# SECRETARIAT OF THE PACIFIC COMMUNITY
# GIZ

## *Coping with Climate Change in the Pacific Island Region (CCCPIR)*

# VANUATU

# *Preliminary Assessment of Solar Photovoltaics for the Meteo Building*

*Final Report*

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# 1 BACKGROUND

The regional programme "Coping with Climate Change in the Pacific Island Region" (CCCPIR) aims to build and strengthen the capacities of Pacific member countries and regional organizations to adapt to, and mitigate, climate change impacts. The programme started in January 2009 and will end on December 31, 2015. CCCPIR has a German government contribution of 17.2 million Euros and is implemented jointly by the German Technical Cooperation (GIZ) and the Secretariat of the Pacific Community (SPC). The overall objective is as follows: "The capacities of regional organizations in the Pacific Islands region and its member states to adapt to climate change and mitigate its causes are strengthened". The CCCPIR Energy Component (component 5) began in January 2012 and its objective is "Public and private service providers in the energy sector are strengthening and improving their climate-related services and their focus on sustainability, reliability and cost-effectiveness in the energy sector within the region".

The activities to be undertaken by CCCPIR in Vanuatu in 2012 have been agreed with the Department of Energy, Mines and Mineral Resources as follows:

- Support the development of the Vanuatu energy road map;
- Support development of a data management system and energy database;
- Carry out studies for energy efficiency in Government buildings; and
- Carry out activities to raise awareness of financing for renewable energy and energy efficiency.

An energy audit report of the Vanuatu Meteorology and Geo-hazards Department (VMGD) Building, referred to as the Meteo Building, was supported through the third activity to provide technical assistance to identify investment opportunities in energy efficiency. Energy reduction potentials were identified mainly from improved lighting systems. As an outcome of the energy audit, the VMGD requested a preliminary assessment of on-site solar photovoltaic (PV) electricity generation to complement potential energy efficiency options and further reduce electricity bills. SPC-GIZ CCCPIR agreed to produce a preliminary assessment of solar PV at the Meteo Building with the purpose of assisting the VMGD to make an informed decision regarding using solar energy to reduce its electricity bill.

# 2 INTRODUCTION

A solar PV system is considered to produce electricity independently of the main grid. In the case of Vanuatu, where the main grid is fuelled almost entirely by diesel, the solar PV system also reduces diesel use and carbon dioxide emissions (one of the greenhouse gases which cause climate change). A solar PV system could be incorporated into the building (on the roof) or placed on a ground-based structure on land belonging to the VMGD adjacent to the Meteo building.

SPC-GIZ CCCPIR has prepared this preliminary assessment to provide an overview of the potential for and benefits from solar PV at the Meteo building. This report will provide:

- An overview of solar photovoltaic (PV) systems;
- An overview of different options for the installation of solar PV at the Meteo Building;
- Cost estimates and electricity savings compared to current consumption
- An overview of technical and non-technical aspects that should be considered;
- Next steps to take a solar PV project forward.

# 3 OVERVIEW OF PHOTOVOLTAICS

Solar photovoltaic (PV) systems convert the sun's light energy into electricity. PV systems have the advantages of being silent in operation, having a very low visual impact and being well suited for use in urban areas, including on-site generation at various buildings (residential homes, offices, hotels, etc.). A disadvantage is that they require a large, shadow-free area to produce a significant amount of electricity.

A PV system is made up of various components. These are shown in **Error! Reference source not found.** below. A PV array is made up of several PV modules which can be arranged in different shapes and sizes. The semi-conductor material that generates electricity is encapsulated between a glass front and a backing sheet and has an aluminium frame. The other main specialised solar equipment is an inverter to convert the electricity from DC (direct current) to the AC current used by the mains grid and used by almost all electrical and electronic equipment.

PV modules can be integrated into the roof of a building to form part of the roof structure, or can be mounted on top of an existing roof. There are also products available where the PV semi-conductor is integrated into the roof material (although there is a loss of efficiency in energy conversion and an increase in cost). The modules can also be mounted onto specially made structures on the ground, if there is sufficient shadow-free space around a building.

Cables run from the PV modules to inverters which are normally installed in a room close to where the PV modules are installed. The distance from PV modules to inverters is minimised to keep energy losses along the cable (and cost of the cable) to a minimum. The PV modules produce DC electricity. An inverter converts DC electricity into AC electricity, which can then be fed into the electricity distribution board of the building. The electrical energy produced by the PV modules (array) can either be used immediately at the point of generation - to power appliances within the building - or can be fed into the main grid. This is controlled automatically by the system without any interruption in the electrical supply.

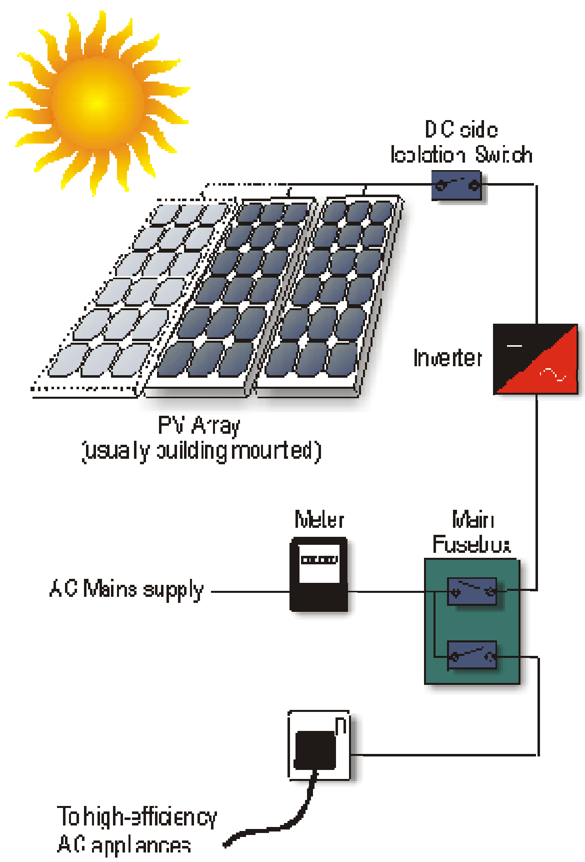


**Figure 1: PV system schematic**

The best orientation for the PV array in Vanuatu is facing North with an inclination angle of 20°. A minimum tilt angle of 10°s is recommended to enable the rain washing down dust from the panels. It is important to consider shadows over the area where the solar panels will be mounted as even a small amount of shading can dramatically reduce system output as it affects other parts of the PV generator. If shading is unavoidable, the interconnection between single modules can be optimised to keep losses due to shading as low as possible.

## 4 GEOGRAPHIC SITUATION AND SOLAR ENERGY POTENTIAL

Vanuatu is located south of the equator, about three quarters from Hawaii to Australia, centred near $16^o$ degrees south latitude and $167^o$ east longitude and is made up of 80, mostly mountainous, islands of volcanic origin with narrow coastal plains. About 41% of all land is cultivable with 14% utilised. Total land area is 12,200 $km^2$ with 65 islands populated.

The climate is tropical with a monsoonal pattern. It is hot and wet from November through April, and cooler and drier from May to October. In the capital Port Vila, the average temperature is $26^oC$ and the annual rainfall 2300 mm. Natural hazards include tropical cyclones, volcanism and occasional tsunamis.

Solar energy offers substantial technical potential in Vanuatu. Annual sunshine hours range from 2000 to 2300, averaging 5.7 kWh /$m^2$ / day[1].

## 5 PV AT THE METEO BUILDING

The VMGD is housed within a single double-storey building. There is considerable roof space as well as open space on the ground in front of the building where one or more solar PV systems could be installed.

**Figure 2: Vanuatu Meteorological and Geo-hazards Department**
Source: P. Johnston, PEEP 2

The layout of the VMGD building is shown in the sketch below from the building plans of 2007. The block on the left is the e-Government building which is not included in this assessment. There is significant open space in front of the building and to the left of the access road. The office that is shown in front on the left of the building does not appear in the photo above and therefore it is assumed that all of the space in front of the building is available to be used for PV system installation.

[1] Vanuatu Country Report, PIREP, 2004 and NASA website

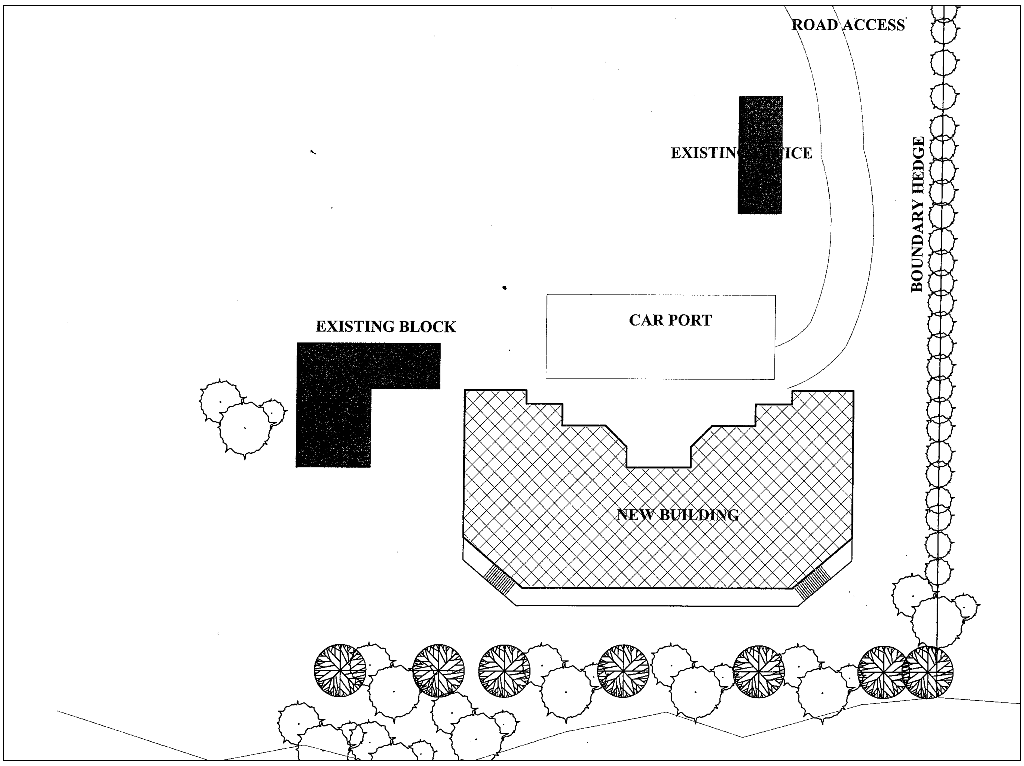


**Figure 3: Layout of VMGD building and access road**
Source: Public Works Department, New Meteo Office Building, Site Plan, 2007

The building envelope is of brick and concrete with a cement roof without insulation. Cracks were observed in the building walls in a number of places. As the building is relatively new this is assumed to be due to faults in construction. This could impact on the ability of the building to resist the additional load of the PV modules if these are installed on the roof.

## 5.1 Options for location of PV system

There are two basic options for location of a solar PV system:

### Option 1: The building roof

This could be the most economic solution as the PV modules can be installed directly onto the roof.

However, in view of the condition of the building mentioned above, a structural assessment of the building would have to be carried out by a civil engineer to ensure the building can withstand the additional load of the PV modules before proceeding with the installation.

The two installation areas on the roof are the flat roof and also another potential area is smaller slanted false roof at the front of the building. These are shown as area A and area B in the building plans from 2007 in the Figure below. No dimensions are given for the roof plan.

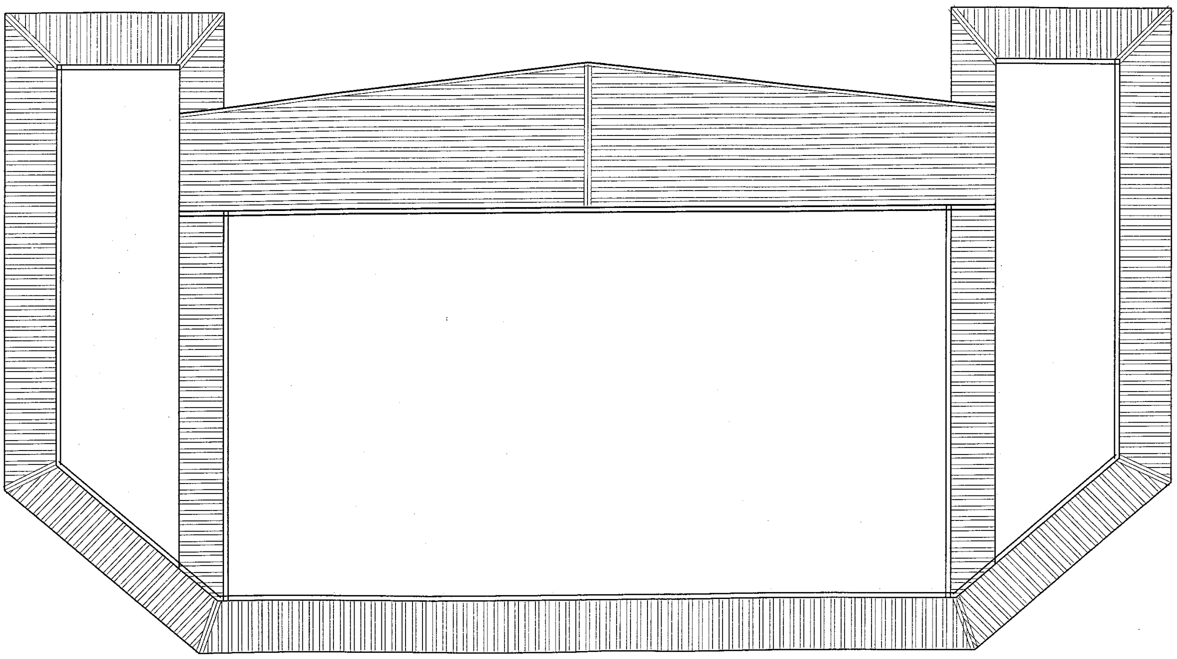

**Figure 4: VMGD roof plan from 2007**
Source: VMGD, 2012

The photo below shows the flat section of the concrete roof. The space shown in the roof plan of 2007 is approximately 30m x 20m (very rough estimation from low resolution scanned drawings of the first floor). As the final drawings of the building are not available, measurements should be made on site to establish exactly how much space is available.

**Figure 5: Flat section of the VMGD roof**
Source: K. Syngellakis, SPC-GIZ CCCPIR

The slanted roof section is shown in the two photos below. The space on the slanted sections might be approximately 30m x 5m (again accuracy is limited for the same reason as above). This gives a total potential PV installation area of $600m^2 + 150m^2 = 750m^2$.

**Figure 6: Slanted false roof at Meteo building**
Source: K. Syngellakis, SPC-GIZ CCCPIR

Taking into account that for the flat roof there will have to be a small mounting structure to bring the modules off the ground and slant them at a minimum $10^o$ and space is needed around all module arrays to allow for easy access for maintenance, the total space available specifically for PV panels might be nearer $600m^2$.

### Option 2: Mounted on a ground structure

This will be more expensive as it will also involve construction of the ground structure. It is recommended that a civil engineer certifies the ground structure design for cyclone resistance. This option also assumes that the VMGD owns the land in front of its building and does not have to lease the land. If land has to be leased, this could significantly change the economics of the solar PV project.

The space in front of the Meteo building is shown on Google earth and in the photo below. In the photo it appears that the buildings shown on Google earth are no longer present and this assessment assumes that all the space in front of the Meteo building could potentially be available. This would be approximately $750m^2$ if all the ground in the shaded triangle area below could be used.


**Figure 7: Space for ground-mounted PV array in front of Meteo Building**
Source: Google earth & P. Johnston, PEEP2

Similarly to the roof space, taking into account the space needed for the mounting structure and space between arrays and a certain distance from the road, the practical space available is estimated to be closer to 500m$^2$.

An additional ground mounted structure could be put in as a car park shading structure, although this would add some more complex civil engineering design and implementation to the project and significant extra cost. The extra area for PV module mounting might be 30m x 5m = 150m$^2$ as shown by the blue square below.

Therefore the total space available for a ground mounted PV system could be in the order of 650m$^2$. Examples of a ground-mounted PV system from Niue and a car park shading structure from Palau are shown in Figure 8 below.

**Figure 8: Ground-installed grid-connected PV systems in Niue and Palau**
Source: REP-5, 2009

**General shadowing situation:** For the roof mounted system, there may be some shadowing from the two raised stairwells. Possibly the shading can be avoided by careful placement of the PV panels but it may reduce the available space on the roof and therefore the size of the PV system. For the ground mounted well in front of the building, there should be no problem with the shadowing. There will possibly be some unavoidable shadowing from the tower (see Figure 7). For a car park structure placed in the existing parking lot, there may be an issue with shadowing during part of the day by the building.

**Orientation and inclination:** The panels on the flat roof and on the ground can be faced north and titled to 20 degrees for optimum solar energy capture and to ensure rain run-off. The panels on the slanted roof will have to follow the orientation and inclination of the roof but energy losses would not be significant.

**Security issues:** The Meteo building is occupied 24 h / 7 days and has a security guard and outside lights. Security for roof mounted panels is therefore considered good. For the ground-mounted panels, there may be a small risk of theft during the night, although the type of fastening used for the panels can make this hard.

## 5.2 Positioning and mounting of PV modules

An optimal orientation of the modules for high performance throughout the year is 20 degrees facing north. For the flat roof and the ground-mounted systems, there may need to be a trade-off between mounting the panels at their optimum angle and packing them closer together so as to fit more panels into the available space. Installing the panels at 20° means that they will produce at their optimum point, but the rows of panels will need to be further apart than if the panels were at 10°, to avoid shading problems. The recommendation would be to have them at 10°, so more panels can be installed on the same area. The drop in production is only 3% (5.58 kWh / $m^2$/yr versus 5.7 kWh / $m^2$ /yr) and overall there will be a higher total production, albeit at a marginally lower efficiency.

Due to high local temperatures the PV modules have to be mounted a certain distance from the flat or inclined roof to let air circulate. The power of PV declines drastically with high temperatures. The modules on the flat roof would have to be lifted off the roof and inclined using a mounting structure, for better energy production but also to ensure the rain washes dust off the PV modules. The inclined roof should be sufficient for rain water cleaning of panels.

The ground-structure mounted systems can be positioned to the optimum orientation and inclination during the project design.

The additional loading on the roof by addition of the PV modules will have to be calculated and a structural assessment carried out to confirm that the building can withstand the extra load. An assessment of resistance to cyclones and design features for this will also have to undertaken as Vanuatu often experiences cyclones and very strong winds. At the system design stage consideration will need to be given to the expected wind loading at the height of the roof.

There are two ways to mount the structure for the PV system on the flat roof: drilling into the concrete (taking care not to pierce the waterproofing membrane, if there is one) and using a ballasted system (whereby the array is held in place by large concrete blocks). However, the ballast option may not be appropriate for a country which experiences cyclones frequently.

Currently the roof seems to have an extra layer of concrete partially covering the whole roof (see photo below). The reason for the extra concrete needs to be clarified and whether the rest of the roof will be covered so that the PV panels are placed on a finished roof. If works are planned or needed to strengthen the roof, these will have to happen first before the PV system can be installed. All deficiencies of the roof will have to be removed before the installation of the PV system can begin.

**Figure 9: Layer of concrete on top of VMGD building roof**
Source: K. Syngellakis, SPC-GIZ CCCPIR, 2012

## 5.3 Electrical integration of the PV System

The supply grid has a nominal voltage of 220-230 V with 50 Hz. The meter (see Figure 10) is placed outside the building next to the back-up generator. The PV system can be connected through the distribution board of the building (see Figure 11), as long as there are spaces available. The meter which is used will have to be checked to make sure it can cope with dual flow of electricity. The billing with the utility will have to be checked and maybe modified.

**Figure 10: Meteo building main meter**
Source: K. Syngellakis, SPC-GIZ CCCPIR, 2012

The Main Essential Distribution Board can form the point of grid interconnection for the PV system. The AC output of the inverters would be connected to the building's electrical network via the existing Main Distribution Board.

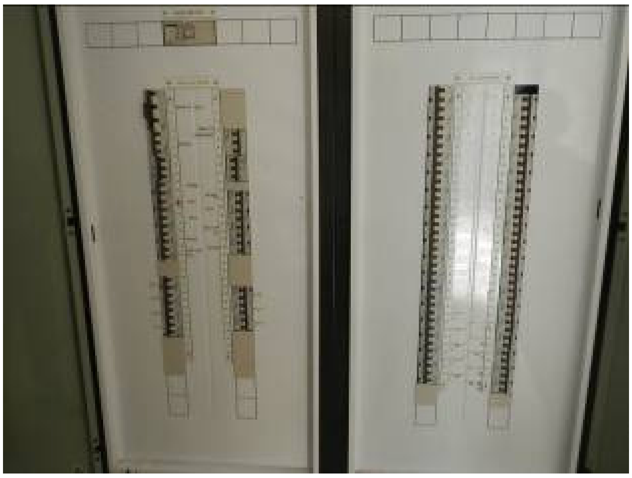

**Figure 11: Distribution Board on ground floor of Meteo building**
Source: K. Syngellakis, SPC-GIZ CCCPIR, 2012

The wiring distances from the roof to the distribution board and from the ground outside to the distribution board should be measured to calculate losses. The distance from the modules to the inverters should be kept to a minimum. Therefore for a roof mounted system, an appropriate location for the inverters would be either in the stairwell or somewhere on the second floor. For the ground mounted systems, an appropriate location would have to be found on the ground floor.

The inverters which convert DC current into the AC current (compatible with the public grid) should be mounted in a dry place in a room with good ventilation. The best location for the inverters is in a dry, well-ventilated, unoccupied room (inverter fans make noise that would be annoying to office workers). Putting the inverters in an air-conditioned room would only serve to increase the amount of energy consumed by the A/C to keep them cool and would not be an energy efficient option.

Special attention should be paid on the selection of solar inverters, as they have to be properly protected against the grid's voltage peaks. A PV system connected to the grid requires protection equipment to disconnect the system in the case of grid over voltages frequency fluctuations or in the case of loss of mains grid supply. Protection is usually built into the inverter, and additional loss of mains protection provided. The inverter should allow a wide band of grid voltage to avoid unnecessary switch-off of the inverters and resulting loss of solar electricity.

The Meteo building has a back-up diesel generator (details given in Table 1 below). This should be taken into account when carrying out the electrical integration of the PV system so that when the main grid is unavailable and the generator is operational, the PV system is also unavailable. This would avoid continued generation by the PV system when the building is powered by the backup generator. When the main grid comes back online and the generator is isolated, the PV system would also come back online automatically.

**Table 1: Back-up generator specifications**

| **Item** | **Specification** |
|---|---|
| Model no. | C150D5 |
| Serial no. | L08S802064 |
| Make | Cummins Power Generation |
| Country of manufacture | Singapore |
| Year of manufacture | 2008 |
| Application | Standby |
| Rated power kW | Prime 109 / Standby 120 |
| Rated power kVA | Prime 136 / Standby 150 |
| Rated current (0.8PF) | Prime 190 / Standby 209 |
| Voltage | 240/415V |
| Frequency | 50Hz |
| Rotating speed | 1500rpm |
| Battery volts | 12VDC |
| Control system | PCC1301 |
| Site altitude before derate | 1000 mASL |
| Site ambient temp. before derate | 35$^{o}$C |
| Genset max. mass (kg) | 1550 |

A schematic of the electrical system of the building would be useful but during the energy audit it was indicated that this is not available. This would be useful to show the connection between the back-up generator, the main electricity metering and the Main Distribution Board.

An electronic energy meter at the inverter can be used to count energy production and consumption. It may also be necessary to replace the existing meter and/or install an additional meter after the distribution board to accurately record imports and exports of electricity from/to the main grid. It is recommended to apply national or Australian standards for the electrical installation. This should be confirmed with the utility.

Lightning protection should be installed as part of the project if not already present for the building. Installation of a PV system might increase risk of lightning hits.

The PV system should be connected to the internet at the Meteo Building so that it can be monitored remotely. A display should be placed in a visible location of the building to show what the PV system is generating and to give a brief overview of the components of the PV system (see also section 7).

# 6 POTENTIAL ENERGY OUTPUT AND COSTS OF PV SYSTEMS

For each area identified on the roof and on the ground a rough estimation of the annual energy production from solar PV has been estimated. The results are listed in Table 2.

**Table 2: Estimated annual energy yield of roof and ground options**

| | **Area available ($m^2$)** | **Energy yield (MWh/year)** | **Power [kWp]** | **Estimated costs (USD)** | **reduction (t $CO_2$/year)** |
|---|---|---|---|---|---|
| Flat roof | 600 | 78 | 63 | 315,000 | 62 |
| Slanted roof | 150 | 18 | 15 | 75,000 | 14 |
| Grass area | 500 | 65 | 52 | 312,000 | 52 |
| Car park area | 150 | 18 | 15 | 90,000 | 14 |
| **TOTAL** | **1400** | **179** | **145** | **792,000** | **142** |

The costing is based on 5 USD/Wp installed for the roof mounted systems and 6 USD/Wp for the ground mounted systems. These are very broad estimates based on costs from projects in other Pacific island countries. Cost per Wp would also depend on how the system in procured, with a completely open tender most likely resulting in the best price. The cost for a full feasibility study and structural assessment of the building for a roof mounted system is not included.

If all four systems were installed they would provide 100% of the estimated electricity consumption for the building which was 169 MWh for 2012.

Compared with savings and costs for energy efficiency, the investment costs for solar PV generation are much higher. The energy efficiency actions have much shorter payback periods, as shown in Table 2 below; although the payback period of 6.3 years for solar PV is very good (a rate of 0.70c/kWh was used for the avoided cost of electricity from the grid).

**Table 3: Comparison of basic payback for energy efficient and solar energy**

| | kWh Saving / year | Annual Saving (USD) | Investment (USD) | Payback (Years) |
|---|---|---|---|---|
| **Efficiency Measures** | | | | |
| Retrofit with T5 fluorescent tubes and replace incandescent lamps with CFLs | 21,367 | 14,957 | 13,275.00 | 0.89 |
| Retrofit the Existing Luminaires with EE Luminaires and replace incandescent lamps with CFLs | 39,066 | 27,346 | 50,110.00 | 1.83 |
| **Solar energy** | | | | |
| Implement all 4 possible PV arrays | 179,000 | 125,300 | 792,000 | 6.32 |

This table does not take into account maintenance costs of the PV systems. These would have to be borne by the VMGD and could be up to 10,000 USD per year. It is likely in practice that there will be no major cost until the inverters have to be replaced after Year 10, at the half-way point of the project, and at this point a considerable lump sum expenditure would be incurred. It would therefore be prudent to set aside some money saved from the electricity bill every year to cover the cost.

The above also does not take into account any revenue from unutilised electricity feeding back into the UNELCO grid. If a net-metering agreement can be reached with the utility they may provide some payment for any kWh fed back into the grid. However, considering the 24/7 functioning of the Meteo building and its large energy consumption, it is likely that there will be minimal PV electricity flowing into the grid and therefore this benefit would be negligible.

# 7 FURTHER CONSIDERATIONS FOR IMPLEMENTATION OF A PV SYSTEM

## 7.1 Grid-connection

The Meteo Department should engage in dialogue with UNELCO early to obtain their cooperation on grid-connection of the PV system and negotiate a net metering arrangement. The meter of a building also usually belongs to the electricity company so if this needs to be changed this will have to be agreed with the utility. In general it is better to inform the utility early of plans to install a grid-connected PV system to avoid misunderstandings and build cooperation. As this would be the first grid-connected PV system in Port Vila (in Vanuatu?), there may be limited knowledge at the utility on grid-connected PV and a hesitation with regard to integration of this technology into their system. Therefore early engagement with UNELCO is recommended to identify any potential issues and solve these together.

## 7.2 Operation and maintenance

The operation of the PV system is automatic and there are no moving parts. This greatly reduces the maintenance needed. Nevertheless some basic maintenance actions should be performed on a regular basis. The values for energy, voltage and current plus any additional status messages are logged and displayed within most solar inverter packages. These values should be monitored and data stored on the inverter should be downloaded and stored for long-term monitoring of the system performance and transmission to external PV experts if more detailed analysis is needed.

System maintenance should include a six-monthly visual inspection and cleaning of the PV modules and an annual inspection of all D.C. and A.C. wiring. The cooling ventilation of the inverters has to be assured by cleaning at a similar frequency. Both actions are also recommended after severe weather. If the PV systems are placed on the roof, it is recommended to inspect the roof itself at the same time as the visual inspection of the PV systems is due and after cyclone events.

All system voltages and currents should be recorded annually in order to check components are still functioning correctly. It is suggested that the building maintenance staff are trained to carry out the necessary basic maintenance and system performance monitoring. The cleaning of the PV modules should only be carried out by staff who have been trained to avoid damage to the cabling or the surface of the PV modules.

## 7.3 Training

The building maintenance staff should be trained in the basic operation and maintenance of the PV system as outlined above. Trouble-shooting of inverter problems should also be included in the training. If possible building maintenance staff could be involved to some degree in the actual installation of the PV system so that they gain a better understanding of the technology. Training in simple repair tasks or exchange of modules or inverters could also be considered although it could be more cost-effective to outsource this to local PV companies. A few spare parts could be stored on site to avoid delays in purchase and shipping. It is recommended that the supplier/installer who is contracted carries out a thorough inspection and maintenance after 5 years of operation. An extended warrantee for the PV system is an important requirement.

All the staff should receive awareness on the PV project, how the PV system works and how much electricity it is providing to the building. This could be done through a series of lunch-time briefings over a few months so that all the staff get an opportunity to learn about the PV system and ask any questions they might have.

## 7.4 Lifetime

PV systems can be expected to last for at least 20 years. The most sensitive parts are the inverters which will probably need replacement after 10 years. An extended warrantee from 5 years to 10 years is available for some inverters.

## 7.5 Waste Management

During installation, operation and de-installation of the PV systems, all waste and packaging has to be treated in an appropriate, controlled and professional way to keep the environmental impact as low as possible.

## 7.6 Visibility and awareness raising

If the PV modules are placed on the roof, they will not be visible. Even if they are placed on the ground, a display or at least a poster showing the PV system set up should be put up to inform the public about the solar potential and the economic and environmental benefit of solar electricity. A large display unit could be placed in a public area of the building, to show visitors and staff how much energy the system is producing. Similarly, the entrance to the building would be a good place for a display or poster for visibility purposes. Likely costs are around 1500 USD depending on the model of display chosen. A simple example is shown in

Figure 12. The display should be readable in daylight conditions and should be very resistant against bleaching, if mounted outside.

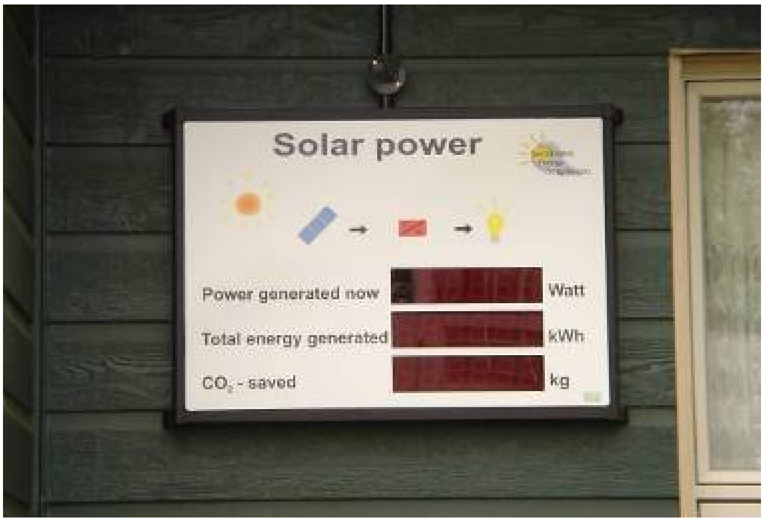


**Figure 12: An example display showing the PV system performance**
Source: REP-5

## 7.7 Clean Development Mechanism (CDM)

In theory, if Vanuatu is participating in the CDM, the installation would allow the issue of CER certificates. However, in practise, due to the very small size of the emission reduction it would not be cost-efficient to request it. The transaction costs would be far greater than the value of the CERs on the market.

## 7.8 Ownership of the PV system

This is straight forward if ownership resides with the Department of Meteorology. Depending on where funds are sourced from, with which organization final ownership resides should be made clear in the financing agreement.

## 7.9 Project risks

The following project risks should be taken into consideration from the beginning of the project and solutions found to eliminate, or if not possible, reduce each risk:

- Meteorological hazards could damage the system (the PV modules, the mounting system or the cabling). All equipment has to be installed in a sustainable way and operating conditions for the inverters have to be assured. Lightning arrestors should be considered.
- Shadowing can have a stronger effect on energy yield than assessed. This should be carefully checked during design of the PV systems. The interconnections of PV modules should be arranged in a way to minimise energy loss due to partial shadowing.
- Parts of the installation could be stolen. The security situation at the installation site(s) has to be improved. Especially during installation of the system, the equipment including cabling needs 24 h surveillance.
- Difficulty in finding appropriately qualified personnel in Vanuatu to carry out repairs and replacement of failed components. This may result in having to bring over expensive overseas contractors.

# 8 CONCLUSIONS AND NEXT STEPS

The study has shown that there is a total potential for approximately 145 kWp of PV at the Meteo building. This would generate approximately 179 MWh of electricity per year and save over 140 tons of carbon dioxide emissions.

This solar energy yield represents just over 100% of the estimated annual electricity consumption of the Meteo building and about 0.3% of the 56.9GWh of electricity generated by UNELCO in 2009.

Next steps to take a PV project forward include:

- A full solar PV feasibility study
- Preparation of technical specifications
- Structural assessment of the building (if roof installation is the preferred option)
- Securing of funding for the investment
- Begin dialogue with UNELCO