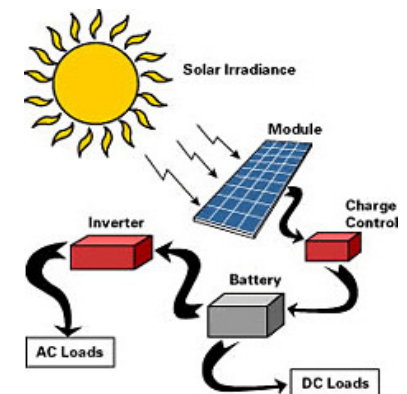




# Introduction to Photovoltaic Systems

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# Photovoltaic System



- i. Photo = Light, Voltaic = Energy -> Light into Energy
- ii. Solar power is energy from the sun and without its presence all life on earth would end.
- iii. Solar is one of the more popular forms of Renewable Energy - *a source of energy that is not depleted when used.*
- iv. Solar energy has been looked upon as a serious source of energy for many years because of the vast amounts of energy that are made freely available, if harnessed by modern technology.



Country	Feed-in-tariff	Renewable Portfolio Standard/ quota	Capital subsidies, grants, rebates	Investment or other tax credits	Sales tax, energy tax, excise tax or VAT reduction	Tradable RE certificates	Energy production payments or tax credits	Net metering
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EU - 27								
Spain	X		X	X	X	X		
United Kingdom	X	X	X		X	X		

Other Developed/Transition Countries								
Canada	(*)	(*)	X	X	X			X
Russia			X			X		
United States	(*)	(*)	X	X	(*)	(*)	X	(*)

Developing Countries								
Brazil			X					
India	(*)	(*)	X	X	X	X	X	
Indonesia	X			X	X			

Caribbean Countries								
Barbados			X	X	X			
Jamaica			X	X	X			
Grenada			X					X

(\*) means that some states/provinces within these countries have state/province level policies but there is no national-level policy.



# Benefits of Solar Energy

- Renewable (cannot be depleted) unlike fossil fuel
- Conservation of National Wealth
- Environmental Impact
  - Clean Power – less CO<sub>2</sub> Emissions
  - Aesthetically Pleasing
  - Less damages to the Flora and Fauna
- Home / Business Security
  - Security services continue with power Outages e.g. Surveillance, Remote Gates, Perimeter Lighting





# Benefits of Solar Energy

- Energy Security
  - Protection from:
    - Power Outages &
    - Increase Utility Prices
- Financial Savings
  - Reduced Installation Cost
  - None/ Reduced Monthly Bills
  - Financial hedge against unstable or rising fossil fuel prices





# Applications of Solar Energy



Solar Farm

Surveillance Cameras



Remote Gate



Construction Sites / Container



Boats / Marine



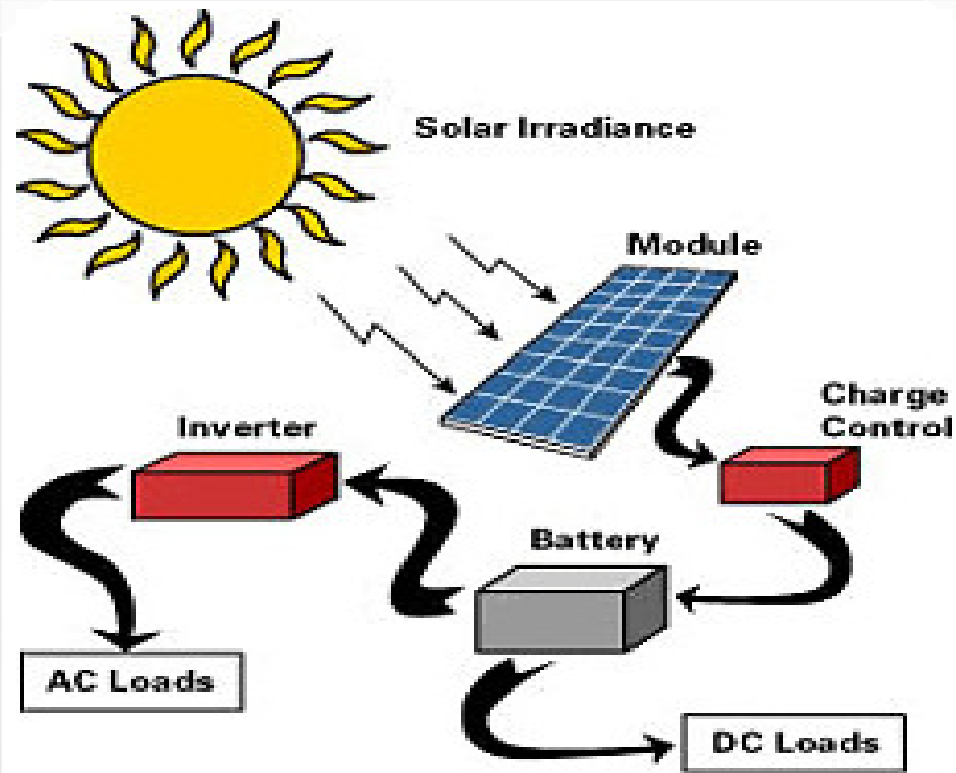
Street / Perimeter Light



Remote Wifi



Solar Powered Buildings



Solar Power System is a power system designed to supply usable solar power by means of Photovoltaic

## Basic Component of a PV Systems





# Components

1. **Solar Panels** – Converts Sunlight to Electricity
2. **Batteries** – Stores Electricity
3. **Charge Controller** – Manages the flow of electricity between the solar panel and the battery
4. **Inverter** – Converts DC Power from the Solar Panel and Batteries to AC Power. Inverters are not always used.
5. **Load** – Application of Electricity e.g. Lights, Computer, Radio
6. **Wires** – Connect the various components together



# Types of PV System

- Off Grid Systems
  - DC Off Grid
  - AC Off Grid
- Grid Tie Systems
- Grid-Tied Battery Backup System
  - Grid-Tied with Emergency Backup
  - Grid-Tied with Off-Grid Capabilities
- Grid Assisted Systems



# I. Off Grid Power System

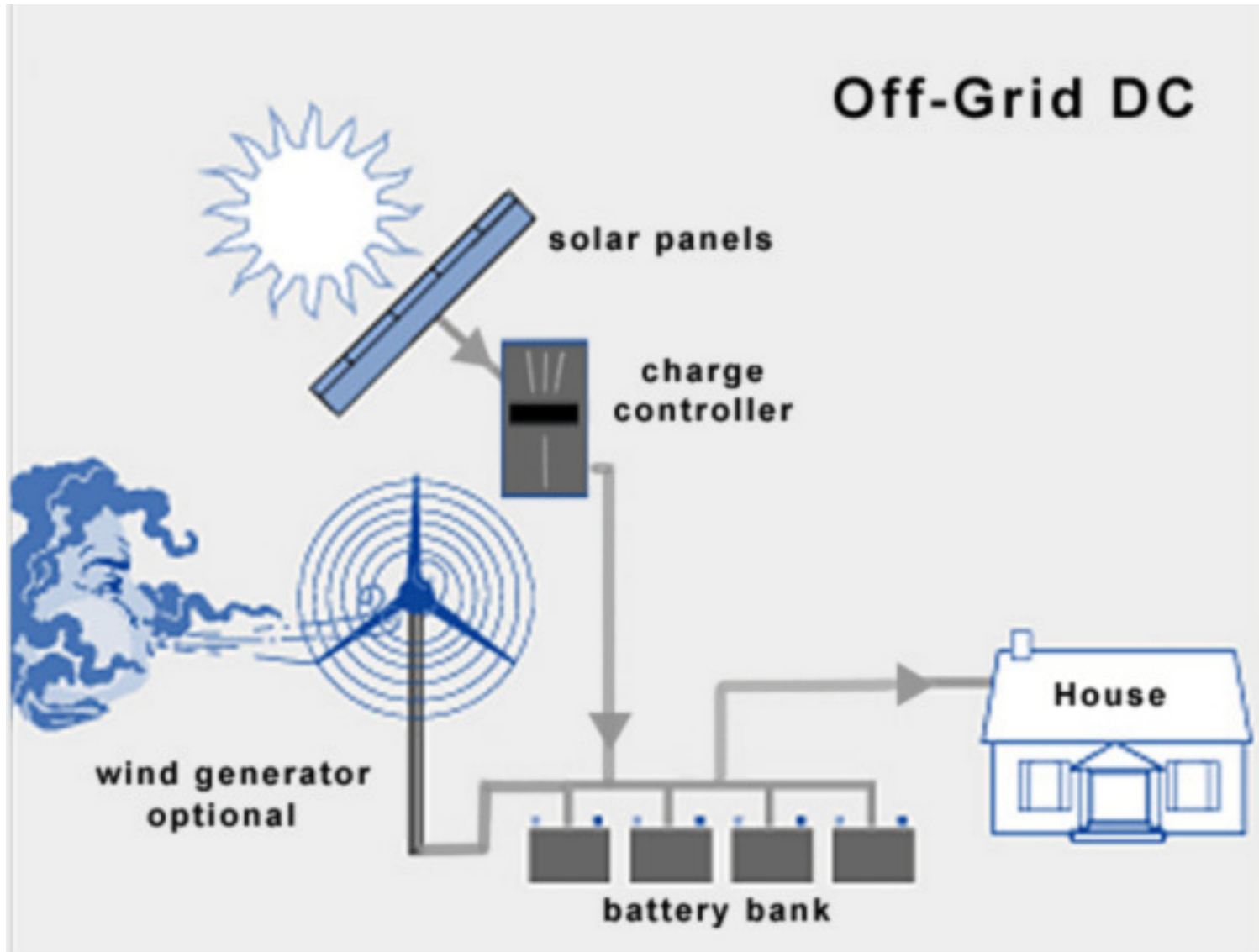
1. When the utility power is unavailable or too expensive to bring in to your home or cabin, solar panels allow you to be your own utility company!
2. *You can live in peace, with no noisy gas/diesel generator to disturb the quiet.*
3. There are several variations of off-grid solar power, depending on your needs and budget.



# I A. Off Grid DC Power System

DC off-grid solar power systems are most often used to power DC appliances in RV's, boats, and cabins, as well as farm appliances like cattle gates and rural telecommunications systems when utility power is not accessible DC solar power is less expensive than AC solar power because an inverter is not required to convert the electricity produced by solar panels and stored in batteries from DC to AC.

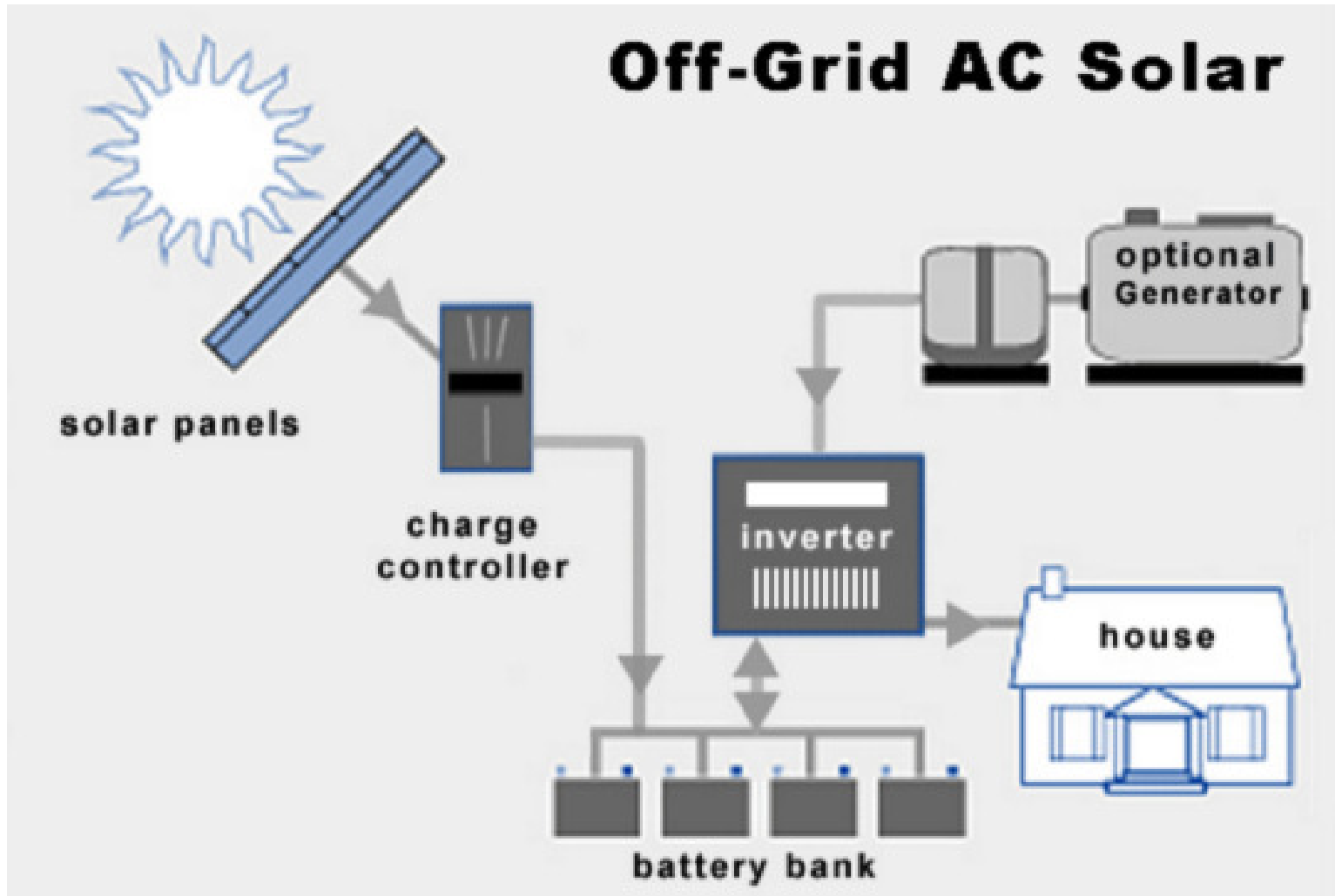
But DC solar power does NOT power standard AC appliances..





## I B. Off Grid AC Power System

1. Off-grid solar power also stores DC electricity in batteries. The addition of an *inverter* allows this system to convert DC electrical current coming from the batteries into AC or alternating current.
2. *AC is the standard form of electricity for anything that "plugs in" to utility power and is the appropriate current for common household appliances.*
3. *While AC off-grid solar power systems are more expensive because of the cost of the inverter, the appliances you are able to use are less expensive and there are more kinds of appliances to choose from.*





## 2. Grid-Tied Solar Power System

Grid-tied solar electric systems generate electricity for your home or business and route the excess power into the electric utility grid for compensation from the utility company.





## 2A. Grid-Tied Solar Power System with Battery Backup (Off-Line)

Provides backup power or off-grid capabilities with the grid-tied system

### **In the event of utility grid outages:**

1. The system will continue to make use of the electricity generated by your solar panels, keeping your battery bank charged until grid power resumes.

(Note the difference between a UPS)

2. They are a great source of emergency backup power during blackouts from hurricanes, tornadoes, severe weather and unreliable electrical grid



## 2.B Grid-Tied Solar Power System with Battery Backup (Online)

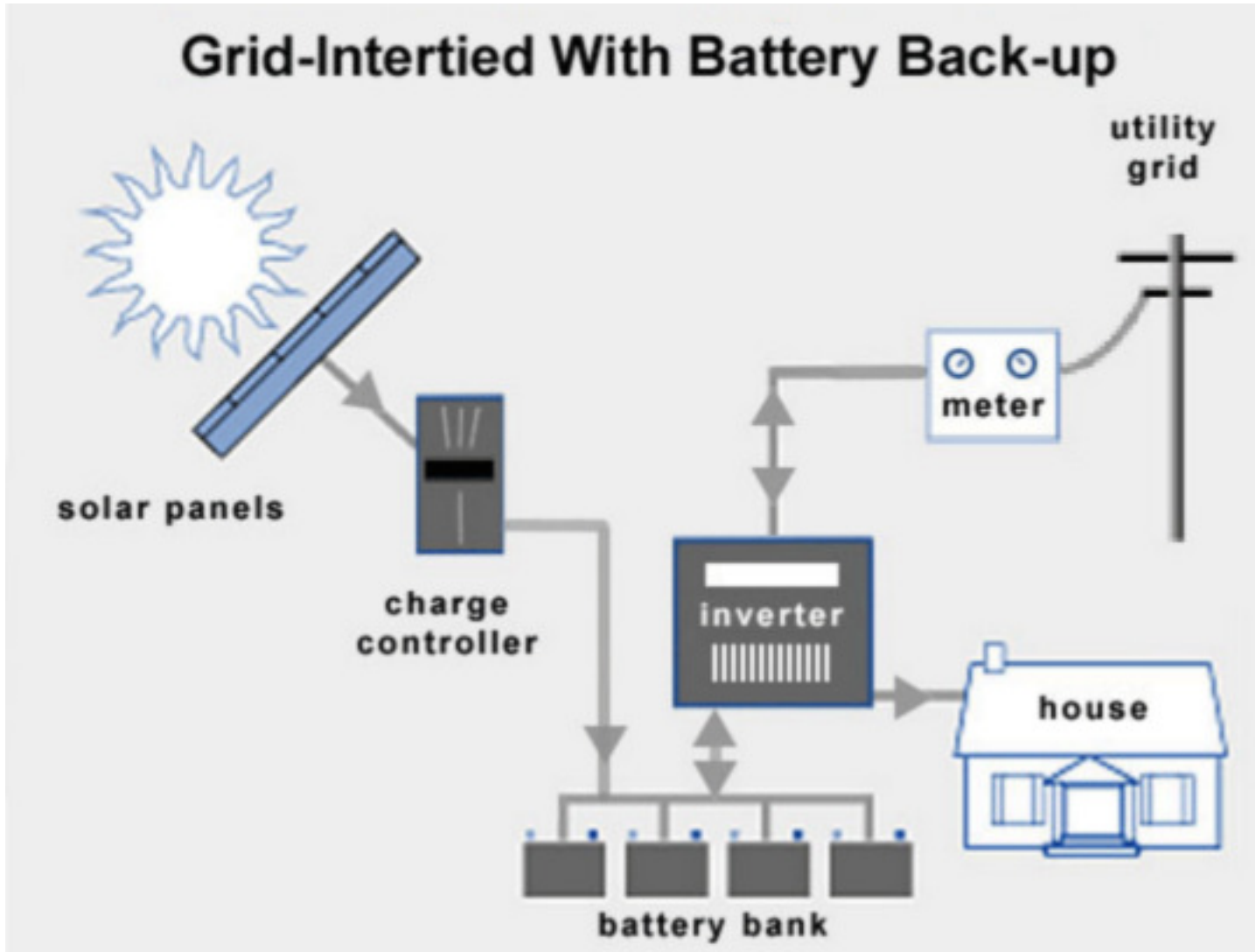
- When the grid is running properly, your home or business will use **power generated from your solar panels or pull electricity from the grid.**
- Any excess power generated over and above your needs go back to your utility company for credits on your power bill in areas *where net-metering is available.*
- In the event of grid blackouts, these systems will switch to "**off-grid mode**" drawing power stored in your battery bank to power your home AND using your solar panels to recharge your battery bank.



## 2.C Grid-Assisted Solar Power System

*These systems come with battery banks, but unlike a normal **grid-tied** system, a **grid-assisted** system can draw extra power FROM the grid (to help power your appliances or charge your batteries), but it cannot feed power back INTO the grid.*

*This is mainly useful for areas that legally do not allow grid-intertied systems, such as Trinidad and Tobago.*





# Current Status of Solar Power

- A Framework was completed in 2011 with subsequent improvements to the Framework thereafter.
- Fiscal support mechanisms: tax credits, import duty exemptions, 0-rating for VAT purposes, wear and tear allowances etc.
- Legislative support: amendment to the T&TEC Act and the RIC Act (in progress)
- Government to lead by example e.g. RE installations in government buildings including hospitals, medical clinics and schools



### Solar

- 25% Tax Credit on Solar Water Heaters (SWH)
- 0% VAT on SWH & Solar PV Systems
- 150% Wear & Tear Allowance for SWH; SWH Plant, Machinery and Equipment, and Solar PV Systems
- Conditional Duty Exemptions for SWH Manufacturers.

### Wind

- 0% VAT on Wind Turbines .
- 150% Wear & Tear Allowance for Wind Turbines and supporting equipment.

### EE

- 150% Allowance for the design and installation of energy saving systems by an Energy Service Company (ESCO)
- ESCO can write off value of assets in two years: -
  - a) 75% Depreciation on plant, machinery and equipment acquisition;
  - b) 25% Wear & Tear allowance in following year.



# Current Status of Solar Power

- Education and training initiatives: inclusion of RE and EE in education curricula of schools, workshops to engage personnel who would be directly engaged in the RE industry e.g. technicians/electricians including T&TEC inspectorate, teachers, 'do-it-yourself' individuals
- Awareness creation re. communication fairs, workshops, various media, micromarketing of incentives for RE and EE
- Strategic pursuits including RE installations in community centres which would also serve as demonstration centres and thereby promote education and awareness.



# Current Status of Solar Power

1. Undertake Pilot Projects – Gasparillo (Solar and Wind, Grid Connect)
2. Several Community Centers
3. Several Schools
4. Standard – Part III of the National Electrical Wiring Code in PV Systems
5. Based on the Government's last Budget, they budgeted to have 10% of Power produced by Renewable Energy

[\\*http://www.energy.gov.tt/our-business/brief-on-renewable-energy-and-energy-efficiency/](http://www.energy.gov.tt/our-business/brief-on-renewable-energy-and-energy-efficiency/)





# Design Considerations

- Current and immediate Future loads must be considered
- The actual load usage per day – daily WH required – especially for simultaneous loads and surges.
- Recommendation for the use of energy efficient AC/DC loads e.g. use of LED Lights
- The people's behavior
- The appropriateness of the building / structure for PV Systems
- Trees or obstacles that could block sunlight
- Location
- Proper Equipment Selection



# Load Data Collection Template

Appliances / Loads	On at the same time 1= yes, 0=No	AC	DC	Qty.	Consumed Power				Surge Power			Hours Used per Day
					Option A		Option B	Option C	Option A - Surge		Option B - Surge	
					Volts (V)	Amps (A)	Watts as Rated	WH per day	Volts (V)	Amps (A)	Watts as Rated	



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