated by the array (in kWhs) is assessed as being 4.4 times the nominal kW rating of the inverter.

What does the design and specification of my Solar PV System involve?

Accredited Designers / Installers

SIEA recommends that the designer and installer of your solar PV system should be accredited by the Clean Energy Council. The Clean Energy Council's accreditation scheme ensures that accredited designers and installers of solar PV power systems:

- Have undergone the necessary professional training

- Follow industry best practice
- Adhere to Australian standards
- Routinely update their skills and product knowledge.

For a list of accredited professionals, please see *solaraccreditation.com.au*.

An accredited Designer/Installer will provide you with a solar PV system design and specification. This will include things such as:

- Establishing your electrical loads over an average day using a load analysis
- Determining the type of panels
- Determining the size of your solar PV system
- Deciding the type of inverter
- Establishing the location of solar panels in relation to angles, available sunlight, shading and temperature.

What size solar PV system should I install?

The size of your solar PV system will depend on:

- the physical unshaded area available for the installation of your panels
- how much you are prepared to spend
- what portion of your electrical consumption you wish to generate.

To work out what size solar PV system you require, you need to analyse your household's daily electricity consumption. Your monthly or quarterly electricity bill measures your household's electricity consumption in kilowatt hours (kWhs). From this figure, you can calculate your average daily electricity consumption, and the average amount of electricity your solar PV system needs to produce to cover your electricity needs.

This process will be completed by your accredited designer during the design and specification stage, as part of their load analysis.

What size panels should I buy?

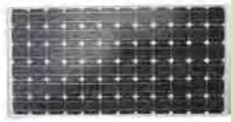
Solar PV panels come in different wattages. The main issues are your budget and whether the solar panels will physically fit in the space you want to install them.

Each solar panel is approximately 1.6 metres long and 0.8 metres wide. A 1kW solar panel system will require around 8-10m² of roof space, and a 1.5kW solar panel system requires around 12 m². This will vary depending on the type of panel installed on your roof.

What sort of panels should I buy?

There are four main types of solar panel available, each with their own benefits. During the design and specification stage, your accredited designer will help you choose which type is the best to suit your needs:

1. **Mono Crystalline (monocrystalline c-Si)**



These panels are a proven technology that has been in use for over 50 years. They are commonly used where space is limited, or where there are high costs associated with installing large panels. They have a very slow degradation, generally losing 0.25 - 0.5% per year.

2. **Poly Crystalline (polycrystalline c-Si)**

These panels are similar to Mono Crystalline panels, but the silicon used is Multi-Crystalline which is easier to make. They are comparable to Mono Crystalline in performance and durability. Slightly more panels are required to produce a given amount of electricity.

3. **Thin Film**

These panels are typically nearly double the size than the other panel varieties. Research is continuing to improve the performance of Thin Film panels and to refine the manufacturing process. They respond well to slightly diffuse light and their efficiency does not drop on hot days.

The most common varieties of Thin Film panels are:

- Cadmium Telluride Thin-Film panels (CdTe)
- Copper Indium Gallium Selenide Thin-Film panels (CIGS)
- Amorphous silicon Thin-Film panels(a-Si)

What angle should the solar panels be on?

Solar PV panels produce most power when they are pointed directly at the sun. In the Solomon Islands, solar modules should face north for optimum electricity production. The orientation of the panels will often have a greater effect on annual energy production than the angle they are tilted at. A minimum tilt of 10° is recommended to ensure self-cleaning by rainfall.

For grid-connected solar PV power systems, the solar panels should be positioned at the angle of latitude to maximise the amount of energy produced annually. Most Solomon Islands homes have a roof pitch of 20° to 30°.

If your roof's slope is not ideal, your accredited designer can create an appropriate mounting frame to correct the orientation and elevation of your panel. Failing this, the designer can advise you on the difference in energy output for different tilt and orientation.

How much sunlight should the panels receive?

The amount of energy in sunlight that a solar PV panel receives over a day is expressed in peak sun hours. As the amount of energy generated by a panel is directly proportional to the amount of energy it receives from sunlight, it is important to install panels so they receive maximum sunlight.

Your accredited designer will calculate the amount of energy generated by the solar PV panel from the peak sun hours available. Peak sun hours vary throughout the year.

Shading / Dirt

Solar PV panels should ideally be in full sun from at least 9am to 3pm. They should not be placed in shaded areas and should be kept free from dust and dirt. Even a small amount of shade - from things like trees, roof ventilators or antennas - will have a large impact on the output of a panel, as it changes the flow of electricity through the panel. Shading or dirt on just one of the cells in a solar panel results in a loss of power from many cells, not just the one that is shaded.

Temperature

The amount of electricity a solar PV panel can generate is reduced as temperatures increase. Solar panels operate best at ambient temperatures up to 25°C. If the ambient temperature is higher than this, the panel's output declines.

What is an inverter? What sort should I buy?

Solar PV panels produce low voltage DC electricity. The inverter converts this into the AC electricity needed to supply power for standard appliances.

The efficiency of an inverter is measured by how well it converts the DC electricity into AC electricity. This usually ranges from 95% to 97.5% for most models. Check the inverter's specifications before you purchase.

Inverters are sized according to the power (kilowatts) they can supply.

Australian Standards

It is important to ensure that your grid connect inverter complies with Australian Standards. This is necessary to ensure that SIEA will allow it to be connected to the grid. Your accredited installer to provide proof that your inverter meets Australian standards. The Clean Energy Council has published a list of all grid connect inverters that meet Australian standards. https://www.solaraccreditation.com.au/solar-products/inverters/approved-inverters.html

What will happen to my meter at home?

When your solar PV system is installed, you will need to have a new meter installed.

If you have a post-pay meter (with a spinning disk) or a pre-paid CashPower meter, this will need to be replaced with a new import/export meter. This is to ensure that it records only the power imported from the grid. Note that SIEA does NOT have a tariff for power exported back into the grid. While this export may be recorded by the new meter, it will not generate any credit for you.

If you are presently on a pre-paid metering arrangement (CashPower), then you will be transferred to a Post-Pay Account. You should consider this and carefully weigh up the advantages and disadvantages before making a decision. This should be understood before you commit to install your solar PV panels.

Your new meter will be a "net meter". On a net feed-in tariff scheme, your "net meter" measures your household's electricity and the electricity generated by your solar PV system together. SIEA reads the meter and calculates the electricity that you have consumed from the grid. Note again that SIEA does NOT have a feed-in tariff for any electricity that you might export.

Your new meter must be installed by SIEA. This will be organised by your accredited Designer/Installer.

The new meters will be provided by SIEA, and you will be charged up-front for the cost of providing and installing them.

Quotation / Contract

The following information is offered as general information only.

Following the design and specification you may request a quotation for the design and installation of the system.

The quotation could provide specifications, quantity, size, capacity and output for the major components, including:

- solar PV modules
- mounting frames
- structure
- inverter
- any additional metering
- data-logging
- travel and transport requirements
- other equipment needed
- any trench digging
- a system user manual.

The quotation should also specify a total price, together with proposed start and completion dates. The quotation should form a basis for your contract with the Designer/Installer.

In addition, a contract for the supply and installation of the power system should be included with the quotation.

The contract should include:

- an estimate of the average daily electricity output (in kWh)
- the estimated annual production
- the estimated production in the best and worst months
- the responsibilities of each party
- warranties and guarantees, including installer workmanship schedule of deposit and progress payments.
- who is responsible for connecting your solar PV system to the SIEA electricity grid

Questions to ask your Designer / Installer

The following information is offered as general information only.

When signing a contract with your Designer/Installer, you need to be informed. Important questions to ask include:

Accreditation

- Is the designer accredited?
- Is the installer accredited?
- What are their accreditation numbers? Will your system be designed <u>and</u> installed by an accredited individual?
- Check the list of accredited installers on the Clean Energy Council website to confirm www.solaraccreditation.com.au
- Contact the Designer/Installer's former customers to find out if the they were knowledgeable, easy to work with, and took the time to explain the systems operation. Also find out if their systems are working well, if there have been any problems, and, if so, if they returned to fix them. Ask for the Designer/Installer business references, and check them, especially if the company's reputation is unknown.

Experience

- How many systems has the Designer/Installer completed?
- How many systems similar to your system has the Designer/Installer completed?
- When was the last time the Designer/Installer completed a system? New products are constantly entering the market. A Designer/Installer who has completed several recent installations will probably be up-to-date on the newest products and the latest regulatory issues.

Quality of Products – Australian Standards

- Do the modules you use meet the Australian Standards? Check the Module List on the Clean Energy Council website to confirm - www.solaraccreditation.com.au
- Do the inverters you use meet the Australian Standards? Check the Inverter List on the Clean Energy Council website to confirm - www.solaraccreditation.com.au
- Do some research on the other balance of system components that your Designer/Installer suggests, such as the mounting hardware. Do the products meet industry standards?
- If you know of other people who have used these products, ask for their feedback: Are they satisfied? Have they had problems?

Warranties

- What kinds of warranties come with the products?
- Which warranties are your responsibility and which are the manufacturer's?
- How long have the equipment manufacturers been in the PV industry? Long warranties are meaningless if the manufacturers aren't around in five years.
- If you have to deal with the panel or inverter manufacturer in the future, do they have a Honiara office?

Service Agreements & Performance Guarantees

- What performance guarantees do you get for the system as a whole?
- How will you know if your system is performing to its maximum potential on a day to day basis?
- Does the Designer/Installer provide some kind of optional service agreement?
- If problems arise with your system, what services will the Designer/Installer provide and for how long?
- Will the Designer/Installer be readily available to troubleshoot and fix problems?
- If something goes wrong, who is responsible for repair or replacement costs?
- Who is responsible for maintaining the system?
- If you are responsible, what kind of training will the Designer/Installer provide?
- Will basic system safety issues be explained?

Paperwork

- Does the Designer/Installer handle organising all the necessary metering changes?

References

- Contact the Designer/Installer's former customers to find out if the they were knowledgeable, easy to work with, and took the time to explain the systems operation. Also find out if their systems are working well, if there have been any problems, and, if so, if they returned to fix them. Ask for the Designer/Installer business references, and check them, especially if the company's reputation is unknown.

Quote

- Does the price quoted include all the necessary metering changes and paperwork for SIEA?
- Does the quote include all labour, transportation and inspection charges?
- Does the Designer/Installer give an accurate estimation of system production with their quotes?

Payment Terms

- What are the payment terms?
- Is there a deposit? When is it required? Is it refundable?

Time Frames

- What is the lead time from your payment to getting electricity from your solar PV system?

The Final Decision

- By installing a solar PV system, you need to take responsibility for it and learn the basic safe operation and proper maintenance of your systems. You should think carefully before selecting a Designer/Installer. Online and mail-order solar PV system suppliers who never visit your home may have difficulty recommending the most appropriate equipment. A comprehensive, on-site solar and load analysis and two-way interview can help ensure a thoughtfully designed and well-planned installation.

What happens after my solar PV system has been installed?

Entering into agreement with SIEA

After your solar PV system has been installed, you will need to enter into an agreement with SIEA. A copy of this can be downloaded from the SIEA website: www.siea.com.sb

Questions to ask SIEA

- What is the cost of the electricity you purchase from SIEA (in cents per kWh)?
- What is the standby charge for solar panels and how will it be applied?
- Penalty clauses (termination costs)
- Billing / payment periods
- Are there any other administration fees?
- Do you organise all the necessary metering changes? If “yes”, the following questions apply:
    - What is the cost of your meter?
    - What is the cost of installing your meter?

Safety Inspections

Following the installation of your solar PV system, safety inspections will be carried out by SIEA. It is the responsibility of either you or your installer to organise these inspections with SIEA.

Dispute resolution

Disputes about the design, installation, operation and maintenance of your solar system are a matter between you and your Designer/Installer. SIEA will not be a party to any dispute over such matters.

Appendix

1. Clean Energy Council - *cleanenergycouncil.org.au/cec/resourcecentre/Consumer-Info/connecting-to-the-grid*
2. Clean Energy Council - *solaraccreditation.com.au/acccec/approvedproducts*
3. Office of the Renewable Energy Regulator - www.orer.gov.au
4. Office of the Renewable Energy Regulator - *www.orer.gov.au/sgu/index*
5. Office of the Renewable Energy Regulator - *www.orer.gov.au*
6. Department of Climate Change and Energy Efficiency
4. www.climatechange.gov.au/government/initiatives/renewable-target/needret/solar-credits-faq.aspx
7. Office of the Renewable Energy Regulator - *www.orer.gov.au*
8. Clean Energy Council - *solaraccreditation.com.au/acccec/approvedproducts/inverters*

Solar Power Consumer Guide

Some guidance in selecting a domestic solar power system.

Why Go Solar?

Solar energy can help save you money on your electricity bill by replacing some of you consumption from the SIEA power grid.

Solar power systems have no moving parts, are extremely reliable, and have a long expected life span. They are self-cleaning, easy to install and require very little in the way of maintenance.

Types of Solar Power Systems

There are two main types of solar power systems – grid-connect, and off-grid (or standalone).

A grid-connect system ensures that you have the electricity that you need whenever you need it automatically and regardless of weather conditions. This is because your property remains connected to the SIEA electricity grid which can then provide back-up at night and during poor daytime weather. SIEA charges for this standby backup service since it must reserve capacity on the grid for such occurrences.

An off-grid solar power system is completely separated from mains power and requires a battery bank for storing electricity that has been generated from the solar panels. This battery can then supply your property at night and during bad weather. It is the more expensive option, but must be used wherever the SIEA grid is not readily available.

This document will concentrate on grid-connected systems.

How a Grid-Connect Solar System Works

Most people in residential areas choose a grid-connect system, usually on the basis of price.

Electricity from the solar panels is converted (via an inverter) into AC power that is suitable for operating domestic appliances. Whenever the system produces more power than is being used, the surplus is fed back (exported) into the SIEA network. In certain circumstances, SIEA may require that there be no exported power into the grid. Note that SIEA does not pay you for any exported energy.

When your solar system is not producing energy (eg at night or in bad weather), your electricity needs are supplied from the SIEA grid.

The process is as follows:

1. Solar panels convert sunlight directly in direct current (DC) power.
2. The inverter converts the solar DC power into 240 volt alternating current (AC) power which is ready to use in your home or to export into the grid.
3. AC power from the inverter goes through your switchboard for use in your home.
4. SIEA's meter records the power supplied from the grid that is consumed in your home, and any power exported.
5. Any surplus power from your solar panels flows back into the SIEA grid.

Solar Power System Components

Solar panels

Solar panels come in different outputs and sizes. Normally solar panels are about one metre wide and 1.7 metres long. So a 3 kW system requires about 24 m^2 of roof space, and a 5 kW system needs around 40 m^2.

There are three types of solar cells used in panels.

Monocrystalline silicon offers high efficiency and good heat tolerance in a relatively small panel.

Polycrystalline (or multi-crystalline) silicon cell based panels are presently the most popular for residential systems. Technology improvements have meant that they can match the performance of mono-crystalline cells.

Amorphous (or thin film) cells use the least amount of silicon and are usually less efficient that other types.

Performance will vary between brands, even for the same technology used. For example, some perform better on hot days.

The cost of a solar panel is usually determined by its output capacity (watts), physical size, brand, durability, warranty period etc. As usual, you get what you pay for.

Solar inverters

Solar panels each produce low voltage DC power. The inverter converts this into the AC power needed for normal appliances.

The efficiency of an inverter is measured by how well it converts the DC into AC. This efficiency generally ranges from 95% to 97.5%. Inverters are sized according to the power that they supply (usually in kilowatts – kW).

Not all inverters are equal and efficiency has a significant impact on the time that your system will take to pay for itself. So, the more efficient the better as less power will be wasted as heat during the conversion process.

Inverters must comply with the relevant Australian Standards, or SIEA will not allow them to be connected to the grid.

Mounting systems

The mounting system is a crucial aspect of a solar array as it must withstand wind stresses from cyclones, and torsional stresses from earthquakes. Ask your supplier about certification and warranty periods.

Cables and connectors

Cabling is usually exposed to strong sunlight, and should be certified to PV1-F and the cable connectors should meet EN50521 standard. Ask your supplier.

Electricity meters

SIEA will install, at your cost, a bi-directional meter. This allows the measurement of power that is consumed from the grid, as well as separately measuring an exported power back into the grid. You will not be able to use any existing pre-pay meters or spinning disk meters.

Solar Panel Installation Factors

Your installer will make sure that the solar panels are positioned on your roof for maximum efficiency and safety, and are correctly wired to the inverter. They will take the following aspects into consideration.

Orientation

As Solomon Islands is in the southern hemisphere, solar panels should be facing as close to true north as possible. However north-west and west-north-west orientation can work if you use most of your power in the afternoon.

Tilting

Depending on location, the angle of panels should be between 20 degrees. This is not as important a consideration as orientation of the panels.

Shading

Your installer should position the panels for full sun between 9am and 3pm and not in shady areas. Shading from trees for example can cause a major reduction in production.

Mounting

The mounting system should be certified by an engineer for the Solomon Islands conditions. The system and brackets should be cyclone rated and wind certified. Ask you supplier for information on certification, warranty and documentation.

Grid-Connect Solar Power System Lifespan

Tests have shown that solar panels show output reductions in power output as the glass dulls, maybe after 20 years or so. Ask for the warranty period. Inverters are more sensitive and may only last 10 to 15 years in ideal conditions before needing refurbishment.

How Big a Solar System Will You need?

The size will depend on:

- Physical unshaded area for the panels
- The power that you want to generate
- Your budget

In general terms the more that the power generated matches what you will consume, the better the benefit. Remember that SIEA does not pay for exported power.

In Australia, the most common household system is rated at 1.5kW output. If you consume about 18 kWh (or units) per day, then a 1 to 2 kW system would reduce your power bill by 25-40% per day.

Remember that you can also have a positive effect on bill by conserving energy by using energy efficiency lights and appliances.

Solar Rebates

There are no solar rebates available in the Solomon Islands for the installation of these systems

Feed-In Tariffs

There is no feed-in tariff in the Solomon Islands. SIEA may require that no power be exported back into the grid in some circumstances.

Standby Tariffs

SIEA charges a daily fee for the connection of solar arrays to the grid. This is to ensure that there is adequate capacity reserved in the grid for providing backup supply for you in the event of bad weather or other similar situation when your solar system does not generate power.

Choosing a Solar Installer

You need to ensure that your system is installed by a suitably qualified person. Such people should have adequate training, follow industry best practice, adhere to the SIEA standards, and regularly update their skills and understanding.

Quotations and contracts

You should ask for a full system quotation including specifications, quantity, size, capacity and output of major components including:

- Solar panels
- Mounting system
- Inverter
- Travel and transport requirements
- Other equipment needed
- System user manual

The quotation should specify a total price which, with the other relevant documentation, should form the basis of your contract with the designer/ installer. Your should ask for the following to be included:

- Average daily electricity output estimate in kilowatt hours (kWh)
- An estimated annual energy production amount in kilowatt hours
- Estimated outputs during the most and least favourable months
- The responsibilities of the installer and the customer, including payment timings
- Warranty and guarantee details

- Who is responsible for connection to the electricity grid
- Who will arrange the meter change-over

Know What Questions to Ask

This system will be a substantial investment and you should find out the facts before committing

Questions for your installer

- Are you accredited in places other than the Solomon Islands
- How many systems have you installed previously
- Can you provide customer testimonials
- Do all of your products meet the Australian standards as required by SIEA

Questions for SIEA

- Will I move to a post-pay account – (normally Yes)
- Are there any other costs for connecting a solar power system
- What contract will I have to sign
- What will I be charged for replacing the meter
- How long will the process take

Some Additional Tips

- Ask around for other people's experience so you can avoid any problems
- Have realistic price expectations. Lower price doesn't always mean lower quality, but it is an indicator. Make sure you are getting the design, installation and the warranties that you expect.
- Shady roof areas don't make for efficient solar generation.
- Compare the components in package deals to make sure you are getting what you expect.
- Beware of hidden costs associated with metering, roof mounting, etc.
- Get a few quotes.
- Remember that warranties may not survive the departure of the installing company.

The EM1000 is SIEA's standard accumulation meter for residential properties with a solar PV system, and has the following features:

1 Pulse Indicator The light (LED) will pulse (on & off) when electricity is being consumed, and these pulses get faster as electricity consumed increases.

2 Scroll Button This button is used to scroll the register displays in the sequence that they have been programmed on the meter. Each press of the scroll button will show the next register display.

3 Display Register This is the display which shows the total electricity consumed, and for the smart power tariff, it will also display the electricity consumed for the different tariff rates. The meter is also programmed to display the time, date, and voltage, current and power factor.

4 Optical Port This is the meter's infrared (IR) device, where the authorised Western Power personnel download the data from the meter using an optical probe cable connected to a handheld unit (HHU).

5 Main Cover Seal The meters are sealed on the main cover at the manufacturing plant. This seal prevents unauthorised personnel from accessing the internal components of the meter.

6 Serial Number Each meter is assigned with a unique individual serial number. The first four digits are the meter code followed by a six digit serial number.

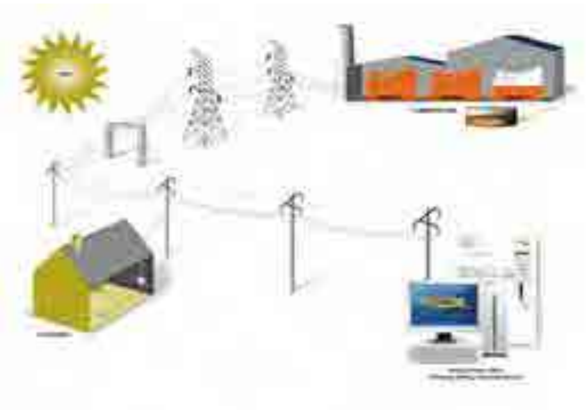
7 Terminal Cover Seal The terminal cover is sealed by SIEA authorised personnel after the meter is installed and wired to the network supply.

Shows accumulated imported energy <u>from grid</u> in kWh's

Shows accumulated exported energy <u>to grid</u> in kWh's

How renewable energy works

It may be helpful and interesting to have an understanding of how renewable energy works on our electricity system. This will give you an insight to our agreement and buyback price, eligibility rules, technical requirements and the significance of your town's hosting capacity.



Although it seems that electricity is available at the flick of a switch, it takes a lot of work and money to get power to your home or business.

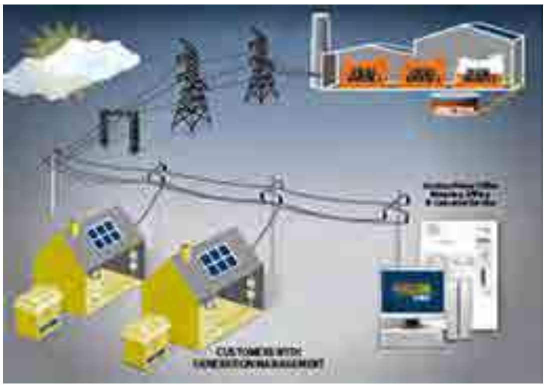
SIEA generates electricity at a power station, distributes this across electricity networks to the meter box, makes sure the network meets safety and reliability standards and then retails this to customers.

There are costs associated with all of these activities, which are partly recovered through the price customers pay for electricity.

As more homes install renewable energy systems, the demand on the power station decreases.

On bright sunny day, solar panels (photo-voltaic) generate electricity that can be used in the home, with any excess fed back to SIEA.

The power station now has to do less work to meet the electricity demand unless the daytime weather changes eg cloud cover.



Generation management devices (such as a battery with a controllable output), reduce the demand on the power station by providing short-term power to the electricity system when renewable energy installations stop generating electricity.

The generation management device will supply electricity for enough time to allow the power station to adjust to the increased electricity demand. The device will recharge from the solar panels until the device has sufficient energy stored to meet the renewable energy generation requirements.

FINAL DRAFT

SOLOMON ISLANDS NATIONAL ENERGY POLICY AND STRATEGIC PLANNING

VOLUME 1: SOLOMON ISLANDS NATIONAL ENERGY POLICY

2014

MINISTRY OF MINES, ENERGY AND RURAL ELECTRIFICATION

ENERGY DIVISION

CONTENTS

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Foreword

I am pleased to present to you the Solomon Islands National Energy Policy (SINEP), which presents the priorities of the Government and the strategic directions for key initiatives in the energy sector over the next 10 years to enable sustainable economic development in the country. This SINEP is an improvement to the 2007 SINEP and is closely linked to the National Development strategy (NDS) of Solomon Islands 2011–2020 and its vision of a 'United and Vibrant Solomon Islands'.

In this regard, Energy is included in the Solomon Islands National Infrastructure Investment Plan and NDS as being integral and important for achieving the goals of the NDS. It is a key driver that is integral for economic growth, social development and for improvement of the livelihood of communities. Against that context, it is, therefore, important that the policy directions in the energy sector is set right for the planning and implementation processes of the strategies and investment plans to ensure there is conformity and linkages that positively support development aspirations of other sectors within the economy.

Solomon Islands have its own challenges and opportunities in terms of our energy situation. Our extremely low national electricity coverage, high energy costs and the high dependency on imported fossil fuel, is exacerbated by the geographical spread of the archipelagic nature of our country, which impacts on our economic and social development. Although our country is blessed with abundant renewable energy resources, it is important that the country utilises its resources wisely and minimizes any potentially detrimental effect on economic and social development.

The aspiration of the Government to increase electricity access that is affordable to the population of Solomon Islands needs policy directions to support effective planning and implementation. Our high dependency on imported fossil fuel needs policy directions on management of the petroleum sub-sector to ensure safety aspects is upheld and energy efficiency is maintained.

This policy was developed in close consultation with energy service providers, representatives of the government and community, the private sector, and development partners. It is therefore, a country-owned and led document.

The SINEP is a living document and can be adjusted in response to future changes and needs that may impact the energy situation of the country.

The government therefore intends to establish an energy advisory committee comprised of high-level multi-sectoral members tasked with monitoring the progress of the SINEP against policy performance indicators.

In conclusion, I wish to thank all national stakeholders and development partners for their contributions to the SINEP. The implementation of the SINEP requires concerted efforts from all stakeholders and I strongly encourage your continual support in contributing to the achievements of the policies identified in this document that will help improve the lives of all Solomon Islanders.

Hon. Moses Garu
Minister for Mines Energy and Rural Electrification

Acknowledgements

The 2014 Solomon Islands National Energy Policy (SINEP) was developed through consultative processes, including workshops, interviews and a desktop review of relevant documents. The Energy Programme of the Secretariat of the Pacific Community's Economic Development Division provided technical assistance for the review and development of the 2014 SINEP. The first in-country visit was conducted in November 2012 and during the second visit the draft policy was presented at the National Energy Forum held in June 2013. The policy was also presented at the Prime Minister's Second Roundtable Discussion held in November 2013. It was also circulated to all government ministries and the private sector for the period October to November 2013.

The efforts of the following agencies and persons are greatly appreciated and acknowledged. Their contributions and insights in the review and formulation of the 2014 SINEP were extremely valuable.

- The Permanent Secretary of the Ministry of Mines, Energy and Rural Electrification who, in November 2013, initiated the review of SINEP; the staff of the Energy Division (ED) for their continued support in organising the workshop consultations and national energy forum and their active participation at these events;
- The Asian Development Bank (ADB) for supporting the renewable energy strategies and investment plan, and their willingness to work together on aligning the policy with renewable energy targets for urban and rural households;
- The World Bank Energy Specialist for Solomon Islands for initial comments provided;
- The private sector, government officials and NGO participants, regional and international partners at the November 2012 national energy workshop on the review and amendments to SINEP and at the June 2013 national energy forum, all of whom actively and willingly reviewed the draft SINEP and the energy efficiency and petroleum strategies and investment plan;
- The presenters at the June 2013 National Energy Forum for their valuable insights into the energy sector issues and challenge: the Central Bank of Solomon Islands, the Ministry of Infrastructure and Transport, the Solomon Islands Electricity Authority, and the private sector's perspective by Geodynamics Limited and the Inter Action Corporation; and the Foreign Investment Division for presenting on the business climate and foreign investment in Solomon Islands;
- The Deputy Director and staff at the Energy Programme of the Economic Development Division of the Secretariat of the Pacific Community for their endurance and guidance in facilitating the review of the 2007 SINEP, and the formulation of the 2014 SINEP and associated strategies and investment plans on energy efficiency and petroleum;
- Pacific Appliance Labelling and Standards (PALS) Programme, funded by the Government of Australia through the Department of Climate Change and Energy Efficiency, for additional funding and resources.

Abbreviations

ADB	Asian Development Bank
EAC	Energy Advisory Committee
ED	Energy Division
FAESP	Framework for Action on Energy Security in the Pacific
NDS	National Development Strategy
PALS	Pacific Appliance Labelling Standards
REIP	Renewable Energy Investment Plan
RD&D	Research and Development and Demonstrations
SBD	Solomon Dollars
SIEA	Solomon Islands Electricity Authority
SINEP	Solomon Islands National Energy Policy
SISEP	Solomon Islands Sustainable Energy Project
SPC	Secretariat of the Pacific Community
TRHDP	Tina River Hydro Development Project

1. Executive Summary

The energy sector is important to the development of the Solomon Island social, economic and environmental status quo. The National Development Strategy (NDS) 2011–2020 highlights three main focus areas that reflect the challenges facing the people of Solomon Islands. These challenges are: (i) poverty alleviation; (ii) access to quality health care and education services; (iii) raising the standard of living; and (iv) improving livelihoods. To combat these challenges, the NDS has the following focus areas:

Overarching focus area: building better lives for all Solomon Islanders;
Central focus areas: (1) taking better care of the people and (2) improving the livelihoods of the people;
Underlining focus area: creating and maintaining the enabling enviornment.

These focus areas are supported by eight national objectives.

Overarching focus area: **Building better lives for all Solomon Islanders**
Objective 1: To alleviate poverty and provide greater benefits and opportunities to improve the lives of Solomon Islanders in a peaceful and stable society

Central focus area 1: **Taking better care of all people of Solomon Islands**
Objective 2: To provide support to the vulnerable
Objective 3: To ensure that all Solomon Islanders have access to quality health care and to combat malaria, HIV, non-communicable and other diseases
Objective 4: To ensure that all Solomon Islanders have access to quality education and for the country to adequately and sustainably meet its manpower needs.

Central focus area 2: **Improving the livelihoods of all the people of Solomon Islands**
Objective 5: To increase the rate of economic growth and equitably distribute the benefits of employment and higher incomes amongst all the provinces and people of Solomon Islands
Objective 6: To build and upgrade physical infrastructure and utilities to ensure that all Solomon Islanders have access to essential services and markets.

Underlining focus area: **Creating and maintaining the enabling environment**
Objective 7: To effectively manage and protect the environment and ecosystems and protect Solomon Islanders from natural disasters
Objective 8: To improve governance and order at national, provincial and community levels and strengthen links between them

The Solomon Islands Government (SIG) views its energy sector as a key enabling factor to support its poverty alleviation effort, accelerate access to better health care and education services, and improve the standard of living and livelihoods of communities. At the same time, the SIG appreciates that, in 2009, access to electricity for the urban areas was only 16%. The widely scattered market on islands that are separated by large areas of sea and that have small, isolated communities make sustainable energy development challenging. Energy policy changes are required to increase energy access, private sector participation and foreign investment, and also to create fiscal incentives for improving energy access, efficiencyand activities that will contribute to expanding the economic base.

Solomon Islands has the potential to increase electricity access and use through renewable energy resources and technologies. However, increasing the use of these renewable energy resources presents challenges. These include a lack of enabling environments to foster private investment in the electricity sector and the need to improve funding opportunities (through consolidating funding proposals) and support to assist the Solomon Islands Energy Authority (SIEA) and the Energy Division (ED) in expanding energy access in both urban and rural areas.

The 2014 Solomon Islands National Energy Policy (SINEP) will provide an enabling platform that will inform decision makers on policy directions and strategies for improving the effectiveness of the Solomon Island energy sector and achieving the NDS 2011–2020 through increased access to reliable, affordable and clean sources of electricity.

The estimate costs for the implementation of the SINEP is given in the table below.

Sub sector	Goals	Estimated budget (USD million)
Planning, coordination, leadership and partnership	Strengthen the energy sector leadership and planning	4.18
Electric power (urban)	Increase access to electricity in urban households to 80% by 2020	64.0
Electric power (rural)	Increase access to electricity in rural households to 35% by 2020	14.95
Renewable energy	Increase the use of renewable energy sources for power generation in urban and rural areas to 50% by 2020	60.05
Petroleum and alternative and gaseous fuels	Increase access of safe, affordable and reliable petroleum fuels to outer islands and remote rural locations Increase the development and penetration of gaseoous fuels and alternative liquid fuels from indigenous raw materials	1.67
Energy efficiency and conservation	Improve energy efficiency and conservation in all sectors by 10.7% by 2019	6.29

Methodology

The policy has been developed through the following;

- a desk review of relevant documents;
- review of the 2007 SINEP and 2009 Strategic Action Plan. Some recommendations were made that contribute to relevant issues in this policy, such as thematic areas and guiding principles to be adopted;
- a participatory and consultative process, engaging various stakeholders in face-to-face interviews. Consultations were done with government departments, development partners, financing institutions, private sector operators and community service organisations. A two-day national workshop was also conducted during the first country visit in November 2012;
- a national energy forum was conducted on 19–20 June 2013, at which there was broad participation by all government ministries, the private sector and development partners' They commented on the draft policy and energy efficiency and petroleum strategies. A list of stakeholders consulted for the formulation of the 2014 draft policy is attached as Annex 1;
- presentation of the policy at the Prime Minister second roundtable in October 2013; and

- the draft 2014 SINEP was circulated in October 2013 to all national and regional stakeholders, including the development partners, for final comment. The final comments were compiled and edited in December 2013.

2 A framework for the national energy policy and its implementation

The 2014 SINEP is intended to guide energy sector planning over the next ten years (2014–2024) and is expected to contribute to the achievement of Solomon Islands' national vision: 'A united and vibrant Solomon Islands' (see Solomon Islands NDS 2011–2020) and the vision of the energy sector (see 2.1 below).

The policy is also intended to guide the development over the next five years of energy sub-sector strategies and investment plans. It is envisaged that the strategies for the different energy sub-sectors will be integrated into the Ministry of Mines, Energy and Rural Electrification (MMERE) five-year corporate plan, which is mainstreamed into government financial resources and budgeting. However, new information should be accommodated and adjustments made to the strategies and investment plans where appropriate and in a timely manner.

2.1 Vision

Unlocking the development potential of Solomon Islands' economic base through a dynamic and effective energy sector

2.2 Mission

Provides the base for appropriate coordination, planning, promotion, development and management, and efficient use of energy resources

2.3 Broad outcomes

- Strengthen the energy sector leadership and planning
- Increase access to electricity in urban households to 80% by 2020.[1]
- Increase access to electricity in rural households to 35% by 2020.
- Increase access of safe, affordable and reliable petroleum fuels to outer islands and remote rural locations
- Increase the use of renewable energy sources for power generation in urban and rural areas to 50% by 2020.
- Increase the development and penetration of gaseous fuels and alternative liquid fuels from indigenous raw materials.
- Improve energy efficiency and conservation in all sectors by 10.7% by 2019.

2.4 Guiding pprinciples

The guiding principles are aligned to Solomon Islands; NDS 2011–2020, the Regional Framework for Action on Energy Security (FAESP) and the Sustainable Energy for All Initiative Goals. The ten guiding principles are to be embraced in the implementation of the policy.

- **Whole-of-energy-sector**: Instigate a whole-of-energy-sector approach and foster partnerships between the relevant institutions and stakeholders. Each institution's roles and responsibilities are to be recognised through proper delineation of roles and avoidance of repetitive or overlapping activities. A strong leadership with legal mandates should be developed and strengthened to coordinate planning and management in the energy sector. The whole-of-energy-sector approach also means looking at all the options in a holistic manner – how the energy sub-sectors connect to each other e.g petroleum uses can be minimised through energy

[1] ADB 2013; Renewable Energy Investment Plan. ADB TA-8130 SOL: Provincial Renewable Energy Project (46014-001). Prepared by SMEC International Pty Ltd.

efficiency and conservation. The deployment the energy services and technologies is determined by understanding the community's needs, the availability of appropriate energy sources rather than a predetermined application, technology and energy source.

- **Environment and climate change**: The energy sector strives to ensure that the environment is protected through the proper management, storage and disposal of renewable energy accessories and parts, energy efficient technologies and parts, and petroleum fuel wastes. While environmental issues are considered the responsibility of the Environment Department, the onus is on private developers and communities to take responsibility for any waste generated through energy sector activities. Climate change is a risk to the development of the nation and therefore efforts to reduce the carbon footprint through the use of renewable energy technologies and energy efficient measures are considered an important part of this energy policy.
- **Capacity building, training and research**: Capacity building, training and research in all aspects of the energy sector are continuous efforts that should be integrated into all sub-sector strategies and activities.
- **Gender:** Gender is to be recognised as an important element for sustainability of energy programmes and provision of efficient and affordable energy services. The *wantok* communal system continues to be a barrier in promoting equitable distribution of energy projects and programmes. However, gender sensitive approaches should be considered in understanding the different energy needs of men, women, and children, as well as in recognising the ability to pay for, operate and maintain the energy services. The gender sensitive approach considers the traditional decision making process and resource ownership and is therefore inclusive of all members of the society or community.
- **Culture and kastom**: the cultural diversity of Solomon Islands is to be valued. Traditional institutions and chiefs form an important part of the country's social fabric and community and, while they are recognised in the country's constitution, they are largely left out of formal governance and administrative structures *(SPC, Solomon Islands Nasional Policy Framework blong KALSA, 2012)*. Acknowledging the traditional administrative structure at the community level and the control and ownership of resources (rivers, land, biomass, etc.) is important for access to land, thereby facilitating improvements to renewable energy resources and the installation of renewable energy technologies.
- **Land issues**: Group and individual identity are defined by their relationship with the land. Of the total land area, 87% is customary land and 13% is alienated land. Alienated land was procured during colonial times and its boundaries are surveyed and registered. Customary lands are not surveyed and boundaries are fixed by geographical features such as rivers and ridges. Therefore ownership can be contested by many communities or land-owners. Promoting energy service systems should consider where land access has been secured and that the resource used should benefit only those communities in order to minimise conflicts over land/resource issues.
- **Legislation and regulations**: Updating of legislation and regular review of regulations to align to changes and needs for effective governance and management of the energy sector.
- **Data management and information**: The availability, accessibility and quality of data and information for all key strategic areas are critical in order to make informed decisions and policy interventions. Continued efforts are needed across all sub-sectors for effective and efficient data collection and management.

- **Financing:** Financing the investment plan is required for implementing the policy with its strategies and activities. The energy sector is a high capital infrastructure and therefore all avenues for sourcing funding should be a priority.
- **Investment**: The Ministry of Commerce, Industry, Labor and Immigration (MCILI) is the lead one-stop agency responsible for the formulation and implementation of economic and industrial development strategies for Solomon Islands. The energy sector is currently one of the priority areas for government and this has encouraged investments in both the Savo Geothermal and the Tina River Hydro Development projects. A conducive and enabling environment for investors is required to increase the uptake of renewable energy technologies. To achieve this, action to be taken could include changes to current policies to include more players (at local, regional and international level) through offering a package of trade and investment incentives for renewable energy and energy efficiency, including duty concessions, investment allowances, tax exemption and tax free regions, low corporate tax rate.
- **Sustainability**: energy sector management should be improved through a stronger emphasis on sustainability principles: economic growth, social development and environmental protection. Therefore, it is very important to recognise the value of natural resources and communities' contribution and participation in project planning and decision making about energy services and technologies. Development partners and energy service providers should also encompass a user pays principle, support community-based activities that empower communities, and provide services and assistance that will achieve sustainable development with or without external support.

2.5 Energy sub sectors

The Solomon Islands energy sector is divided into six sub-sectors (thematic areas) that have been identified as important. These include:

- planning, coordination, leadership and partnership;
- electric power (urban);
- electric power (rural);
- renewable energy;
- petroleum and alternative liquid and gaseous fuels; and
- energy efficiency and conservation.

Each sub-sector is supported with a policy outcome, policy statement, policy details and key priorities. The strategies and investment plans for the energy sub-sectors are developed as separate documents. All are aligned to the policy vision, mission and goals.

3 Policy outcomes and statements

Thematic area 1: Planning, coordination, leadership and partnership

Policy outcome 1.1: Strengthened energy sector leadership and planning through an integrated approach to policy implementation

Policy statements

- Leadership is strengthened through an approved high-level multi-sectoral coordinating mechanism, supported by legislation.
- The energy sector is provided with the appropriate level of legal authority and resources (financial and human) to perform its leadership role.
- Partnerships are established and strengthened at local, national, regional and international levels for the development of energy programmes and projects.

Policy details

The energy sector is vertically structured with the Energy Division responsible for policy development, rural electrification project and administration of *The Petroleum Act 1987*.

More emphasis on strengthening partnerships at local, national, regional and international levels is required to support sustainability and financing of the energy policy and strategies.

Regarding a multi-sectoral coordinating mechanism, an energy advisory committee (EAC) is needed to facilitate the whole-of-energy-sector approach to the planning and management of the energy sector.

Capacity building through informal and formal training should be key priority for the Energy Division staff in order to raise the quality of the work on energy efficiency and conservation, energy data collection, establishing an energy database, licensing for storage of petroleum products, and petroleum safety standards and procedures. Monitoring and evaluation of the energy sector through a more strategic approach, including the use of energy security indicators, could be encouraged in order to improve the reporting on the overall status of the energy sector.

Key priorities	Establish an EAC to coordinate and monitor the implementation of the SINEP.
	Establish an energy regulator through the proposed Energy Act to regulate the energy subsectors: electricity, petroleum, renewable energy, standards, etc.
	Reporting regularly on Energy Division activities and projects, including progress towards the energy policy goal and the NDS focus areas.
	Mainstream the energy sector in other development sectors: transport, agriculture, climate change, education health, investing and financing.
	Establish a mechanism for the provision of energy data to relevant stakeholders through licensing, registration, fiscal incentive provisions, etc.
	Develop a national energy balance database.
	Build capacity in the areas of petroleum storage, and regulating and monitoring petroleum supply and demand.
	Review the *Petroleum Act 1987*.
	Promote and strengthen partnerships with relevant financing and investing in the energy sector through presentations at annual investment/development partners' forums.

Thematic area 2: Electric power (urban)

Policy outcome 2.1: Access to grid connected electricity in the urban areas increased to 80% by 2020[2]

Policy statements

- Establish a profitable, efficient and sustainable business.
- Improve the capacity and condition of the Honiara and outstation networks.
- Develop and implement energy efficiency and conservation in all sectors.
- Extend existing networks to surrounding rural communities where feasible.
- Install renewable energy technologies for demonstrations (head office and solar farm)

Policy details

The electricity sector is managed by the government-owned company, the Solomon Islands Electricity Authority (SIEA). SIEA is totally dependent on diesel for power generation; 80% of energy is produced for Honiara while 20% is for outstations in eight provincial centres. SIEA has a total of 14,000 customers in 2013. It produces around 78 Gwh of energy annually, using 1.7 million litres of diesel a month for power generation, which contributes to 80% of the total expenses of the company. While SIEA operates in a commercial way, a major challenge is the non-payment of government institutions and commercial and residential customers. The Solomon Islands Sustainable Energy Programme (SISEP) started in June 2009 has improved the operational efficiency, system reliability and financial sustainability of SIEA by improved financial and operational management, reduction of losses, and increased revenue collection. The current focus of SIEA, critical to its ongoing financial sustainability is on:

i. reducing arrears from state owned enterprises, in particular Solomon Islands Water Authority;
ii. addressing metering deficiencies and fraud by large commercial/industrial consumers;
iii. implementing improved financial controls and reporting, including replacing SIEA's existing general ledger accounting system (WB report no. ISR4675);
iv. a tariff review; and
v. professional staff development.

With only 14% electrification rate in the urban areas of Honiara and provincial centres in 2009, SIEA also needs to increase its renewable energy mix to meet the increasing demand for electricity.

Key priorities	Increase access to affordable electricity in the urban and semi-urban areas.
	Improve the efficiency of SIEA.
	Create a regulatory framework (under the proposed Energy Act) to regulate the participation of independent power producers and integrate power purchase agreements.
	Regulate the provision and standards of renewable energy technologies for on-grid connections.
	Regulate and monitor the electricity tariff as related to increased fuel prices.
	Sustain a 24-hour electricity service to Honiara and the outstations.
	Improve on the cooling system of the Lungga generators (gain 2.5 MW) by December 2013.
	Install 2 x 1.5 Mw diesel generators at Honiara Power Station by August/September 2013.
	Install 2 x 5.0 Mw Diesel Generators at Lungga Power station by 2015/2016
	Install new diesel generators at Noro, Munda, Tulagi.

[2] ADB. 2013. Renewable energy investment plan, ADB TA-8130 SOL: Provincial Renewable Energy Project (46014-001). Prepared by SMEC International Pty Ltd. Page 53.

Thematic area 3: Electric power (rural)

Policy outcome 3.1: Access to electricity in rural households and institutions increased to 35% by 2020[3]

Policy statements

- Increase the supply and coverage of electricity by responding to community requests.
- Increase the supply of modern energy services in rural schools, telecommunication and health centres.
- Planned and sustainable energy development consistent with government objective
- Develop a renewable energy policy and a rural electrification policy.

Policy details

Access to electricity in both the rural and urban areas has made slow progress since 2005. However, there is an increase of 7% rural households that use solar PV systems for lighting in 2009. The 2009 household income and expenditure survey showed an estimate of 71,749 households relying on kerosene and traditional biomass for lighting. There are about 619 primary schools and health centres that require modern sources of energy. There are 135 high schools and three hospitals that require a reliable and affordable source of electricity. A capacity of 100 Watts solar PV home systems with batteries (lead acid type) are appropriate for these rural and remote services and households while off-grid mini and micro hydro–power of 1000 Watts are appropriate at the community level within the specific hydro site.

Key priorities	Sustainability of renewable energy technologies in rural areas
	Regulate the provision and standards of renewable energy technologies.
	Regulate the price of petroleum and power/electricity.
	Promote legislation and fiscal incentives to encourage wide use of renewable energy.
	Deployment of energy services that will create paid jobs at the community level
	Create awareness and include training opportunities for renewable energy opportunities and technologies on wind, biomass and hydro resources.

3

Thematic area 4: Renewable energy

Policy outcome 4.1: Use of renewable energy sources for power generation in urban and rural areas increased to 50% by 2020

Policy statements

- Establish an appropriate, reliable, affordable and sustainable renewable energy-based power supply.
- Assess, cost, promote and enhance the potential for renewable energy resources.
- Increase productivity in rural communities with the use of renewable energy services.
- Develop renewable energy policy instruments (standards and regulations, net metering policies, market-based instruments, procurement strategies) to meet the renewable energy targets.
- Facilitate partnerships in development of renewable energy developments.

Policy details

The share of renewable energy for power generation in Solomon Islands in 2009 was only 0.6%. A renewable energy resource summary shows the generating electricity capacity for the different renewable energy resources:

- geothermal: available but not fully explored except for the Savo Island geothermal resource currently being explored with estimated potential between 20 and 40 MW;
- hydro: small hydro approximate potential of 11 MW, a total estimated hydro potential of approximately 300 MW;
- wind: no detailed wind assessment has been carried out;
- solar energy: solar radiations estimated at 5.5 to 6.5 kwh/m2/day with potential for small, off-grid solar schemes of a total capacity of less than 1 MW;
- traditional biomass energy: timber wood/forest waste and biofuel with an approximate potential of 20 MW; and
- off-grid biomass/biogas schemes to serve rural communities with total potential of about 500 kW.

The Levelised Cost of Energy (LCOE) for different renewable energy options and technologies shows that solar PV appears to be the best option for renewable generation in remote villages. Solar PV costs USD 0.24 per kWh, while other options of a hybrid of a solar PV system with a biomass gasifier or with biofuel and hydro have an LCOE between 0.27 and 0.28 USD per kWh, with the exception of wind at 0.50 USD per kWh. However the utility scale renewable generation options such as the Tina Hydro Development Project and the Savo Geothermal will have a lower LCOE.[4]

Increasing renewable energy largely depends on public policies that foster public / private partnerships and create policy instruments for renewable energy. These policy instruments include the setting up of regulations and standards, quantity instruments, procurement strategies and price instruments.

Research, development and assessment of renewable energy technology options, including biomass gasification, is considered vital due to the high land mass area of Solomon Islands. The scaling up of successful trials on bio-fuel use for power generation and transport also requires policy support.

[4] ADB. 2013. Renewable Energy Investment Plan TA-8130 SOL: Provincial Renewable Energy Project (46014-001).

Key priorities	○ Establish guidelines on the sustainability of renewable energy technologies in rural areas, schools, telecommunications and health centres in partnership with communities and government sectors.
	○ Monitor and maintain renewable energy projects (Tina River Hydropower and Savo Geothemal schemes and provincial centres RE projects)
	○ Proper dispose of used equipment, such as batteries, lights, bulbs, accessories.
	○ Establish and regulate renewable energy resources and technology standards, e.g. biofuel and solar PV home systems.
	○ Create and regulate financial incentives, standards and market-based policy instruments in meeting the renewable energy targets.
	○ Encourage research and development, and demonstrations (RD&D).

Thematic area 5: Petroleum and alternative liquid and gaseous fuels

Policy outcome: 5.1: Access to safe, affordable and reliable petroleum products and alternative liquid fuels and gaseous fuels increased

Policy statements

- The monitoring and regulating of petroleum prices is done through transparent and coordinated ways.
- A reliable supply of quality petroleum products at landed cost is supplied to all people in Solomon Islands.
- Petroleum storage and handling facilities conform to local and international safety and environmental standards.
- Suppliers and users of petroleum products dispose of petroleum-related wastes in an environmentally sound manner.
- Research in alternative liquid and gaseous fuels is promoted, supported and well coordinated.

Policy details

The energy sector remains dependent on petroleum products for driving the economy, in particular the electricity and transport (land, air and sea) sectors, and therefore it is very important that the petroleum sub-sector is regulated properly to maintain fair and unbiased prices to both the suppliers and the users. What remains a challenge in Solomon Islands is the proper handling, storage and distribution of the petroleum products in the outer and remote islands. In addition, enforcement of the *Price Control Act* in the outer islands is not effective due to the lack of human resources and financial constraints. A one cent levy on the imported petroleum product was recommended to assist the Price Control Unit to check that proper prices are applied in rural and remote areas. *The Petroleum Act 1978* is also outdated, with provisions for fines irrelevant and inappropriate. There are currently no safety and environmental standards due to limited capacity in developing these standards. While there may be international standards that are available, these standards need to be adapted to the local context. Activities related to alternative fuels are limited to small-scale use trials, such as the ADB and SIEA 360 kW biofuel plant trial in Auki. SIEA is promoting the use of coconut oil. In addition, SIEA has a power purchase agreement with Solomon Tropical Products Ltd on using biofuel while a transport trial is being developed in Honiara.

The challenges faced by SIEA in maintaining the use of coconut oil is the shortage of supply due to the limited supply of copra from plantation owners and farmers. There is also competition from well established exporters to foreign markets with links to local farmers. The potential for harnessing biomass through the gasification process of by-products and forest waste needs to be properly assessed.

Key priorities	Improve the supply of petroleum products to outer islands and remote locations
	Establish fuel storage (depots) to the islands for ease of distribution
	Effectively monitor the regulated petroleum prices in the nine provinces.
	Encourage the use of alternative liquid fuels in power generation and transport through • Support private sector to establish professional alternative fuel producers; • Supporting primary producers that can supply raw materials; and • Construct infrastructure as necessary to support new alternative fuel industry.
	Provide financial support/investment to support primary producers that supply raw materials for alternative fuels.
	Invite private sector companies to identify markets and invest in land transport fuels and power generation capacity in addition to SIEA.

Thematic area 6: Energy efficiency and conservation

Policy outcomes 6.1

- Reduce electricity consumption in Government services by 20% in 2019, while increasing efficiency of service delivery by 2019
- Reduce electricity consumption in the residential services by 10% in 2019
- Reduce electricity consumption in commercial services by 5% in 2019
- Reduce electricity consumption in industrial services by 5% in 2019
- Build a sufficient body of expertise within government in order to develop national energy efficiency targets by 2019
- Increase nationwide levels of awareness leading to strong demand for energy efficiency products and services
- Include as mandatory course materials on energy efficiency and conservation at all levels of the education systems by 2019
- By 2019, realise electricity savings of 2.56 GWh from mandatory implementation of minimum energy performance standards and energy labelling for freezers, refrigerators, lights and air conditioning units
- By 2019, fully realise incentives for the purchase and use of efficient vehicles and cooking technologies

Policy statements

- Promote energy conservation and efficiency measures at government, residential, commercial and businesses sectors.
- Encourage energy efficiency in appliances, equipment and technologies.

Policy details

The standards on efficient appliances and the ways in which electricity use in households, government buildings and public institutions, as well as petroleum use in the electricity and transport sector, are all part and parcel of this energy sub-sector. Information sharing and dissemination on energy efficient practices and appliances is important. Information is more easily conveyed to people through demonstration, yet there have been few demonstrations of energy efficient appliance in past years. A regional programme has been developed to reduce this gap in most countries where energy efficiency has not been a priority for the government. Solomon Islands needs to commit its resources to promoting, regulating and increasing the use of energy efficient appliances and fuel efficient vehicles.

Key Priorities	Residential, Commercial and Industrial sector initiatives	Carry out demand-side management activities. Conduct energy audits of commercial and industrial buildings.
	Government led activities	Carry out extensive data collection and collation. Conduct energy audits of government-owned buildings. Conduct government energy awareness programmes. Replace inefficient lights. Reduce overall electricity consumption.
	Public awareness	Conduct energy awareness programmes in Honiara and outer islands. Develop and adapt course materials for use in schools.
	Appliances, equipment and technologies	Promote energy labelling and standards for freezers, refrigerators, lights and air conditions. Offer tax incentives for the use of energy efficient vehicles including LPG vehicles.

4 Linking the policy to the strategies and investment plans

The strategies and investment plans[5] for each policy sub-sector are developed as separate volumes to this policy document. The Energy Programme of the Economic Development Division of the Secretariat of the Pacific Community is providing technical assistance in developing both the *Energy efficiency and conservation strategies and investment plan* (EE-EC-IP) and the *Petroleum strategies and investment plan* (PS-IP). The ADB has formulated the *Renewable Energy Investment Plan* (RE-IP), which includes strategies, activities and investments for both urban and rural electrification. SIEA is formulating its *Power sector strategies and action* plan which is also aligned to this policy framework.

The strategies for each energy sub-sector are presented in Tables 1 to 6. The strategies are to guide the formulation of short-term and long-term activities for achieving the goals and targets for each sub-sector. The investment costs and responsible agencies are also highlighted in the policy so to get a clear estimate of the capital investment required for implementing the policy.

Table 1: Planning coordination, leadership and partnership strategies and investment costs

Thematic Area 1: Planning, coordination, leadership and partnership **Policy outcome:** Strengthened the energy sector leadership and planning through an integrated approach to policy implementation	
STRATEGIES	**Policy statement 1.1** Leadership is strengthened through an approved high-level multi-sectoral coordinating mechanism supported by legislation.
	1.1.1 Achieve government leadership and effective coordination and partnership through the Energy Advisory Committee.
	1.1.2 Support the regulation of the energy sector – off-grid and on-grid electrification.
	1.1.3 Establish standards and certification to cover all electrical equipment.
	1.1.4 Support and review the energy legislation (*The Petroleum Act* and the recommendations on the study of the review of the *Electricity Act*).
	1.1.5 Support the formulation and enacting of an Energy Act.
	Policy statement 1.2 The energy sector is provided with appropriate level of resources (financial and human) to perform its leadership role.
	1.2.1 Submit annual budgets on time.
	1.2.2 Follow processes for membership with donor agencies and meet deadlines.
	1.2.3 Identify funding services.
	1.2.4 Empower institutions through professional staff development.
	Policy statement 1.3 Partnerships are established and strengthened at local, national, regional and international levels for the development of energy programmes and projects.
	1.3.1 Develop targeted training programmes and awareness campaigns for communities on the operation and maintenance of renewable energy projects.
	1.3.2 Promote provincial and community institutional structure and set-up during project planning and implementation.
	1.3.3 Holds timely meetings of energy working groups and energy advisory committees with meeting records documented.

[5] SPC, in collaboration with the Energy Division, has developed energy efficiency and conservation and petroleum strategies and investment plans for 2013–2018.

Responsible agencies	• Ministry of Mines, Energy and Rural Electrification, Energy Division • Energy Advisory Committee members, including Ministry of Public service; Public Service Commission; Attorney General's Chamber; SIEA; Solomon Islands National University; Ministry of Education & Human Resources Development; Ministry of Foreign Affairs & External Trade; Ministry of Finance & Treasury; Ministry of Development Planning & Aid Coordination; Ministry of Provincial Government; Ministry of Rural Development; Ministry of Commerce, Industries, Labour & Immigration.
Estimated inputs	USD 4.18 million (2014–2017)[6]

Table 2: Electric power (urban) strategies and investment costs

Thematic area 2: Electric power (urban) **Policy Outcome 2.1** Access to grid-connected electricity in the urban areas increased to 80% by 2020	
STRATEGIES	**Policy statement 2.1** Establish a profitable, efficient and sustainable business
	2.1.1 Reform SIEA to operate commercially to deliver reliable, affordable and efficient electricity services.
	2.1.2 Re-structure the current SISEP programme to adequately meet changes in events and current challenges faced by the SIEA.
	2.1.3 Reduce government and SOE's electricity bills
	2.1.4 Complete the tariff review and implement
	Policy statement 2.2 Improve the capacity and condition of the Honiara and outstations network
	2.2.1 Progress the Lungga Expansion Project 2.2.2 Complete the 33kV cable, 11kV Switchgear (Honiara), Network Upgrades (Honiara) Projects under the SISEP programme
	Policy statement 2.3 Develop and implement energy efficiency & conservation programme
	2.3.1 Improve awareness and understanding of energy efficiency and conservation in all sectors.
	2.3.2 Investigate non-technical losses and implement actions
	2.3.3 Resolve and implement street – lighting issues
	Policy statement 2.4 Extend existing networks to surrounding rural communities where feasible
	2.4.1 Develop and strengthen collaboration between Ministry of Lands and SIEA to address land access for transmission and distribution.
	2.4.2 Establish an independent body to regulate electricity supplies and standards to maintain quality.
	2.4.3 Establish an independent body to regulate the independent power producers and power purchase agreements.
	Policy statement 2.5 Install renewable energy technologies for demonstrations (head office and solar farm)

[6] Exchange rate : 1 SBD to 0.1264 USD

	2.5.1 Install 1.5 MW solar at Head office in Lungga
Responsible agencies	SIEA, Energy Division, Ministry of Land, Honiara Town Council, prospective independent power producers, Asian Development Bank, World Bank, CIF-SREP
Estimated inputs	USD 64 million[7] (2014–2017)

Table 3: Electric power (rural) strategies and investment costs

Thematic area 3: Electric power (rural) **Policy outcome:** Access to electricity in rural households and institutions increased to 35% by 2020	
STRATEGIES	**Policy statement 3.1** Increase the supply and coverage of electricity by responding to community requests.
	3.1.1 Encourage extension of SIEA to nearby rural communities.
	3.1.2 Encourage public / private partnership for power generation.
	Policy statement 3.2 Increase the supply of modern energy services in rural schools, telecommunication and health centres.
	3.2.1 Improve and increase the use of solar and hydro power.
	3.2.2 Encourage the use of other renewable energy sources, including geothermal.
	3.2.3 Work with communities and townships to establish electrification for rural communities.
	Policy statement 3.3 Planned and sustainable energy development consistent with government objective[8]
	3.3.1 Develop policies for managing Independent Power Producers
	3.3.2 Develop and implement land access policy and strategy
	3.3.3 Develop a National Public Private Partnership Policy for power generation
	Policy statement 3.4 Develop a renewable energy policy and rural electrification policy
	3.4.1 Implement the Rural Electrification Master Plan (JICA-funded project) and recommendations in the 2006 Maunsell *Report on review of the Solomon Islands Electricity Act and Rural Electrification Framework.*
Responsible agencies	SIEA, Energy Division, prospective independent power producers, Asian Development Bank, Renewable Energy Services Company
Estimated inputs	USD 15.20 million[9] (2015–2020)

[7] SIEA Capex Project 2014–2017
[8] This policy statement is also relevant to the RE policy statement and strategies
[9] Costs only for 619 primary schools and health centres with 2 kW capacity including telecommunication use.

Table 4: Renewable energy strategies and investment costs

Thematic area: Renewable energy **Policy outcome**: The use of renewable energy sources for power generation in urban and rural areas increased to 50% by 2020[10] (baseline year 2011 with power generation of 82.4GWh).	
STRATEGIES	**Policy statement 4.1** Establish an appropriate, reliable, affordable and sustainable energy-based power supply systems.
	4.1.1 Support the development and implementation of the Tina River Hydropower Development Project (TRHDP).
	4.1.2 Support the development and implementation of the Savo Geothermal Project.
	4.1.3 Improve SIEA energy services through off grids (hydro and solar) and generating plants.
	4.1.4 Replicate successful public / private partnership models for mini hydro systems and solar PV.
	4.1.5 Replicate successful and scaling-up of deployment of solar PV home systems.
	4.1.6 Prioritise the provision and maintenance of renewable energy infrastructure.
	4.1.7 Develop appropriate frameworks for independent power producers.
	4.1.8 Develop appropriate frameworks and laws to manage land access for renewable energy projects.
	Policy statement 4.2 Assess, cost, promote and enhance the potential for renewable energy resources.
	4.2.1 Undertake an assessment of wind energy potential.
	4.2.2 Undertake an assessment of geothermal energy potential.
	4.2.3 Undertake an assessment of biofuel potential based on coconut.
	4.2.4 Undertake an assessment of gasification potential from by-products and forest waste.
	4.2.5 Promote research and development of other new renewable energy technologies.
	4.2.6 Support the assessments on the suitability of renewable energy technologies.
	2.4.7 Develop training and capacity development on new renewable energy technologies.
	2.4.8 Complete feasibility studies and reports for all renewable energy potential sites and make them available for planning purposes.
	2.4.9 Present investment costs against deployment of renewable energy technology at donor roundtable discussions.
	Policy statement 4.3 Increase productivity in rural communities with the use of renewable energy services.
	4.3.1 Encourage the establishment of rural centres powered by renewable energy at provincial level.
	4.3.2 Encourage Renewable Energy Services Company (RESCO's) involvement in productive uses of renewable energy sources.
	4.3.3 Promote the use of renewable energy technologies for rural ICT stations
	4.3.4 Promote the use of renewable energy technologies in rural schools and health centres.
	4.3.5 Promote the use of low-cost specific renewable energy technologies (e.g. solar charging stations, solar pico lanterns).
	Policy statement 4.4 Develop renewable energy policy instruments (standards, net metering policies, market-based instruments, and procurement strategies) to meet the

[10] Estimate 2020 generation is 115.8GWh (BlizClim study in 2012). The REIP RE target is 100% RE use by 2050.

	renewable energy targets.
	4.4.1 Develop a clear policy on tax holiday incentives and duty tax exemptions for renewable energy technology deployment.[11]
	4.4.2 Develop enabling instruments and initiatives to encourage RESCO and financial institutions to invest in renewable energy initiatives.
	4.4.3 Promote benefits to financial institutions to provide concessional loans and term extension funds for renewable energy electrification projects.
	4.4.4 Promote and support the financing of the Renewable Energy Investment Plan
	4.4.5 Regulate relevant standards for on-and off-grid connections of renewable energy technologies.
	Policy statement 4.5 Facilitate partnerships in development of renewable energy developments.
	4.5.1 Develop an appropriate framework for access to land for renewable energy developments.
	4.5.2 Develop a framework for public and private partnership.
Responsible agencies	SIEA, Energy Division, prospective independent power producers, Asian Development Bank, Renewable Energy Services Company
Estimated inputs	USD 60.05 million[12]

Table 5: Petroleum and alternative liquid/gaseous fuels strategies and investment costs

Thematic Area: Petroleum and alternative liquid/gaseous fuels **Policy outcome**: Access to safe, affordable and reliable petroleum products and alternative liquid fuels increased	
STRATEGIES	**Policy Statement 5.1** The monitoring and regulating of petroleum prices is done through transparent and coordinated ways.
	5.1.1 Ensure an appropriate and effective regulatory framework is in place.
	5.1.2 Ensure compliance to regulated oil and gas prices.
	Policy Statement 5.2 A reliable supply of quality petroleum products at landed cost is supplied to all people in Solomon Islands.
	5.2.1 Ensure a secure and reliable supply of petroleum products within Solomon Islands.
	5.2.2 Develop appropriate technical guidelines and standards for oil storage permits.
	Policy statement 5.3 Petroleum storage and handling facilities conform to local and international safety and environmental standards.
	5.3.1 Ensure that petroleum storage and handling facilities conform to local and international safety and environmental standards.
	Policy statement 5.4 Suppliers and users of petroleum products dispose petroleum related wastes in an environmentally sound manner.
	5.4.1 Ensure that the draft contingency oil spill plan is finalised and implemented.
	5.4.2 Ensure there is regulation for disposal of petroleum-related wastes.
	Policy statement 5.5 Research in alternative sources of liquid and gaseous fuels is

[11] The proposed National Energy Advisory Committee TOR is also to approve tax incentives for renewable energy technologies. Therefore the Income Revenue Department is to be included as one of the members.
[12] Based on RE investment plans' estimated projections for mini-grid (pico hydro) and solar power home systems based on REIP Report V1.1

	promoted, supported and well-coordinated.	
	5.5.1 Promote the use of bio-fuel for power generation and transportation.	
	5.5.2 Research and demonstrate appropriate design of biogas digesters.	
	5.5.3 Promote the use of LPG for cooking and lighting	
Responsible agencies	Price Control Unit of the Ministry of Commerce, Industry, Labour and Immigration; petroleum companies, Ministry of Environment, Energy Division; copra oil producers, SPC – Petroleum Advisory Team	
Estimated inputs	USD 1.67 million	

Table 6: Energy efficiency and conservation strategies and investment costs

Thematic area: Energy efficiency and conservation **Policy outcomes**: • Reduce electricity consumption in Government services by 20% in 2019, while increasing efficiency of service delivery by 2019 • Reduce electricity consumption in the residential services by 10% in 2019 • Reduce electricity consumption in commercial services by 5% in 2019 • Reduce electricity consumption in industrial services by 5% in 2019 • Build a sufficient body of expertise within government in order to develop national energy efficiency targets by 2019 • Increase nationwide levels of awareness leading to strong demand for energy efficiency products and services • Include as mandatory course materials on energy efficiency and conservation at all levels of the education systems by 2019 • By 2019, realise electricity savings of 2.56 GWh from mandatory implementation of minimum energy performance standards and energy labelling for freezers, refrigerators, lights and air conditioning units • By 2019, fully realise incentives for the purchase and use of efficient vehicles and cooking technologies	
STRATEGIES	**Policy Statement 6.1** Promote energy efficiency and conservation measures at government, residential, commercial and industrial sectors
	6.1.2 Encourage demand side management and ensure the transformation towards a more efficient use of energy
	6.1.3 Ensure wider public engagement in energy efficiency
	Policy Statement 6.2 Encourage energy efficiency in appliances, equipment and technologies.
	6.3.1 Ensure there is appropriate standards, guidelines and tax incentives for the use of energy efficient appliances, equipment and technologies
Responsible agencies	Pacific Appliance Labelling Standards (PALS) – SPC, Energy Division, SIEA, 27 heads of ministries and staff, energy efficiency companies (EECOS), Customs Department, oil companies, provincial councils, Ministry of Education, NGOs
Estimated inputs	USD 6.29 million (2014 – 2019)

5. Scale of iimplementation

5.1 Institutional framework

The Energy Division is the leading coordinating agency for implementing the policy, while the administration and oversight of the progress is to be monitored by a high-level multi-sectoral committee to be known as the Energy Advisory Committee (EAC). The Ministry of Development Planning and Aid Coordination is the key member of the committee and its coordinating role in promoting congruence between government priorities and donors is considered important. The EAC is to be chaired by the Permanent Secretary of the Ministry of Mines, Energy and Rural Electrification, with core members from the 12 ministries, as illustrated in Figure 1.

A technical working group (TWG) is required to provide technical advice on the implementation of energy projects and programmes. The TWG will include alternate members from the various energy sub-sectors, including the electricity/power companies, petroleum oil companies, a regulatory body such as the Commerce Commission, the Price Control Unit, and related government ministries and private agencies, including donor partners. The proposed TWG is to report to the EAC on project implementation and progress and is to be coordinated and chaired by the ED, which also provides technical support and reporting to the EAC. The TWG will allow external project partners, such donors, Division or consultants to provide and also get feedback on projects implementations. The proposed institutional structure is provided in Figure 1.

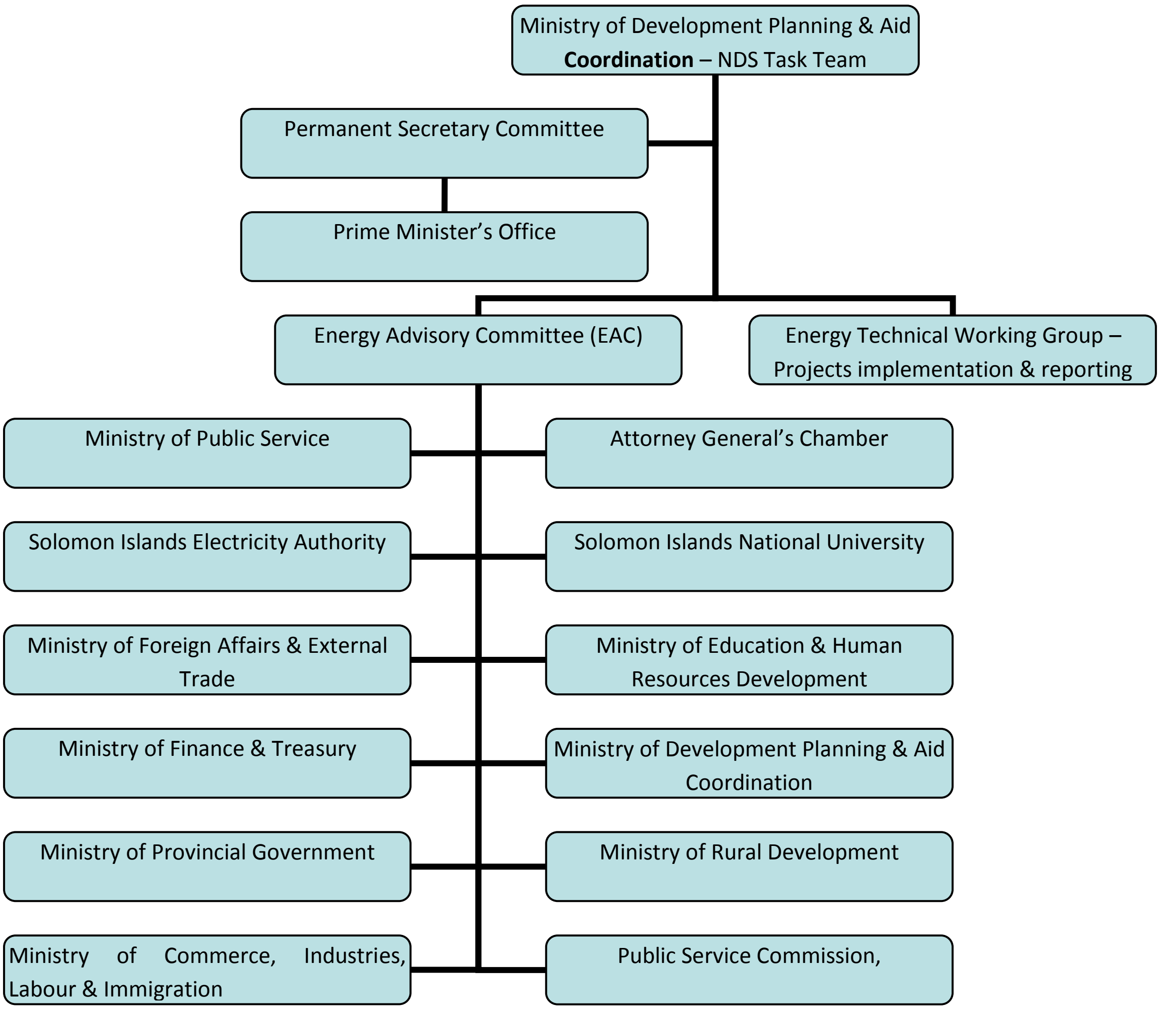

Figure 1: Composition and management structure of the Energy Advisory Committee

5.2 Governance and regulation

The current institutional framework for governance and coordination is vertically structured and there is no overall coordination or regulation for the energy sector. Petroleum pricing and storage are regulated through the *Price Control Act* and *Petroleum Act* respectively but both acts need updating as the fines are outdated.

Consideration should be given to the merits of developing an energy act to mandate new efforts under the policy and subsequent strategies. An energy regulator is to be established under the proposed energy act, which mandates the terms and conditions of the independent power producers, and regulates standards for off-grid and on-grid connections and other energy sector regulations.

During the National Energy Forum, there was a recommendation that the Commerce Commission be engaged to regulate the RE standards and certification. However, technical knowledge and capacity development are needed to set up and regulate standards for all relevant stakeholders.

5.3 Monitoring and evaluation

To monitor the progress of the 2014 SINEP, a log-frame matrix is to be put together with strategies and activities, performance indicators, means of verification and time-lines. The log-frame matrix will become an implementation plan for the policy. Each energy sub-sector has goals and quantified targets, which can be easily monitored. A review of the implementation plan is to be done annually, and this should indicate what needs to be done if monitoring shows a lack of progress.

The progress of SINEP will be monitored and performance evaluated against the performance indicators of the policy and against the energy security indicators. The 2009 energy security indicators for Solomon Islands can be used as a baseline for planning and monitoring progress if there is no other baseline information available.

In addition, SINEP outputs should also be monitored according to the NDS objectives and goals. The policy outcomes, statements, strategies and activities are to be mainstreamed into the MMERE Corporate Plan, which then feeds into NDS policies and strategies thus progress to be assessed effectively at a macro level.

Annexes 1: List of organisations interviewed and consulted

Government
Central Bank of Solomon Islands
Customs & Excise Division
Foreign Investment Division of the Ministry of Commerce, Industry and Immigration
Ministry of the Prime Minister's Office
Ministry of Education and Human Resources Development
Ministry of Environment, Conservation and Disaster Management
Ministry of Infrastructure and Development.
Ministry of Development Planning and Aid Coordination
Ministry of Mines Energy and Rural Electrification
Ministry of Rural Development
Price Control Unit of Ministry of Commerce, Industry, Labour and Immigration
Solomon Island Electricity Authority

Development partners and CROP agencies
Asian Development Bank
Clinton Foundation
IUCN-Oceania Regional Office
Japanese International Cooperation Agency – Solomon Islands
New Zealand High Commission
Pacific Power Association
Secretariat of the Pacific Community
United National Development Partners – Solomon Islands Office

Private sectors and civil societies
Development Services Exchange
Downstream Community
Geodynamics Limited
Humphrey Engineering Ltd
InterAction Corporation
Rokotanikeni Women's Group
Solomon Island Maritime Transport Association

添付資料⑪

FINAL DRAFT

SOLOMON ISLANDS NATIONAL ENERGY POLICY AND STRATEGIC PLAN

VOLUME IV: RENEWABLE ENERGY STRATEGIES & INVESTMENT PLAN

2014

MINISTRY OF MINES, ENERGY AND RURAL ELECTRIFICATION

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1. Minister's Foreword

The Renewable Energy Strategy and Investment Plan (RE-SIP) lays out the Solomon Island's renewable energy targets and policy outcome and strategies and financial requirements for achieving a sustainable energy future for all Solomon Islanders.

The Solomon Islands is blessed with potential renewable energy resources however most of these resources have not been exploited due to a number of barriers and challenges including the geographical locations of these resources which are far away from available demand. In addition, there have been limited opportunities in terms of financial and technical resources and capacities, our cultural and social issues to enhance the use of these resources. These challenges have contributed to a low percentage of total populations having access to electricity.

The government realised the potential that the energy sector will contribute to the economic growth and therefore has included the energy sector as its priority list for investment. In 2009 through its foreign investment reform, the government has created better enabling environment for private sectors and investment through the amendment of its Foreign Investment Act 2005 and Regulation 2006. The government is looking well ahead to the contribution of the two renewable energy developments being supported for private investments; the Tina Hydro Power Development and the Savo Geothermal Project.

The targets that have been assessed and adopted in the 2014 National Energy Policy for utilising the renewable energy potentials are promising for all Solomon Islanders. The potential for renewable energy use and technologies for power generation has been assessed through the Asian Development Bank Renewable Energy Investment Plan and has identified renewable energy targets for the short term (2020), the medium term (2030) and long term (2050). There is expectation that the 100% renewable energy share in the power generation can be achieved by 2050. The RE-SIP is a five years strategy, therefore will provide guidance to meeting the short term renewable energy target of 50% renewable energy by 2020.

The Energy Division of the Ministry of Mines, Energy and Rural Electrification is to coordinate the effective deliverables of the RE-SIP and the SINEP policy outcomes for rural electrification while the state owned utility, the Solomon Islands Electricity Authority will coordinate the implementation of renewable energy options for the urban areas, including its outstations in the provinces.

Again I need to reiterate the need for the activation of a national Energy Advisory Committee , comprised of high –level multi-sectoral members tasked with assessing, monitoring the progress of the RE-SIP including other energy strategies and investment plans and to achieve the overarching focus area of our National Development Strategy; building better lives for all Solomon Islands.

It is with great pleasure to know that this RE –SIP when implemented effectively will contribute to improving the livelihoods of all the people of the Solomon Islands through the access to sustainable, appropriate and affordable energy services and therefore I urge all stakeholders and those that have interest in this RE –S IP to provide support, guidance and advice throughout its implementation and its future continuation.

I wish to thank all national stakeholders including the communities and the development partners that have contributed toward developing this renewable energy strategy and investment plan.

Hon. Moses Garu

Minister for Mines, Energy and Rural Electrification

2. Executive summary

The Renewable energy strategy and investment plan (RE –SIP) provides a way forward for strengthening the renewable energy sector in the Solomon Islands, highlighting the potentials and investments for the renewable energy options, resources and technologies.

The RE-SIP has three main objectives;

1. Provides guidance including funding requirement in utilising the renewable energy potentials and therefore increasing the access to appropriate, reliable, sustainable and affordable energy services. In both the urban and rural areas.
2. To identify and provides plans on how each of the un-electrified rural and urban households of the Solomon Islands will be served with an appropriate and affordable renewable energy technology.
1. Provides policy guidance and instruments (standards, regulations, net –metering policies) to enhance the use of renewable energy resources and their potentials.

The Solomon Islands government has set a 50% renewable energy use for power generation by 2020 to be achieved through its Tina Hydro Development Project and the Savo Geothermal projects, both developments to be commissioned by the end of 2017.

The RE –SIP includes both renewable energy options and investments for solar and hydro resources for both rural and urban areas. The RE-SIP proposed rural electrifications to all households, provincial centres and institutions, through micro grid solar and hydro and solar home systems for rural households.

The RE-SIP has one policy outcomes which is aligned to the 2014 Solomon Islands National Energy Policy (SINEP); the use of renewable energy sources for power generation in urban and rural areas increased to 50% by 2020.

There are three policy statements which are aligned to the strategies;

1. Establish an appropriate, reliable, affordable and sustainable energy-based power supply systems
2. Assess, cost, promote and enhance the potential for renewable energy resources
3. Facilitate partnerships in development of renewable energy development

The RE-SIP is based on achieving the SIG 2020 target of 50% of energy being supplied by renewables in particular the Savo Geothermal, Tina Hydro Development, micro grid hydro where there is water resources available and sola PV for SIEA outstations and standalone solar PV systems of 100Wp for rural households. Land issues are still key challenges in particular for the use of hydro resources and therefore solar home systems can be considered the best option for rural areas, when land issues, population density and access are taken into account.

The RE-SIP will require a total investment of $75.00 million to 2020 to achieve a 44% country wide household electrification rate and a total investment of $234.15 million to 2030 to achieve a 71% household electrification rate.

3. Introduction

The REIP Report prepared under the Asian Development Bank technical assistance through its Provincial Renewable Energy Project provided much needed information for the development of the RE-SIP. The final report was presented to the Energy Division of the Ministry of Mines, Energy and Rural Electrification in June 2013. The REIP findings and recommendations was adopted as part of this RE –SIP while the policy outcomes and strategies were identified during the review of the 2009 SINEP and at the National Energy Forum conducted in Honiara in November 2013.

The RE –SIP is presented as Volume 4 of the 2014 National Energy Policy and Strategic Plan of the Ministry of Mines, Energy and Rural Electrification.

The RE –SIP is presented into three sections; the Energy Sector Overview, Renewable Technologies and Options, Renewable energy Strategy and Investment Plan.

Preface and Acknowledgment

The formulation of the RE – SIP strategy was done as part of the review and formulation of the 2014 Solomon Islands National Energy Policy (SINEP) and the formulation of the subsequent energy sub sectors strategies and investment plan ; the energy efficiency and conservation strategies and investment Plan (EE-EC-SIP) and petroleum strategies and investment plan (PET-SIP).

The Ministry of Energy, Mines and Rural Electrification has been instrumental in directing the development of SINEP and energy sub sectors strategy and investment plans as it sees a need for a more cohesive approach to its planning and that all its efforts are aligned to the National Development Strategy key focus areas. A five years approach to budget allocations by Parliament has also been adopted by the Solomon Islands Government in 2014 and this provides a clear direction in financial resources that are available against implementation of sectoral policies and strategies.

The RE- SIP is a five year plan and is intended as a guiding document to the Solomon Islands government and development partners.

4. Energy Sector Overview

4.1 Physical Description

There are about 996 islands in the Solomon Islands (SI), totalling 28,450 square kilometres (km^2), of which land accounts for 27,540 km^2, dispersed over 800,000 km^2 of sea. Approximately 350 islands are inhabited including the six main islands of Guadalcanal (the largest, where the capital Honiara is located), Malaita, Makira, Isabel, Choiseul and New Georgia. The group lies between 155° 30' and 170° 30' East longitude and between 5° 10' and 12° 45' South latitude, northeast of Australia. The climate is tropical monsoon, with few extremes of temperature and weather. The islands are mostly rugged and mountainous with some low coral atolls. The Exclusive Economic Zone extends to 200 nautical miles (370 km) with an area of 1.34 million km^2.

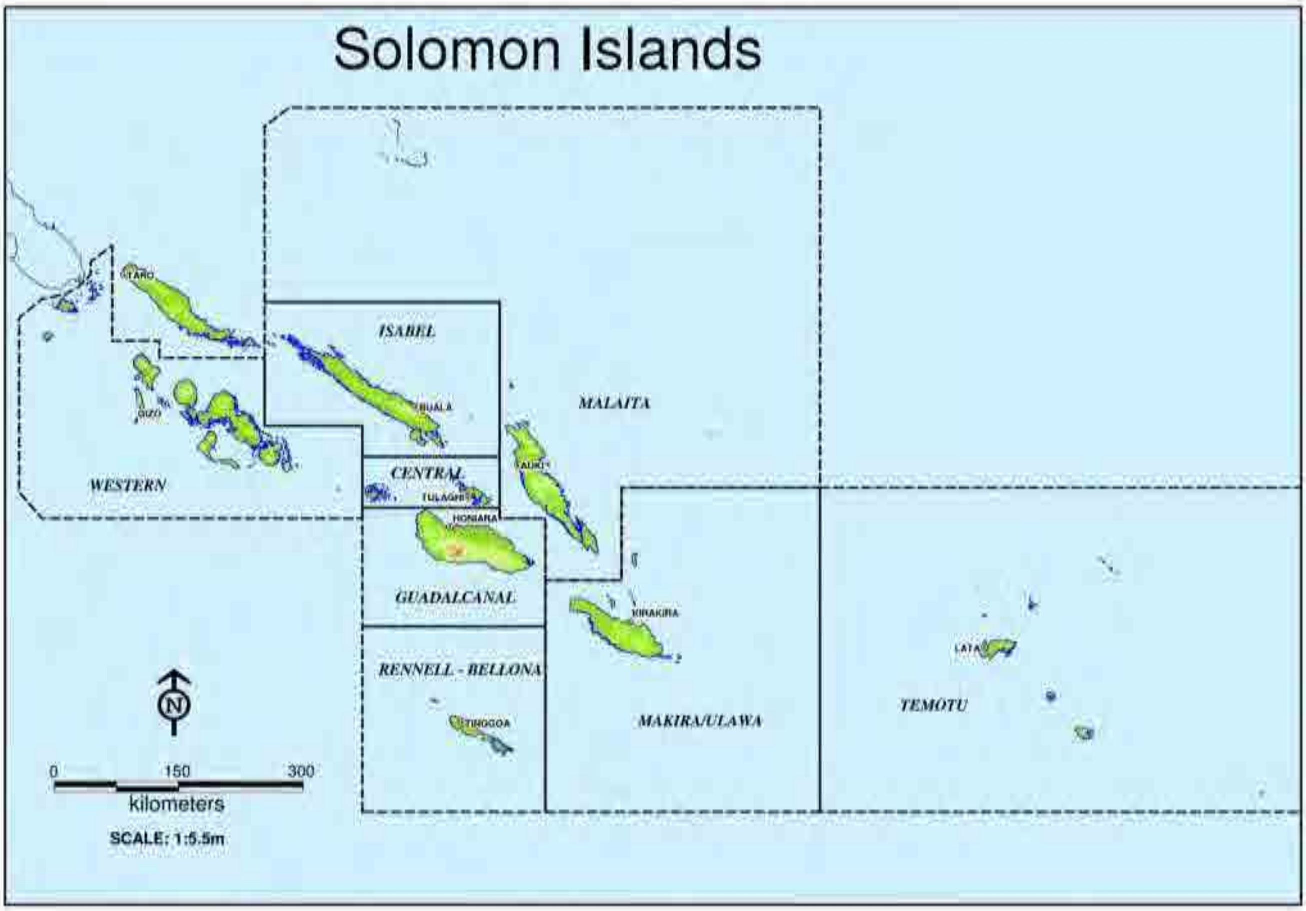


Figure 1 Solomon Islands

3.2 Population

The population of Solomon Islands on 22 November 2009 was 515,870. This means an increase of 106,828 persons (26%) compared with the population size of 409,042 reported in the Census of 21 November 1999. The annual rate of growth since 1999 was 2.3%, which is lower than the annual growth rate between 1986 and 1999 (2.8%) census. Males were 51.3% of the total, out numbering females by 264,455 to 251,415. About 80.3% of the population (75,916 households) lived in rural villages and 19.7% were considered urban. Overall, there were 17 people per km^2 and the average household size was 5.5 persons. Urban and rural population by island is shown in

Table 1.

About 63.5% of the 2009 urban population lived in Honiara, accounting for 12.5% of the national total. From 1999 to 2009, the overall population increased rapidly at an average annual growth rate (AAGR) of 2.3% per annum. The urban population grew even more rapidly with an AAGR of 4.7 %.

Table 1 Population of the Solomon Islands (2009)

Island or group	Total	Urban	Rural
Choiseul	26,372	810	25,562
Western	76,649	9,755	66,894
Isabel	26,158	971	25,187
Central	26,051	1,251	24,800
Rennell-Belona	3,041	-	3,041
Guadalcanal *	93,613	15,241	78,372
Honiara	137,596	5,105	132491
Malaita	40,419	2,074	38,345
Makira	21,362	1982	19,380
Temotu	64,609	64609	0
National Total	**515,870**	**101,798**	**414,072**

Source: Solomon Islands Government (SIG), Solomon Islands National Statistics Office. 2012. *Statistical Bulletin No 6: 2012, Basic Tables and Census Description, 2009 Population and Housing Census.* Honiara

Table 2 Growth of Urban Population 1976-2009

Province	Urban Centre	1976	1986	1999	2009
Choiseul	Taro				810
Western	Gizo	2,707	3,710	6,882	9,755
Isabel	Buala	1,414	1,901	451	971
Central	Tulagi	808	1,622	1,333	1,251
Renbel	Tingoa				
Guadalcanal					15,241
Malaita	Auki	1,926	3,252	1,606	5,105
Makira	Kirakira	1,767	2,588	979	2,074
Temotu	Lata	795	1,295	361	1,982
Honiara		14,942	30,413	49,107	64,609
National Total		**24,359**	**44,781**	**63,732**	**101,798**

Source: Solomon Islands Government (SIG), Solomon Islands National Statistics Office. 2012. *Statistical Bulletin No 6: 2012, Basic Tables and Census Description, 2009 Population and Housing Census.* Honiara

Table 3 Honiara Population and Persons per Household 1970-2009

Year	1970	1976	1986	1999	2009
Population	12,006	14,942	30,413	49,107	64,609
AAGR, %/annum	-	3.7%	7.4%	3.8%	2.8%
Persons / household	5.4	5.5	7	7.1	7.2

Source: Solomon Islands Government (SIG), Solomon Islands National Statistics Office. 2012. *Statistical Bulletin No 6: 2012, Basic Tables and Census Description, 2009 Population and Housing Census.* Honiara

3.3 Economic Overview

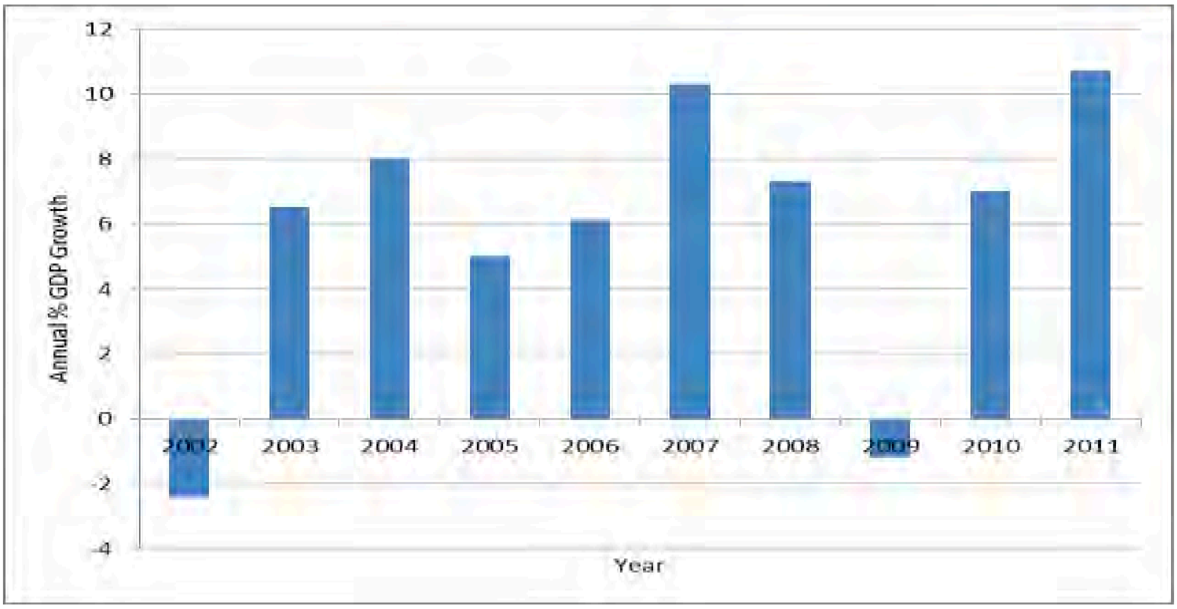
The economy of the Solomon Islands is made up of a mixed subsistence sector on which the majority of the population is dependent, and a small monetised sector dominated by large scale commercial enterprises. These sectors straddle both rural and urban space. Production in the mixed subsistence sector includes household production for self-consumption and surpluses for sale to local and urban markets as well as household production of cash crops for the export market. The monetised sector comprises commercial enterprises and organisations involved in primary production, manufacturing and the service industries. This includes the provision of public goods and services by the government and goods and services provided by statutory bodies.

The Solomon Islands dollar has performed erratically against major currencies for well over a decade with a slight appreciation in 2011. The appreciation came about as a result of a 5% revaluation of the Solomon Dollar in June 2011.

Between 2007 and 2009, GDP in real (constant dollar) terms declined by 1.2% as a result of the global economic crisis. CBSI reported in its annual 2011 report "*Despite subdued growth in the global economy, Solomon Islands economic performance registered another year of record growth. The economy grew in real term by 10.7% in 2011. This growth was driven primarily by strong performance in commodities particularly logs and minerals during the year. Non-forestry & non-mining sectors also contributed to the overall growth, boosted primarily by activities in the agriculture, telecommunications & transportation, construction and fisheries sectors. Strong international commodity prices across the year, especially in the first six months, generally lifted production levels in the agriculture, fishery and other commodities. Higher trade volumes boosted growth in the transport sector, whilst investment in development infrastructure projects contributed to growth in the construction and communication sectors*."

Performance has been improved considerably for the modern monetised sectors of the Solomon Islands economy. Table 4 shows economic growth - or contraction - by sector. Some key indicators of commodity production are also provided in **Error! Reference source not found.**.

Figure 2 Change in Real GDP (2002-2011)



Source: CBSI. 2011, 2012*. Annual Report.* Honiara

Table 4 Real Gross Domestic Product 2002 - 2012 (1985 = 100)

Sector	2003	2004	2006	2007	2008	2009	2010	2011	2012
Agriculture	70.9	77.3	102.7	147.6	167.7	167.7	177.7	197.7	188.6
Forestry, Logging, Sawmilling	131.7	135.6	188.3	381.5	398.6	287	379.5	501.9	506.1
Fishing	72.3	76.8	104.4	116.5	122.1	117.4	128	140.4	150.7
Mining & Exploration	38.2	36.7	-3.2	5	5.6	55.7	55.7	533.4	877.5
Manufacturing	158.1	149.8	134.3	144.1	147.7	141.8	141.3	146.7	171.5
Electricity and Water	183.4	214.4	211.8	285.6	291.1	283	296.1	316.1	335.9
Construction	21.8	26.1	35.9	101.2	110.3	115.3	115.7	122.2	144.4
Retail and Wholesale Trade	119.9	131.7	136.6	152.6	162.4	167.8	171.2	181.6	190.3
Transport and Communications	114.7	129.8	139.2	223	250.8	260.5	275	327.9	348.1
Finance	231.4	228.3	223.5	257.8	262.6	267.5	272.5	284	296.5
Other Services	172.4	138.5	119.1	154.8	171.4	184.4	198.9	202.8	222.6
Index of Monetary GDP Production	122	118	127.6	179.1	194	187.8	205.2	225.1	230.4
Annual % movement	-12.3	-3.6	7.7	13.1	8.4	-3.3	9.2	9.7	2.4
Index of Primary Production	84.1	89.6	121.2	190.3	206.6	181.8	209.5	249.5	247.6

Sector	2003	2004	2006	2007	2008	2009	2010	2011	2012
Annual % movement	-10.4	6.4	33.7	17.2	8.5	-12	15.2	19.1	0.8
Non-Monetary: Food	151.9	155.9	160.5	179.2	184.2	189.4	193.8	188.9	193.3
Non-Monetary: Construction	147.2	150.1	155.6	173.8	178.6	182.7	186.9	182.3	186.5
Non-Monetary GDP Index	151.5	155.4	160	178.8	183.8	188.9	193.2	188.4	192.7
Index of Total GDP Production	127.9	125	133.9	178.5	191.4	187.9	202.7	224.2	235
Annual % movement	-9	-2.4	6.5	10.8	7.3	-1.9	7.9	10.6	4.8

Source: CBSI. 2013. *Quarterly Review*. Honiara

Table 5 Production by Major Commodities 2000 - 2012

Year	Copra (mt)	Coconut Oil (mt)	Palm Oil (mt)	Palm Kernel (mt)	Cocoa (mt)	Fish (mt)	Logs ('000 m^3)	Gold (ounce)	Silver (ounce)
2004	21,831	12	--	--	4,181	27,249	1,043	--	--
2005	26,182	28	--	--	4,928	23,853	1,118	--	--
2006	21,213	59	5,427	1,236	3,835	29,597	1,130	--	--
2007	27,903	741	17,151	4,829	4,470	21,196	1,446	--	--
2008	38,979	520	21,981	3,285	4,326	25,378	1,523	--	--
2009	24,740	89	25,123	3,098	4,553	19,300	1,045	--	--
2010	25,389	123	28,615	3,205	5,376	21,385	1,428	--	--
2011	35,280	470	31,592	3,537	6,495	28,195	1,937	51,054	19,043
2012	26,493	399	31,846	3,387	4,838	29,377	1,948	67,819	28,993

Source: CBSI. 2013. *Quarterly Review*. Honiara

In 2011, the GDP in nominal (current dollar) terms was $5,578 million, an increase of 17% from a revised 2010 level of $4,754 million. This presented an increase by 15% to $10,332 per capita.

3.3.1 Household Expenditure

The 2005/6 household (HH) income and expenditure studies suggest that incomes and expenditures vary considerably by province. The survey report states "*In theory, household income should equal household expenditure but in practise as in most income and expenditure surveys in the pacific region, the information collected from the HIES 2005/6 recorded that a majority of the households' income were relatively lower than their corresponding expenditures*". Households' annual expenditure to its annual income by province **Error! Reference source not found.** shows that expenditure in most cases was significantly higher than income. In Honiara expenditure was well above those of other locations. In 2005/6, Honiara residents had an annual average household expenditure of about SI$ 75,053 per household or SI$ 4,887 per capita.

Table 6 Average Annual Household Per Capita Expenditure and Household Size by Province

Province	Average Annual Household Expenditure	Median Annual Household Expenditure	Average Household Size	Average Annual Per Capita Expenditure	Median Annual Per Capita Expenditure
	(SI$)	(SI$)	(No.)	(SI$)	(SI$)
Choiseul	21,980	14,037	6.18	3,557	2,271
Western	28,024	21,278	6.00	4,671	3,546
Isabel	19,035	17,116	5.12	3,718	3,343
Central	32,223	23,144	5.82	5,537	3,977
Rennell - Bellona	35,432	28,092	6.57	5,393	4,276
Guadalcanal	30,285	24,597	5.78	5,240	4,256
Malaita	21,018	16,538	6.36	3,305	2,600
Makira-Ulawa	18,965	15,130	6.65	2,852	2,275
Temotu	15,759	12,389	5.53	2,850	2,240
Honiara town	75,053	58,367	6.93	10,830	8,422
Solomon Islands	30,069	20,035	6.15	4,887	3,256

Source: SIG, National Statistics Office. *2006. Housing Income & Expenditure Survey (HIES) 2005/2006.* Honiara

3.3.2 Investment Climate

The ease of doing business in the Solomon Islands has improved significantly since the passage of the Companies Act and the Foreign Investment Act in 2009. It has been recognised by successive governments, the importance of overseas investment in broadening the economic base.

The 2013 ranking by World Bank and International Finance Corporation places Solomon Islands at:

- 92/185 for ease of doing business placing it 13th in the Asia Pacific region of 24 counties
- 9/185 for starting business, making it much easier to start a business, (apart from Samoa and Tonga) than most of the other Pacific Island Countries
- 18/185 for getting connected to the electricity grid, it is easy to connect to the grid in the Solomon Islands on an International basis but difficult in comparison to others in the region
- 8/185 for protecting investors and 15/185 for obtaining credit. These rankings indicate relatively high levels of investor protection.

Since the commencement of the Foreign Investment Act 2009, proposals that usually take a minimum of 30 days to approve can successfully be completed in 5 days. Approvals that are subject to exchange control approval has been relaxed which has resulted in the shorter timeframe for registration.

Land is a complex and integral part of the Solomon Islands way of life and generally communally owned by clans or tribes. Children inherit land rights through either the father or mother depending on the lineal system practised by the particular clan. Title to land is either customary or registered and means that:

- The Government recognises that all customary land is owned, usually in a lineage group; registered land has its ownership and boundaries recorded in a land registry in Honiara and these are guaranteed by law rather than by custom.
- About 88% of land is customary and 12% registered. In 1977, an Amendment Bill to the Lands and Titles Ordinance converted perpetual estates registered and owned by non-Solomon Islanders and Solomon Islanders alike into 75 year fixed term estates (leases from government) with development conditions.

3.4 Institutional Arrangements for Energy Sector

3.4.1 Energy Policy

A number of draft energy policies have been developed since the 1980s, including the following:

- *Solomon Islands National Energy Policy and Guidelines* (1995), which included an annex, titled *Solomon Islands Rural Electrification Policy - Background*.
- *National Economic Recovery, Reform and Development Plan for 2003-2006* (NERRDP), issued in October 2003.
- National Energy Policy Framework, endorsed by Cabinet, 2007.

3.4.2 Energy Legislation

The following acts of parliament of the Solomon Islands deal directly or indirectly with energy issues:

- *Electricity Act* (1969)
- *Petroleum (Exploration) Act* (1996)
- *Petroleum Act* (1939).
- *Consumer Protection and Price Control Act (1995)*
- *Environmental Act* (1998)

The *Electricity Act* (1969) (Chapter 128 of the Laws of the Solomon Islands) and associated regulations provides a legal framework for is the establishment of a state-owned, vertically integrated utility providing grid supply to urban and provincial centres. In 1982, the Act was amended to align with utility practice at the time and allow the SIEA to expand its jurisdiction.

The *Consumer Protection and Price Control Act* (Chapter 64 of the Laws of the Solomon Islands) was revised in 1995. It establishes price control rules throughout the country including price control of petroleum products and LPG. No legislation has yet been enacted for regulating biofuels.

The *Environmental Act* (1998) commenced operation in September 2003 and its associated regulations were gazetted in 2008. Under the Act there are formal requirements for environmental impact assessments, and requirements for energy sector investments such as power stations or oil storage, these are specifically mentioned under the second schedule (section 16) “Prescribed Developments”.

3.4.3 Energy Division

An Energy Division within the Ministry of Mines, Energy and Rural Electrification is responsible for energy policy, renewable energy development and project implementation. The Director of Energy is responsible to the Permanent Secretary, appointed through the normal public service mechanism, who in turn is responsible to the Minister.

The roles and responsibilities of the Energy Division include:

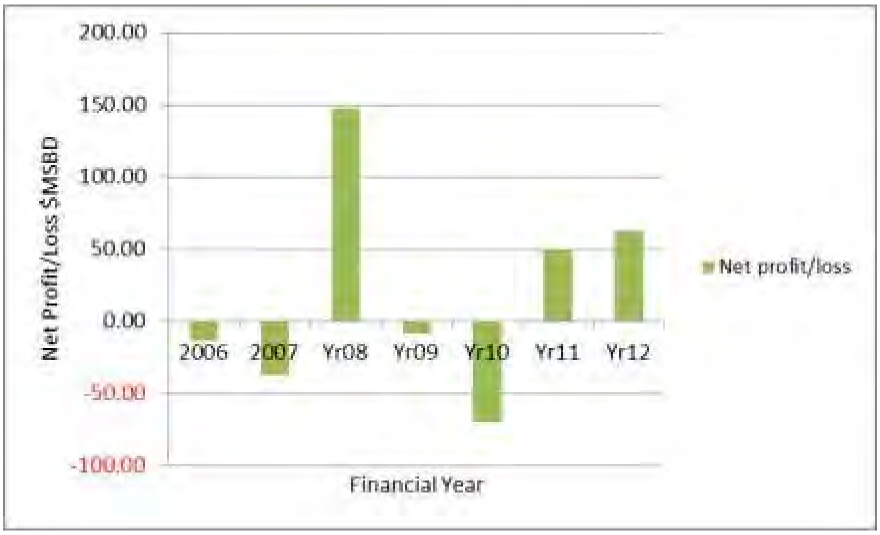
- Develop and monitor a national energy work programme(s) by which energy policies will be achieved
- Coordinate activities and programmes of the energy sector participants
- Develop and maintain a comprehensive energy sector database for policy formulation, planning and monitoring through the collection and collation of information on energy supply, demand, etc.
- Monitor, review and provide recommendations on fuel pricing electricity tariffs, and government charges and subsidies, to ensure that the full and correct price signals are conveyed to consumers wherever possible
- Develop and maintain the capacity to monitor and evaluate the landed price of petroleum, the petroleum company cost elements, the pricing formula, and government charges so as to negotiate and maintain equitable pricing and proper contractual arrangement for petroleum products
- Monitor, review and provide recommendations on future developments in public and private energy sector infrastructure. In particular, encourage public sector agencies to adopt a list cost, financially and environmentally sustainable strategy to meeting energy demand
- Formulate and secure proposals for donor assistance where appropriate, and screen out those lacking in technical maturity economic viability or environmental sustainability
- Provide advice to government and its agencies concerning energy investment budgets and / or specific project funding
- In conjunction with other ministries and agencies, develop, implement and monitor regulations and standards governing the energy sector, particularly concerning the safety of petroleum handling/storage facilities and environmental guidelines for the petroleum sector, such as oil spill contingency plans and waste oil disposal
- Work closely with the relevant government and non-government organisations on the environmental aspects of energy projects and programmes
- Develop and assist in implementing energy conservation and efficiency programmes for the government, commercial sector and the public, including education campaigns and the evaluation of energy efficient appliances and technology
- Develop education/awareness programmes to highlight fuel substitution options
- Monitor and review the development of new and renewable energy resources and technologies particularly with regard to photovoltaic, solar thermal technology and biomass
- Train local staff.

3.4.4 Solomon Islands Electricity Authority

The Solomon Islands Electricity Authority is responsible for electric power supply and distribution to Honiara, nine provincial centres, and Noro Township in the Western Province. The SIEA is a state owned enterprise a statutory body established by an act of Parliament. The Minister of Mines Energy and Rural Electrification, along with the Minister of Finance, appoints a board consisting of six members and a chair.

SIEA provides power to urban centres through diesel generators, except for Buala town on Isabel Province and Malu’u substation in Malaita which includes supply by mini-hydro (both hydropower stations were not operational at the time of report). Various boarding schools, rural training centres, health centres, rural fisheries centres, tourist resorts, private shops and residents located away from SIEA grid use their own diesel generators, micro hydropower or solar PV to generate electricity. As shown in **Error! Reference source not found.**, SIEA's financial position has improved in recent years since the 2010 net loss of $65,994,811. The SIEA 2012 annual report noted a year end net profit of $62,701,365.

Figure 3SIEA Net Profit/Loss ($SI million)



Source: SIG,SIEA. 2012. *Annual Reports 2006-2012.* Honiara

3.4.5 Rural Electrification Service Companies (RESCOs)

There are a number of Rural Electrification Service Companies (RESCO) in the Solomon Islands that sell solar PV equipment. One RESCO (Willies Electric Power and Solar) specialises in solar pv systems and has pioneered the concept of accepting local products in payment for solar installations, thereby avoiding the common problem in rural areas of poor access to cash. It also provides training in solar installation and maintenance. Since 2008, the SIG through the MMERE has acted as a partial RESCO and has been implementing solar electrification projects at rural schools and clinics as well as providing infrastructure for rural communities such as solar battery-charging stations and solar water-pumping.

3.4.6 Petroleum Supply Companies

Petroleum products are imported into the Solomon Islands by South Pacific Oil and Markwarth Oil, both Solomon Islands' based companies. The storage depots of both companies are at the main port in central Honiara. Origin Gas Ltd. of Australia is the sole importer and distributor of liquid petroleum gas (LPG). Origin's main LPG storage is also in Honiara. Origin operates in Honiara and Noro in the Western Province and sells LPG to private outlets, some of which distribute to customers in other locations. Major users of LPG, apart from hotels and restaurants for cooking and heating, include air conditioning in Honiara.

3.4.7 Inter-Ministerial Energy Committees

The establishment of a national energy committee was proposed in the mid-1990s but did not eventuate. A committee was set up to oversee the feasibility study activities of the Komarindi Hydropower Scheme. A similar set up was proposed for the UNDP/GEF/SPREP Pacific Islands Climate Change Project (PICCAP), which dealt with greenhouse gas (GHG) emissions and a national GHG inventory. The committee considered energy issues, as it must deal with GHGs, and the Energy Division was represented. PICCAP formally ended in 1999, the Solomon Islands Meteorological Services (SIMS) continues to deal with climate change/GHG issues and consults with the Energy Division through a Climate Change Country team. The team consists of representatives from government departments, NGOs, and the private sector but reportedly has not met since October 2002.

The committee arrangements have become inactive over the years as confirmed by the Energy Division. The Energy Division will pursue establishment of an Energy Advisory Committee in 2014. Following Cabinet's approval (11 July 2013) to establish a "Labelling & Standards Steering Committee" to coordinate implementation of the Australian Govt funded "Pacific Appliances Labelling & Standards project", the Energy Division plans to have this committee play the role of Energy Advisory Committee and to eventually assume that role after the PALS project is completed.

3.5 Energy Supply and Demand

3.5.1 Energy Supply

The Solomon Islands are almost entirely dependent on imported refined petroleum fuels for national energy needs for electricity generation, for transport by land, sea and air and for lighting. Biomass provides more than 61% of gross national energy production, petroleum products for about 38%, and hydropower and solar are estimated as one percent.

3.5.2 Cooking Fuel

Fuel wood is by far the most common cooking fuel in the Solomon Islands, used **Error! Reference source not found.** by 93% of the population as their main fuel, increasing to 97% if Honiara is ignored. Even in Honiara, more than half of households primarily use wood or wood products for cooking. Malaitans, who make up nearly half of Honiara's population, have no traditional access to land on Guadalcanal and therefore undertake illegal cutting in the outskirts of the city. A commercialised fuel wood market is well established in Honiara. Supplies come mainly from secondary forest and logged over areas of Tenaru and Mt Austin, about 10 km from Honiara. Drift wood is also used as and when available.

Table 7 Cooking Fuel, by Household and by Province (2009)

Location	Total	Electricity - main grid	Kerosene	Wood Coconut shells	Char-coal	Households using Biomass fuel	% Households Using Biomass	Gas	Other
	Households (N°)								
Choiseul	4,712	8	23	4,588	11	4,599	97.6%	74	8
Western	13,762	60	141	12,990	109	13,099	95.2%	441	21
Isabel	5,143	5	40	4,860	132	4,992	97.1%	104	2
Central	4,905	12	7	4,790	0	4,790	97.7%	96	-
RenBell	688	-	4	666	0	666	96.8%	18	-
Guadacanal	17,163	39	39	16,423	21	16,444	95.8%	617	24
Malaita	24,421	34	77	24,016	12	24,028	98.4%	254	28
Makira	7,173	30	8	7,068	2	7,070	98.6%	47	18
Temotu	4,303	6	12	4,258	0	4,258	99.0%	25	2
Honiara	8,981	331	261	4,761	131	4,892	54.5%	3,281	216
Total	**91,251**	**525**	**612**	**84,420**	**418**	**84,838**	**93.0%**	**4,957**	**319**

Source: SIG. 2012. *2009 Population and Housing Census.* Honiara

3.5.3 Electricity

As Table 8 shows, only 21% of households in the Solomon Islands had access to electricity in 2009, ranging from well just over 8% in Central Province to 67% in Honiara. Overall, 56% of those households electrified received power from SIEA. Away from Honiara, only 37% of electrified households had SIEA service, 28% had their own source of supply, and 23% reported that they received electricity from a private company.

As **Error! Reference source not found.** shows, in 2012 total consumption was about 63.5 GWh of which domestic consumers accounted for 14%, commercial 63%, industrial 1% and 8% by Government. The Honiara system accounted for 89.7% of total demand, Auki 3.3%, Noro 2.6%, Gizo 1.9% and six others less than 1% each.

SIEA has a national tariff (**Error! Reference source not found.**), with substantial cross-subsidies from Honiara consumers to SIEA consumers on the outer islands. In early 2013, the cost of electricity was 86 US¢/kWh for domestic consumers and 92 US¢/kWh for commercial or industrial consumers. There is an '*automatic fuel price adjustment*' (AFPA), varying with the cost of diesel fuel the present AFPA is 27 SI¢/kWh. Many businesses have their own generator due to frequent SIEA outages. If a business generates its own power in an SIEA service area, it is charged at a rate of half of the normal SIEA charge per kWh (except in Honiara where SIEA is unable to meet demand).

Error! Reference source not found. shows the annual maximum demand in each SIEA grid (system) in kW peak from 2000 to 2012. For the past twelve years and longer, peak demand has usually exceeded firm capacity e.g. during April 2013 one unit at Lunga Generating Station in Honiara was out of commission on a 10,000 hour maintenance overhaul which resulted in rotating load shedding. The CAGR (Compound

Average Growth Rate) for maximum power demand across all systems for the last 10 years, 2003 to 2012 is 3.49%.

Table 11 shows annual energy demand in each SIEA grid (in GWh per annum) over the last 12 years. The table shows that energy demand growth has been mixed and has probably been constrained by the lack of significant grid extension in recent years and the relatively high tariff, pointing towards supressed demand. The CAGR for energy demand across all systems for the last 10 years, 2003 to 2012 is 4.06%.

Table 8 Households by Source of Electricity & by Province (No. 2009)

Location	Total	Electricity - main grid	Own Generator	Solar	HH with electricity	% HH with electricity	Gas	Kerosene Lamp	Coleman lamp	Wood / coconut	Other	None
Choiseul	4,712	194	52	478	724	15.4%	19	3,869	17	2	76	5
Western	13,762	1,665	145	1,149	2,959	21.5%	10	10,425	19	88	238	23
Isabel	5,143	298	62	870	1,230	23.9%	20	3,825	16	3	47	2
Central	4,905	189	33	188	410	8.4%	7	4,476	-	-	10	2
RenBell	688	3	1	515	519	75.4%	-	145	-	-	12	12
Guadacanal	17,163	1,411	229	597	2,237	13.0%	20	14,198	20	411	227	50
Malaita	24,421	827	74	2,969	3,870	15.8%	48	19,211	26	228	963	75
Makira	7,173	265	48	424	737	10.3%	8	5,735	74	62	471	86
Temotu	4,303	116	8	532	656	15.2%	2	3,431	22	68	119	5
Honiara	8,981	5,780	31	202	6,013	67.0%	13	2,835	36	3	60	21
Total	**91,251**	**10,748**	**683**	**7,924**	**19,355**	**21.2%**	**147**	**68,150**	**230**	**865**	**2,223**	**281**

Source: SIG. 2012. *2009 Population and Housing Census.* Honiara

Table 9 SIEA Annual Energy Demand by Customer Type (MWh 2012)

Category	Honiara	Noro	Munda	Gizo	Auki	Malu'u	Buala	Kira	Lata	Tulagi	Total	% of total
Domestic	7,532,481	157,136	68,004	104,992	1,016,787	28,601	120,516	55,781	17,335	3,664	9,105,297	14%
Commercial	38,036,290	511,174	350,544	753,747	842,369	18,092	139,993	116,519	60,981	217,402	41,047,111	65%
Industrial	6,122,577	990,659	12,975	9,838	113,292	141	141	463		2,596	7,252,682	11%
Govt	4,699,220		95,554	274,806	59,526	11,728	47,016	63,777	34,731	3,895	5,290,253	8%
Min. Charge	0	353	3,766	4,419	8,638	5,540	4,481	5,997	143	354	33,691	0%
Others	551,776	2,925	10,543	79,608	66,179	1,358	9,644	2,646	44,590	1,062	770,331	1%
Total	**56,942,344**	**1,662,247**	**541,386**	**1,227,410**	**2,106,791**	**65,460**	**321,791**	**245,183**	**157,780**	**228,973**	**63,499,365**	**100%**
% of total	89.7%	2.6%	0.9%	1.9%	3.3%	0.1%	0.5%	0.4%	0.2%	0.4%	100.0%	-

Source: SIG, SIEA. 2013. *Customer Demand Statistics.* Honiara

Table 10 SIEA Tariff April 2013 (SI$)

Category	Charge (SI$)
Domestic	6.1867/kWh
Commercial & Industrial	6.6465/kWh
High Voltage Tariff	6.4746/kWh
Minimum Charge	20.00/month

Category	Charge (SI$)
Note: Costs incl. AFPA, SI$ 0.2785/kWh	

Source: SIG, SIEA. 2013. *Customer Demand Statistics.* Honiara

Table 10 SIEA Historical Maximum Power Demand by System (kW Peak)

System	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Honiara	10,300	9,200	8,800	9,280	9,910	10,790	11,470	12,600	12,610	12,880	13,780	13,870	14,241
Noro/Munda	1,730	1,530	1,439	1,350	1,520	730	750	860	800	580	550	440	410
Gizo	315	355	350	332	340	495	360	380	360	390	450	423	450
Auki	315	343	385	435	320	288	274	315	320	365	367	360	360
Buala	65	70	70	65	70	85	75	80	78	80	70	74	72
Kirakira	68	52	51	46	45	65	70	88	75	67	45	71	62
Lata	65	65	60	57	64	80	86	93	82	107	82	92	88
Malu'u	33	40	40	40	30	31	29	30	24	22	22	22	30
Tulagi	60	68	65	60	60	65	64	74	69	89	79	103	92
Total Demand, Power	**12,951**	**11,723**	**11,260**	**11,665**	**12,359**	**12,629**	**13,178**	**14,520**	**14,418**	**14,580**	**15,445**	**15,455**	**15,805**
Demand Growth		-9%	-4%	4%	6%	2%	4%	10%	-1%	1%	6%	0%	2%

Source: SIG, SIEA. 2013. *Customer Demand Statistics.* Honiara

Table 11 SIEA Historical Annual Energy Demand by System (GWh/Annum)

System	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Honiara	49.63	47.13	45.39	45.07	51.44	58.30	59.40	66.75	68.59	69.76	74.52	74.67	75.29
Noro/Munda	7.47	4.77	6.97	6.41	6.78	4.20	4.35	4.75	4.76	3.38	3.43	2.28	3.32
Gizo	1.85	1.89	1.64	1.89	1.91	1.88	2.00	1.92	1.88	1.86	2.26	1.96	2.48
Auki	1.76	1.69	1.71	1.57	1.53	1.60	1.57	1.67	1.42	1.58	2.05	1.96	1.88
Buala	0.00	0.33	0.34	0.33	0.37	0.39	0.30	0.49	0.32	0.33	0.38	0.29	0.38
Kirakira	0.33	0.34	0.32	0.29	0.25	0.33	0.34	0.37	0.32	0.34	0.32	0.40	0.07
Lata	0.27	0.24	0.26	0.26	0.25	0.36	0.30	0.27	0.26	0.44	0.22	0.13	0.30
Malu'u	0.10	0.05	0.05	0.06	0.08	0.14	0.19	0.61	0.27	0.08	0.03	0.40	0.14
Tulagi	0.33	0.39	0.37	0.40	0.33	0.37	0.42	0.45	0.36	0.42	0.41	0.35	0.17
Total Demand, Energy	**61.72**	**56.84**	**57.06**	**56.28**	**62.95**	**67.55**	**68.86**	**77.28**	**78.19**	**78.19**	**83.62**	**82.43**	**84.04**
Demand Growth		-8.6	0.4	-1.4	10.6	6.8	1.9	10.9	1.2	0.0	6.5	-1.5	1.9

Source: SIG, SIEA. 2013. *Customer Demand Statistics.* Honiara

3.5.4 Prospective Demand Growth

Table 12 shows prospective SIEA peak demand to 2030 assuming a CAGR of 3.5% and *Table 13* shows prospective SIEA energy demand to 2030 assuming a CAGR of 4.1%. Both of these figures are based on the SIEA historical CAGR 2003 - 2012. These growth rates can be compared with PIREP 2004 which assumed a) a base case of 4% CAGR, b) a low growth case of 2%, c) a high case of 6% and also with JICA 1998 which assumed a projected average growth rate of 5.2% for power and energy. The projected power and energy demands are no more than roughly indicative but provide a basis for estimating future generation requirements until 2016. A horizon year of 2016 should provide sufficient time for the planned rehabilitation of the diesel outstations, the Lunga and Honiara diesel upgrades and the development of smaller scale renewable generation options. The larger scale renewable generation options on Guadalcanal including Tina River Hydro and Savo Geothermal, of indicative capacity of 20 MW each, will take longer to develop and construct and should be considered for meeting demand growth in the period 2015-2020.

Table 12 SIEA Projected Maximum Power Demand by System (kW Peak)

System	2012	2013	2014	2015	2016	2020	2025	2030
Honiara	14,241	14,739	15,254	15,787	16,338	18,745	22,257	26,427
Noro/Munda	410	424	439	455	470	540	641	761
Gizo	450	466	482	499	516	592	703	835
Auki	360	373	386	399	413	474	563	668
Buala	72	75	77	80	83	95	113	134
Kirakira	62	64	66	69	71	82	97	115
Lata	88	91	94	98	101	116	138	163
Malu'u	30	31	32	33	34	39	47	56
Tulagi	92	95	99	102	106	121	144	171
Total Demand	**15,805**	**16,357**	**16,929**	**17,520**	**18,133**	**20,803**	**24,701**	**29,330**
Demand Growth	3.49%							

Source: SIG, SIEA. 2013. *Customer Demand Statistics & Consultant's Estimates.* Honiara

Table 13 SIEA Projected Annual Energy Demand by System (GWh/Annum)

System	2012	2013	2014	2015	2016	2020	2025	2030
Honiara	75.29	78.34	81.53	84.84	88.28	103.52	126.32	154.14
Noro/Munda	3.32	3.46	3.60	3.74	3.89	4.57	5.57	6.80
Gizo	2.48	2.58	2.69	2.80	2.91	3.41	4.16	5.08
Auki	1.88	1.95	2.03	2.12	2.20	2.58	3.15	3.84
Buala	0.38	0.40	0.41	0.43	0.45	0.52	0.64	0.78
Kirakira	0.07	0.07	0.08	0.08	0.08	0.10	0.12	0.15
Lata	0.30	0.31	0.33	0.34	0.35	0.41	0.50	0.62
Malu'u	0.14	0.15	0.16	0.16	0.17	0.20	0.24	0.29
Tulagi	0.17	0.18	0.19	0.19	0.20	0.24	0.29	0.35
Total Demand	**84.04**	**87.45**	**91.00**	**94.70**	**98.54**	**115.55**	**141.00**	**172.05**
Demand Growth	4.06%							

Source: SIG, SIEA. 2013. *Customer Demand Statistics & Consultant's Estimates.* Honiara

4 Renewable Technologies and Options

4.3 Geothermal

There are surface manifestations of geothermal energy in West Guadalcanal, the Ngokosoli river valley of Vella Lavella, Simbo Island, and Savo Island. There is an on-going feasibility study for a 20 MW geothermal generation plant on Savo Island. In the initial stages exploration of potential sites is required to identify good sites for geothermal based power generation, which will require the drilling of trial wells. Geothermal is a good resource for future base load renewable generation but may be constrained by difficulties with land acquisition, transmission line routing and volcanic activity. The economics of geothermal generation are also sensitive to scale.

4.4 Hydropower

There is substantial hydropower potential in the Solomon Islands. The total hydroelectric potential of the Solomon Islands is estimated to be 326 MW[1]. A feasibility study conducted by the SIG, with support from the World Bank and the Government of Australia, proposed a 15-20 MW hydropower development on the Tina River near Honiara, with annual electricity production of 60 GWh. Feasibility studies on the Tina River hydropower scheme proposed for Honiara are continuing. The Energy Division is currently assessing 4 small-scale hydro schemes for provincial centres to reduce SIEA's use of diesel-based power generation in outer island provincial centres[2].

Table 14 Small Scale Hydro Feasibility Studies

Type	Location	Capacity kW	Planned Commissioning Year
Hydro, run-of-river	Fiu river, Auki, Malaita Province	750	2017
Hydro, run-of-river	Luembalele river, Lata, Temotu Province	190	tba
Hydro, run-of-river	Huro river, Kirakira, Makira Province	120	tba
Hydro, run-of-river	Mase river, Western Province	1,750	tba

Hydropower is attractive in the Solomon Islands for centralised power generation to supply the SIEA urban grids. Hydropower fed mini-grids can also be an option in rural areas depending on a suitable site location and water resources. As shown in **Error! Reference source not found.**, there is a history of community rural based micro hydro plants feeding small mini-grids.

Table 15 Community Rural Based Micro Hydro Plants Feeding Small Mini-Grids

Type	Location	Year	Capacity	Generation	Funding	Comments
Hydro	Iriri Settlement Kolombangara	1983	10 kW	3-4 kW	Unido	Not operating due to weir and penstock failures, etc. Community is still considering whether to refurbish this system
Hydro	Malu'u River (Malaita)	1986	32 kW	15 kW	NZ Aid	Not operational due to on-going land disputes
Hydro	Vavanga (Kolombangara)	1994	12 kVA	4-5 kW (now 8 kW)	AusAID +Australian Citizens	Reconstructed on a new site with a new 8 kW turbine / genset. Commissioned June 2006. Currently operating reliably
Hydro	Buala Santa Isabel	1996	185 kW	185 kW	GTZ	Present status unknown
Hydro	Ghatere (Kolombangara	1997	12 kW		AusAID + Australian Citizens	Not operating due to turbine failure, flood damage, theft of electrical equipment, etc. Community is still considering whether to refurbish this

[1] *Japan International Cooperation Agency, Master Plan Study of Power Development in Solomon Islands*, 2001, volume 1, p 5-1.

[2] Asian Development Bank, TA-8130 SOL: Provincial Renewable Energy Project, 2013

Type	Location	Year	Capacity	Generation	Funding	Comments
						system.
Hydro	Manawai Harbour (Malaita)	1997	50 kW	15-25 kW	Republic of China	Operating. Various economic and rural development spin-offs.
Hydro	Bulelavata (New Georgia)	1999	29 kW	14 kW	AusAID	Has operated reliably for 7 years. Supplies power to 20 houses plus a large boarding school.
Hydro	Raeao (Malaita)	2002	25 kW	14 kW	Republic of China	Operational.
Hydro	Nariaoa (Malaita)	2004	25 kW		Republic of China	We understand that this project has been completed, but its current operational status is not known

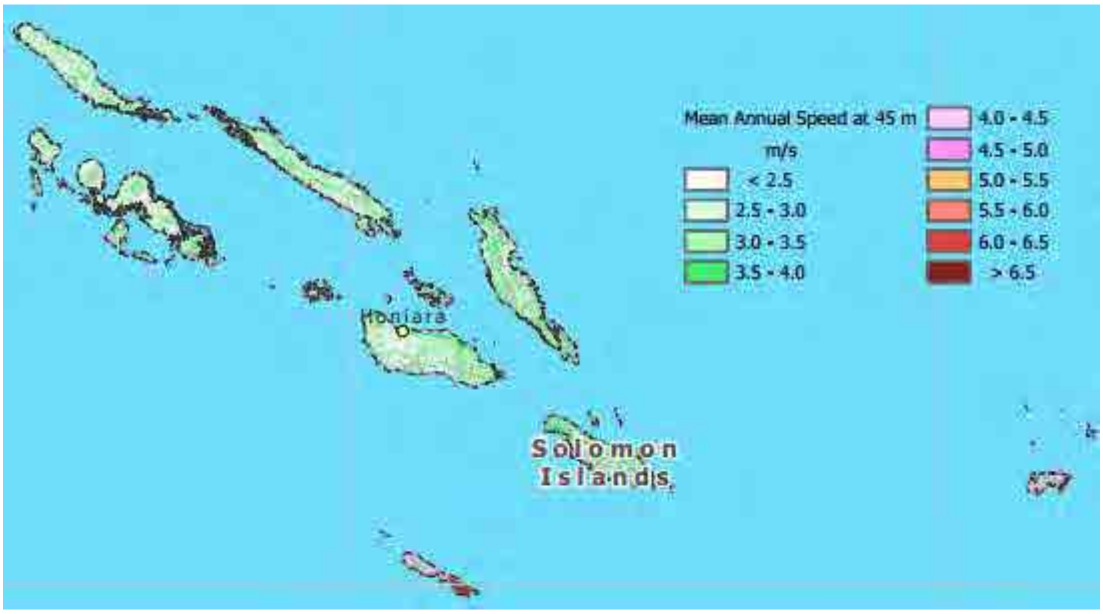
4.5 Ocean

Ocean energy would appear to be promising as an option based on extrapolating results from Fiji and Vanuatu. Annual average wave power could be roughly 14 kW/metre of wave front, with a wide range varying by site. However the technology for tidal and ocean generation is still in an early stage of development and therefore would not be an immediate option for renewable generation in the Solomon Islands.

4.6 Wind

There is little data on the Solomon Island wind energy potential derived directly from in country wind data logging. The NASA-NREL data derived from remote sensing, shows a poor wind regime in the Solomon Islands. The average wind speed is about 3.5 m/sec. On the basis of the NASA-NREL wind data, it is likely that wind power will have a higher LCOE than other renewable generation options presented.

Figure 4 Mean Annual Wind Speed at 45 m (m/s)



Source: ASTAE/WB. 2006. *Wind Resource Maps, Pacific Island.* Consultant's Report. Washington D.C.

The Energy Division is currently installing four wind monitoring systems in the provinces[3]. For a wind energy project it is essential to monitor and record wind speed data for minimum period of one year at potential sites. Thus in the absence of wind speed data, large wind power projects are not recommended. However small scale wind power projects may be used as independent stand-alone system or as a hybrid with solar. Small wind turbines are being used in places like hotels etc. in Honiara but they are unlikely to be financially viable. Due to the poor wind resource indicated by the NASA data and absence of actual site data, wind energy is generally not recommended as a renewable generation option.

[3] Pacific Islands Greenhouse Gas Abatement and Renewable Energy Programme

4.7 Solar

As the Solomon Islands lies near the equator, there is considerable solar energy potential, with insolation values of 5 kWh/m^2/day or higher which are among the highest levels in the region. A number of small-scale and demonstration projects are operational, including solar home systems (SHS) provided through Government funding since 2011 while Government of Republic of China (Taiwan) has supplied SHSs (2009) for all constituencies in the country and solar systems for rural schools. The respective Governments' of Italy & Turkey have complemented the Government of Solomon Islands programme to provide solar lighting for rural-based schools including boarding schools and rural clinics. In September 2012, the Government launched a 2 year-pilot project on installation of SHSs for 2000 households in the country that requires each household to pay the cost of installation (including transportation) and operation & maintenance costs over the 2 years period. RESCOs contracted by the Government will install the SHSs and service the systems over the lifetime of the pilot phase[4]. Depending on the outcome of the pilot phase, the Government plans to rollout this programme to cover rest of the rural population. There was a solar lighting scheme through SOPAC/REEEP co-operation, with tailored financing mechanisms, allowing recipients to pay for installations via non-fiscal means, for example with crop production.

Figure 4 Mean Annual Direct Normal Solar Insolation Contours (kWh/m^2/day)

Source: NREL/NASA

There is no data on solar radiation (direct and indirect) available in the Solomon Islands based on terrestrial measurement over an extended period of time. NREL-NASA data indicates the Solomon Islands are endowed with good year round solar radiation resource (5.1 kWh/m^2/day to about 5.6 kWh/m^2/day direct normal annual average). This is one of the more abundant renewable energy resources available in the Solomon Islands. The main advantages solar energy has in the Solomon Islands are as follows:

- A good solar energy resource is available in almost all provinces, even in remote inland areas and can be used in stand-alone or household applications. Stand-alone and household solar will eliminate the construction of transmission and distribution lines
- A good year round solar resource
- During the last year the cost of solar panels have fallen by about 50% making it price competitive with other sources of fossil fuel and renewable energy generation.

4.8 Biomass

There are four options for using biomass energy in the Solomon Islands.

- Biomass gasification technology can be utilised for power generation using waste from the forestry industry or coconut processing industry.

[4] This project is funded under the Pacific Environmental Fund provided by the Government of Japan

- Direct combustion for power generation where biomass waste and by products are burnt to raise steam to generate electricity via a turbo alternator.
- Direct usage of coconut oil (CNO) as a substitute for diesel fuel oil or as an admixture to the diesel fuel for existing diesel gensets.
- Biodiesel manufactured from biomass - Biodiesel consists of long chain fatty acids derived from vegetable oils or animal fats and can be used in diesel engines. Biodiesel refers to the pure fuel before blending with diesel fuel. Biodiesel blends are denoted as, "BXX" with "XX" representing the percentage of biodiesel contained in the blend (ie: B20 is 20% biodiesel, 80% petroleum diesel).

Biomass Power- Biomass Gasification

The first option for biomass based renewable generation is biomass gasification. The Solomon Islands have large palm oil plantations and the waste product from these plantations could be used as a feedstock for biomass gasification for power generation. The biogas produced by the biomass gasification process can be used in dual fuel engines mixed with diesel (20% diesel and 80% biomass gas) and also alone in 100% gas engines.

The main disadvantage of biomass gasification based power plant is that it is a complex process requiring additional mechanical plant as well as diesel or gas engine genset to generate electricity. Due to the difficulty and cost of transporting biomass feedstock biomass gasification generation is best located adjacent to processing industries which have an abundant biomass by product. The other disadvantage of this form of generation is that the gasification process involves a complex chemical and mechanical process and the capacity for managing this may not be available in rural areas.

Biomass Power- Direct Combustion

A direct combustion steam electric power system is for the most part indistinguishable from other steam electric power systems (for example, oil and coal) that combust fuel in a boiler to generate steam for power production. A biomass-fired boiler generates high-pressure steam by direct combustion of biomass in a boiler. There are two major types of biomass combustion boilers - pile burners utilising stationary or traveling grate combustors and fluidised-bed combustors. Current biomass combustor designs utilise high efficiency boilers and stationary or traveling grate combustors with automatic feeders that distribute the fuel onto a grate to burn. Fluidised-bed combustors are the most advanced biomass combustors. In a fluidised-bed combustor, the biomass fuel is in a small granular form (for example, rice husk) and is mixed and burned in a hot bed of sand. Injection of air into the bed creates turbulence, which distributes and suspends the fuel while increasing the heat transfer and allowing for combustion below the temperature that normally creates nitrogen oxides (NOx) emissions. This form of biomass power generation is a complex process and relies on good operation and maintenance practices when running and maintaining the steam raising boiler and steam turbine.

Biomass Power - Coconut Oil

Most compression engines will run on coconut oil (CNO). The chemical and physical characteristics of CNO vary considerably from diesel which provides challenges for trouble free operation. The use of CNO as a substitute for diesel is technically feasible but as a minimum requires water free oil filtered to 2 micron and generally fuel heating and a higher degree of operator attention. The technical feasibility of CNO use in diesel engines requires the following fuel system and engine modifications to avoid problems:[5]

- Fuel heating
- Blending fuel
- Additional filtration
- Dual fuel tanks for diesel and CNO
- Fuel pump replacement
- Injector replacement
- Conditioning of CNO prior to use
- Additional monitoring of engine and lubrication system
- Earlier replacement of filters
- Earlier oil changes.

5 ADB. 2013. *Final Project Workshop - ADB TA 7329 Access to Renewable Energy in the Pacific, CNO Use in SIEA Outstations*. Consultant's Presentation. Honiara.

The conclusion of a recent CNO blending trial in Auki noted that there are no technical issues which would stop the use of CNO in SIEA outstation generators provided the CNO used meet the required standards. There is however an increased capital and operating cost associated with this. It was also noted that using CNO derived from small existing milling facilities will not financially benefit SIEA to any significant degree when compared with diesel.

Figure 5 Auki CNO Trial Processing & Storage Equipment

Source: ADB. 2012. Access to Renewable Energy in the Pacific. Consultant's Report. Manila (TA 7329)

Biomass Power- Biodiesel

Biodiesel is a high-cetane fuel, which can be fully blended with fossil diesel to run compression ignition engines. It offers low emissions of GHG, sulphur compounds and particulate matter compared with fossil diesel. In current practice, a 5-20% (B5, to B20) 1st generation biodiesel (fatty acid methyl ester, FAME) is blended with fossil diesel. A full blending (up to B100) is also possible with advanced processing methods[6]

Commercial production of biodiesel is based on trans-esterification of vegetable oils (chemically or mechanically extracted). In the Solomon Islands this would principally be palm oil, coconut oil, animal fats and waste oil through the addition of methanol (also bio methanol or other alcohols) and catalysts, with glycerine as a by-product. Biodiesel production from animal fats and waste oils is cheaper and more efficient, but the basic feedstock is limited. The production of biodiesel in the Solomon Islands would require setting up a processing plant and importing the methanol, bio methanol and catalysts for use in the production process.

4.9 Renewable Energy Technology Assessment

4.9.1 Levelized Cost of Energy

The LCOE is the constant unit cost (per kWh or MWh) of a payment stream that has the same present value and represents the total cost of building and operating a generating plant over its life. It can be used for comparing differing RET technologies with different operating characteristics.

A conservative approach has been used for the determination of LCOE for various technologies. The range of capital costs and O&M costs assumed were principally sourced from International Renewable Energy Agency (IRENA), ESMAP and the consultant's estimates. These costs and their source are detailed in **Error! Reference source not found.**. The renewable resource data for wind and solar were based on NREL and NASA data.

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6 IRENA, IEA-ETSAP. 2013. *Production of Liquid Biofuels, Technology Brief.* http://www.irena.org/Publications/ReportsPaper.aspx?mnu=cat&PriMenuID=36&CatID=141.

Table 16 Assumptions Used for Calculating LCOE

N°	Potential Renewable Energy Technology and diesel based generation	Capital Cost (US$/kW)	O & M Cost	Data Source
1	Geothermal	5,500	USD $100 /kW/year	IRENA
2	Hydropower	3,500	2% of capital cost	IRENA
3	Micro hydropower	15,350	USD $212 /kW/year	Auki HPP Estimate SMEC
4	Wind	3,567	USD $38 /kW/year	NREL
5	Solar PV	4,874	USD $30 /kW/year	Solar PV Estimate, SKM
6	Biomass gasification	5,500	6.6% of capital cost	IRENA
7	Biomass direct combustion	4,000	5% of capital cost	IRENA
8	Biomass coconut oil	970	USD $0.025-$0.07 kWh	Consultants estimates
9	Diesel based generation	970	USD $0.025-$0.07 kWh	Diesel estimates, SKM

Source: IRENA, ESMAP, NREL and Consultant's estimates as detailed

Table 17 Calculations of LCOE for Various Renewable Options

Electrification Option	System Configuration	LCOE (US$/kWh)
Geothermal	Geothermal	$0.14
Hydropower	Large scale hydropower	$0.10
Micro hydropower	Micro hydropower	$0.42
Wind	Wind plus diesel hybrid	$0.49
Solar PV	Solar PV plus diesel hybrid	$0.49
Solar PV home system	Solar PV plus battery	$0.61
Biomass gasification	Biomass gasification	$0.39
Biomass direct combustion	Biomass direct combustion	$0.29
Biomass coconut oil	Biomass coconut oil gensets	$0.51
Diesel based generation	Diesel gensets	$0.51

Source: Homer Energy LLC. 2013. *Homer 2 v 2.81 Software.* http://homerenergy.com/software.html

4.9.2 Conclusion

The main findings of the LCOE assessment can be summarised as follows:

- Small hydropower would appear to be the best of the options considered for renewable generation in the Solomon Islands grid supply and for remote villages where there is an available water resource. The next best options for remote villages and individual households based on LCOE alone are biomass followed by solar PV plus battery.
- Land issues are key when considering the renewable energy options available, land issues can mean that the least cost renewable generation option is excluded from consideration.
- Renewable energy options for urban and rural electrification need a site specific solution.
- Solar energy is widely and consistently available throughout the country and can be used for utility scale, commercial scale, village mini-grids and solar home systems. Solar home systems can be considered the best option for rural areas when land issues, population density and access are taken into account.

5 Renewable Energy Strategy and Investment Plan

5.1 Renewable Energy policy outcome, statement and strategies

Policy outcome: Use of renewable energy sources for power generation increased to 50% by 2020 [7]

Policy statement 1: Establish an appropriate, reliable, affordable and sustainable renewable energy-based power supply in urban and rural areas

Strategies	
1.1	Support the development and implementation of the Tina River Hydropower Development Project (TRHDP).
1.2	Support the development and implementation of the Savo Geothermal Project.
1.3	Improve SIEA energy services through isolated grids (hydro and solar) and generating plants.
1.4	Replicate successful and scaling-up of deployment of solar PV home systems in rural households
1.5	Encourage the establishment of rural centres including ICT powered by renewable energy at provincial level
1.6	Encourage Renewable Energy Services Company (RESCO's) involvement in productive uses of renewable energy sources.
1.7	Promote the use of renewable energy technologies in rural schools.
1.8	Promote the use of renewable energy technologies in health centres.
1.9	Promote the use of low-cost specific renewable energy technologies (e.g. solar charging stations, solar lanterns).

Policy statement 2: Assess, cost, promote and enhance the potential for renewable energy resources.

Strategies
2.1 Undertake an assessment and data collection on wind energy potential.
2.2 Undertake an assessment and data collection on geothermal energy potential.
2.3 Undertake an assessment of biofuel potential based on coconut.
2.4 Undertake an assessment of gasification potential from by-products and forest waste.
2.5 Undertake an assessment and data collection on mini hydro sites
2.6 Develop training and capacity development on new renewable energy technologies.

Policy statement 3: Develop renewable energy policy instruments (standards and regulations, net metering policies, market-based instruments, procurement strategies) to meet the renewable energy targets.

Strategies	
3.1	Develop a clear policy on fiscal incentives e.g tax holiday incentives and duty tax exemptions including loans for renewable energy technology deployment[8]
3.2	Develop clear policies and legislations/regulation on net metering
3.3	Establish standards for on- and off-grid connections of renewable energy technologies.

[7] 35% in rural areas by 2020 and 45% of grid connected in the urban and provincial centres

[8] The proposed National Energy Advisory Committee TOR is also to approve tax incentives for renewable energy technologies. Therefore the Income Revenue Department is to be included as one of the members.

5.2 Time Bound Renewable Energy Investment Plan

This section develops a time bound renewable energy investment plan, together with renewable energy targets. The REIP is based on the SIG Energy Policy target of **50% renewable energy by 2020.** The renewable energy target is an installed capacity target.

5.3 Renewable Energy Targets

The renewable energy targets are separately tabulated for rural and urban areas so that each area can be targeted with a different approach to electrification. To some extent this is historical as SIEA is active in the urban areas of each Province but has no presence in rural areas. Urban areas are more economically supplied by grid based electrification limited from centralised sources of generation whereas rural areas are more suited to individual technologies such as solar home systems or mini-grids in the case of smaller villages. The proposed electrification targets are as follows:

Table 18 Rural Households Electrification Targets

Technology	2015		2020		2030	
	N°	%	N°	%	N°	%
Diesel self-generation	4,471	5	4,870	5	3,390	3
Hydro mini-grid	894	1	4,870	5	11,299	10
Solar home systems	4,471	5	19,480	20	47,457	42
Biomass / CNO	0	0	4,870	5	11,299	10
Total	**9,835**	**11**	**34,090**	**35**	**73,445**	**65**

Source: Consultants estimates, 2013

The rural household electrification targets place emphasise a rapid scale up of solar home systems such as 100 W_P solar systems with battery storage to supply minimum electrification requirements. Also included are hydropower based mini-grids to supply smaller groups of houses and villages.

Table 19 Urban Households Electrification Targets

Technology	2015		2020		2030	
	N°	%	N°	%	N°	%
Grid	13,565	65	19,365	75	31,686	85
Solar home systems	209	1	1,291	5	1,864	5
Total	**13,774**	**66**	**20,656**	**80**	**33,550**	**90**

Source: Consultants estimates, 2013

It is anticipated that the grid will be supplied by the following range of renewable energy technologies:

Table 20 Urban grid Connected Generation Targets

Technology	2015	2020	2030
Diesel	100%	50%	10%
Hydro	0%	41%	50%
Utility scale solar	0%	4%	10%
Geothermal	0%	0%	25%
Biomass / CNO	0%	5%	5%
Total	**100%**	**100%**	**100%**

Source: Consultants estimates, 2013

The urban grid generation targets emphasise small hydropower and geothermal in the medium to long term. At this stage the 2030 grid maximum demand is projected to be 33MW of which the Honiara grid will be 28MW. For the whole of the Solomon Islands the target total households electrified by year are shown in **Error! Reference source not found.**.

Table 21 All Households Electrification Targets

Year	Total HH	Diesel	Hydro	Utility solar	Geo-thermal	Biomass / CNO	SHS	Total
2015	110,314	16%	1%	0%	0%	0%	4%	**21%**
2020	123,218	12%	10%	1%	0%	4%	17%	**44%**
2030	150,269	4%	18%	2%	5%	9%	33%	**71%**

Source: Consultants estimates, 2013

The following graphs represent the electrification targets; the target for the change in the grid connected generation mix from one that is predominately based on diesel gensets to renewables is shown below:

Figure 6 Rural Household Electrification Rate –

2014-2030

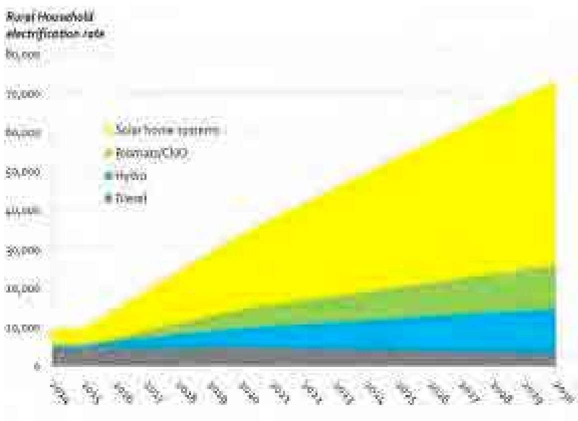


Figure 7 Urban Household Electrification Rate - 2014-2030

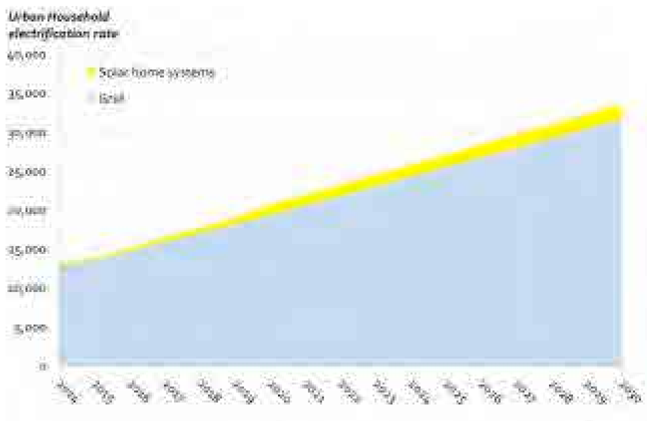


Figure 8 Total Household Electrification Rate - 2014-2030

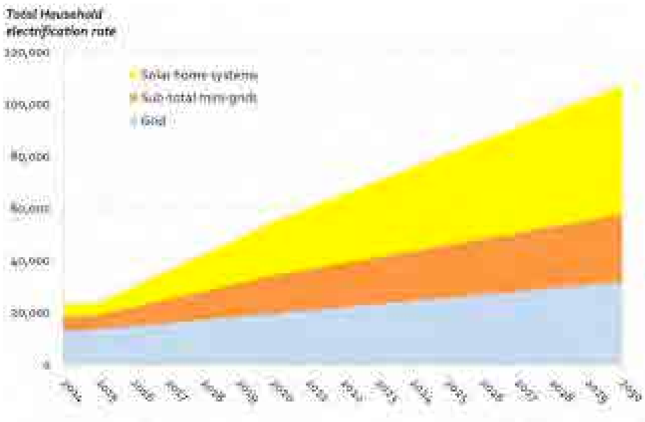
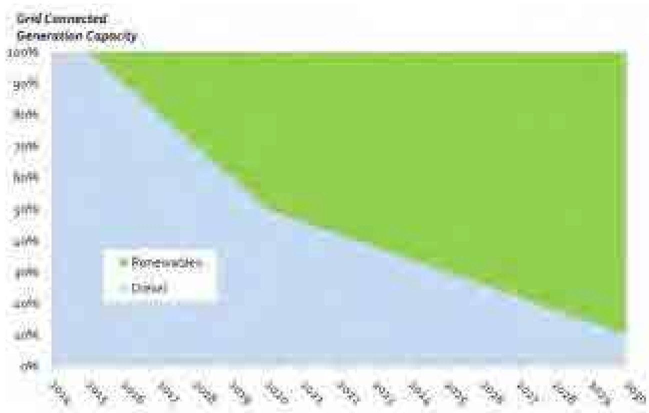


Figure 9 Grid Connected Generation Mix - 2014-2030



Source: Consultants estimates, 2013

5.4 Renewable Energy Strategies and Actions Timelines

The renewable energy strategies, actions and timelines have been collated from the REIP proposed activities as well as from the Renewable Energy Development programme developed by the Energy Division and submitted as part of the MTDS 2014 TO 2016. In addition proposed projects from development partners such as SPC, PPA, SPREP etc are included. The table below provides a timeline for the five years, 2014 to 2019.

Strategies	2014	2015	2016	2017	2018	2019
Policy statement 1: Establish an appropriate, reliable, affordable and sustainable renewable energy-based power supply						
Tina River Hydro development and implementation, a prospect of 14 MW						
Acquisition & Registration of land required for the project completed by August 2014						
Development consent confirmed with the Ministry of Environment						
Development Agreements and Documents signed with identified winning bidder (developer) by Sept 2015						
Constructions commenced						
Transmission line planning, design and procurement (SIEA)						
Construction period						
Expected to be commissioned in 2018						
Savo Geothermal scheme , a prospect of approx. 20 to 40 MW						
Exploration Drilling						
Land Acquisition completed 2014						
Engineering and Financing completed						
Construction						

Strategies	2014	2015	2016	2017	2018	2019
commences 2015						
Construction period						
Commissioning of geothermal-power plant - December 2017						
Solar PV Grid - SIEA office – a total of 62kW						
Head office Solar 60- - 100kW – Planning, design and procurement						
Head office solar – installation and commissioning						
Phase 2 Solar 1.5 kW solar farm planning design and procurement						
Phase 2 Solar – 1.5 kW solar farm construction & commissioning						
Solar Electrification for Rural Schools and Clinics						
Selection of schools and clinics for solar electrification and site visits (Jan 2014)						
Design of systems (June 2014						
Procurement of equipment (August 2014)						
Installation of SHS						
Micro-Hydro for Economic Growth Centres and Government Administration Centres: Provincial Centres Renewable Energy projects						
Set up Technical Management Unit within SIEA						
Land acquisition for Fiu, Huro and Leumbalele						
Construction commences on Fiu Hydro scheme						
Commissioning of Fiu Hydro Scheme						
Land acquisition for Noro-Munda Hydro scheme 2016						
Commissioning of Huro Luembalele hydro						
Construction commences Noro-Munda hydro						
Commissioning of Noro - Munda Hydro						
Solar Equipment for Rural ICT stations (PIGGAREP +)						
Preparatory works started – Jan to June 2014						
International and local consultants recruited and contracts signed ; end of May						
Equipment procurement						

Strategies	2014	2015	2016	2017	2018	2019
Installation and commissioning - August 2014						
Rural Home Solar systems Project – targets of 3,000 HHs per year (total of 15,000 HHs)						
Pre-selection phase- selection of SHS recipient and respective location – targeting 3000 HHs per year						
Procurement of SHS equipment by August 2014						
Sub- contracting RESCOs – October 2014						
Capacity building of RESCOs November 2014						
Payment for installation and service maintenance received from solar recipients by Dec 2014						
Assembly of SHS and installation at sites commences Jan 2015 – up till 2018						
Promote the use of low-cost specific renewable energy technologies (e.g. solar charging stations, solar lanterns) – SPC Melaneia Million Miracle programme (M3P), BlizClim						
Site selection and partnership with NGO (						
Business model study - BlizClim						
Hardware component procurement and installation initial 200 HHs						
Replication for business model in other communities						
Replication of Biofuel based on coconut – SIEA for provincial centers						
CNO demonstration for Auki completed and CNO supply contract signed						
Feasibility studies for CNO uses at Lata, Kira Kira, Noro and Taro						
SIEA up scaling of CNO use						
Policy statement 2: Renewable energy assessment and data collection on renewable energy resources						
Feasibility Studies completed for Mase River						
Update feasibility studies for 2 hydro sites						

Strategies	2014	2015	2016	2017	2018	2019
per year						
Proposal development for Renewable energy Assessment of gasification on potential from by-products and forest waste						
Develop training and capacity development on new RETs especially with hydro and solar PV						
Policy Statement 3: Develop renewable energy policy instruments (standards and regulations, net metering policies, market-based instruments, procurement strategies) to meet the renewable energy targets.						
Develop clear policy on fiscal incentives on RE private sector participation						
Draft net metering policy for Independent power producers						
Establish and adopt standards for on- and off-grid connections of renewable energy technologies.						

5.5 Renewable Energy Costs

The renewable energy capital costs are separately tabulated for rural and urban areas as they represent a different approach for each area. The urban areas will be supplied by the grid. The grid in turn will be supplied by renewable generation including hydropower, geothermal, biomass and utility scale solar. Rural areas are more suited to individual technologies such as solar home systems or mini-grids in the case of smaller villages. The average capital cost to electrify an urban household will be USD 5,915 for the period 2014-2030 whereas each rural household which will cost on average USD 596 to electrify. This can be explained to a certain extent as follows:

- Rural areas will be predominately electrified by 100 W_p solar home systems and mini-grids
- Urban areas will be supplied by the grid which will require grid extension capital costs and new renewable generation to be installed as diesel plant is retired. In addition grid supply is planned to have greater capacity in the vicinity of 1000 W per household.

Table 22 Rural Electrification Capital Costs ($ million)

Renewable Technology	Capital costs ($ million)							
	2014	Avg pa	2015-20	Avg pa	2021-30	Avg pa	2014-30	Avg pa
Grid	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mini-grids	0.05	0.03	8.05	1.01	11.71	1.17	19.76	1.10
Solar home systems	0.04	0.02	6.52	0.82	12.03	1.20	18.55	1.03
Total	**0.09**	**0.05**	**14.57**	**1.82**	**23.74**	**2.37**	**38.31**	**2.13**

Source: Consultants estimates, 2013

Table 23 Urban Electrification Capital Costs ($ million)

Renewable Technology	Capital costs ($ million)							
	2014	Avg pa	2015-20	Avg pa	2021-30	Avg pa	2014-30	Avg pa
Grid	0.37	0.37	60.05	10.01	134.71	13.47	195.12	11.48
Mini-grids	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Solar home systems	0.00	0.00	0.47	0.08	0.25	0.02	0.72	0.04
Total	**0.37**	**0.37**	**60.52**	**10.09**	**134.95**	**13.50**	**195.84**	**11.52**

Source: Consultants estimates, 2013

Table 24 Total Electrification Capital Costs ($ million)

Renewable Technology	Capital costs ($ million)							
	2014	Avg pa	2015-20	Avg pa	2021-30	Avg pa	2014-30	Avg pa
Grid	0.37	0.37	60.05	10.01	134.71	13.47	195.12	11.48
Mini-grids	0.05	0.05	7.99	1.33	11.71	1.17	19.76	1.16
Solar home systems	0.04	0.04	6.96	1.16	12.28	1.23	19.27	1.13
Total	**0.46**	**0.46**	**75.00**	**12.50**	**158.69**	**15.87**	**234.15**	**13.77**

Source: Consultants estimates, 2013

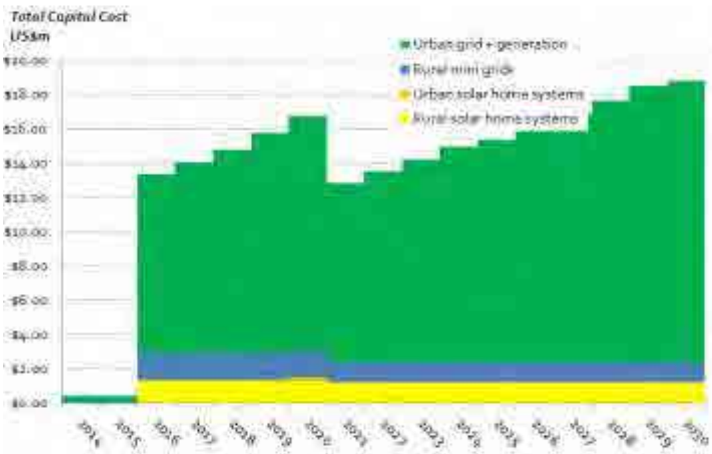
Table 25 Electrification Cost per Household ($/HH)

Renewable Technology	Rural average costs ($/HH)	Urban average costs ($/HH)
	2014-30	2014-30
Grid	0	6,158
Mini-grids	949	0
Solar home systems	430	430
Total	**500**	-

Source: Consultants estimates, 2013

The following graph represents the REIP capital costs:

Figure 10 Total Capital Cost - 2014-2030



Source: Consultants estimates, 2013

The RE-SIP is based on achieving the SIG 2020 target of 50% of energy being supplied by renewables. The REIP will require a total investment of $75.00 million to 2020 to achieve a 44% country wide household electrification rate and a total investment of $234.15 million to 2030 to achieve a 71% household electrification rate.

APPENDIX A - Provincial Renewable Energy Options

APPENDIX B – Barrier Analysis

Summary of Barriers to the Implementation of Renewable Energy Technology

Type	Barrier	Barrier Removal
Business Environment	1) Perceptions of sovereign risk add to the financing difficulties for utility and commercial scale renewable energy projects 2) SIEA has sole authority to provide and/or supply electricity	1) Promote smaller scale RETS in the short term to reduce the level of perceived risks 2) Distribution Code for Distributed Generation" has been drafted and is pending approval by MMERE under this code distributed generation will be allowed to connect to the SIEA network.
Governance	1) Lack of legislation for regulating biofuels 2) Present system of taxes and subsidies in the Solomon Islands effectively penalises renewable energy 3) Regulatory approvals are regarded as slow, unwieldy and inefficient	1) Update the petroleum legislation to include biofuels and establish a regulatory framework for the industry. 2) Review the taxes and duties that apply to RETs, this could best done by the Solomon Islands Customs and Excise Division of the Ministry of Finance & Treasury. 3) Removal or lowering of this barrier will enhance the ability of RET SME to be established in the Solomon Islands. This barrier is not specific to RET SMEs so lowering this barrier will require efficiencies to be developed across all the Ministries that influence the use of RETs.
Size of Markets	1) Islands are small with dispersed populations, the electricity market is small	1) Promote RETs that align with the market size such as solar home systems and mini and micro hydro.
Access to Markets	1) Air and shipping services between provincial centres and outer islands are infrequent and unreliable 2) Land transport is difficult	1) This barrier is not unique to the energy sector and to a certain extent will be addressed by the priority projects noted in the Solomon Islands National Infrastructure Investment Plan which include, roading upgrades, airport upgrades and new wharves 2) Ensure RETs are portable, robust and can be easily moved by the types of transport available
Institutional Capacity	1) National and provincial government agencies lack resources and training 2) Renewable energy roles and responsibilities of the SIG agencies are still unclear 3) Insufficient professional and trades qualifications to support RETs, Government institutions have limited capacity to train and certify people for such roles 4) Commercial arrangements during operational phase of RETS unclear	1) Remove this barrier with resources and training for key agencies e.g. MMERE. 2) MMERE to clarify the roles and responsibilities of the National Government agencies, provincial governments, wards, SIEA, development agencies, and other stakeholders 3) Develop RET professional and trades qualification training programmes 4) Develop training programmes for use during the operation and maintenance phase of RET schemes focussing on RE technologies that are easily understood, easy to operate and have minimal maintenance requirements

Type	Barrier	Barrier Removal
Currency Issues	1) Exchange rate stability concerns	1) Minimise exchange rate risk by, e.g. PPAs for larger generators with indexation or payment terms denominated in more stable currencies
Ability to Pay	1) Limited ability to pay for electricity especially in rural areas	1) Promote low first cost RETs that can be expanded as income develops e.g. 100 W solar home systems that could be expanded with additional solar panels, batteries and lights
Access to Banks	1) Rural population have limited access to banks and irregular incomes	1) Target low cost RETs, review options for payment for RETs by barter
Land Usage Rights	1) Procuring land usage for RET purposes can be difficult and time consuming 2) Land usage rights and compensation generally take time to resolve and are subject to delays 3) Land acquisition for household and community scale RETs 4) There is no precedent for private ownership of hydro plants in the Solomon Islands 5) Without clear usage rights over land, private investors and lenders are unlikely to commit to projects 6) Effective models are needed for obtaining land usage rights that will outlast a project	1) Develop land procurement procedures and standard form contracts for procuring land rights for differing RE technologies 2) Use models that share the benefits of a project amongst the landowners over the life of the project 3) Prioritised RETs that occupy minimal land area or can be installed at the household and community scale. 4) Deliver a larger scale privately owned RETs, ensuring all safeguard standards are met, this will then serve as a model for subsequent RET projects. 5) Locate utility or community scale RETs on alienated land so that long term leases can be negotiated with a single owner 6) Standard form procedures, contracts and PPAs for benefit sharing amongst all landowners. SIG to ensure that the land requirements for RETs, distribution lines and transmission lines are included in any revised legislation
Financial	1) Energy Division is poorly resourced 2) RETs can have higher initial costs compared to conventional fossil fuel energy 3) Lack of access to finance at the community level to fund utility scale RETs 4) Landowners cannot use land as equity for loans	1) SIG budget allocation. 2) Target low cost RETs that can be self-financed; 3) Use low cost community RE technologies and construction methods, coupled with RETS that can be constructed by community labour; 4) Develop alternatives to land as security for loans for RETS
Technical	1) Lack of RET technical standards 2) Shortage of RET technical skills and virtually no industry away from Honiara and Noro 3) Vandalism and theft of remotely located utility and community scale RETs	1) Mandate standards for RETs imported into the Solomon Islands 2) Develop training programmes for RET technical skills. 3) Minimise vandalism and theft by including fences and other security measures when specifying RET installations

Type	Barrier	Barrier Removal
	4) No geothermal RET experience and limited experience with biomass 5) Grid extension and for utility scale RETS difficult. 6) Negative past experience due to poor quality equipment creating low consumer confidence in solar PV. 7) Disposal of lead acid batteries associated with solar home systems is a potential environment risk.	4) Pilot projects for RETs for technologies that show promise for future use 5) Develop best practice land procurement procedures and standard form contracts for procuring land for distribution line extensions to connect RETs to the existing grid. 6) Specify minimum quality standards 7) Develop lead acid battery recycling
Knowledge and Public Awareness	1) Lack of public awareness of RE opportunities and technologies with the exception of PV. 2) Knowledge of pros and cons of solar PV is limited. 3) Lack of knowledge of RE resource potentials 4) Low customer confidence due to lack of awareness and information on products and performance. 5) Difficult to confirm the quality of PV products. 6) No laboratory facilities exist to test the quality of biofuels (or petroleum fuels).	1) Actively promote RETs including alternative options such as run-of-river mini/micro hydro, large hydro, geothermal and biofuels 2) Introduce a quality rating system and provide details of recommended PV equipment. 3) Publicise the renewable energy GIS 4) Improve customer confidence by commercial installations of RETs in high visibility areas in each main centre 5) Provide a readily accessible list of PV equipment that meets minimum performance standards 6) Align the implementation of biofuel testing with the introduction of petroleum fuel testing

添付資料⑫

Solomon Islands Exemptions Committee
P.O. Box G9
Honiara
Telephone: (677) 21493
Email: tmanepunia@mof.gov.sb (TIMOTHY)

1st August 2013

NON-STATUTORY EXEMPTION APPLICATION FORM

This form must be used to apply for various discretionary exemptions from taxes and duties administered by the Solomon Islands Customs and Excise Division and the Solomon Islands Inland Revenue Division. This form is not required to access statutory exemptions (provided by law).

Applications for exemptions are considered by the Revenue and Customs Exemptions Committee, which provides recommendations to the Minister of Finance and Treasury. Exemptions can be granted by the Minister in full, part, or not granted, consistent with the recommendations of the Committee. The Committee hereby specifies that this form is the appropriate form to be used to apply for exemptions, consistent with [Regs name, 2.03(1)].

Conditions attached to exemptions that are granted must be complied with. Information concerning the details of exemptions that have been granted will be published quarterly, including the names of recipients, nature of business activity and the nature and period of the exemption.

An application will not be considered unless it has been lodged at least two months prior to the activity for which an exemption is sought, except applications under section 9 of the Income Tax Act which must be lodged within 6 months of the commencement of business operations.

Exemption applications must be on this form and be fully completed. Additional documents may also be required to assess an application. Guidance is provided to assist applicants on each page and a summary of the exemptions process and requirements is provided at the end of this form.

If you have difficulty in completing this form or want any further information, please contact [Committee Secretary].

PART A: DETAILS OF PERSON APPLYING FOR EXEMPTION

Name: ....

Address: ....

....

....

....

Telephone: ....

Fax: ....

E-Mail Address: ....

PART B: DETAILS OF ORGANIZATION OR BUSINESS TO BE CONSIDERED FOR EXEMPTION

Organization Name: ....

Business or Trade Name: ....

Date of Registration with Registrar of Companies: ....

Certificate of Registration Number: ....

Commencement Date of Business Activities: ....

Business Address: ....

....

....

Nature of Business: ....

Sector/Industry: ....

Is the organization a not-for-profit agency?: Yes / No

Is the organization registered for goods tax?: Yes / No

Company Shareholder(s): .... Share: ....%

.... Share: ....%

.... Share: ....%

.... Share: ....%

Additional Information/Requirements:

1. Attach copy of Certificate of Incorporation.
2. If the organization is a not-for-profit agency, attach documents demonstrating it is of good national or international standing. This will include evidence:
   a. that the organization has a constitution and a permanent office in Solomon Islands;
   b. that the organization operates on a strictly not-for-profit basis; and;
   c. of a good history of compliance with any taxes and duties payable by the organization (including PAYE obligations).
3. If the organization is a not-for-profit agency, attach documentary evidence of the source of funds (donor) and the details of the not-for-profit project.

PART C: COMPLIANCE HISTORY OF ORGANIZATION

Taxpayer Identification Number (TIN): ....

[CED equivalent Number?]: ....

Name and address of tax agent or accountant:

....

....

....

Total number of current employees: ....

Total annual value of current employee wages: ....

State liability and tax/duties paid in the past four years:

Year:	....		....		....		....	
	Liability	Paid	Liability	Paid	Liability	Paid	Liability	Paid
Import duty								
Export duty								
Goods tax								
Sales tax								
Provisional tax								
Income tax								
Stamp duties								
PAYE								
Withholding tax								
Vehicle licences								

If full tax or duty liability has not been paid in one or more of the past four years, explain why:

....

....

....

....

....

Additional Information/Requirements:

1. Attach copies of any other relevant documents.

PART D: EXEMPTION APPLICATION INFORMATION

Indicate taxes and duties for which an exemption is requested, the value of each exemption and the period over which it will apply:

Tax/Duty	☑	Value	Period (dates from – to)
Import duty			
Export duty			
Stamp duty			
Goods tax			
Sales tax			
Income tax			
Total			

When is the project, investment or transaction expected to commence? ....

Describe the project, investment or transaction for which an exemption is requested:

....

....

....

....

....

Explain why the project, investment or transaction would be unable to profitably proceed without an exemption (see additional information below):

....

....

....

....

....

Does the application include exemptions for any excluded items (see list below)? Yes / No

Additional Information/Requirements:

1. An application cannot be for a project, investment or transaction that would be able to profitably proceed without public support. An exemption for such a purpose would increase private profit at the cost of public revenue.
    a. Attach the business case or other documents that demonstrate that public support is necessary.
2. Excluded items include the following:
    a. goods purchased for resale;
    b. consumable items to be used in the normal course of business, including, but not limited to, fuel, oil, lubricants and spare parts;
    c. road vehicles which are to be used wholly or partly for private purposes; and
    d. goods for private use.

PART E: EXEMPTION DETAILS
Import duty (E1)

NOTE: Complete this Part if the application includes a request for an exemption from import duty.

List each item to be imported for which an exemption is sought and whether each is a capital good:

Tariff item	Description	Capital good ☑	Qty	Proposed import date	Value	Duty rate

For imports of capital goods, indicate how these may qualify for an exemption (see additional information below):

As inputs to a new business commencing operations in Solomon Islands: Yes / No

As inputs to modernize or expand existing business operations in Solomon Islands: Yes / No

Rural community development: Yes / No

Indicate whether the following apply for any items for which a duty exemption is sought (see additional information below):

Goods eligible for exemption under a statutory exemption: Yes / No

Goods excluded from receiving a duty exemption: Yes / No

Additional Information/Requirements:

1. If exemptions are sought for more items than can be listed in the table above, separately attach the details of the additional items.
2. An application for an exemption from import duty on capital goods must be limited to capital goods that will be used:
   a. in a new business commencing operations in Solomon Islands;
   b. to modernize or expand existing business operations in Solomon Islands; or
   c. for rural community development.
3. An application for an exemption from import duty cannot include any of the following items:
   a. goods eligible for exemption under a statutory exemption; or
   b. goods excluded from receiving a duty exemption.

PART E: EXEMPTION DETAILS
Export duty (E2)

NOTE: Complete this Part if the application includes a request for an exemption from export duty.

List each item to be exported for which an exemption is sought:

Tariff item	Description	Qty	Proposed export date	Value	Duty rate

Indicate whether the following apply for any items for which a duty exemption is sought (see additional information below):

Goods eligible for exemption under a statutory exemption: Yes / No

Goods excluded from receiving a duty exemption: Yes / No

Logs or timber liable for export duty: Yes / No

Additional Information/Requirements:

1. If exemptions are sought for more items than can be listed in the table above, separately attach the details of the additional items.
2. An application for an exemption from duty cannot include any of the following items:
   a. goods eligible for exemption under a statutory exemption;
   b. goods excluded from receiving a duty exemption; or
   c. logs or timber liable for export duty.

PART E: EXEMPTION DETAILS
Stamp duty (E3)

NOTE: Complete this Part if the application includes a request for an exemption from stamp duty.

List each item for which an exemption is sought:

Description	Qty	Date of execution	Value	Tax rate

Indicate whether the following apply for any items for which an exemption is sought (see additional information below):

Documents eligible for exemption under a statutory exemption: Yes / No

Additional Information/Requirements:

1. If exemptions are sought for more items than can be listed in the table above, separately attach the details of the additional items.
2. An application for an exemption from stamp duty cannot include documents eligible for exemption under a statutory exemption.

PART E: EXEMPTION DETAILS
Goods tax (E4)

NOTE: Complete this Part if the application includes a request for an exemption from goods tax.

List each item for which an exemption is sought:

Description	Qty	Proposed purchase or import date	Value	Tax rate

Indicate whether the following apply for any items for which an exemption is sought (see additional information below):

Goods eligible for exemption under a statutory exemption: Yes / No

Is the applicant registered for goods tax? Yes / No

Is the applicant required to be registered for goods tax? Yes / No

Additional Information/Requirements:

1. If exemptions are sought for more items than can be listed in the table above, separately attach the details of the additional items.
2. An application for an exemption from goods tax on capital goods must be limited to capital goods that will be used:
   a. in a new business commencing operations in Solomon Islands;
   b. to modernize or expand existing business operations in Solomon Islands;
   c. for rural community development;
   d. as replacement buildings or plant and equipment proven to be lost in certain natural disasters (as specified by regulation); or
   e. in the development or enhancement of tourism operations in Solomon Islands.
3. An application for an exemption from goods tax cannot include goods eligible for exemption under a statutory exemption.
4. An application for an exemption from goods tax cannot be made by a person who has failed to register for goods tax, despite being required to do so.

PART E: EXEMPTION DETAILS
Sales tax (ES)

NOTE: Complete this Part if the application includes a request for an exemption from sales tax.

List each item for which an exemption is sought:

Description	Qty	Date of sale	Value	Tax rate

Additional Information/Requirements:

1. If exemptions are sought for more items than can be listed in the table above, separately attach the details of the additional items.

PART E: EXEMPTION DETAILS
Income tax (E6)

NOTE: Complete this Part if the application includes a request for an exemption from income tax.

Describe the project, investment or transaction for which an exemption is requested and the associated operations in detail:

....

....

....

....

....

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....

Describe the source and amount of capital employed in the operations:

....

....

....

....

....

Indicate whether the following apply for any income for which an exemption is sought (see additional information below):

Income eligible for exemption under a statutory exemption: Yes / No

Additional Information/Requirements:

1. An application cannot include a request for an exemption from income tax on income eligible for a statutory exemption.
2. Attach documentation that shows:
   a. the extent of local value added in production; or
   b. an estimation of time to recover the cost of capital.

PART F: NATIONAL INTEREST ASSESSMENT

Total value of exemption requested (revenue to be foregone): ....

Have exemptions previously been granted for the project, investment or transaction? Yes / No

If so, provide the following details:

Order number: ....

Date of order: ....

Revenue foregone: ....

Describe the nature and value of any other public assistance previously or currently received:

....

....

....

State how the exemptions applied for would further the National Interest (see additional information below):

....

....

....

....

....

State how the project, investment or transaction will be financed:

....

....

....

If private financial commitments are to be made to counter any environmental impact of the project, investment or transaction, describe their nature:

....

....

....

Additional Information/Requirements:

1. A list of factors that are regarded as relevant in assessing whether a project, investment or transaction furthers the National Interest is specified by Regulation. These are reproduced at the end of this form.

PART G: NATIONAL INTEREST ASSESSMENT: BENEFITS AND COSTS

Estimate the following:

Profit of the project:	....
Profit of the project accruing to Solomon Island residents:	....
If the project is not-for-profit, value of the project:	....
Number of additional positions (employment) in Solomon Islands:	....
Value of wages from these additional positions:	....
Additional Government revenue arising directly from the project:	....
Value of other forms of public assistance for the project:	....
Effect of the exemption on profit of competitors:	....
Restoring the environmental impact of the project:	....
Private financial commitments to counter environmental impacts:	....

Additional Information/Requirements:

1. Attach documents that support the estimates provided in this Part.

PART H: DECLARATION

I (name) ....

of (address) ....

declare that:

- the information given in this application including any and all attachments is true and accurate; and
- I agree to the public release of information concerning this application (including information provided in the application) as required by Solomon Islands law.

(signature) ....

(date) ....

Exemption Application Form: Summary of process and requirements

This attachment summarizes the exemptions process and a number of the application requirements. The next section outlines the process, including the committee steps and processing timeframes. The list of factors specified by Regulation as relevant to the assessment of National Interest is also included along with a list of documents that are likely to be necessary to attach to an application. Finally, information concerning the information published about each exemption for transparency and accountability is provided.

Process

The Solomon Islands Government established the Exemption Committee to consider and make recommendations to the Minister of Finance on all exemption requests. The Committee follows guidelines prescribed in Regulation when considering requests for exemption. The Committee is also responsible for the following

- Overseeing the proper administration of the scheme
- Designing and publishing Exemption forms, and the education of the public about the processes for applying, and the criteria against which applications are considered
- Providing summary information to the Minister of Finance on a quarterly basis
- Ensuring the Minister has the information necessary for publication of exemptions, including Gazette notices
- Providing advice to the Minister on amendment to the schedule of statutory exemptions

[Insert process of application, including address to send applications.]

The Committee must inform applicants within five working days of receiving an application if further information is required. The Committee may require other information from applicants, or that a person appears to provide further information or make representation on the application.

If an application is not recommended due to lack of information, an applicant may make a new application if further information, not available in the original application, is available. This would not necessarily apply if an applicant withheld relevant information in their original application.

National Interest Assessment

The Exemption Committee will not recommend to the Minister that an exemption be granted unless the Exemption Committee assesses that:

a) the project will further the National Interest; and
b) the economic benefit of the proposed project to Solomon Islands exceeds the economic cost.

In assessing whether a project will further the National Interest, the Committee will consider the following positive and negative factors.

Positives

a) the contribution to economic growth, particularly in rural areas;
b) the contribution to the national development goals for Solomon Islands;
c) consistency with Government development and growth strategies;
d) the replacement of business assets in areas that have been the subject of a Ministerial Order that a state of disaster exists in all or part of Solomon Islands in accordance with Section 12 of the National Disaster Council Act (Cap.148);
e) increased employment opportunities for Solomon Islanders, including:
    i. the creation of a substantial number of new jobs;
    ii. a contribution to diversity in the job market;
    iii. the creation of jobs in rural areas;
f) the contribution to the export of goods produced or manufactured in Solomon Islands;
g) the contribution to infrastructure assets in Solomon Islands, particularly in rural areas;
h) the potential contribution to increased tax, duty or excise revenue in the medium to long term (5-10 years);
i) the contribution to income/profit distributed in rural communities;
j) the contribution to the overall wellbeing of citizens of Solomon Islands, rather than just an individual, association or family;
k) the contribution to incoming tourism or tourism infrastructure in Solomon Islands; and
l) the sustainability of the organizations and business activity associated with the project, investment or transaction.

Negatives

a) whether the proposed project, investment or transaction requires public support through an exemption to be viable; (Note: It is not in the National Interest to provide an exemption for a project, investment or transaction that does not require public support to proceed. In this case, an exemption simply increases private profit while reducing public revenue.)
b) distortionary effects, including discouraging or disadvantaging businesses or sectors that have not been granted an exemption;
c) the cost to revenue, particularly in the short term;
d) other forms of government or donor assistance provided, including other concessionary tax, duty or excise arrangements;
e) environmental costs (taking account of credible commitments to counter these and restore the environment); and
f) social costs.

Documents to be attached to Exemption Applications

Copies of all relevant documents are to be attached an exemption application. Documents likely to be relevant include the following:

- Business plan
- Project plan
- Cost-benefit analysis
- Feasibility study
- Financial assessment of project
- Financing plan
- Cash flow forecasts
- Sensitivity analysis of key assumptions
- Details of resourcing commitments
- Other relevant applications
- Prior year tax, duty and excise payment history
- Certificate of registration under the Foreign Investment Act 2005
- Resource planning or other consents necessary for the project to proceed
- Evidence of the source of funds for SIG or donor-funded projects

Publication of information

The Minister is required to table in Parliament and publish in the Gazette information in respect of all exemptions granted, including the following:

- Name and address of the investor
- Nature of their business activity
- Nature and period of the exemption granted
- Reason for granting the exemption

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添付資料⑬

C. 44 (Sale)
(In Duplicate)

SOLOMON ISLANDS

H.M. CUSTOMS AND EXCISE

Claim for Exemption from Import Duty

(This form is to be submitted in duplicate with the relevant import entry)

Date .... *Claimant* ....

Port .... *Ship/Aircraft/W'house* ....

Importer .... *Rotation No.* ....

Agent .... *Port of Loading* ....

TARIFF ITEM	DESCRIPTION	QTY	VALUE	DUTY CONCESSION	DUTY RATE	DUTY REMITTED
		TOTAL				

To: The Proper Officer of Customs, ... *(Place)*

I hereby claim exemption from/duty renission on the goods described above under the provisions on ....

....

(exemption item No. or remission letter ref.)

I undertake to comply fully with Section 29 of the Customs and Excise Act, the text of vhich appears on the reverse of this form and with any special conditions referred to in the authority referred to above.

(Signed)..

Designation..

(This Certificate is to be signed only by the person entitled for the exemption or remission).

OFFICE USE ONLY

.... *Proper Officer*

.... *Collector*

Section 29, the Customs and Excise Act (Cap. 58)

29. If any goods which are ordinarily liable to duty at a given rate are allowed by law to be and are in fact, entered at a lower rate of duty, or free of duty, on any special conditions, or for use for special purpose, or because they are the property of or intended for use by some particular person or functionary, and if such conditions are not obeserved, or the goods are at any time within two years of the date of importation thereof used, for any other than specified purpose, or being goods entered as aforsaid because they are the property of or to functionary continues to own or use such goods and they remain within the Solomon Islands after he ceases to be a functionary as aforesaid, such goods, unless the full duties thereon or such lesser amount as the comptroller either generally or in any particular case may decide shall be chargeable, shall have been paid, shall be forfeited, and the importer and any person who shall be knowingly concerned in the use of such goods contrary to such conditions, or for some purpose other than that specified or in any way contrary to this section shall each incur for each such offence a penalty of two hundred dollars or treble the duty paid value of such goods at the election of the comptroller unless the full duties on such goods or such lesser amount as aforesaid shall be paid with the prior consent of the comptroller.

This space should be used for any special certificate or undertaking which may be required under the terms of the relevant exemption item or remission authorization.

添付資料⑭

SAI GLOBAL

LICENCE

for

AS 4777.1-2005 Grid connection of energy systems via inverters - Installation requirements

Licensee: Solomon Islands Electricity Authority

Date: Wednesday, 6 November 2013 10:55 AM

Licence Agreement

This is an agreement between the end user of the Product ("Licensee") and SAI Global Limited, 286 Sussex Street, Sydney NSW 2000 AUSTRALIA, ABN 67 050 611 642.

1. Definitions and Interpretations

Australian Standards means Australian Standards and includes Joint ISO/Australian Standards, Joint NZ/Australian Standards, current Draft Australian Standards, and amendments to Australian Standards.

Concurrent Users means the maximum number of people able to access the Product at any one time, and is limited to the number of Licences purchased.

ISO Standards means Standards published by the International Organization for Standardization (ISO), for which SAI Global is an authorised distributor.

IEC Standards means Standards published by the International Electrotechnical Commission (IEC), for which SAI Global is an authorised distributor.

Internal use means use of the Product within the Licensee's organization.

Licence means the right to access and use the Product.

Licensee means the purchaser and user of the Product.

Product means Australian Standards, ISO Standards and IEC Standards ordered and purchased through the InfoStore.

AS 4777.1—2005

Australian Standard™

Grid connection of energy systems via inverters

Part 1: Installation requirements

STANDARDS AUSTRALIA

This Australian Standard was prepared by Committee EL-042, Renewable Energy Power Supply Systems and Equipment. It was approved on behalf of the Council of Standards Australia on 6 April 2005. This Standard was published on 20 May 2005.

The following are represented on Committee EL-042:

Alternative Technology Association
Australian Electrical and Electronic Manufacturers Association
Business Council for Sustainable Energy
Electrical Regulatory Authorities Council
Electrical Safety Organisation, New Zealand
Electricity Engineers Association, New Zealand
ElectroComms & Energy Utilities Industries Skills Council
Energy Efficiency & Conservation Authority of New Zealand
Energy Networks Association
Institution of Professional Engineers, New Zealand
Ministry of Economic Development, New Zealand
National Electrical and Communications Association
New Zealand Electrical Institute
Research Institute for Sustainable Energy
Sustainable Energy Authority, Victoria
University of New South Wales

Keeping Standards up-to-date

Standards are living documents which reflect progress in science, technology and systems. To maintain their currency, all Standards are periodically reviewed, and new editions are published. Between editions, amendments may be issued. Standards may also be withdrawn. It is important that readers assure themselves they are using a current Standard, which should include any amendments which may have been published since the Standard was purchased.

Detailed information about Standards can be found by visiting the Standards Web Shop at www.standards.com.au and looking up the relevant Standard in the on-line catalogue.

Alternatively, the printed Catalogue provides information current at 1 January each year, and the monthly magazine, *The Global Standard*, has a full listing of revisions and amendments published each month.

Australian Standards™ and other products and services developed by Standards Australia are published and distributed under contract by SAI Global, which operates the Standards Web Shop.

We also welcome suggestions for improvement in our Standards, and especially encourage readers to notify us immediately of any apparent inaccuracies or ambiguities. Contact us via email at mail@standards.org.au, or write to the Chief Executive, Standards Australia, GPO Box 5420, Sydney, NSW 2001.

This Standard was issued in draft form for comment as DR 04340.

Australian Standard™

Grid connection of energy systems via inverters

Part 1: Installation requirements

Originated as AS 4777.1—2002.
Second edition 2005.

Published by Standards Australia GPO Box 5420, Sydney, NSW 2001, Australia

ISBN 0 7337 6700 1

PREFACE

This Standard was prepared by the Australian members of the Joint Standards Australia/Standards New Zealand Committee EL-042, Renewable Energy Power Supply Systems and Equipment and is based on requirements developed by a group of utility, photovoltaic and inverter industry experts coming together under the auspices of the Energy Networks Association. After consultation with stakeholders in both countries, Standards Australia and Standards New Zealand decided to develop this Standard as an Australian, rather than an Australian/New Zealand Standard. This Standard replaces AS 4777.1—2002 on publication.

The objective of this Standard is to provide guidance for installers of inverter energy systems intended for the injection of electric power through an electrical installation to the electricity distribution network.

It is Part 1 of AS 4777, *Grid connection of energy systems via inverters* which is published in parts as follows:

AS 4777.1 Part 1: Installation requirements (this Standard)

AS 4777.2 Part 2: Inverter requirements

AS 4777.3 Part 3: Grid protection requirements

This Standard should be read in conjunction with the regulations, service and installation rules of the electricity distributor approving the connection.

This Standard has been revised to include a number of minor clarifications and corrections (principally in Clauses 5.3.3 and 5.6.4 and figures 1, 2 and 3).

This Standard was developed with the assistance of the following organisations—

(a) Australian Greenhouse Office;

(b) Research Institute for Sustainable Energy, Murdoch University; and

(c) University of New South Wales.

The term 'informative' has been used in this Standard to define the application of the appendix to which it applies. An 'informative' appendix is provided for information and guidance.

CONTENTS

STANDARDS AUSTRALIA

Australian Standard
Grid connection of energy systems via inverters

Part 1: Installation requirements

1 SCOPE

This Standard specifies the electrical installation requirements for inverter energy systems and grid protection devices with ratings up to 10 kVA for single phase units, or up to 30 kVA for three-phase units, for the injection of electric power through an electrical installation to the electricity distribution network.

NOTES:

1 Although this Standard does not apply to larger systems, similar principles can be used for the installation of such systems.

2 This Standard does not cover detailed installation requirements for the energy source(s) and its associated wiring.

2 APPLICATION

This Standard should be used in conjunction with the installation requirements of the appropriate electrical distributor. The connection of an inverter energy system to an electrical installation connected to the electricity distribution network shall be approved by the appropriate electrical distributor.

3 NORMATIVE REFERENCES

The following normative documents contain provisions which, through reference in this text, constitute provisions of this Standard.

AS	
1319	Safety signs for the occupational environment
4777	Grid connection of energy systems via inverters
4777.2	Part 2: Inverter requirements
4777.3	Part 3: Grid protection requirements
AS/NZS	
3000	Electrical Installations (known as the Australian/New Zealand Wiring Rules)

4 DEFINITIONS

For the purpose of this Standard, the following definitions apply:

4.1 Distribution board

A switchboard other than a main switchboard.

4.2 Electrical installation

The definition in AS/NZS 3000 shall apply.

4.3 Electricity distribution network

The portion of an electrical system that is operated by an electrical distributor.

4.4 Grid

An alternative term for an electricity distribution network.

4.5 Grid protection device

A device complying with the requirements of AS 4777.3.

4.6 Intermediate distribution board

A distribution board located (in an electrical sense) between a main switchboard and a distribution board to which an inverter energy system is directly connected.

4.7 Inverter

A device that uses semiconductor devices to transfer power between a d.c. source or load and an a.c. source or load.

NOTE: For the purposes of this Standard, a.c. to a.c. convertors that use semiconductor devices are considered to be inverters.

4.8 Inverter energy system

A system comprising one or more inverters together with one or more energy sources (which may include batteries for energy storage), controls and one or more grid protection devices.

4.9 Islanding

Any situation where the electrical supply from an electricity distribution network is disrupted and one or more inverters maintains any form of electrical supply, be it stable or not, to any section of that electricity distribution network.

4.10 Lockable switch

A switch or circuit breaker that has provision for insertion of a mechanical device to prevent the switch being closed.

NOTE: A mechanical device in this context could constitute sealing with plastic cord, a pin or other mechanical device that prevents operation of the switch.

4.11 Residual current device (RCD)

A device intended to isolate supply to protected circuits, socket-outlets or electrical equipment, in the event of a current flow to earth which exceeds a predetermined value.

4.12 Shall

Indicates that a statement is mandatory.

4.13 Should

Indicates a recommendation.

4.14 Uninterruptible power supply (UPS) system

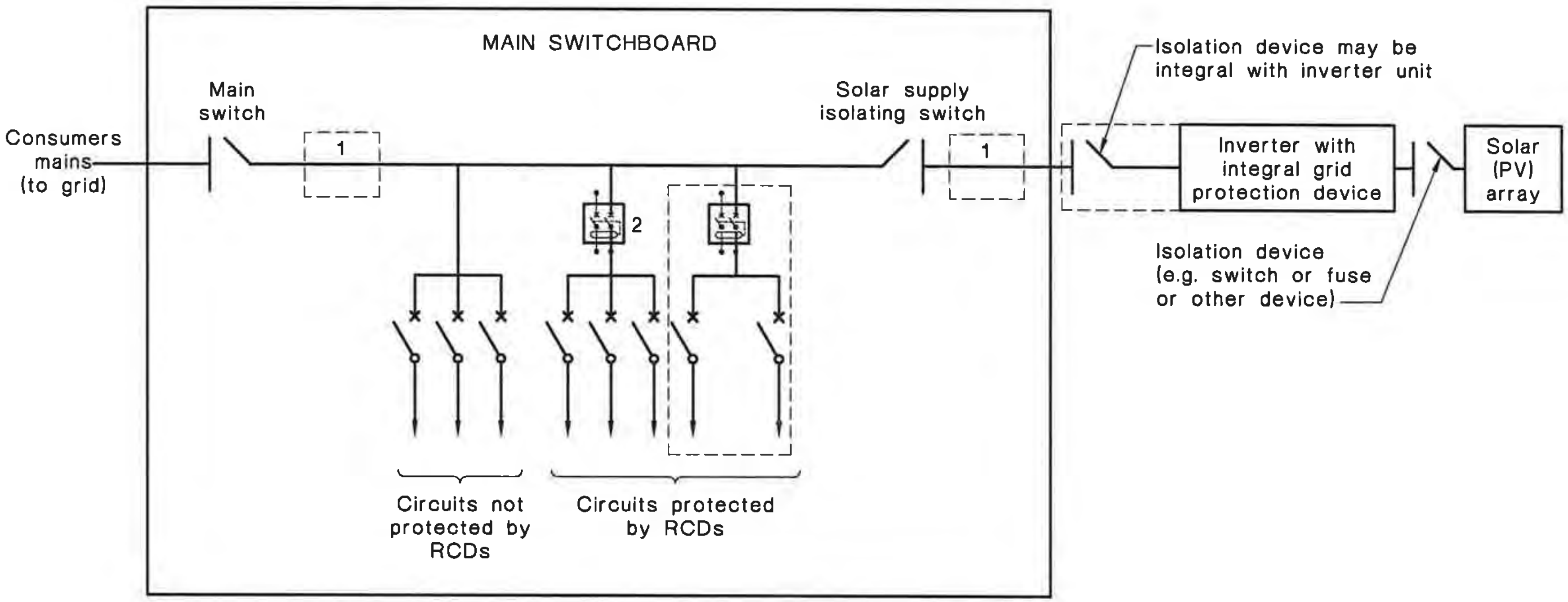
A power system comprising inverters, switches, control circuitry and a means of energy storage (e.g. batteries) for maintaining continuity of electrical supply to a load in the case of a disruption of power supply from an electricity distribution network.

5 INSTALLATION REQUIREMENTS

5.1 General

The installation shall comply with the appropriate requirements of Standard AS/NZS 3000 and this Standard. Some possible installation configurations are shown in Figures 1, 2 and 3.

NOTE: The configurations shown are for guidance only and many other configurations are acceptable.

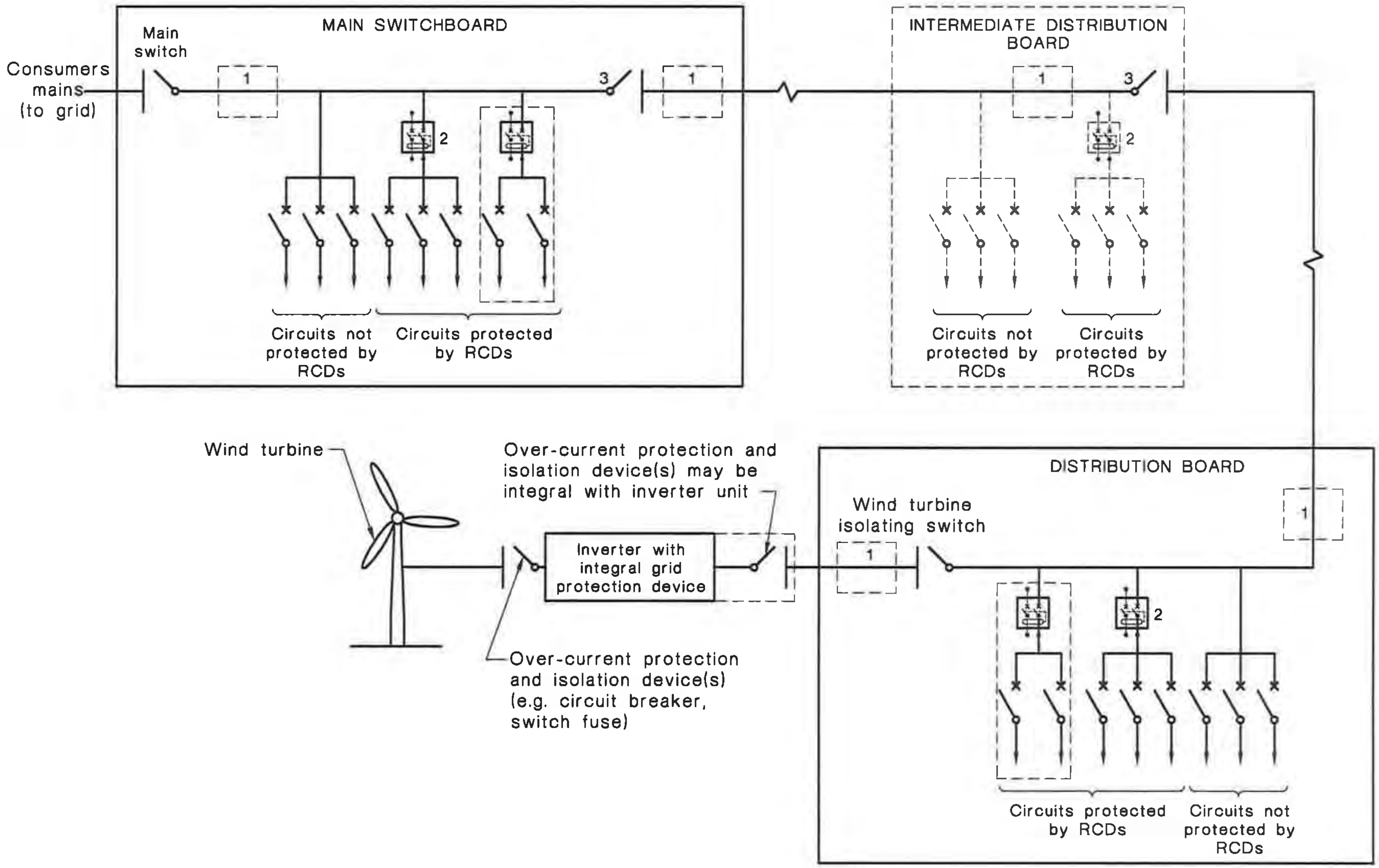


NOTES:

1 An RCD is not to be placed between the consumers mains and the solar supply (see Clause 5.3.4).

2 More than one RCD may be used, each protecting a number of circuits or each individual circuit may be protected by its own RCD.

FIGURE 1 GUIDANCE FOR A SIMPLE INSTALLATION OF AN INVERTER ENERGY SYSTEM



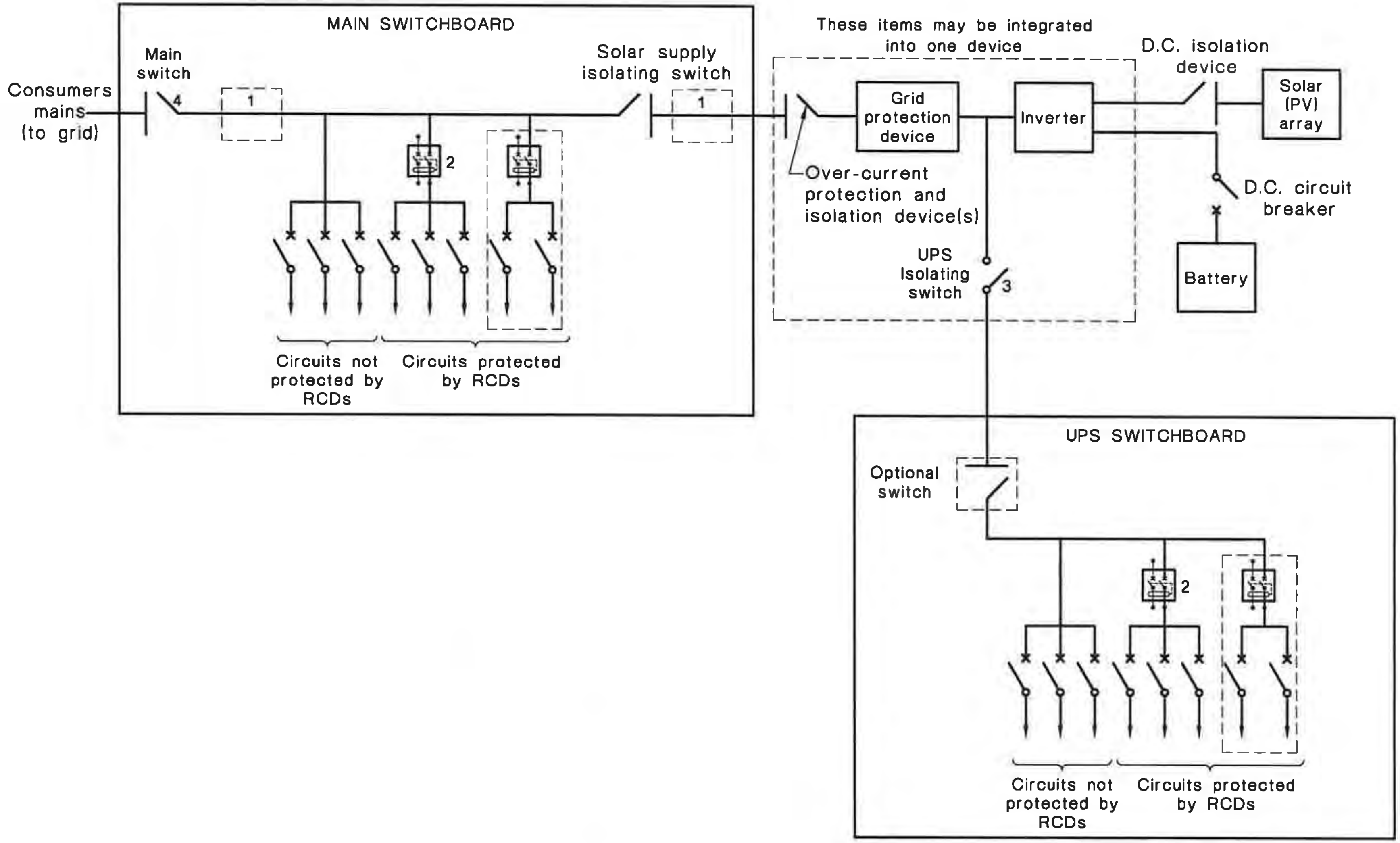
NOTES:

1 An RCD is not to be placed between the consumers mains and the solar supply (see Clause 5.3.4).

2 More than one RCD may be used, each protecting a number of circuits or each individual circuit may be protected by its own RCD.

3 Sub-main protective/control device (see AS/NZS 3000).

FIGURE 2 GUIDANCE FOR THE INSTALLATION OF AN INVERTER ENERGY SYSTEM ON A REMOTE DISTRIBUTION BOARD



NOTES:

1 An RCD is not to be placed between the consumers mains and the solar supply (see Clause 5.3.4).

2 More than one RCD may be used, each protecting a number of circuits or each individual circuit may be protected by its own RCD.

3 Sub-main protective/control device (see AS/NZS 3000).

4 Attention is drawn to the requirements in AS/NZS 3000 regarding switches and marking for alternative supply systems.

FIGURE 3 GUIDANCE FOR THE INSTALLATION OF AN INVERTER ENERGY SYSTEM INCORPORATING A UPS SYSTEM

Particular attention is drawn to:

(a) Requirements covering alternative supplies.

(b) Sizing circuit-breakers and cables to allow for the output a.c. current from the inverter or, in the case of an inverter energy system configured as a UPS, the input a.c. current to the inverter.

(c) Sizing cables to allow for voltage drops or voltage rises.

NOTE: The voltage at the inverter terminals may be higher than the grid voltage. Cables should be sized so that normal operation of the inverter does not cause the voltage at the inverter terminals to exceed voltage limits.

(d) The requirements of AS/NZS 3000 for protection and isolation.

Special additional installation requirements for UPS systems are contained in Clause 5.6.

5.2 Inverter and grid protection device

The inverter shall comply with the requirements of AS 4777.2.

The inverter energy system shall incorporate a grid protection device which shall comply with the requirements of AS 4777.3. The grid protection device may be integral with an inverter. The settings of the grid protection device shall not exceed the capability of the inverter.

5.3 A.C. circuit arrangements

5.3.1 *Connection to switchboard*

The inverter energy system shall be connected by fixed wiring to a dedicated circuit on a switchboard.

The inverter energy system should be connected directly to the main switchboard. In installations where this is not possible or not desirable, the inverter energy system should be connected to the distribution board located physically nearest to the inverter, and the main switchboard. All intermediate distribution boards shall be appropriately labelled in accordance with Clause 5.5.

5.3.2 *Cable sizing*

All the cables between the inverter energy system and any switchboard and all the cables between any distribution boards and a main switchboard which carry current from the inverter energy system shall be rated for at least the full *output* current of the inverter energy system and, if the inverter energy system is configured as a UPS, for at least the full *input* current of the inverter energy system.

5.3.3 *Isolation switches*

The main switch for the switchboard, to which the inverter energy system is connected, shall be a lockable switch.

An appropriately labelled lockable isolation switch or circuit breaker, which is lockable in the OFF position and operates in all active conductors, shall be provided on the switchboard to which the inverter energy system is directly connected. This switch shall be capable of breaking the full output current of the inverter. Operation of this switch shall isolate the inverter energy system from that switchboard. This isolation switch shall be installed to the requirements for main switches, as specified in AS/NZS 3000.

NOTE: This switch is to provide isolation of the inverter energy system for persons working on other parts of the electrical installation.

5.3.4 *Residual current devices (RCDs)*

The inverter energy system shall be connected to the electrical installation on the grid side of any residual current devices (RCDs).

NOTE: The inverter energy system is a potential source of supply. It is important that the inverter energy system be connected on the grid side of any RCDs in order to maintain the integrity of the protection afforded by the RCDs. Providing an RCD on the output of the inverter energy system is not a suitable alternative.

5.3.5 *Inverter overcurrent protection*

If the inverter is not in close proximity to the switchboard into which it is feeding, some form of overcurrent protection shall be provided to prevent excessive current flowing through the cables feeding into the switchboard unless the inverter is supplied from a current limited source.

NOTES:

1 Typically cable lengths of 3 m would be considered as close proximity.

2 A solar (PV) array is a current limited source.

3 The preferred location for this overcurrent protection device is at the inverter end of the cable.

5.4 Isolation of inverter from energy source

An isolation device shall be provided between the energy source and the inverter unless the inverter is physically integral with the energy source. This device shall comply with the requirements for devices for isolation and switching in AS/NZS 3000 and be capable of safely breaking voltage and current under both normal and fault conditions.

NOTE: An appropriately rated plug and socket may comply with this requirement.

5.5 Labels

5.5.1 *General*

The purpose of the following requirements for labels is to clearly indicate that the electrical installation has multiple supplies and which circuits are affected by these supplies.

Signs relating to the inverter energy system shall be placed on the switchboard to which the inverter energy system is directly connected. If the inverter energy system is directly connected to a distribution board, signs shall also be placed on the main switchboard and all intermediate distribution boards.

Signs shall comply with AS 1319, be indelible, be legible from at least 0.8 m and be sized appropriately for the location.

Signs should describe the type of energy source installed (e.g. SOLAR, WIND etc.), since particular generation sources have specific electrical characteristics.

Examples of signs are given in Appendix A.

NOTE: To provide assistance for emergency services, information should be provided at the main switchboard on where the inverter (and the distribution board, to which it is connected, if it is not the main switchboard) is located, unless it is adjacent to the main switchboard.

5.5.2 *Switchboard to which inverter energy system is directly connected*

The following signs shall be installed on the switchboard to which the inverter energy system is directly connected. These signs are—

(a) a sign containing the text 'WARNING', 'DUAL SUPPLY' and 'ISOLATE BOTH NORMAL AND *(type)* SUPPLIES BEFORE WORKING ON THIS SWITCHBOARD', where '*(type)*' refers to the type of energy source installed. This sign shall be installed in a prominent position on the switchboard;

(b) a sign containing the text '*(type)* SUPPLY', where '*(type)*' refers to the type of energy source installed. This sign shall be installed adjacent to the main switch for the inverter energy system.

5.5.3 *Other switchboards*

Where the inverter energy system is directly connected to a distribution board, signs shall be installed in prominent positions on the main switchboard and all intermediate distribution boards. These signs shall contain the text 'WARNING', 'DUAL SUPPLY' and 'ISOLATE (*type*) SUPPLY AT (*distribution board*) BEFORE WORKING ON THIS SWITCHBOARD', where '(*type*)' refers to the type of energy source installed and '(*distribution board*)' refers to the name of the distribution board to which the inverter energy system is directly connected.

5.6 Additional requirements for UPS systems

5.6.1 *General*

UPS systems shall comply with all requirements in Clauses 5.1 to 5.5 as well as these additional requirements.

5.6.2 *Grid protection device*

The grid protection device shall comply with the requirements in AS 4777.3 for use with UPS systems.

5.6.3 *Circuit arrangement*

The UPS shall supply an identifiably separate set of circuits. Where possible, these should be in a separate load centre or switchboard.

5.6.4 *RCDs*

When installing RCDs to protect UPS circuits, the RCDs shall be installed on the UPS output of the inverter energy system (see Figure 3).

5.6.5 *Warning sign*

A warning sign shall be installed in the main switchboard warning that when operating in the UPS mode, the neutral and earth circuits may be live even though the active circuits are dead.

NOTE: An explanation of this problem is in Appendix B.

APPENDIX A
SIGN EXAMPLES
(Informative)

A1 OVERVIEW

This Appendix provides examples of appropriate signs, as specified in Clause 5.5. The examples are for an inverter energy system supplied by a solar array and connected to a distribution board labelled 'DB01'.

A2 SIGNS ON SWITCHBOARD TO WHICH INVERTER ENERGY SYSTEM IS DIRECTLY CONNECTED

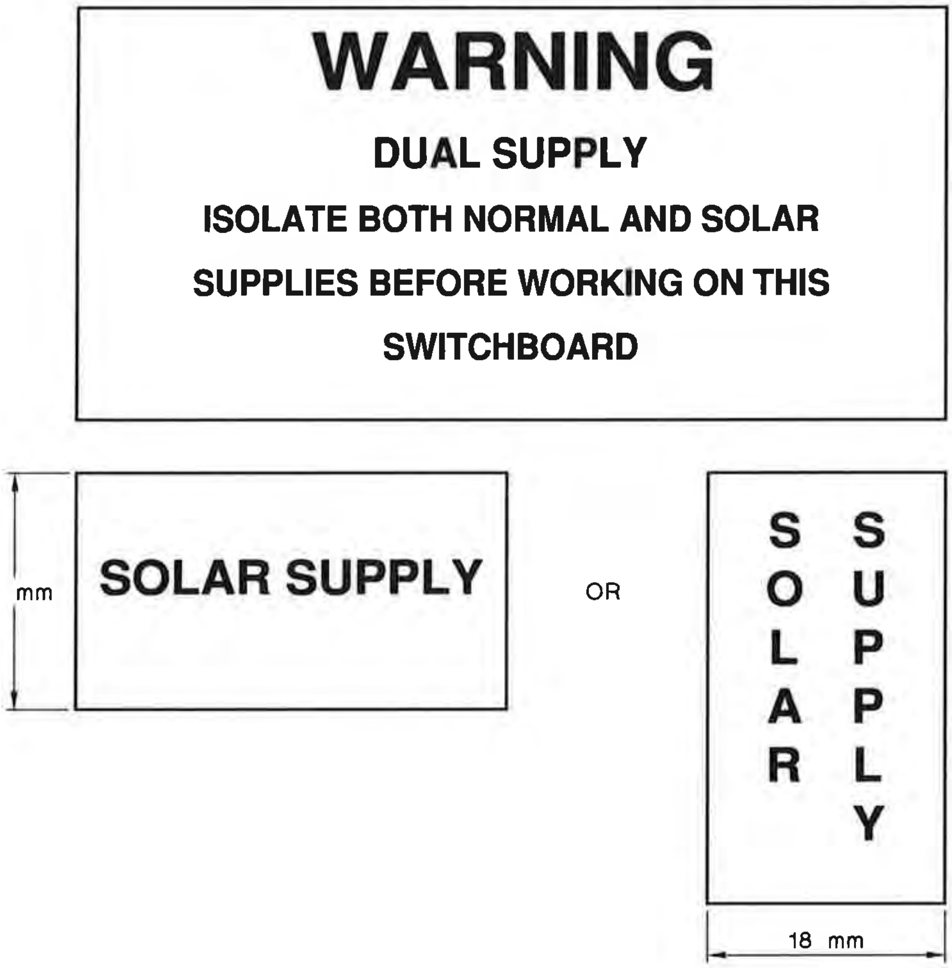


FIGURE A1 EXAMPLES OF SIGNS REQUIRED ON SWITCHBOARD TO WHICH A SOLAR SUPPLY IS CONNECTED.

A3 SIGNS ON MAIN SWITCHBOARD AND INTERMEDIATE DISTRIBUTION BOARDS

WARNING

DUAL SUPPLY

ISOLATE SOLAR SUPPLY AT

DISTRIBUTION BOARD DB01

FIGURE A2 EXAMPLE OF THE SIGN REQUIRED ON INTERMEDIATE DISTRIBUTION BOARD

APPENDIX B
DANGER DURING UPS OPERATION
(Informative)

B1 NORMAL OPERATION

A detailed review of Figure B1 indicates that when operating in the 'fully powered' mode any earth fault will create a fault circuit consisting of the following elements—

(a) from the power source (grid supply or the inverter);

(b) through the current limiting device (circuit breaker or fuse);

(c) through the active supply to the device;

(d) through the fault to earth;

(e) through the earth circuit to the MEN link on the Main Switchboard;

(f) through the neutral circuit to the power source (grid supply or the inverter); or

(g) through the power source to trip the current limiting device (circuit breaker or fuse) which breaks the fault circuit.

Thus for the circuit to work correctly, and safely, the MEN link must be installed correctly and link the earth circuit to the neutral circuits.

B2 UPS OPERATION

If the Main Switchboard is not receiving power from the grid due to either—

(a) the grid supply failing (due to a maintenance shutdown or an accident); or

(b) the Main Switch on the switchboard being switched OFF;

it would appear that the Main Switchboard is DEAD and hence SAFE.

An examination of Figure B1 shows that if a fault occurs in a circuit being supplied from the UPS Switchboard, the fault circuit will be through the UPS earth circuit to the Main Switchboard earth, through the MEN link on the MAIN SWITCHBOARD to the neutral to the UPS inverter. Thus in a fault situation, the Main Switchboard WILL conduct current through the earth circuit, MEN link and the neutral circuit to the inverter supply.

This is why the grid protection device is NOT to break the neutral circuit from the Main Switchboard to the inverter in the event of a break in the power supply, when the inverter supplies a UPS system.

It is also important that if it is intended to carry out maintenance or installation work on the Main Switchboard whilst the UPS system is operating, then the earth circuit from the UPS switchboard, through the MEN link and back through the neutral to the inverter supplying the UPS switchboard, must not be broken as it could lead to a dangerous situation. If it is necessary to break this circuit, then the UPS switchboard should be shut down.

It is not possible to provide an MEN link at the UPS switchboard as AS/NZS 3000 does not permit more than one MEN link in the same building because this could lead to dangerous situations due to earth/neutral loops.

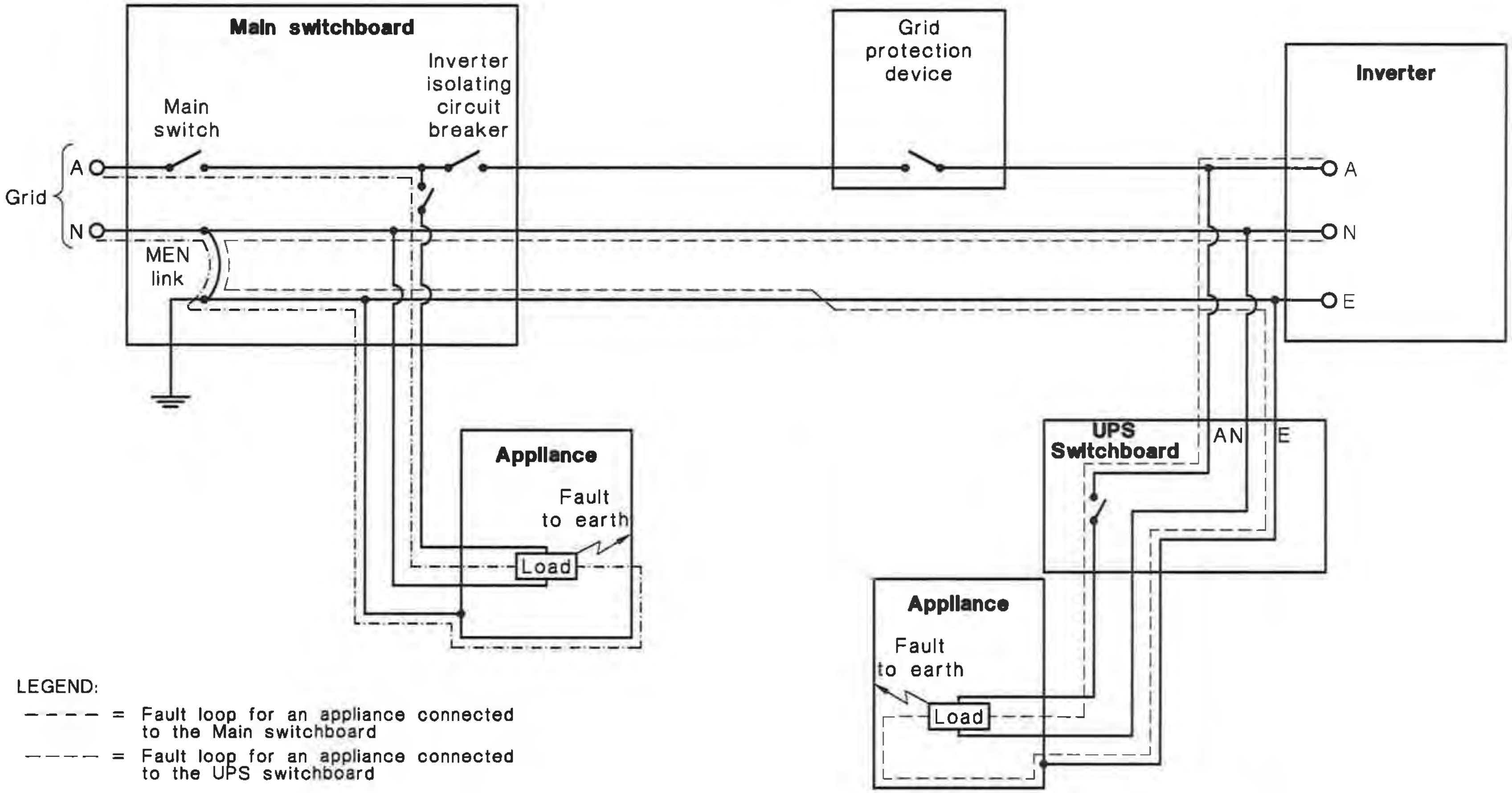


FIGURE B1 FAULT CIRCUIT DURING NORMAL OPERATION

NOTES

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AS 4777.2-2005 Grid connection of energy systems via inverters - Inverter requirements

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AS 4777.2—2005

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Australian Standard™

Grid connection of energy systems via inverters

Part 2: Inverter requirements

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This Australian Standard was prepared by Committee EL-042, Renewable Energy Power Supply Systems and Equipment. It was approved on behalf of the Council of Standards Australia on 6 April 2005. This Standard was published on 20 May 2005.

The following are represented on Committee EL-042:

Alternative Technology Association
Australian Electrical and Electronic Manufacturers Association
Business Council for Sustainable Energy
Electrical Regulatory Authorities Council
Electrical Safety Organisation, New Zealand
Electricity Engineers Association, New Zealand
ElectroComms & Energy Utilities Industries Skills Council
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This Standard was issued in draft form for comment as DR 04341.

Australian Standard™

Grid connection of energy systems via inverters

Part 2: Inverter requirements

Originated as AS 4777.2—2002.
Second edition 2005.

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PREFACE

This Standard was prepared by the Australian members of the Joint Standards Australia/Standards New Zealand Committee EL-042, Renewable Energy Power Supply Systems and Equipment and is based on requirements developed by a group of utility, photovoltaic and inverter industry experts coming together under the auspices of the Energy Networks Association. After consultation with stakeholders in both countries, Standards Australia and Standards New Zealand decided to develop this Standard as an Australian, rather than an Australian/New Zealand Standard. This Standard replaces AS 4777.2—2002 on publication.

The objective of this Standard is to provide regulators, electricity distributors and manufacturers with the requirements and tests for inverters intended for the injection of electric power through an electrical installation to the electricity distribution network.

It is Part 2 of AS 4777, *Grid connection of energy systems via inverters* which is published in parts as follows:

AS 4777.1 Part 1: Installation requirements

AS 4777.2 Part 2: Inverter requirements (this Standard)

AS 4777.3 Part 3: Grid protection requirements

This Standard has been revised to—

(a) simplify requirements for EMC;

(b) clarify harmonic limits;

(c) clarify test parameters and tolerances; and

(d) resolve some issues found as a result of application of the Standard.

This Standard was developed with the assistance of the following organisations—

(i) Australian Greenhouse Office;

(ii) Research Institute for Sustainable Energy, Murdoch University; and

(iii) University of New South Wales.

The term 'normative' has been used in this Standard to define the application of the appendix to which it applies. A 'normative' appendix is an integral part of a Standard.

CONTENTS

STANDARDS AUSTRALIA

Australian Standard

Grid connection of energy systems via inverters

Part 2: Inverter requirements

1 SCOPE

This Standard specifies the requirements for inverters, with ratings up to 10 kVA for single-phase units or up to 30 kVA for three-phase units, for the injection of electric power through an electrical installation to the electricity distribution network.

NOTES:

1 Although this Standard does not apply to larger systems, similar principles can be used for the design of such systems.

2 Although this Standard is written on the basis that the renewable energy is from a d.c. source (e.g. photovoltaic array), this Standard may be used for systems where the energy is from a variable a.c. source (e.g. wind turbine or micro-hydro system) by appropriate changes to the tests.

3 This Standard does not include EMC requirements. These are mandated by the Australian Communications Authority (ACA). Users attention is drawn to Australian Communication Authority's document '*Electromagnetic Compatibility—Information for suppliers of electrical and electronic products in Australia and New Zealand*' for guidance.

2 NORMATIVE REFERENCES

The following normative documents contain provisions which, through reference in this text, constitute provisions of this Standard.

AS	
4777	Grid connection of energy systems via inverters
4777.3	Part 3: Grid protection requirements
60038	Standard voltages
AS/NZS	
3100	Approval and test specification—General requirements for electrical equipment
60950	Information technology equipment—Safety
60950.1	Part 1: General requirements
61000	Electromagnetic compatibility (EMC)
61000.3.3	Part 3.3: Limits—Limitation of voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current less than or equal to 16 A per phase and not subject to conditional connection
61000.3.5	Part 3.5: Limits—Limitation of voltage fluctuations and flicker in low-voltage power supply systems for equipment with rated current greater than 16 A
IEC	
60255	Electrical relays
60255-5	Part 5: Insulation coordination for measuring relays and protection equipment—Requirements and tests

ACA Electromagnetic Compatibility—Information for suppliers of electrical and electronic products in Australia and New Zealand

3 DEFINITIONS

For the purpose of this Standard, the following definitions apply.

3.1 Electricity distribution network

The portion of an electrical system that is operated by an electrical distributor.

3.2 Grid

An alternative term for an electricity distribution network.

3.3 Grid protection device

A device complying with the requirements of AS 4777.3.

3.4 Inverter

A device that uses semiconductor devices to transfer power between a d.c. source or load and an a.c. source or load.

NOTE: This Standard is written on the basis that the renewable energy is from a d.c. source (e.g. photovoltaic array), but the energy may be from a variable a.c. source (e.g. wind turbine or micro-hydro system) and hence, for the purposes of this Standard, a.c. to a.c. converters that use semiconductor devices are considered to be inverters, as the requirements in this Standard are applicable to such systems.

3.5 Inverter energy system

A system comprising one or more inverters together with one or more energy sources (which may include batteries for energy storage), controls and one or more grid protection devices.

3.6 Islanding

Any situation where the electrical supply from an electricity distribution network is disrupted and one or more inverters maintains any form of electrical supply, be it stable or not, to any section of that electricity distribution network.

3.7 Nominal grid voltage

The definitions of AS 60038 shall apply.

3.8 Ripple control

A means of one-way communication based on transmitting electrical signals over an electricity distribution network.

3.9 Uninterruptible power supply (UPS) system

A power system comprising inverters, switches, control circuitry and a means of energy storage (e.g. batteries) for maintaining continuity of electrical supply to a load in the case of a disruption of power supply from an electricity distribution network.

4 INVERTER REQUIREMENTS

4.1 General

The inverter shall comply with the appropriate electrical safety requirements of AS/NZS 3100.

NOTE: AS/NZS 3100 allows that if an individual Standard dealing with specific features of the design, construction and testing of any particular class or type of equipment is issued, it supersedes the general requirements of AS/NZS 3100 that are specifically dealt with in that individual Standard.

4.2 Compatibility with electrical installation

The inverter shall have a.c voltage and frequency ratings compatible with AS 60038.

NOTE: The nominal voltage at the point of supply is 230 V a.c. single phase line-to-neutral and 400 V a.c. three phase line-to-line with a tolerance of +10% -6% and a frequency of 50 Hz.

4.3 Power flow direction

Power flow between the energy source and the grid may be in either direction.

4.4 Power factor

The power factor of the inverter, considered as a load from the perspective of the grid, shall be in the range from 0.8 leading to 0.95 lagging for all output from 20% to 100% of rated output. These limits shall not apply if the inverter is approved by the relevant electricity distributor to control power factor outside this range for the purpose of providing voltage support.

Compliance shall be determined by type testing in accordance with the power factor test described in Appendix A.

NOTE: Lagging power factor is defined to be when reactive power flows from the grid to the inverter; that is, when the inverter acts as an inductive load from the perspective of the grid.

4.5 Harmonic currents

The harmonic currents of the inverter shall not exceed the limits specified in Tables 1 and 2 and the total harmonic distortion (THD) (to the 50th harmonic) shall be less than 5%. Compliance shall be determined by type testing in accordance with the harmonic current limit test specified in Appendix B.

NOTE: The inverter should not significantly radiate or sink frequencies used for ripple control by the local electrical distributor. The distributor should be consulted to determine which frequencies are used.

TABLE 1

ODD HARMONIC CURRENT LIMITS

Odd harmonic order number	Limit for each individual odd harmonic based on percentage of fundamental
3, 5, 7 and 9	4%
11, 13 and 15	2%
17, 19 and 21	1.5%
23, 25, 27, 29, 31 and 33	0.6%

TABLE 2

EVEN HARMONIC CURRENT LIMITS

Even harmonic order number	Limit for each individual even harmonic based on percentage of fundamental
2, 4, 6 and 8	1%
10 – 32	0.5%

NOTE: The harmonic limits in Tables 1 and 2 are based on those in IEEE 929-2000 *IEEE Recommended Practice for Utility Interface of Photovoltaic (PV) Systems.*

4.6 Voltage fluctuations and flicker

The inverter shall conform to the voltage fluctuation and flicker limits as per AS/NZS 61000.3.3 for equipment rated less than or equal to 16 A per phase and AS/NZS 61000.3.5 for equipment rated greater than 16 A per phase. Compliance shall be determined by type testing in accordance with the appropriate Standard.

4.7 Impulse protection

The inverter shall withstand a standard lightning impulse of 0.5 J, 5 kV with a 1.2/50 waveform. Compliance shall be determined by type testing in accordance with the impulse voltage withstand test of IEC 60255-5.

4.8 Transient voltage limits

When type tested in accordance with the transient voltage limit test described in Appendix C, the voltage-duration curve derived from measurements taken at the a.c. terminals of the inverter shall not exceed the limits listed in Table 3.

NOTE: The voltage-duration limits listed in Table 3 are graphically illustrated in Figure 1.

TABLE 3

TRANSIENT VOLTAGE LIMITS

Duration	Instantaneous voltage	
	Line-to-neutral	Line-to-line
Seconds	Volts	Volts
0.000 2	910	1 580
0.000 6	710	1 240
0.002	580	1 010
0.006	470	810
0.02	420	720
0.06	390	670
0.2	390	670
0.6	390	670

4.9 Direct current injection

In the case of a single-phase inverter, the d.c. output current of the inverter at the a.c. terminals shall not exceed 0.5% of its rated output current or 5 mA, whichever is the greater.

In the case of a three-phase inverter, the d.c. output current of the inverter at the a.c. terminals, measured between any two phases or between any phase and neutral, shall not exceed 0.5% of its rated per-phase output current or 5 mA, whichever is the greater.

If the inverter does not incorporate a mains frequency isolating transformer, it shall be type tested to ensure the d.c. output current at the a.c. terminals of the inverter is below the above limits at all power levels.

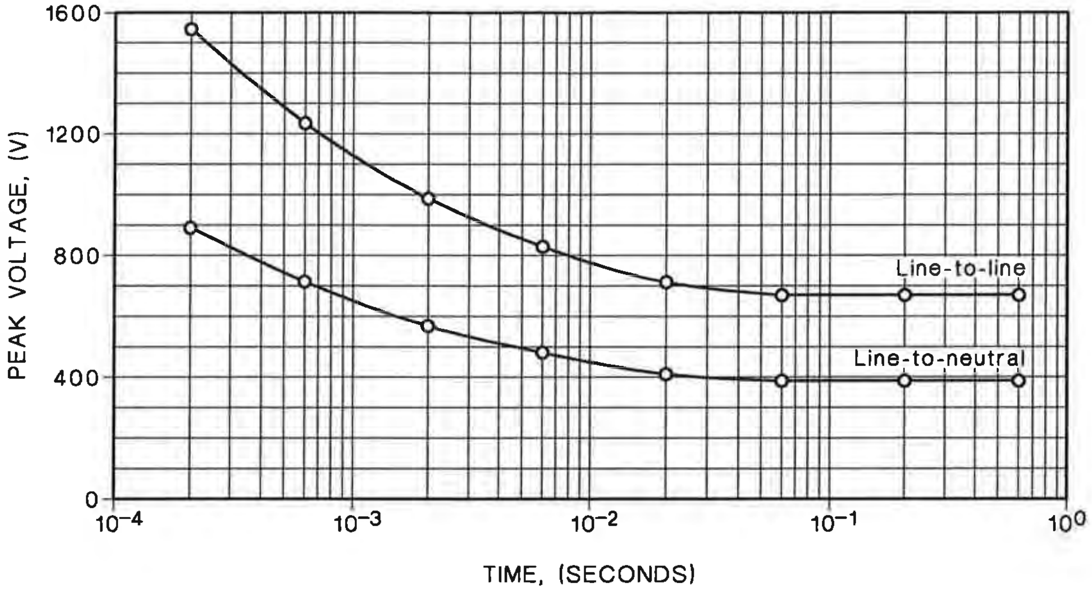


FIGURE 1 VOLTAGE-DURATION CURVE OF TRANSIENT VOLTAGE LIMITS

4.10 Data logging and communications devices

Any electronic data logging or communications equipment incorporated in the inverter should comply with the appropriate requirements of AS/NZS 60950.1. Particular attention is drawn to requirements for electrical insulation and creepage and clearance distances.

APPENDIX A
POWER FACTOR TEST
(Normative)

A1 TEST SPECIFICATIONS

The power factor test shall be carried out as follows:

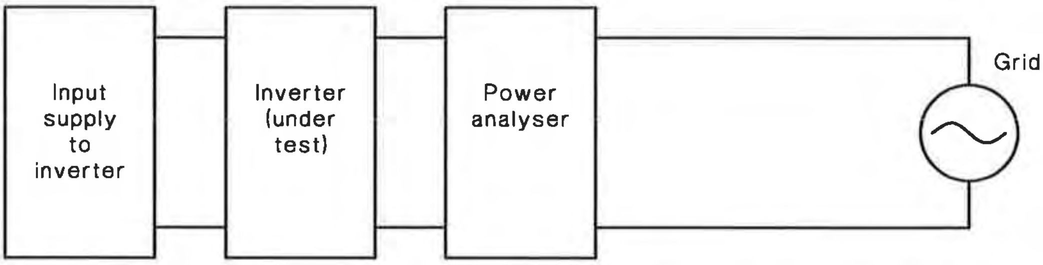
(a) The inverter shall be connected into a test circuit similar to that shown in Figure A1. The grid voltage shall equal the nominal voltage to within 5%.

(b) The d.c. supply shall be varied until the a.c. output of the inverter, measured in volt-amperes, equals (20 ±5)% of its rated output.

(c) The power factor of the inverter output shall be measured.

(d) Steps (b) and (c) shall be repeated with the inverter operating at (30 ±5)%, (40 ±5)%, (50 ±5)%, (60 ±5)%, (70 ±5)%, (80 ±5)%, (90 ±5)% and (100 ±5)% of its rated output, measured in volt-amperes.

When subjected to the test described above, the power factor shall comply with the limits specified in Clause 4.4.



NOTE: This test circuit applies to a single-phase system. To test a three-phase system, an equivalent three-phase circuit is required.

FIGURE A1 CIRCUIT FOR POWER FACTOR TEST

APPENDIX B
HARMONIC CURRENT LIMIT TEST
(Normative)

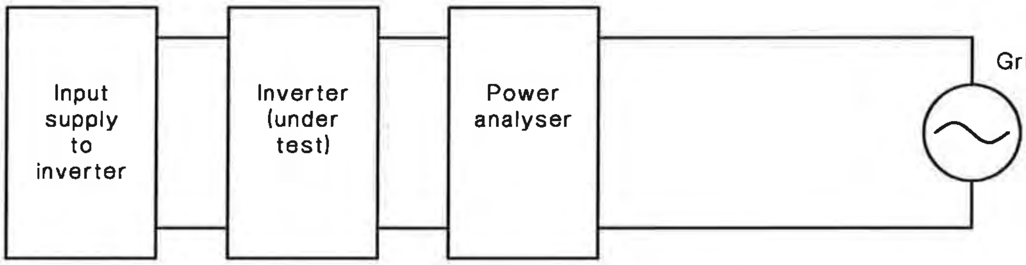
B1 TEST SPECIFICATIONS

The harmonic current limit test shall be carried out as follows:

(a) The inverter shall be connected into a test circuit similar to that shown in Figure B1.

(b) The d.c. supply shall be varied until the a.c. output of the inverter, measured in volt-amperes, lies in the range (100 ±5)% of its rated output.

(c) The harmonic current content of the inverter output shall be measured.



NOTE: This test circuit applies to a single-phase system. To test a three-phase system, an equivalent three-phase circuit is required.

FIGURE B1 CIRCUIT FOR HARMONIC CURRENT LIMIT TEST OF A SINGLE-PHASE SYSTEM.

B2 HARMONIC CURRENT LIMITS

When the inverter is subjected to the test described in Clause B1 above, the harmonic currents of the inverter shall not exceed the limits specified in Table 1 and Table 2.

B3 SUPPLY SOURCE DURING HARMONIC TESTS

While the harmonic current measurements are being made, the test voltage at the a.c. terminals of the inverter shall meet the following requirements:

(a) The test voltage shall be maintained at the nominal voltage ±5% at the discretion of the testing authority.

(b) The test frequency shall be maintained at (50 ±1)Hz.

(c) In the case of a three-phase supply, the angle between the fundamental voltages of each pair of phases shall be maintained at (120 ±1.5)°.

(d) The harmonic ratios of the test voltage shall not exceed the limits listed in Table B1.

TABLE B1
HARMONIC LIMITS OF TEST VOLTAGE

Harmonic order number	Limit based on percentage of fundamental
3	0.9%
5	0.4%
7	0.3%
9	0.2%
even harmonics 2–10	0.2%
11– 50	0.1%
Total harmonic distortion (to the 50th harmonic)	5%

APPENDIX C
TRANSIENT VOLTAGE LIMIT TEST
(Normative)

C1 GENERAL

To prevent damage to electrical equipment connected to the same circuit as the inverter, disconnection of the inverter from the electricity distribution network shall not result in transient overvoltages beyond the limits specified in Table 3.

C2 TEST SPECIFICATIONS

The transient voltage limit test shall be carried out as follows:

(a) The inverter shall be placed in a test circuit similar to that shown in Figure C1.

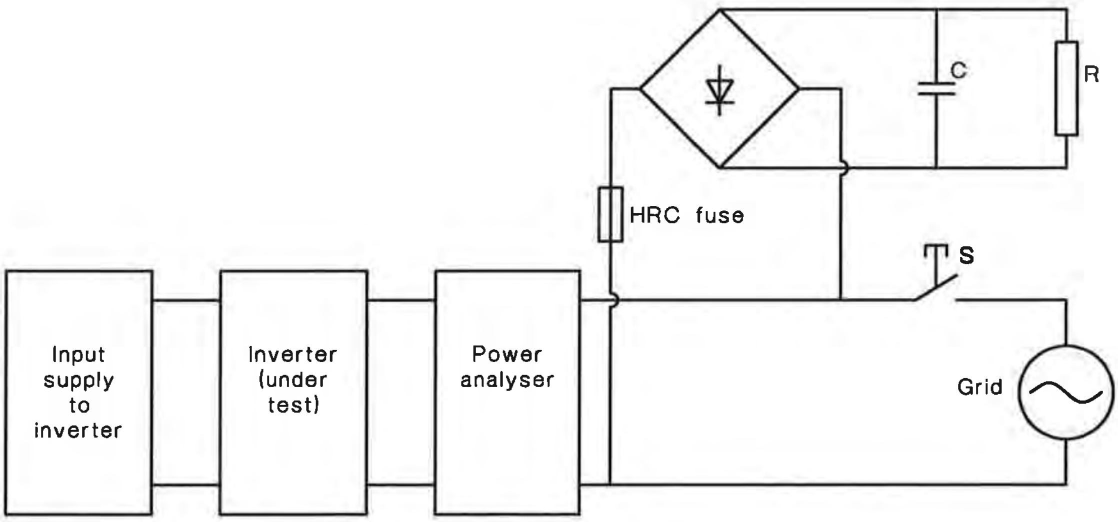
(b) The voltage at the a.c. terminals of the inverter before the switch is opened, shall be maintained at the nominal voltage ±5% at the discretion of the testing authority.

(c) The d.c. supply shall be varied until the a.c. output of the inverter, measured in volt-amperes, equals (10 ±5)% of its rated output.

(d) The switch S shall be opened.

(e) The voltage across the a.c. terminals of the inverter shall be recorded at a sample frequency of at least 10 kHz. If the inverter has multiple sets of a.c. terminals, only the a.c. terminals used to connect the inverter to the test circuit (grid connection) shall be monitored.

(f) Steps (b) to (e) shall be repeated with the inverter operating at (50 ±5)% and (100 ±5)% of its rated output, measured in volt-amperes.



C = 100μF
R = 560 kΩ

NOTE: This test circuit applies to a single-phase system. To test a three-phase system, an equivalent three-phase circuit is required.

FIGURE C1 CIRCUIT FOR TRANSIENT VOLTAGE LIMIT TEST

C3 TRANSIENT VOLTAGE LIMITS

When subjected to the test described in Clause C2, the voltage-duration curve derived from the sampled a.c. voltage at the inverter terminals shall not exceed the limits specified in Table 3.

NOTE: A voltage-duration curve is calculated using the sampled instantaneous voltage over the complete trip time of the inverter. For each voltage (maximum voltage step 10 V), the number of samples greater than that voltage are counted. This number is then multiplied by the sample interval to derive a duration for that voltage. The voltage-duration curve is the locus of all points derived from this process. The inverter is deemed to comply with the transient voltage limit test if the derived voltage-duration curve lies beneath the appropriate curve of Figure 1 at all points.

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添付資料⑯

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for

AS 4777.3-2005 Grid connection of energy systems via inverters - Grid protection requirements

Licensee: Solomon Islands Electricity Authority

Date: Wednesday, 6 November 2013 10:55 AM

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Australian Standard™

Grid connection of energy systems via inverters

Part 3: Grid protection requirements

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This Australian Standard was prepared by Committee EL-042, Renewable Energy Power Supply Systems and Equipment. It was approved on behalf of the Council of Standards Australia on 6 April 2005. This Standard was published on 20 May 2005.

The following are represented on Committee EL-042:

Alternative Technology Association
Australian Electrical and Electronic Manufacturers Association
Business Council for Sustainable Energy
Electrical Regulatory Authorities Council
Electrical Safety Organisation, New Zealand
Electricity Engineers Association, New Zealand
ElectroComms & Energy Utilities Industries Skills Council
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This Standard was issued in draft form for comment as DR 04342.

AS 4777.3—2005

Australian Standard™

Grid connection of energy systems via inverters

Part 3: Grid protection requirements

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PREFACE

This Standard was prepared by the Australian members of the Joint Standards Australia/Standards New Zealand Committee EL-042, Renewable Energy Power Supply Systems and Equipment and is based on requirements developed by a group of utility, photovoltaic and inverter industry experts coming together under the auspices of the Energy Networks Association. After consultation with stakeholders in both countries, Standards Australia and Standards New Zealand decided to develop this Standard as an Australian, rather than an Australian/New Zealand Standard. This Standard replaces AS 4777.3—2002 on publication.

The objective of this Standard is to provide regulators, electricity distributors and manufacturers with the requirements and tests for grid protection devices to be used in inverter energy systems intended for the injection of electric power through an electrical installation to the electricity distribution network.

It is Part 3 of AS 4777, *Grid connection of energy systems via inverters* which is published in parts as follows:

AS 4777.1 Part 1: Installation requirements

AS 4777.2 Part 2: Inverter requirements

AS 4777.3 Part 3: Grid protection requirements (this Standard)

This Standard has been revised to—

(a) simplify requirements for EMC; and

(b) clarify the grid performance test including tolerances on test values.

This Standard was developed with the assistance of the following organisations—

(i) Australian Greenhouse Office;

(ii) Research Institute for Sustainable Energy, Murdoch University; and

(iii) University of New South Wales.

The terms 'normative' and 'informative' have been used in this Standard to define the application of the Appendix to which they apply. A 'normative' Appendix is an integral part of a Standard whereas an 'informative' Appendix is only for information and guidance.

CONTENTS

STANDARDS AUSTRALIA

Australian Standard

Grid connection of energy systems via inverters

Part 3: Grid protection requirements

1 SCOPE

This Standard specifies the requirements for grid protection devices intended to be used in inverter energy systems, with ratings up to 10 kVA for single-phase units, or up to 30 kVA for three-phase units, and for the injection of electric power through an electrical installation to the electricity distribution network.

NOTES:

1 Although this Standard does not apply to larger systems, similar principles can be used for the grid protection of such systems.

2 These devices do not replace devices used for protection and/or isolation as required in AS/NZS 3000.

3 Although this Standard is written on the basis that the renewable energy is from a d.c. source (e.g. photovoltaic array), this Standard may be used for systems where the energy is from a variable a.c. source (e.g. wind turbine or micro-hydro system) by appropriate changes to the tests.

4 This Standard does not include EMC requirements. These requirements are mandated by the Australian Communications Authority (ACA). Users attention is drawn to Australian Communications Authority's document *'Electromagnetic Compatibility—Information for suppliers of electrical and electronic products in Australia and New Zealand'* for guidance.

2 NORMATIVE REFERENCES

The following normative documents contain provisions which, through reference in this text, constitute provisions of this Standard.

AS

60038 Standard voltages

AS/NZS

3000 Electrical Installations (known as the Australian/New Zealand Wiring Rules)

3100 Approval and test specification—General requirements for electrical equipment

60950 Information technology equipment—Safety

60950.1 Part 1: General requirements

61000 Electromagnetic compatibility (EMC)

61000.3.3 Part 3.3: Limits—Limitation of voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current less than or equal to 16 A per phase and not subject to conditional connection

61000.3.5 Part 3.5: Limits—Limitation of voltage fluctuations and flicker in low-voltage power supply systems for equipment with rated current greater than 16 A

IEC		
60255	Electrical relays	
60255-5	Part 5:	Insulation coordination for measuring relays and protection equipment—Requirements and tests
ACA	Electromagnetic Compatibility—Information for suppliers of electrical and electronic products in Australia and New Zealand	

3 DEFINITIONS

For the purpose of this Standard, the following definitions apply.

3.1 Active anti-islanding protection

A method of preventing islanding by actively varying the output of the inverter energy system.

3.2 Electricity distribution network

The portion of an electrical system that is operated by an electrical distributor.

3.3 Grid

An alternative term for an electricity distribution network.

3.4 Inverter

A device that uses semiconductor devices to transfer power between a d.c. source or load and an a.c. source or load.

NOTE: This Standard is written on the basis that the renewable energy is from a d.c. source (e.g. photovoltaic array), but the energy may be from a variable a.c. source (e.g. wind turbine or micro-hydro system) and hence, for the purposes of this Standard, a.c. to a.c. converters that use semiconductor devices are also considered to be inverters, as the requirements in this Standard are applicable to such systems.

3.5 Inverter energy system

A system comprising one or more inverters together with one or more energy sources (which may include batteries for energy storage), controls and one or more grid protection devices.

3.6 Islanding

Any situation where the electrical supply from an electricity distribution network is disrupted and one or more inverters maintains any form of electrical supply, be it stable or not, to any section of that electricity distribution network.

3.7 Nominal grid voltage

The definition of AS 60038 shall apply.

3.8 Passive anti-islanding protection

A method of preventing islanding based on monitoring the electricity distribution network.

3.9 Electromechanical switch

An electrical switch in which the OFF state results in the physical separation of conductors (e.g. a mechanical relay). This DOES NOT include transistors or similar semiconductor devices.

3.10 Uninterruptible power supply (UPS) system

A power system comprising inverters, switches, control circuitry and a means of energy storage (e.g. batteries) for maintaining continuity of electrical supply to a load in the case of a disruption of power supply from an electricity distribution network.

4 GENERAL AND SAFETY REQUIREMENTS

4.1 General

Grid protection of the inverter energy system shall be provided by a grid protection device. This does not preclude the grid protection device being integral to the inverter, nor a single grid protection device being used to protect an inverter energy system comprising multiple inverters.

Compliance with this Standard shall be determined by type testing the grid protection device on its own and, if necessary, in combination with an inverter. Compliance of this combination shall be conditional on their being used together in the same manner in which they have been type tested. Compliance of one combination of inverter and grid protection device does not preclude compliance of either device as part of a different combination.

4.2 Electrical safety

The grid protection device shall comply with appropriate electrical safety requirements of AS/NZS 3100.

NOTE: AS/NZS 3100 allows that if an individual Standard dealing with specific features of the design, construction and testing of any particular class or type of equipment is issued, it shall supersede the general requirements of AS/NZS 3100 that are specifically dealt with in that individual Standard.

4.3 Connection to low-voltage distribution network

The grid protection device shall be compatible with the low-voltage distribution network.

NOTE: The nominal voltage is 230 V a.c. single phase line-to-neutral and 400 V a.c. three phase line-to-line with a tolerance of +10% -6% at a frequency of 50 Hz.

4.4 Voltage flicker

The grid protection device shall conform to the voltage flicker limits specified in AS/NZS 61000.3.3 for equipment rated less than or equal to 16 A (a.c. current) or AS/NZS 61000.3.5 for equipment rated at greater than 16A (a.c. current). Compliance shall be determined by type testing in accordance with the appropriate Standard.

4.5 Impulse protection

The grid protection device shall withstand a standard lightning impulse of 0.5 J, 5 kV with a 1.2/50 waveform. Compliance shall be determined by type testing in accordance with the impulse voltage withstand test of IEC 60255-5.

4.6 Data logging and communications devices

Any electronic data logging or communications equipment incorporated in the inverter should comply with the appropriate requirements of AS/NZS 60950.1. Particular attention is drawn to requirements for electrical insulation and creepage and clearance distances.

5 GRID PROTECTION REQUIREMENTS

5.1 General

The grid protection device shall operate—

(a) if supply from the grid is disrupted; or

(b) when the grid goes outside preset parameters (e.g. under/over voltage, under/over frequency); or

(c) to prevent islanding.

Specific requirements are contained in Clauses 5.2 to 5.5.

5.2 Disconnection device

The grid protection device shall incorporate a disconnection device which shall prevent power (both a.c. and d.c.) from the inverter energy system entering the grid when the disconnection device operates.

NOTE: The disconnection device need not disconnect sensing circuits.

The disconnection device shall incorporate an electromechanical switch if—

(a) there is no galvanic isolation between the energy source(s) and the grid; or

(b) the inverter system continues to provide electrical power to any portion of the electrical installation (i.e. it operates as an uninterruptible power supply (UPS) system) in the event of the disruption of the grid supply.

NOTES:

1 Galvanic isolation can be achieved by using either a two winding high-frequency transformer or a two winding mains frequency transformer.

2 Galvanic isolation is not required on sensing circuits.

Any disconnection device intended for use with a UPS system shall only break the active conductor(s).

The disconnection device may incorporate semiconductor devices if galvanic isolation exists between the energy source(s) and the grid and the system does not operate as an uninterruptible power supply system.

5.3 Voltage and frequency limits (passive anti-islanding protection)

The grid protection device shall incorporate passive anti-island protection in the form of under- and over-voltage and under- and over-frequency protection. If the voltage goes outside the range V_{min} to V_{max} or its frequency goes outside the range f_{min} to f_{max}, the disconnection device (see Clause 5.2) shall operate within 2 s, where—

(a) V_{min} shall lie in the range 200-230 V for a single-phase system or 350-400 V for a three-phase system;

(b) V_{max} shall lie in the range 230-270 V for a single-phase system or 400-470 V for a three-phase system;

(c) f_{min} shall lie in the range 45-50 Hz; and

(d) f_{max} shall lie in the range 50-55 Hz.

The limits V_{max}, V_{min}, f_{max} and f_{min} may be either preset or programmable. The values V_{max}, V_{min}, f_{max} and f_{min} may be negotiated with the relevant electricity distributor. The settings of the grid protection device shall not exceed the capability of the inverter.

5.4 Limits for sustained operation

The introduction of limits for sustained operation is under consideration.

NOTE: See Appendix A for further information about the proposal.

5.5 Active anti-islanding protection

The grid protection device shall incorporate at least one method of active anti-islanding protection. Examples of such methods include shifting the frequency of the inverter away from nominal conditions in the absence of a reference frequency (frequency shift), allowing the frequency of the inverter to be inherently unstable in the absence of a reference frequency (frequency instability), periodically varying the output power of the inverter (power variation) and monitoring for sudden changes in the impedance of the grid by periodically injecting a current pulse (current injection).

NOTE: Active anti-islanding protection is required in addition to the passive anti-islanding protection described in Clause 5.3 above to prevent the situation where islanding may occur because multiple inverters provide a frequency and voltage reference for one another.

The active anti-islanding protection system shall operate the disconnection device (see Clause 5.2) within 2 s of disruption to the power supply from the grid.

5.6 Reconnection procedure

Only after all the following conditions have been met shall the disconnection device operate to reconnect the inverter to the electricity distribution network–

(a) the voltage of the electricity distribution network has been maintained within the range V_{min}–V_{max} for at least 1 m, where V_{min} and V_{max} are as defined in Clause 5.3; and

(b) the frequency of the electricity distribution network has been maintained within the range f_{min}–f_{max} for at least 1 m, where f_{min} and f_{max} are as defined in Clause 5.3; and

(c) the inverter energy system and the electricity distribution network are synchronized and in-phase with each other.

5.7 Security of protection settings

The internal settings of the grid protection device shall be secured against inadvertent or unauthorized tampering. Changes to the internal settings shall require use of a tool and special instructions not provided to unauthorized personnel.

NOTE: Special interface devices and passwords are regarded as tools.

5.8 Compliance with grid protection requirements

Compliance with the anti-islanding protection requirements shall be determined by type testing in accordance with the anti-islanding protection tests described in Appendix B.

APPENDIX A
LIMITS FOR SUSTAINED OPERATION
(Informative)

It is considered that equipment intended for operation at nominal voltages of 230 V (single-phase) or 400 V (three-phase) can endure operation near 200 V and 270 V (single-phase) and 350 V and 470 V (three-phase) but this equipment should not be expected to operate for extended periods at these extreme voltages.

Consideration is being given to introducing graded trip requirements whereby operation at, or near, extreme voltages is permitted for limited periods with the permitted duration reducing as the operating voltage nears the limit. Thus if the grid voltage moves towards a limit value (per Clause 5.3), disconnection could be required if the voltage stays near the limit for an extended duration (even if it never passes the limit).

Users of this Standard are requested to consider this Proposal and Committee EL-042, *Renewable Energy Power Systems and Equipment* would welcome comments on this proposal.

Comments should be forwarded to—

Projects Manager
Committee EL-042
Standards Australia
GPO Box 5420
SYDNEY NSW 2001

or by e-mail to mail@standards.org.au with the first line stating: 'For Projects Manager EL-042'

APPENDIX B
GRID PROTECTION DEVICE TESTS
(Normative)

B1 GENERAL

To protect the electricity distribution network from islanding, the inverter shall disconnect from the electricity distribution network whenever the supply from the electricity distribution network is disrupted.

Anti-islanding protection shall be assessed by means of the following tests.

B2 UNDER-AND OVER-VOLTAGE TRIP SETTINGS AND RECONNECTION TEST

B2.1 Tests

The under- and over-voltage trip settings and reconnection test shall be carried out as follows:

(a) The inverter and grid protection device shall be connected into a test circuit similar to that shown in Figure B1.

(b) The under-voltage trip setting of the grid protection device shall be set to its minimum value, or 200 V, whichever is the greater.

(c) The variable a.c. supply shall be set so that the voltage at the a.c terminals of the device under test equals the nominal grid voltage and its frequency equals (50 ±0.2) Hz, and the input supply shall be varied until the a.c. output of the device under test, measured in volt-amperes, equals (50 ±5)% of its rated output or 1 kVA, whichever is the lesser.

(d) The variable a.c. supply shall be slowly adjusted to decrease the voltage at the a.c. terminals of the device under test until the device under test disconnects from the variable a.c. supply. The a.c. voltage at which disconnection occurs shall be recorded.

(e) The variable a.c. supply shall be adjusted to return the voltage at the a.c. terminals of the device under test to the nominal grid voltage. The time taken for the device under test to reconnect to the variable a.c. supply shall be recorded.

(f) The output voltage of the variable a.c. supply shall be set to a voltage equal to the under-voltage trip setting, as recorded at step (d), plus 2 V. The voltage shall then be decreased as rapidly as possible but at a rate less than any dV/dt protection incorporated in the device under test. The time interval between the voltage passing through the voltage measured at step (d) and the device under test disconnecting from the variable a.c. supply shall be recorded.

(g) The over-voltage trip setting of the grid protection device shall be set to its maximum value, or 270 V, whichever is the lesser.

(h) The conditions of step (c) shall be re-established.

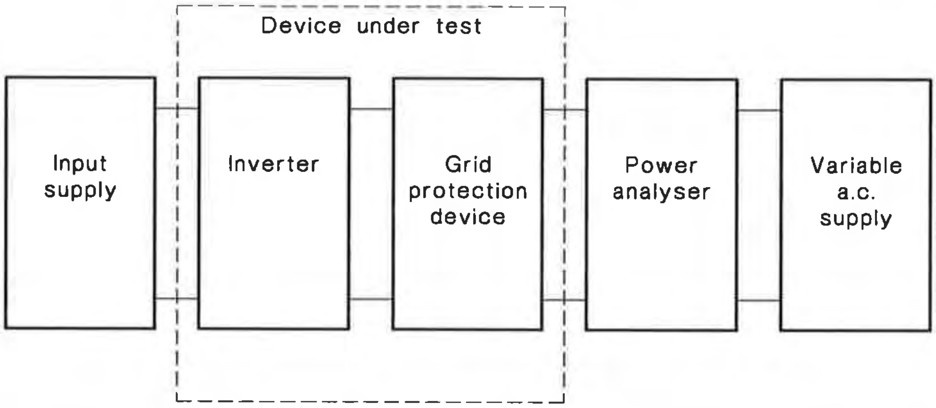
(i) The voltage of the variable a.c. supply shall be adjusted slowly to increase the voltage at the a.c. terminals of the device under test until the device under test disconnects from the variable a.c. supply. The a.c. voltage at which disconnection occurs shall be recorded.

(j) Step (e) shall be repeated.

(k) The output voltage of the variable a.c. supply shall be set to a voltage equal to the over-voltage trip setting, as recorded at step (i), less 2 V. The voltage shall then be increased as rapidly as possible but at a rate less than any dV/dt protection incorporated in the device under test. The time interval between the voltage passing through the voltage measured at step (i) and the device under test disconnecting from the variable a.c. supply shall be recorded.

B2.2 Criteria for acceptance

When subjected to the tests described in Paragraph B2.1, the voltage recorded at step (d) shall equal the under-voltage set point ±5 V, the voltage recorded at step (i) shall equal the over-voltage set point ±5 V, the disconnection times recorded at steps (f) and (k) shall each be less than or equal to 2 s and the reconnection times recorded at steps (e) and (j) shall each be 1 min or greater.



NOTE: The above test circuit applies to a single-phase system. To test a three-phase system, an equivalent three-phase circuit is required.

FIGURE B1 TEST CIRCUIT FOR UNDER- AND OVER-VOLTAGE AND UNDER- AND OVER-FREQUENCY TRIP SETTINGS AND RECONNECTION TESTS

B3 UNDER- AND OVER-FREQUENCY TRIP SETTINGS AND RECONNECTION TEST

B3.1 Tests

The under- and over-frequency trip settings and reconnection test shall be carried out as follows:

(a) The inverter and grid protection device shall be connected into a test circuit similar to that shown in Figure B1.

(b) The under-frequency trip setting of the grid protection device shall be set to its minimum value, or 45 Hz, whichever is the greater.

(c) The variable a.c. supply shall be set so that the voltage at the a.c terminals of the device under test equals the nominal grid voltage and its frequency equals (50 ±0.2) Hz, and the input supply shall be varied until the a.c. output of the device under test, measured in volt-amperes, equals (50 ±5)% of its rated output power or 1 kVA, whichever is the lesser.

(d) The frequency of the variable a.c. supply shall be adjusted slowly to decrease the frequency at the a.c. terminals of the device under test until the device under test disconnects from the variable a.c. supply. The frequency at which disconnection occurs shall be recorded.

(e) The frequency of the variable a.c. supply shall be adjusted to return the frequency at the a.c. terminals of the device under test to (50 ±0.2) Hz. The time taken for the device under test to reconnect to the variable a.c. supply shall be recorded.

(f) The output frequency of the variable a.c. supply shall be set to a frequency equal to the under-frequency trip setting, as recorded at step (d), plus 0.1 Hz. The frequency shall then be decreased as rapidly as possible but at a rate less than any df/dt protection incorporated in the device under test. The time interval between the frequency passing through the frequency measured at step (d) and the device under test disconnecting from the variable a.c. supply shall be recorded.

(g) The over-frequency trip setting of the grid protection device shall be set to its maximum value, or 55 Hz, whichever is the lesser.

(h) The conditions of step (c) shall be re-established.

(i) The frequency of the variable a.c. supply shall be adjusted slowly to increase the frequency at the a.c. terminals of the device under test until the device under test disconnects from the variable a.c. supply. The frequency at which disconnection occurs shall be recorded.

(j) Step (e) shall be repeated.

(k) The output frequency of the variable a.c. supply shall be set to a frequency equal to the over-frequency trip setting, as recorded at step (i), less 0.1 Hz. The frequency shall then be increased as rapidly as possible but at a rate less than any df/dt protection incorporated in the device under test. The time interval between the frequency passing through the frequency measured at step (i) and the device under test disconnecting from the variable a.c. supply shall be recorded.

B3.2 Criteria for acceptance

When subjected to the test described above, the frequency recorded at step (d) shall equal the under-frequency set point ±0.1 Hz, the frequency recorded at step (i) shall equal the over-frequency set point ±0.1 Hz and the disconnection times recorded at steps (f) and (k) shall each be less than or equal to 2 s and the reconnection times recorded at steps (e) and (j) shall each be 1 min or greater.

B4 GRID TRIP TEST

B4.1 General

For the grid trip test, the inverter and grid protection device shall be connected into a test circuit similar to that of Figure B2. The test shall be carried out using three different load conditions—

(a) light electronic load;

(b) load match; and

(c) load match plus 10%.

For load condition (a), a test load circuit similar to that shown in Figure B3 shall be used. This consists of a full-wave rectifying bridge connected to a 100 μF capacitive element and a 560 kΩ resistive element in parallel. For load conditions (b) and (c), a test load circuit similar to that of Figure B4 shall be used. This consists of resistive, inductive and capacitive loads in parallel. In both cases, the inductive load shall be chosen such that it draws 100 VAR from the grid and the capacitive load shall be chosen such that it supplies 100 VAR to the grid. For load condition (b), the resistive load shall be chosen such that it draws a load equal to the real power output of the inverter. For load condition (c), the resistive load shall be chosen such that it draws a load that exceeds the real power output of the inverter by 10%.

Values for L and C can be calculated using the following formulae:

$$L = \frac{V^2}{2\pi f \times 100}$$

$$C = \frac{100}{2\pi f \times V^2}$$

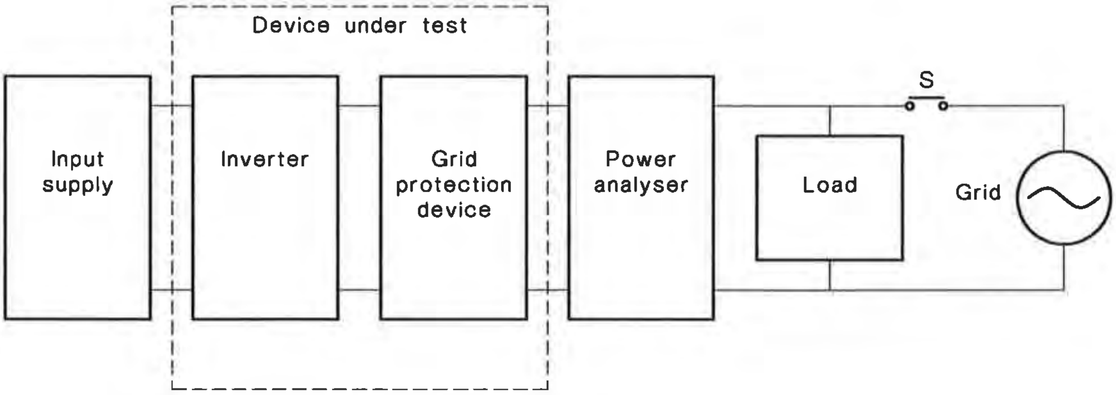
where

V = grid voltage

f = grid frequency

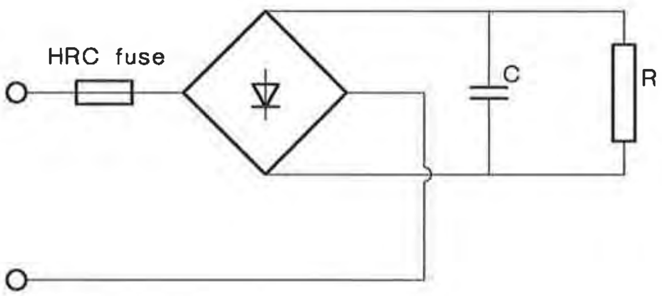
C = capacitance

L = inductance



NOTE: This test circuit applies to a single-phase system. To test a three-phase-system, an equivalent three-phase circuit is required.

FIGURE B2 CIRCUIT FOR GRID TRIP TEST



C=100μF
R=560 kΩ

NOTE: This load applies to a single-phase system. To test a three-phase system, an equivalent three-phase load is required.

FIGURE B3 TEST LOAD FOR GRID TRIP TEST UNDER LOAD CONDITION (A)

B4.2 Grid trip test under load condition (a)

The grid trip test under load condition (a) shall be carried out as follows:

(a) The inverter and grid protection device shall be connected into a test circuit similar to that shown in Figure B2 with a load similar to that shown in Figure B3. The grid voltage shall equal the nominal grid voltage ±5%.

(b) The input supply to the device under test shall be varied until the a.c. output of the device under test, measured in volt-amperes, equals (10 ±5)% of its rated output.

(c) The switch S shall be opened and the time for the device under test to disconnect from the test circuit shall be recorded.

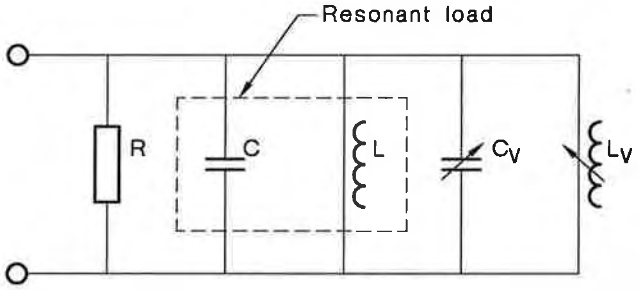
(d) Switch S shall be closed and the input supply to the device under test shall be varied until the a.c. output of the device under test, measured in volt-amperes, equals (50 ±5)% of its rated output.

(e) Step (c) shall be repeated.

(f) Switch S shall be closed and the input supply to the device under test shall be varied until the a.c. output of the device under test, measured in volt-amperes, equals (100 ±5)% of its rated output.

(g) Step (c) shall be repeated.

When subjected to the above test, all three disconnection times shall be less than 2 s.



NOTES:

1 This load applies to a single-phase system. To test a three-phase system, an equivalent three-phase load is required.

2 The C and L form a resonant load where the reactive power of each component is approximately equal to 100 VAR, i.e. L = C = 100 VAR.

3 C_v and L_v are the components used in steps B 4.3 (d) and B 4.4 (d) and are not part of the resonant loads.

FIGURE B4 TEST LOAD FOR GRID TRIP TEST UNDER LOAD CONDITIONS (B) AND (C).

B4.3 Grid trip test under load condition (b)

The grid trip test under load condition (b) shall be carried out as follows:

(a) The inverter and grid protection device shall be connected into a test circuit similar to that of Figure B2 with a test load similar to that shown in Figure B4. The resistive load shall be chosen to draw a load approximately equal to the real power output of the device under test required in each of the following three power level tests. The inductive load shall be chosen such that it draws approximately 100 VAR from the grid. The capacitive load shall be chosen such that it supplies approximately 100 VAR to the grid. The grid voltage shall equal the nominal grid voltage ±5%.

(b) The input supply to the device under test, measured in volt-amperes, shall be varied until the a.c. output of the device under test, measured in volt-amperes, equals (10 ±5)% of its rated output.

(c) The resistive load (R) shall be increased or decreased until the real power consumption of the test load matches the real power output of the inverter to within ±5%.

(d) Either the inductive or capacitive load shall be adjusted until the reactive power consumption of the test load matches the reactive power output of the device under test ($Q_{\text{Load}} + Q_{\text{Testload}} = Q_{\text{Inverter output}}$) to ±5%.

NOTE: The purpose of the procedure up to this point is to bring the 50 Hz components of power at the utility disconnection switch to zero. System harmonic voltages will result in harmonic currents in the test circuit. The harmonic currents will typically make it very difficult to make the measurement of power or current flow at the disconnection switch equal to zero.

(e) The switch S shall be opened and the time for the device under test to disconnect from the test circuit shall be recorded.

(f) The switch S shall be closed and the input supply to the device under test shall be varied until the a.c. output of the device under test, measured in volt-amperes, equals (50 ±5)% of its rated output.

(g) Steps (c) to (e) shall be repeated.

(h) The switch S shall be closed and the input supply to the device under test shall be varied until the a.c. output power of the device under test, measured in volt-amperes, equals (100 ±5)% of its rated output.

(i) Steps (c) to (e) shall be repeated.

When subjected to the above test, all three disconnection times shall be less than 2 s.

B4.4 Grid trip test under load condition (c)

The grid trip test under load condition (c) shall be carried out as follows:

(a) The inverter and grid protection device shall be connected into a test circuit similar to that shown in Figure B2 with a test load similar to that shown in Figure B4. The resistive load shall be chosen such that is draws a load 1.1 times the real power output of the device under test required in each of the following three power level tests. The inductive load shall be chosen such that it draws approximately 100 VAR from the grid. The capacitive load shall be chosen such that it supplies approximately 100 VAR to the grid. The grid voltage shall equal the nominal grid voltage ±5%.

(b) The input supply to the device under test shall be varied until the a.c. output of the device under test, measured in volt-amperes, equals (10 ±5)% of its rated output.

(c) The resistive load (R) shall be increased or decreased until the real power consumption of the test load matches 110% of the real power output of the device under test (i.e. overloads the device under test by 10%) to ±5%.

(d) Either the inductive or capacitive load shall be varied until the reactive power consumption of the test load matches the reactive power output of the device under test to ±5%.

NOTE: The purpose of the procedure up to this point is to bring the 50 Hz components of power at the utility disconnection switch to zero. System harmonic voltages will result in harmonic currents in the test circuit. The harmonic currents will typically make it very difficult to make the measurement of reactive power at the disconnection switch equal to zero.

(e) The switch S shall be opened and the time for the device under test to disconnect from the test circuit shall be recorded.

(f) The switch S shall be closed and the input supply to the device under test shall be varied until the a.c. output of the device under test, measured in volt-amperes, equals (50 ±5)% of its rated output.

(g) Steps (c) to (e) shall be repeated.

(h) The switch S shall be closed and the input supply to the device under test shall be varied until the a.c. output of the device under test, measured in volt-amperes, equals (100 ±5)% of its rated output.

(i) Steps (c) to (e) shall be repeated.

When subjected to the above test, all three disconnection times shall be less than 2 s.

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