Asia-Pacific Economic Cooperation

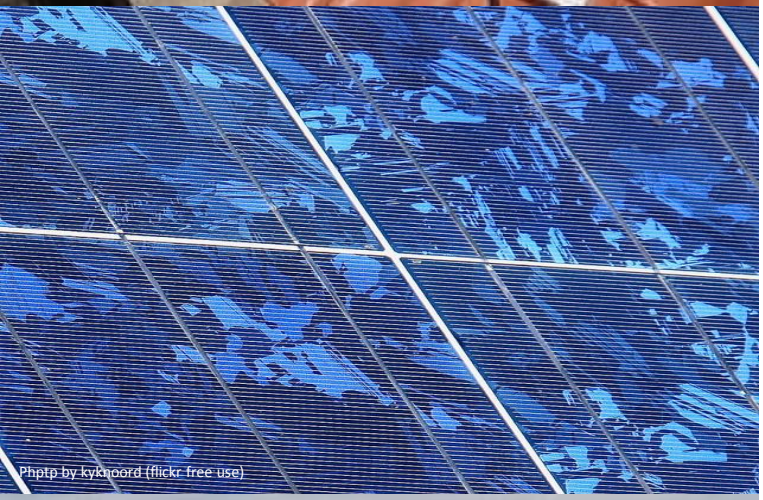
# Rooftop Solar PV System Designers and Installers

# Training Curriculum

APEC Secretariat

March 2015


Phptp by marufish (flickr free use)


Phptp by kyknoord (flickr free use)


Phptp by thomas kohler (flickr free use)

# INVERTER BATTERY

*Training of PV Designer and Installer*

APEC
Asia-Pacific Economic Cooperation

Cu International Copper Association
Copper Alliance

castlerock consulting

# Contents

A. What is an inverter?

B. How does it work?

C. Inverter output

D. Example of battery inverters

E. Inverter charger vs solar charge controller

# A. What is an inverter?

Asia-Pacific Economic Cooperation

A device which capable turning DC power into AC power, while at the same time regulating voltage, current, and frequency of the signal. This is the common function of an inverter, but there is also a type of inverters that can also charge the batteries in the same time. This type of inverter called inverter/charger or a bi-directional inverter.


# A. What is an inverter?

Primarily in a residential grid tied system, a grid inverter is all that is required to have a working solar PV system.

However, in many countries, it make sense to have a battery backup to the grid tied system. The purpose is twofold:

- Backup system when there is a blackout. This is especially important in locations where blackouts are often present
- Energy storage when the solar PV panels are producing more energy than the needed by the loads. This excess energy will be stored until the loads are higher than the solar PV production (such as at night). Especially needed in locations where there is no option for net metering or feed in tariff to sell the electricity to the grid

# A. What is an inverter?

Asia-Pacific Economic Cooperation

A battery inverter normally cannot be connected directly to the solar PV panels. It is meant to work only with batteries to use the batteries to produce AC power for the loads.

There are two types of battery inverters:

- DC to AC inverter only
- Bi-directional inverter

A DC to AC inverter only is typically used for smaller off grid systems, the batteries are only charged with the solar PV panels through a solar charge controller.

A bi-directional inverter is used for a grid-interactive system or an off grid system where it has a generator back up to charge the batteries. The generator will supply AC power to the inverter which then charges the batteries

# A. What is an inverter?

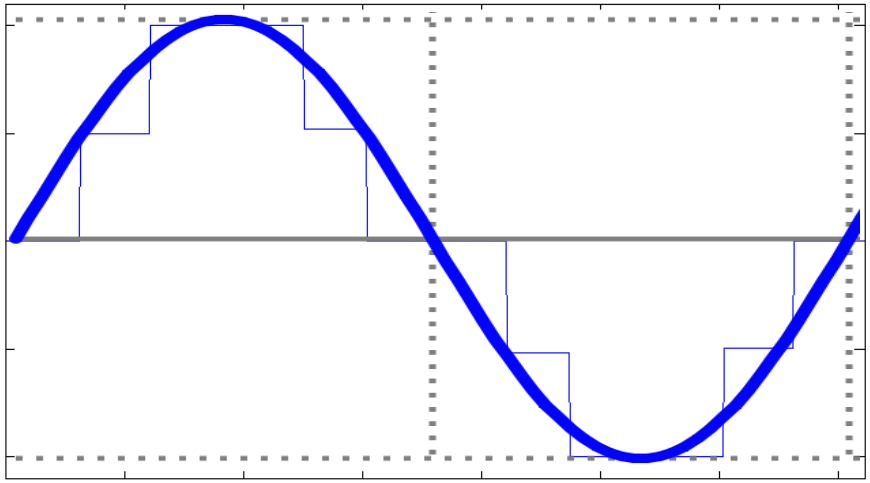
Asia-Pacific Economic Cooperation

A DC to AC inverter can be very simple and inexpensive, starting with just 50 watts of output. It is also available up to 5000 Watts and even higher in some cases. Beware that the less expensive inverters may not produce a pure sinewave output. Instead the cheaper inverters will produce what's called a modified sinewave.

The types of loads that can be used with a modified sinewave inverters are limited. Anything that has an AC motor (air conditioning, refrigerators, etc) and sensitive electronics may be damaged with prolonged use of a modified sinewave power source. At best they will run with more noise and a 20% reduction in efficiency. At worst, the motor may experience pulsating torque condition that can reduce its lifetime.Also be aware of any AC-DC converters used in gadget chargers and some laptop chargers.

A modified sinewave inverter is best used when the loads are simple resistive such as incandescent lights, heating elements, etc

# A. What is an inverter?



**Pure Sinewave vs. Modified Sinewave**

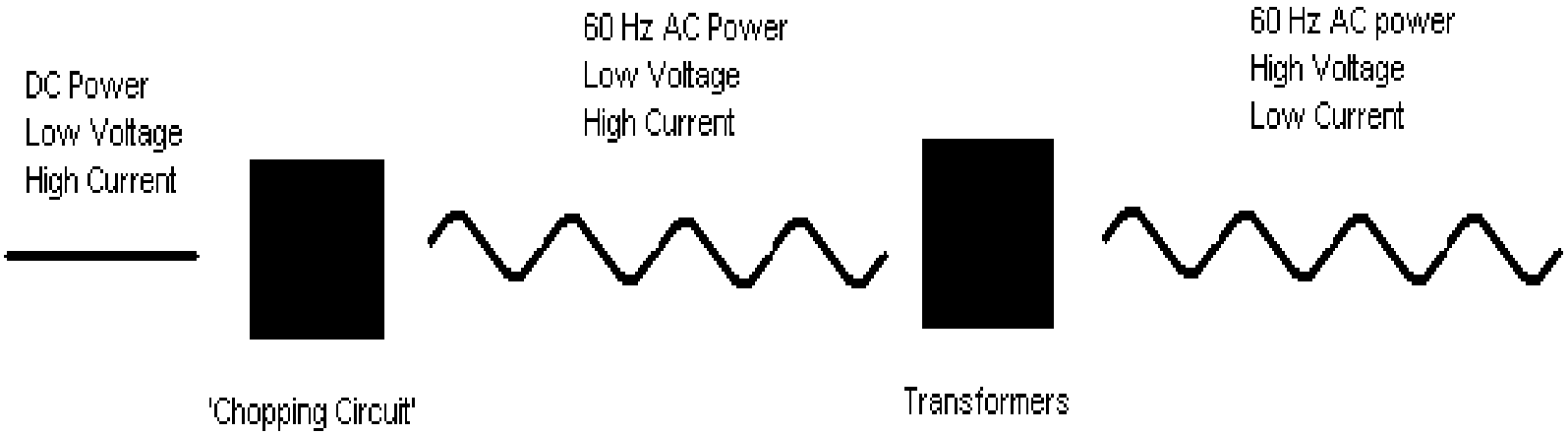
As shown here, a modified sinewave is just a square wave with several signal transitions per period to reduce the harmonic distortion. The sharp transitions is what can damage inductive loads such as AC motors. For each sharp step experienced, there is a tremendous amount of impulse that is generated because of the high change in voltage within a short period of time

# B. How does it work?

Asia-Pacific Economic Cooperation

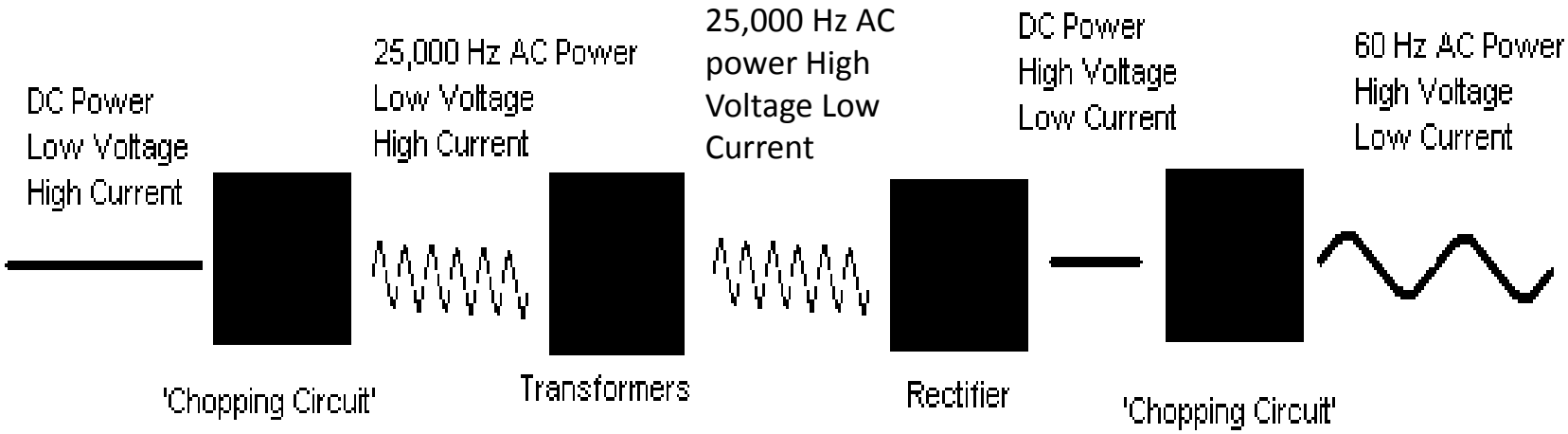
Types of electrical inverters according to converting method:

1. Takes low voltage high current power from a battery and sends it through a 'chopping' circuit which changes it to low voltage high current AC power at 60Hz. The power then goes through a series of large transformers which output 120V AC power at 60Hz



# B. How does it work?

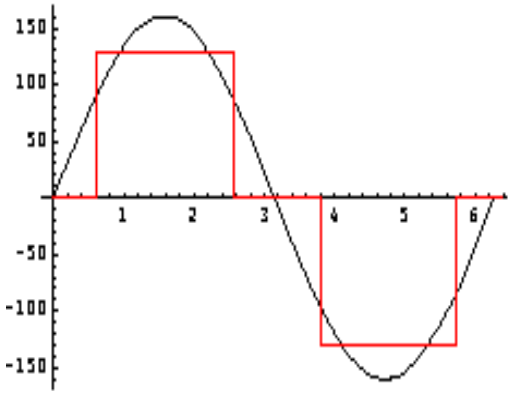
2. Using two chopping circuits to make it possible for a much smaller and lighter transformer to be used. The DC power is converted to very high frequency AC power which is easier to transform into high voltage low current power. The power is then rectified back into DC power and sent through a second chopping circuit to turn it into 60Hz 120V AC.



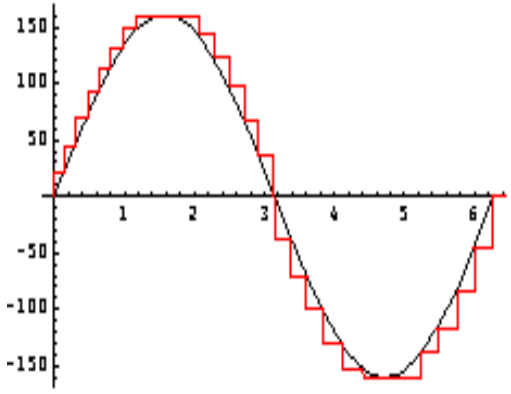
# C. Inverter output : electrical wave forms

Asia-Pacific Economic Cooperation

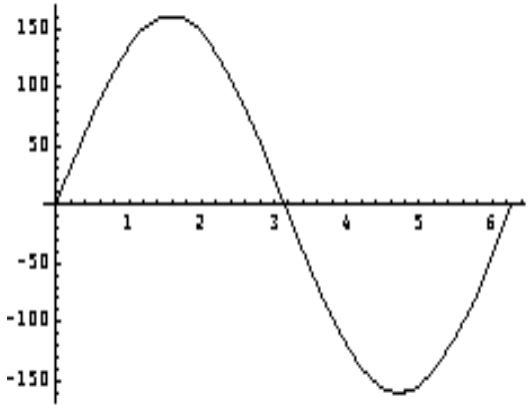
Different types of inverters give outputs with different wave forms




Square Wave



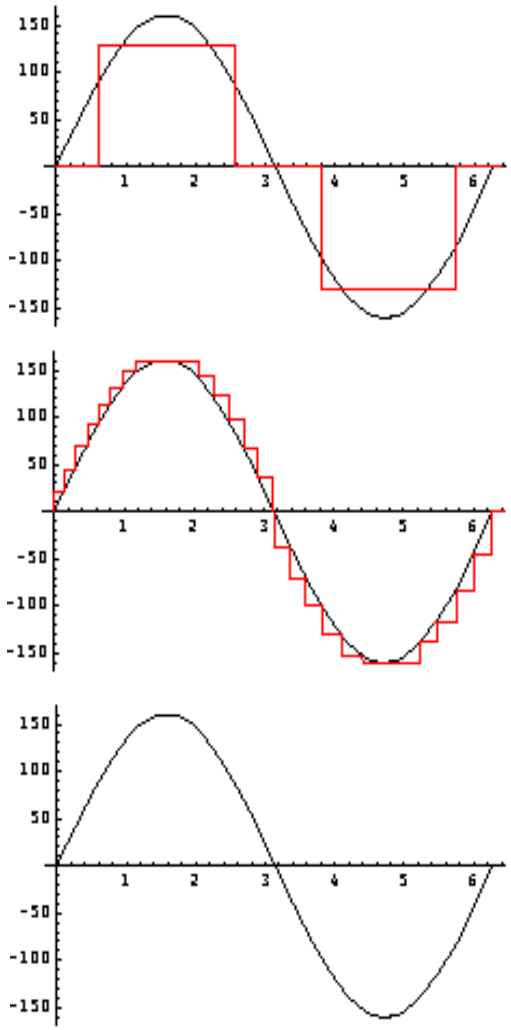

Modified Sine Wave




True Sine Wave

**Graphs of voltage as a function of time**

# C. Inverter output: different types




- **Square wave** inverters are the most unacceptable inverter output quality
- **Modified sine wave** output will power almost everything in your house but may cause premature failure on some types of equipment
- **True sine wave** output is exactly the same and can be synchronized with the power provided by a utility company, and is necessary for a grid-tie system

# D. Example of Battery Inverters


**Outback FX/VFX Off-Grid True Sinewave Sealed & Vented Inverter/Chargers**

An off-grid inverter with true sinewave output which can also as a battery charger (if any others electric input)

**SMA Sunny Island 6.0H – 8.0H**

An off-grid inverter with true sinewave output which can also as a battery charger (if any others electric input)

# D. Example of Battery Inverters


Off Grid Solar Inverters

**Luminous off-grid Solar Inverter**

An off-grid inverter with solar charge (MPPT technology) included

# E. Inverter/charger vs Solar Charge Controller

There are two ways of using a battery inverter:

- AC coupled
- DC coupled

An AC coupled system has very limited DC cabling required. It primarily runs on the AC bus. The only DC cabling required is from the solar panels to grid inverter and if present, from the batteries to the battery inverter.

A DC coupled system has more DC cabling required. It runs everything on the DC bus up to the output to the load. DC cabling is required from the solar PV panels to the charge controller to the batteries and to the inverter

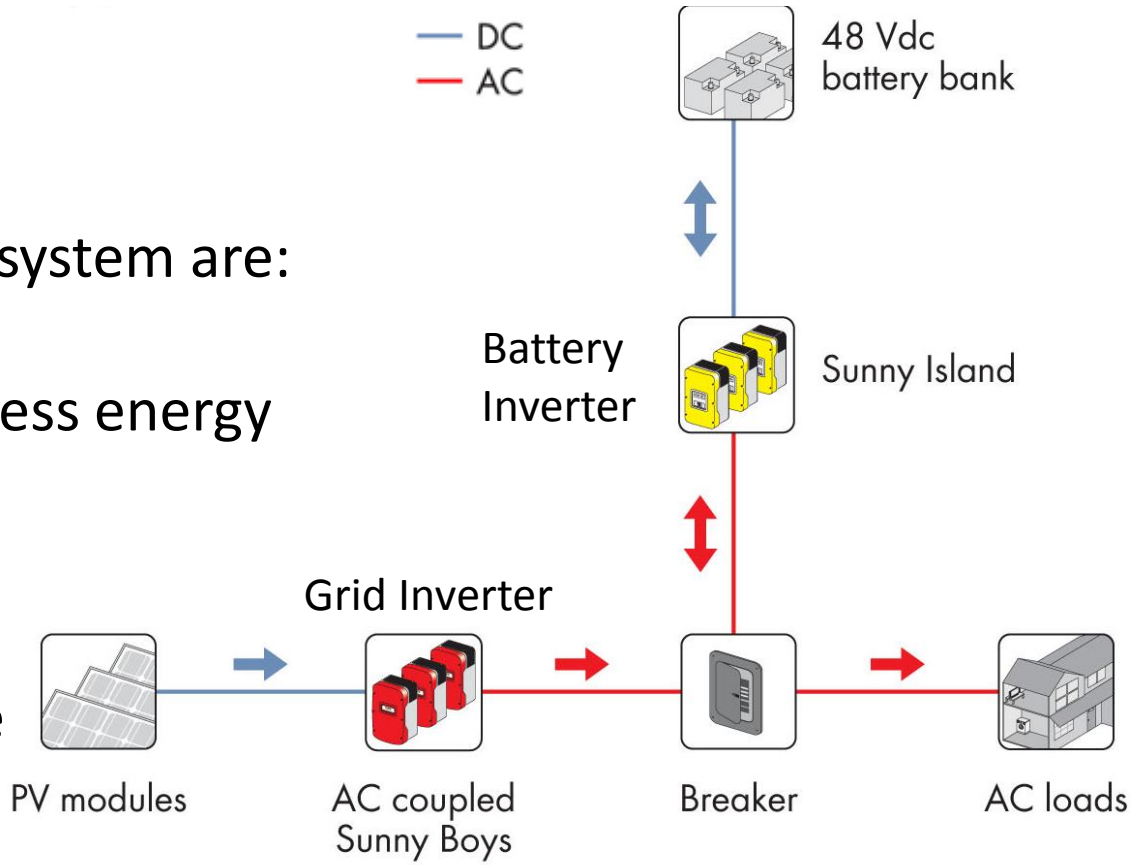
# E. Inverter/charger vs Solar Charge Controller

In the AC coupled system the main components are:

- Solar PV panels
- Grid inverter
- Battery inverter
- Batteries

The advantages of this system are:

- Less DC wiring
- Better control of excess energy
- Less battery cycling
- Easier to add more components such as more batteries or more power sources



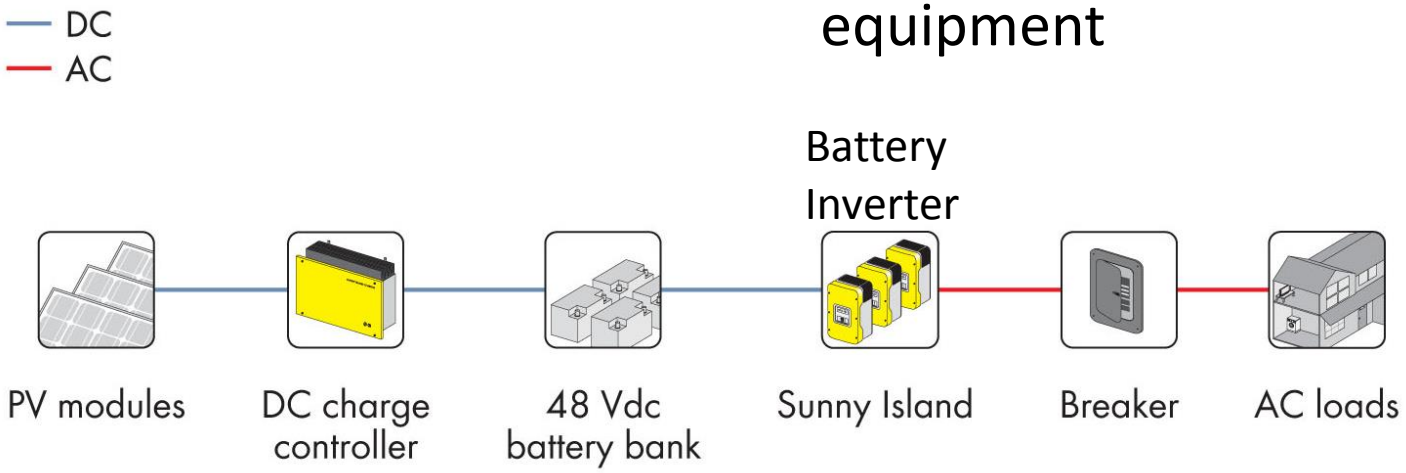
# E. Inverter/charger vs Solar Charge Controller

In the DC coupled system the main components are:

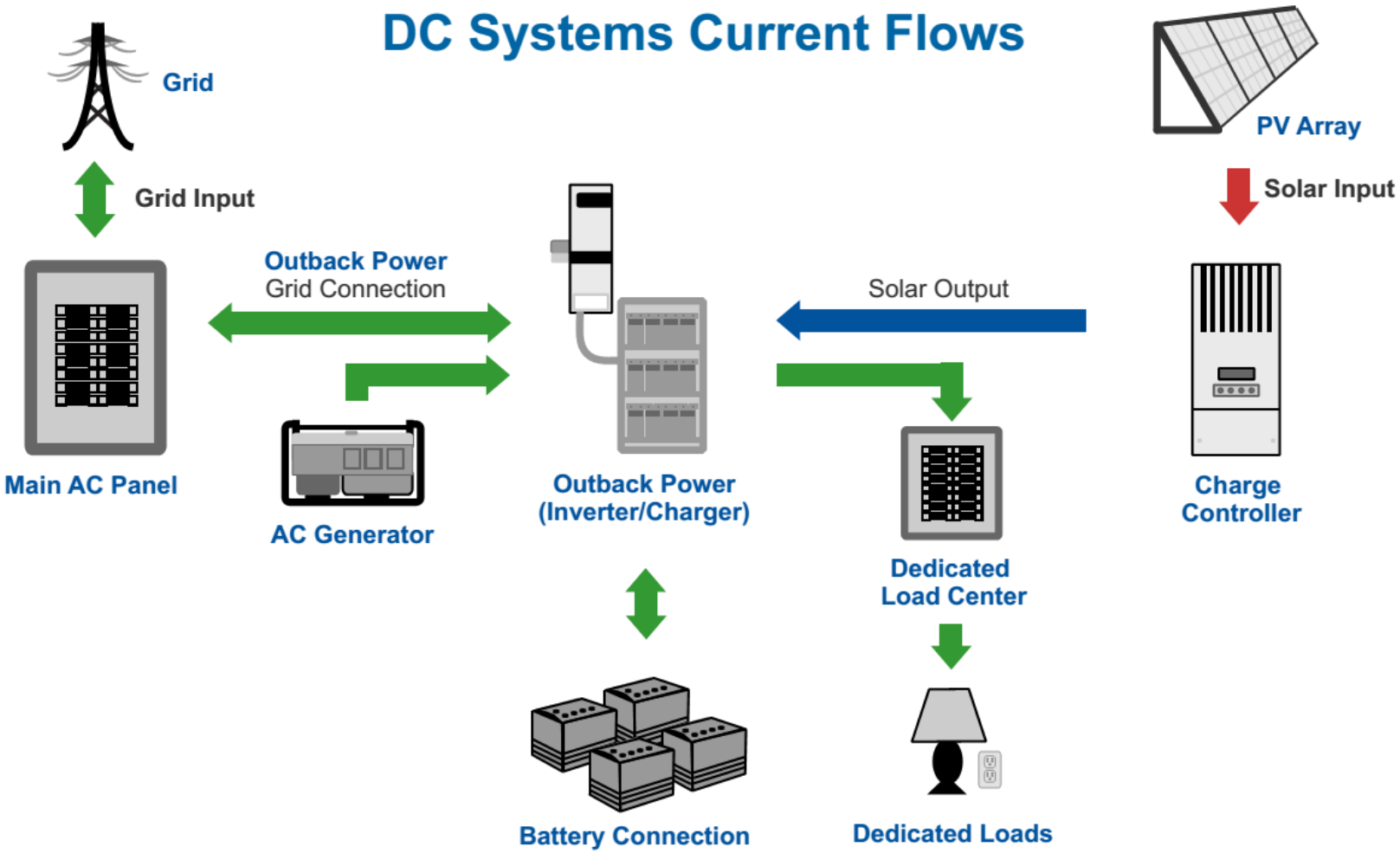
- Solar PV panels
- Solar charge controller
- Battery inverter
- Batteries

The advantages of this system are:

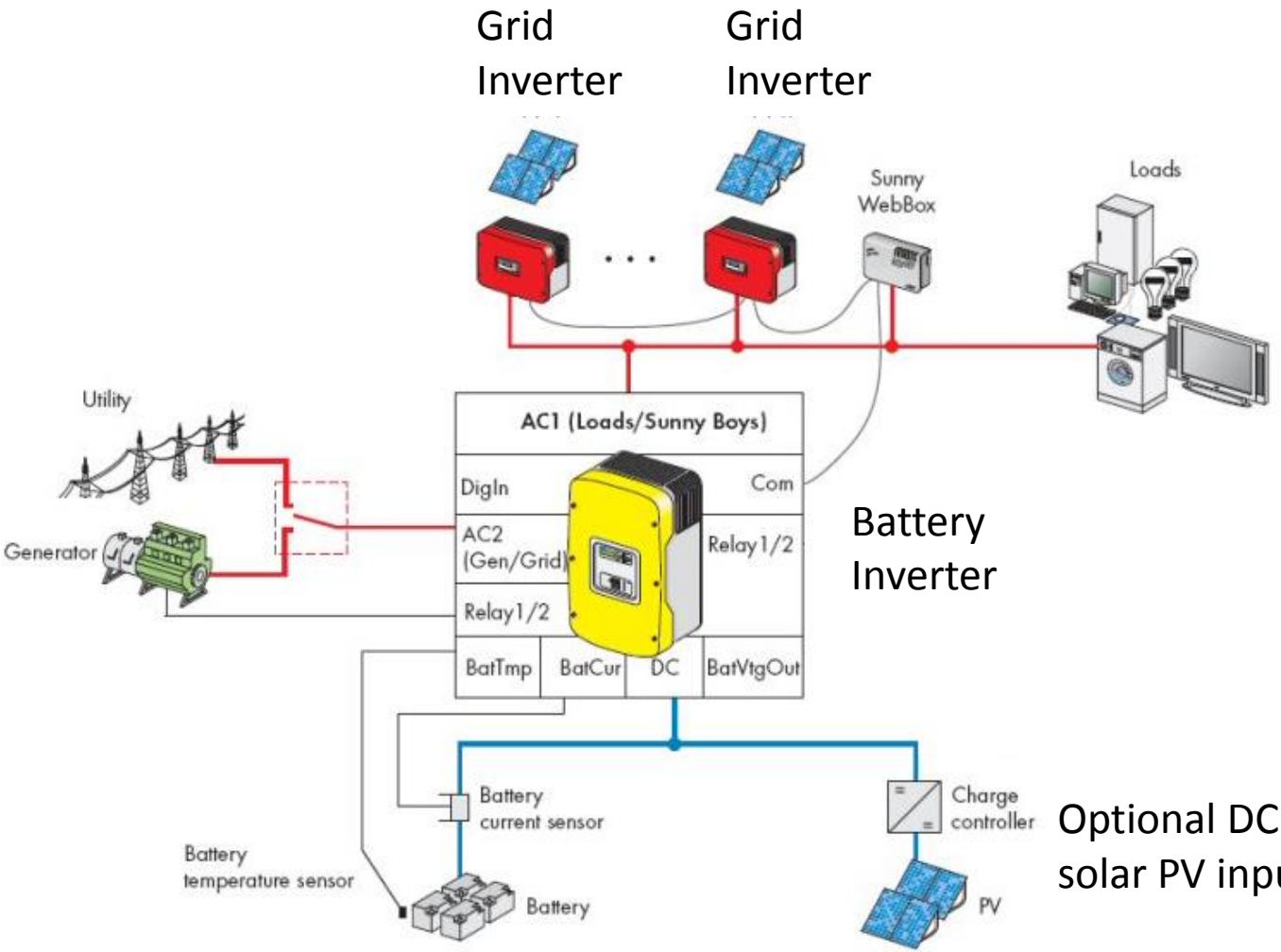
- Typically less expensive overall
- Better control of battery charging
- Best for stable load conditions such as BTS tower or radio equipment



# F. DC Coupled Grid Interactive System



# F. AC Coupled Grid Interactive System




Asia-Pacific
Economic Cooperation

Project Number : EWG 22/2013A

Produced By

Andre Susanto
Chitra Priambodo
Castlerock Consulting - http://www.castlerockasia.com/

For
Asia Pacific Economic Cooperation Secretariat
35 Heng Mui Keng Terrace
Singapore 119616
Tel: (65) 68919 600
Fax: (65) 68919 690
Email: info@apec.org
Website: www.apec.org



APEC#215-RE-03.8