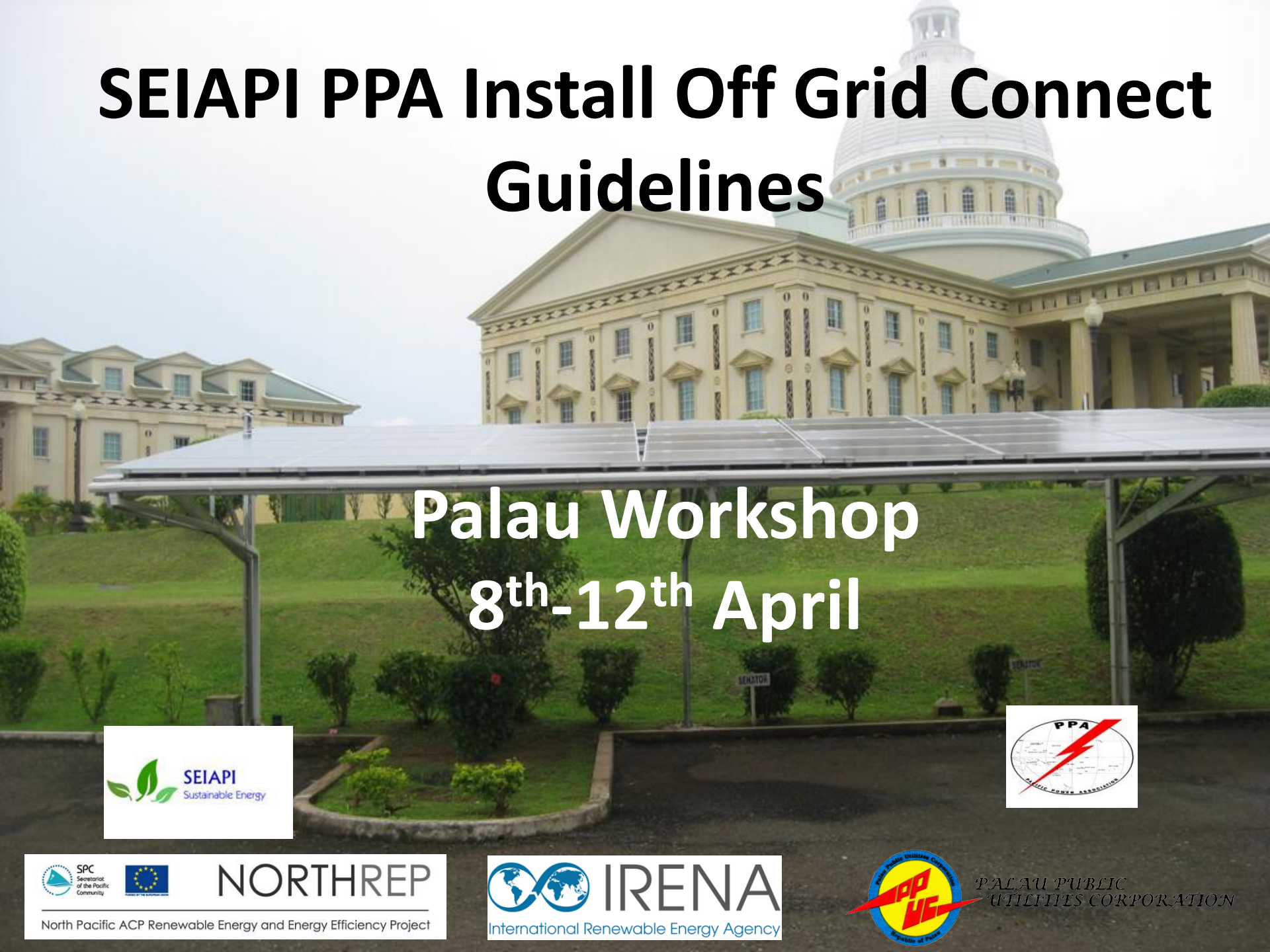
SEIAPI PPA Install Off Grid Connect Guidelines



Palau Workshop
8th-12th April

SEIAPI Sustainable Energy

PPA Pacific Power Association

SPC Secretariat of the Pacific Community

NORTHREP
North Pacific ACP Renewable Energy and Energy Efficiency Project

IRENA
International Renewable Energy Agency

PPUC Palau Public Utilities Corporation

PALAU PUBLIC UTILITIES CORPORATION

Standards for Installation

In Australia and New Zealand the main standards required are …

AS/NZS 3000	Wiring Rules
AS/NZS 4509	Stand-alone power systems
AS 4086.2	Secondary batteries for stand-alone power supplies
AS/NZS5033	PV Array
AS 3010.1	Electrical Installations - Supply Generating set
AS 3595	Energy management programs
AS 1359.51	Noise level limits
AS 1768	Lightning Protection

Standards for Installation

In USA PV systems must be in accordance with following codes and standards:

- Electrical Codes-National Electrical Code Article 690:Solar Photovoltaic Systems and NFPA 70
- Uniform Solar Energy Code
- Building Codes- ICC, ASCE 7
- UL Standard 1701; Flat Plat Photovoltaic Modules and Panels
- UL Standard 1741 , Standard for Inverter, converters, Controllers and Interconnection System Equipment for use with Distributed Energy Resources

Documentation

All complex systems require a user manual for the customer. Off-grid power systems are no different. The documentation for system installation that should be provided are …

- List of equipment supplied.
- Shutdown and isolation procedure for emergency and maintenance.
- Maintenance procedure and timetable.
- Commissioning records and installation checklist.
- Warranty information.
- System connection diagram.
- Equipment manufacturers documentation and
- handbooks for all equipment supplied.
- Battery record logbook.
- Generating set service logbook

PV Array Installation

Same requirements a grid installation guidelines.

BATTERY INSTALLATION

The main safety considerations are …

- explosion due to spark in the presence of hydrogen build up
- excessive currents caused by battery shorts
- leakage of battery acid from battery cells
- personal safety in the presence of acid

To negate the risk of explosion there must be no opportunity for hydrogen to build up this requires adequate ventilation with no possibility of spark ignition.

BATTERY ENCLOSURE

The main considerations for the battery enclosure are …

- it must be safe, with restricted access (ie. Prevent children easily accessing the batteries)
- all equipment must be readily accessible for maintenance
- it must have adequate ventilation
- it should be vermin proof

VENTILATION CALCULATIONS-METRIC

The minimum area required for natural ventilation for both inlet and outlet apertures (for wet lead acid batteries) are given by …

$$A = 100\ q_v\ cm^2$$

Where q_v is the minimum exhaust ventilation rate in litres per second = 0.006 x n x I

and n = the number of battery cells

I = the charging rate in amperes

VENTILATION CALCULATIONS- IMPERIAL

The minimum area required for natural ventilation for both inlet and outlet apertures (for wet lead acid batteries) are given by …

$$A = 15.5\ q_v\ in^2$$

Where q_v is the minimum exhaust ventilation rate in litres per second = 0.006 x n x I

and n = the number of battery cells

I = the charging rate in amperes

VENTILATION SEALED BATTERIES

The charging rate I in the ventilation formula is **0.5A** per **100Ah** at the **3h rate (C_3)** of discharge of battery capacity for lead acid batteries.

e.g. battery has C_3 rating of **500Ah** therefore the charge current used in ventilation formula is :
(500Ah/100Ah) x 0.5A = 2.5A

PLACEMENT of VENTILATION

Best practice is to provide input ventilation vents below the level of battery and the output vents on the opposite side of the batteries, as high as possible in the enclosure to prevent hydrogen build up.

ACID LEAKAGE

Provision must be made to contain any spilled electrolyte. Battery trays should be able to hold at least the electrolyte content of one cell of the battery bank.

ACID SPLASHES

- A ready supply of water should be available and any person working on the batteries should wear rubber gloves, safety glasses and long sleeved protective clothing. Eye wash equipment should be available, in case of accident.
- Walls near the batteries should be protected by acid resistant paint or non-metallic sheet.

SAFETY and WARNING SIGNS

A "battery explosion warning" sign must be mounted so that it is clearly visible on approach to the battery bank. An "electrolyte safety" sign should be mounted adjacent to the battery bank.

SPARK IGNITION SOURCES

- Electrical equipment or storage for other equipment should not be mounted above the battery bank.

- Connection or disconnection of any equipment at the battery terminals must not occur where there is any possibility of the presence of any hydrogen build up.

PREVENTING SPARKS

- battery charging equipment should be hard wired, do not use temporary connection.
- battery terminals should be shrouded to prevent inadvertent short circuits.
- ensure sufficient clearance between battery terminals and metal walls (or insulate using non-metallic sheet)
- maximise separation between battery terminals
- use insulated tools during any battery work

OVERCURRENT PROTECTION FROM **BATTERIES**

- Battery shorts are prevented by shrouding terminals and ensuring safe separation between live terminals.

- Battery shorts are controlled by using appropriate circuit protection.

OVERCURRENT PROTECTION FROM **BATTERIES Cont.**

- Overcurrent protection is to be provided in each battery output conductor except where one side of the battery bank is earthed (ground),

  in which case only the unearthed (ungrounded) conductor requires overcurrent protection.

- Normal practice is to either fuse the positive and earth (ground) the negative or fuse all conductors

LOCATION OF BATTERY FUSES

- Battery fusing preferably should not be in the same enclosure as the battery bank but if they are then they should be either a minimum of 500mm away from the batteries or 100mm below the top of the batteries.
- Another method to keep the fuse separate from the battery bank is to place a vertical partition between the batteries and the fuse, thereby keeping the fuse as close to the batteries as possible but isolated from any hydrogen build up.

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SIZING OF BATTERY FUSES

- Based on largest current that could be drawn.
- If Inverter: Obtain inverter manufacturers data
  - Continuous power rating (Watts)
  - 3 to 10 second surge rating (Watts)
  - Average inverter efficiency

- For each power rating determine the current drawn from the battery bank using …

$$I = \frac{\text{Inverter Power Rating (W)}}{\text{(inverter efficiency x nominal battery voltage)}}$$

- Consult HRC fuse curves

CABLE SELECTIONS

For extra low voltage (ELV) systems …

- All cables should be sized to meet the maximum current
- Cable losses between the PV array and the battery bank should never exceed 5%
- Cable losses between the battery bank and any DC load should never exceed 5%

NOTE : the rated voltage or current carrying capacity (CCC) of any cable must never be exceeded eg. some automotive types are rated at 32V

VOLTAGE DROP CALCULATIONS- Metric

$$Vd = (2 \times L \times I \times \rho) \div A$$

where

L = route length of cable in metres

I = current (A)

ρ = resistivity of Cu wire ($\Omega/m/mm^2$)

= 0.0183 Ω

A = Cross Sectional Area (CSA) of cable (mm^2)

VOLTAGE DROP CALCULATIONS- Imperial

The voltage drop (Vd in volts) is given by …

$Vd = (2 \times L \times I \times \rho) \div 1000$

where L = route length of cable in metres

I = current (A)

ρ = resistivity of Cu wire (Ω/1000 ft)

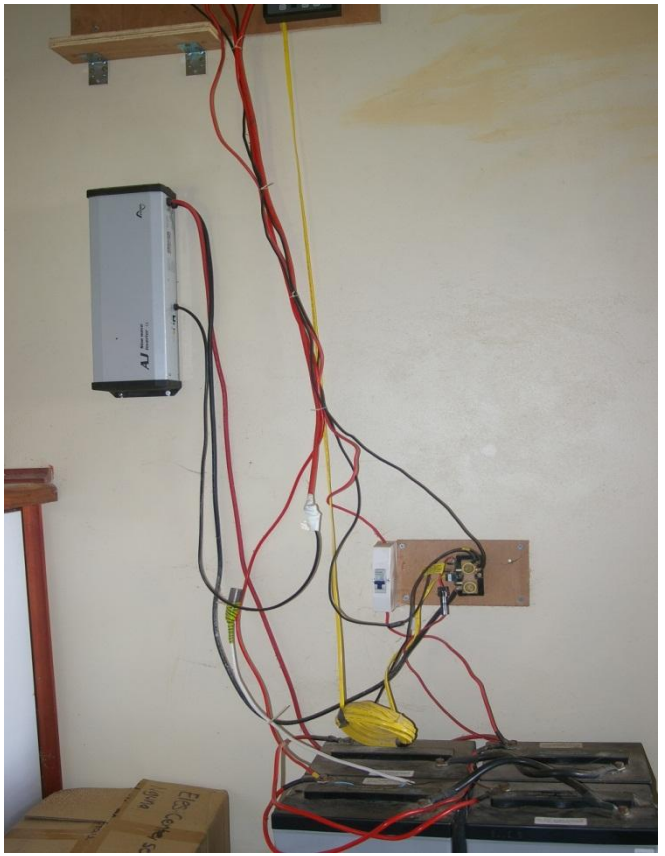
Note: Resistivity values for copper wire at 75°C are listed in Chapter 9, Tables 8 and 9 of the US National Electric Code

CABLE PROTECTION

- All ELV sub-circuits, including PV array and auxiliary charging circuits should be protected by HRC fuses or circuit breakers.
- In addition these circuits being capable of being isolated without the use of tools.
- Any circuit breaker used in DC circuits must be rated for the appropriate DC voltage and be non-polarised.

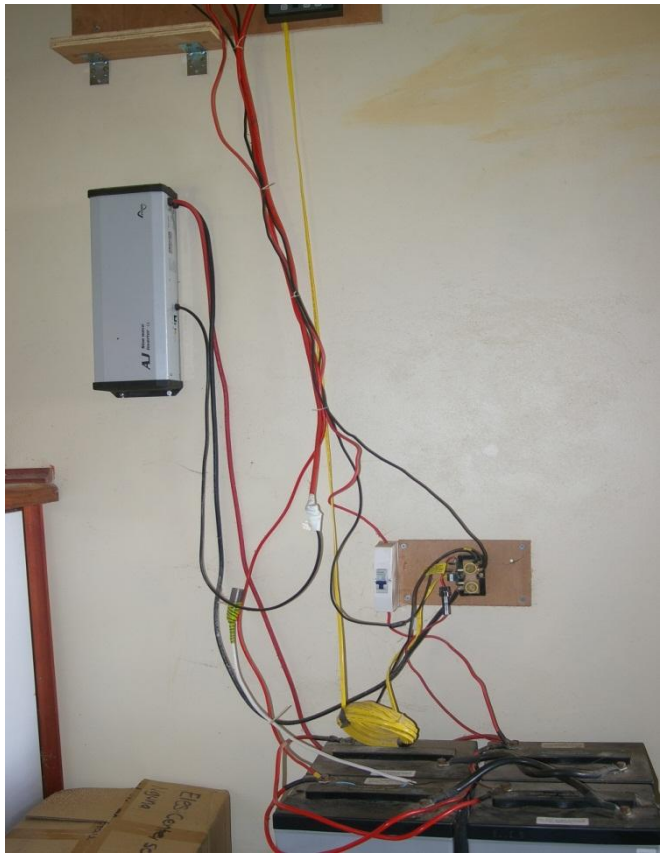
CABLE INSTALLATION

- Installed in a neat and tidy manner
- All cables used in the installation should be securely fixed in place to minimise any movement of the cable.
- Any exposed cabling will be protected from UV and mechanical damage eg. run in conduit.
- Crimp style termination of wiring should use the appropriate crimping tool



INSTALLATION CHECKLIST

- The guidelines include a checklist which can be used by the installer at the completion of the installation to confirm that they have followed the guidelines



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