

PV System



Green Energy-Green Planet

www.solartraining.ca
syed@solartraining.ca

Irtaza Syed

P-PhD, MAsC, Electrical Engineering, Ryerson University, Toronto, Canada

PV Technology Overview

**Global Energy Scenario • Global Electricity Scenario
Global Solar Electricity Scenario • Canadian Electricity Scenario
Canadian Electricity Future • Ontario Electricity Scenario
Energy Conservation • PV System • PV System Types
PV System Key Components**

Global Energy Scenario

- 85% of world's energy from fossil fuel sources oil, coal & gas
- 15% of energy supply from Non-fossil sources
 - hydroelectric(7%)
 - nuclear(6.5%)
 - geothermal, solar, tidal, wind, wood, waste amounting to 1.5%
- World energy consumption is growing about 2.5% per year
(U.S. Energy Information Administration)

- Estimated fossil fuel reserves availability
 - Oil → 2040
 - Gas → 2042
 - Coal → 2112

(University of Queensland, Australia)

- Fossil fuels burning produces 21.3 billion tonnes of CO₂ per year
- Main cause of global warming
(U.S. Energy Information Administration)

Global Electricity Scenario

- Global Production
 - Gross electricity production 21198.1 TWh @ 2010
 - Total growth rate of 3.2% @ 2000-10 (15451.3 to 21198.1 TWh)
 - Total growth rate of 5.5% @ 2009-10 (20089.7 to 21198.1 TWh)

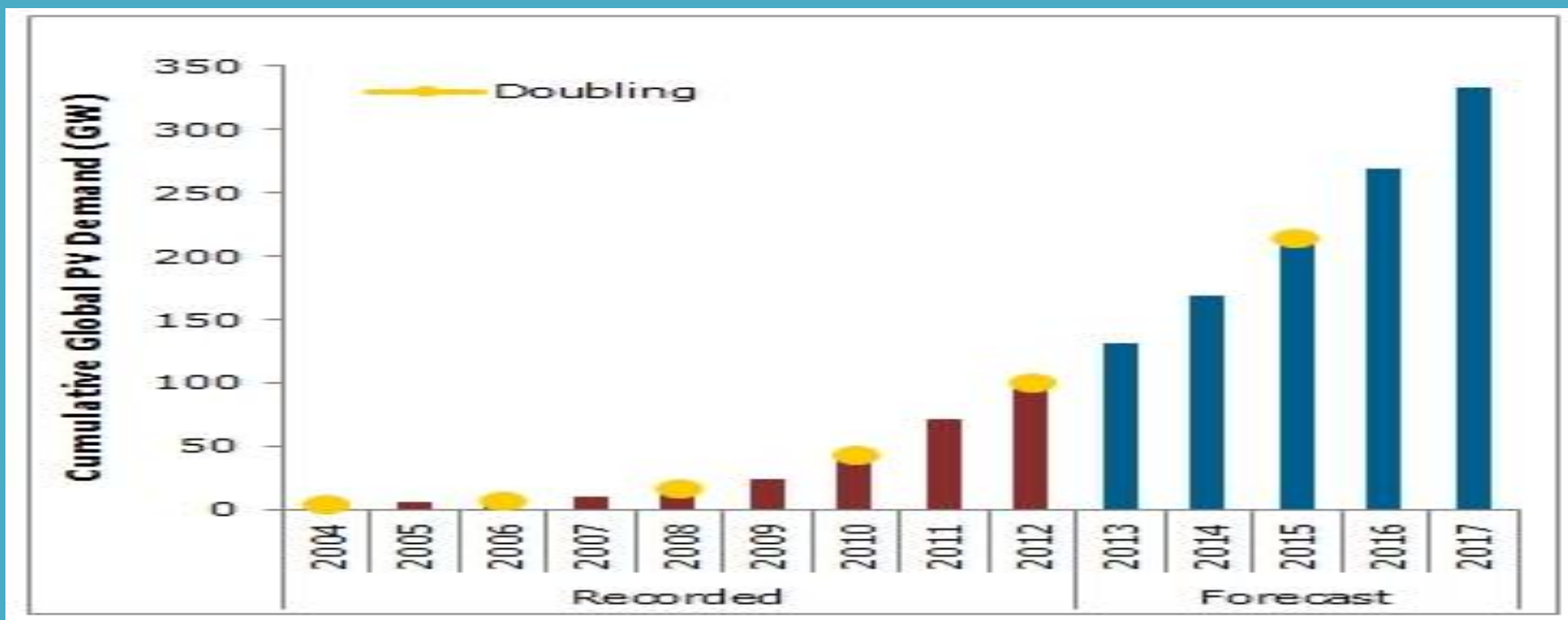
- Renewable Share
 - Gross RE share of 4158.7 TWh @ 2010 (19.6% of production)
 - RE growth rate of 3.6% @ 2000-10 (2915.7 to 4158.7 TWh)
 - RE growth rate of 5.6% @ 2009-10 (3939.5 to 4158.7 TWh)

- Solar Share
 - SE share of 33.2 TWh @ 2010 (> 200 GW under construction)
 - SE growth rate of 38.1% @ 2000-10 (1.3 to 33.2 TWh)
 - PV 31.6 TWh
 - ST 1.6 TWh
 - SE growth rate of 56.4% @ 2009-2010 (21.2 to 33.2 TWh)

www.energies-renouvelables.org/observ-er/html/inventaire/pdf/13e-inventaire-Chap01-Eng.pdf
www.iea.org/aboutus/faqs/renewableenergy

Global Solar-Electricity Scenario (2004-17)

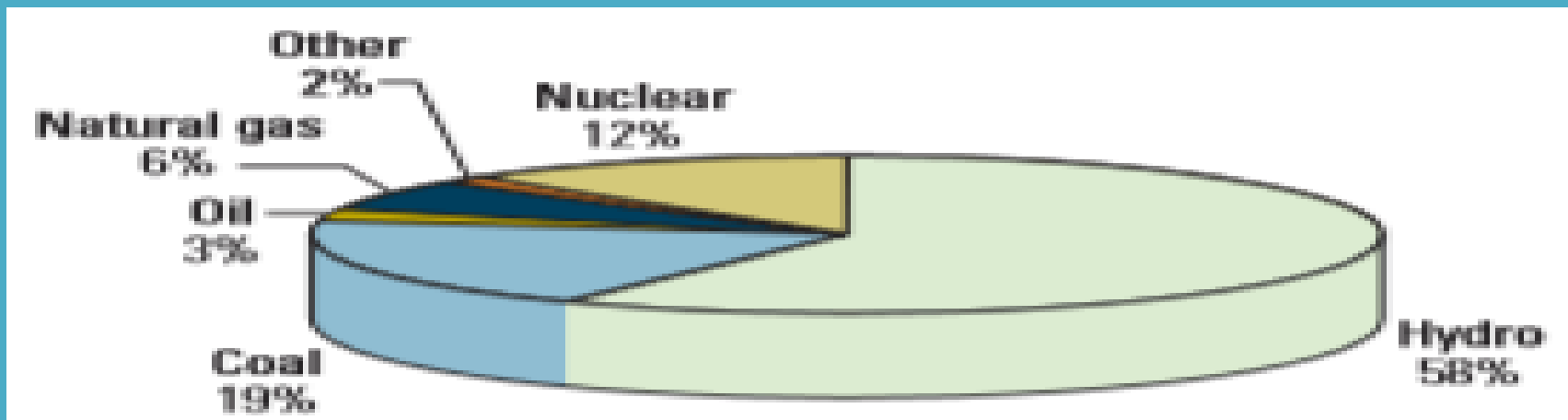
- Global Production (expected > 450 GW @ 2017)
 - Attractive policies globally (Rebates, FIT's, etc)
 - Ever increasing energy demand & depleting fossil fuel
 - Global warming (mass education/awareness & sensitivity)
 - Global prices decline



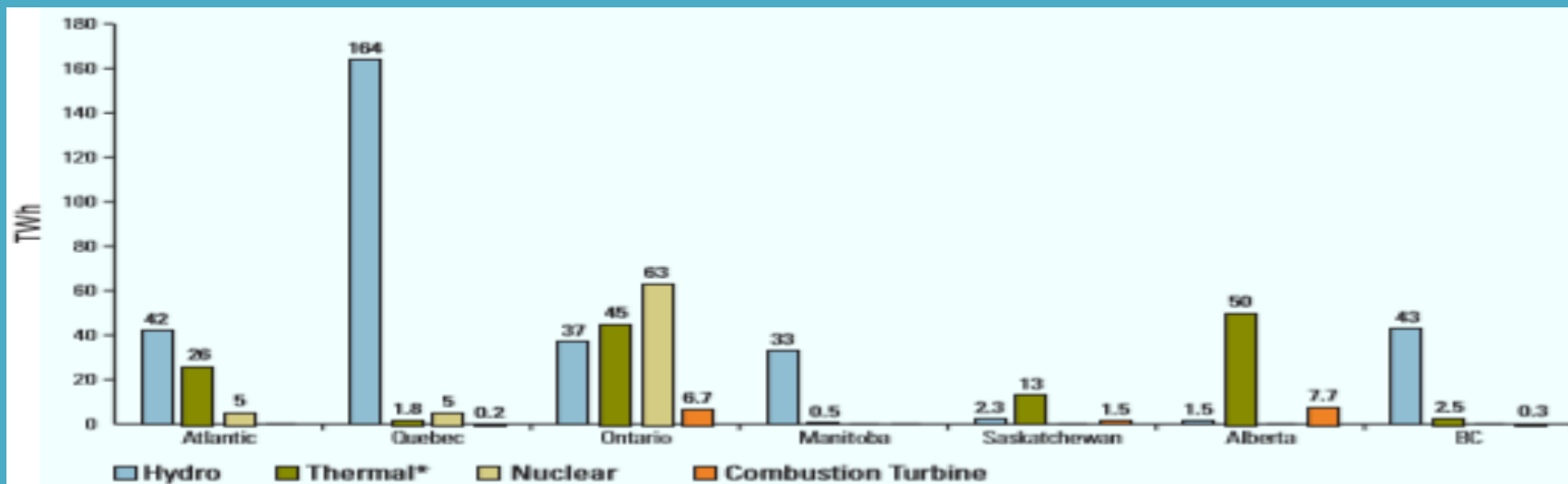
www.renewableenergyworld.com/rea/news/article/2013/03/reaching-new-heights-cumulative-pv-demand-to-double-again-by-2015?cmpid=SolarNL-Saturday-March23-2013

Canadian Electricity Production

- Canada wide

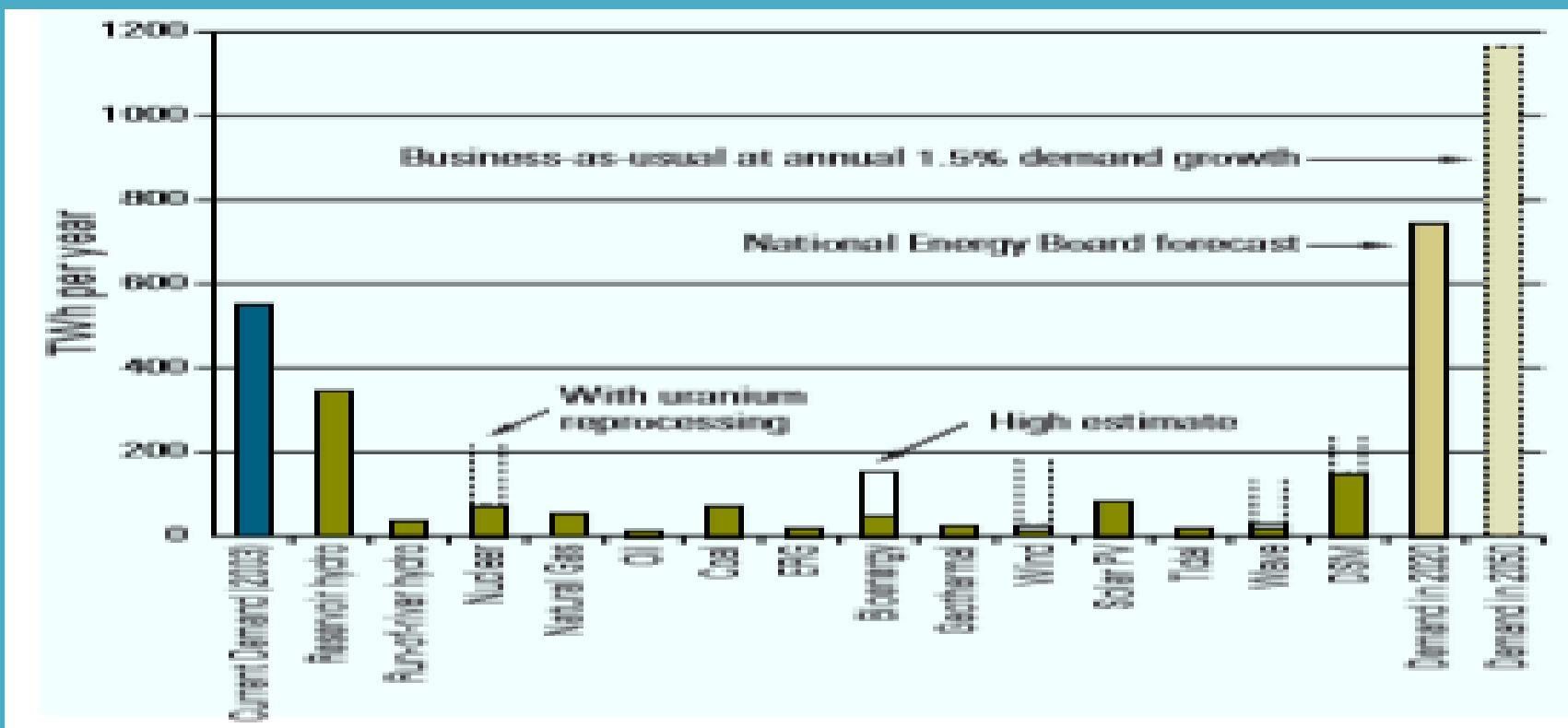


- Province wise



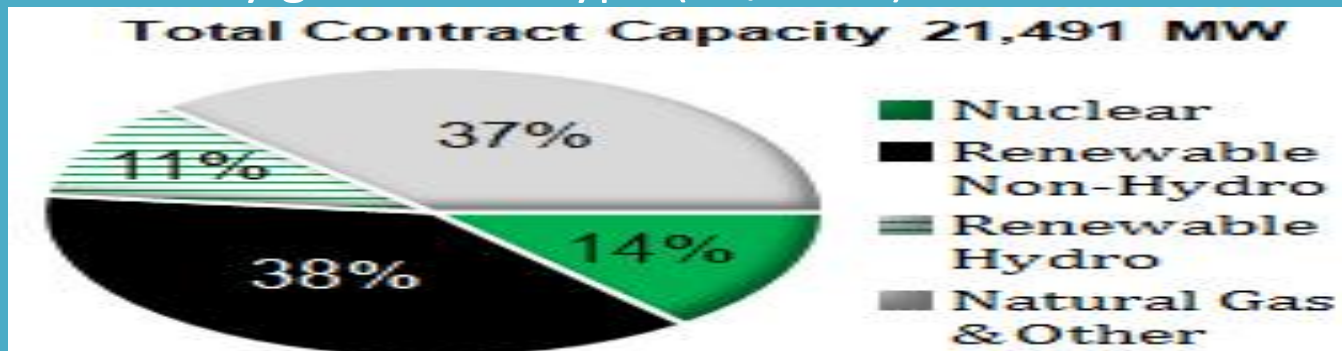
Canadian Electricity Future

- Canada wide demand 530 @ 2003, 730 @ 20 & 1170 TWh @ 2050
- Gap will be met by new generations including solar (PV & ST)
- Canada wide potential (approximate)



Ontario Electricity Scenario

- Ontario Power Gen
 - 19 GW Generation (65 Hydro, 5 Thermal & 2 Nuclear) @ 2013
 - 141 TWh demand @ 2011
 - OPG provided 84.7 TWh (60 of demand)
- OPA www.opg.com/power/
 - Power by generation type (09/2012)



- 1991 MW Solar (24% of 8,156 MW (38% of total))
- 606 MW operational & 1305 MW under development
- Roof-top FIT ≤ 10 kW @ 54.9¢ jan/2013, Orig: 80.2¢
- Ground-mount FIT ≤ 10 kW @ 44.5¢ jan/2013, Orig: 64.2¢

<http://www.powerauthority.on.ca/current-electricity-contracts>

Energy Conservation

TOP TEN

FASTEST, EASIEST, AND BEST EVER MONEY-SAVING TIPS

1 Use CFL or LED Bulbs

One compact fluorescent light bulb (CFL) or light emitting diode (LED) can save you three times its purchase cost in electricity. CFLs last up to 10 times longer than incandescent bulbs and can use up to 75% less electricity. You can replace an incandescent 100W light bulb with an 18W - 23W compact fluorescent and still get the same amount of light.

2 Install a Programmable Thermostat

During the heating season, set your programmable thermostat to automatically lower the heat by a few degrees at night or when you are away. If you have air conditioning, you can use your programmable thermostat during the cooling season to automatically turn it off or increase the temperature when you are not at home. Your energy savings will easily pay for the cost of the thermostat in the first year.

3a Replace Your Old Refrigerator or Freezer

Refrigerators and freezers are two of the biggest electricity users in your home - these old, inefficient appliances can cost well over \$10/month in electricity. When purchasing a new one, be sure to check the EnerGuide label and look for the ENERGY STAR® symbol so you are certain of energy savings when making your buying decision.

3b Get Rid of Your Second Refrigerator

It may be convenient having an extra refrigerator, but those cold beverages are costing you every day... up to \$125 per year

5 Look for the ENERGY STAR® Label

ENERGY STAR® is an international symbol that identifies many energy efficient products. The ENERGY STAR® symbol helps businesses and consumers identify products that are at the "top of their class" in terms of energy efficiency.

6 Eliminate Drafts in Your Home

Air leakage around windows, doors, vents and electrical outlets can account for as much as 25% of your total heating costs. That means there are significant savings available if you caulk and weather-strip windows, doors, dryer and other vents, and install insulated plates on electrical outlets.

7 Install Insulation

You can save energy and money by increasing the amount of insulation in your home, to keep it warmer in the winter and cooler in the summer. The attic and basement are good places to start, because those areas represent as much as 15% - 30% of your home's overall heating and cooling losses. Upgrading insulation levels is one of the smartest energy saving investments you can make.

8 Use Motion Sensor Switches and Timers

To avoid leaving your outside lights on for long periods of time, install a motion sensor that turns the lights on automatically when someone approaches the house and then turns the lights off after a pre-set period of time. Install timers on selected lights to avoid leaving lights on around the clock and to make your home look occupied when you are away.

9 Rely on Your Fans

Use fans instead of air conditioning when possible. Ceiling and portable fans cost pennies to operate and can lower the temperature in the room by up to 2°C.

4 Wash Your Laundry in Cold Water

You can save energy and money by washing all of your laundry in cold water. If you currently both wash and rinse in warm water, and you switch entirely to cold, you could save over \$14 a month (based on electric water heating). There are many laundry detergents designed specifically for cold water washing.

10 Use LED Seasonal Lighting

Using LED lights both inside and outside your home, during the holiday season, is a great way to conserve energy and save money. LED lights use up to 95% less



Renewable Energy Systems

- RE System
 - produce energy from natural (Non-fossil) resources
 - usually have no or low environmental effect
- RE Resources
 - usually replenish-able by nature
 - usually available in never ending supply
- Types
 - ➔ Wind Energy Systems
 - ➔ Solar Energy Systems
 - ➔ Geothermal Energy Systems
 - ➔ Bio-fuels Energy Systems
 - ➔ Hydro Energy Systems
 - ➔ Ocean Energy Systems
 - ➔ Fuel Cells Energy Systems
- Centralised as well distributed energy system possible
- Usually storage is required for continuous energy supply

Micro-Grid

- Microgrid (MG)
 - group of one or more generating source(s) & load(s)
 - usually based on RE sources
 - usually have storage as an integral part
 - Off-Grid (autonomous) or On-Grid (grid connected)
 - Island & Utility Interactive Modes
 - Single Controllable Entity

- MG Benefits
 - Energy reliability & security
 - Energy independence
 - Island Mode & Utility Interactive Mode
 - Peak Shaving & Profitability (or spinning reserves)
 - Utilization of more than one (types) of RE sources
 - Centralised or distributed generation & control
 - Reduces green gas emissions
 - Can improve grid profile

Solar Energy Systems

■ Photo Voltaic (PV) System

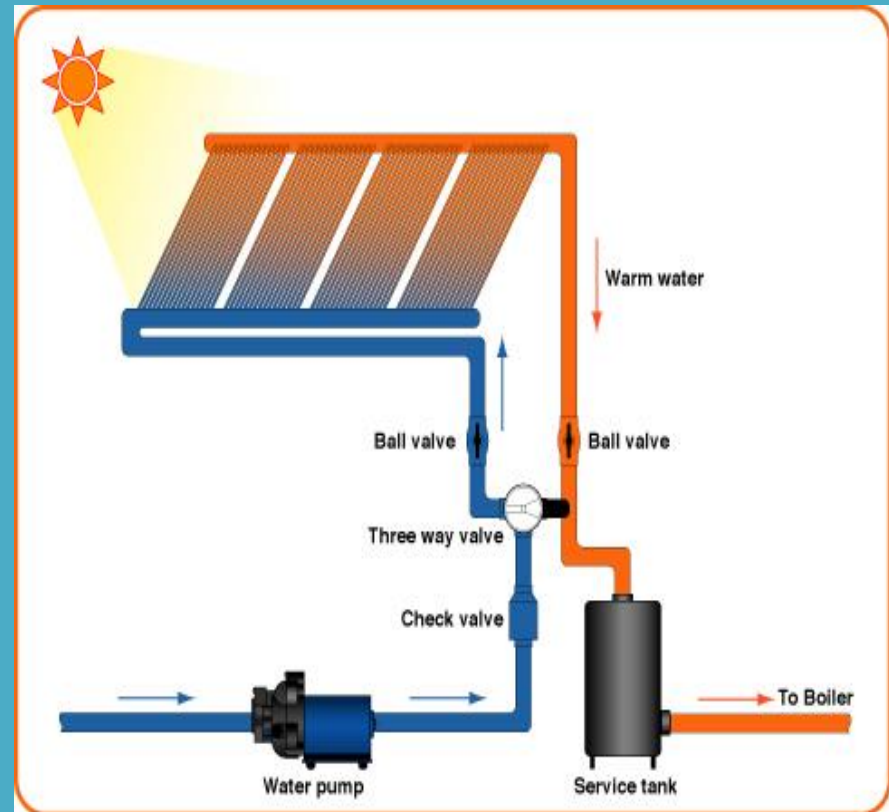
- sunlight into electricity
- supply local loads, grid or both
- loads can be ac or dc



11-megawatt power tower (Seville, Spain)
624 moveable mirrors to reflect sunlight
R-sunlight heat water pipes atop tower
Hot water creates steam
Steam drives turbine

■ Solar Thermal (ST) System

- sunlight into heat
- water, pools, space heating
- heat fluids for generation



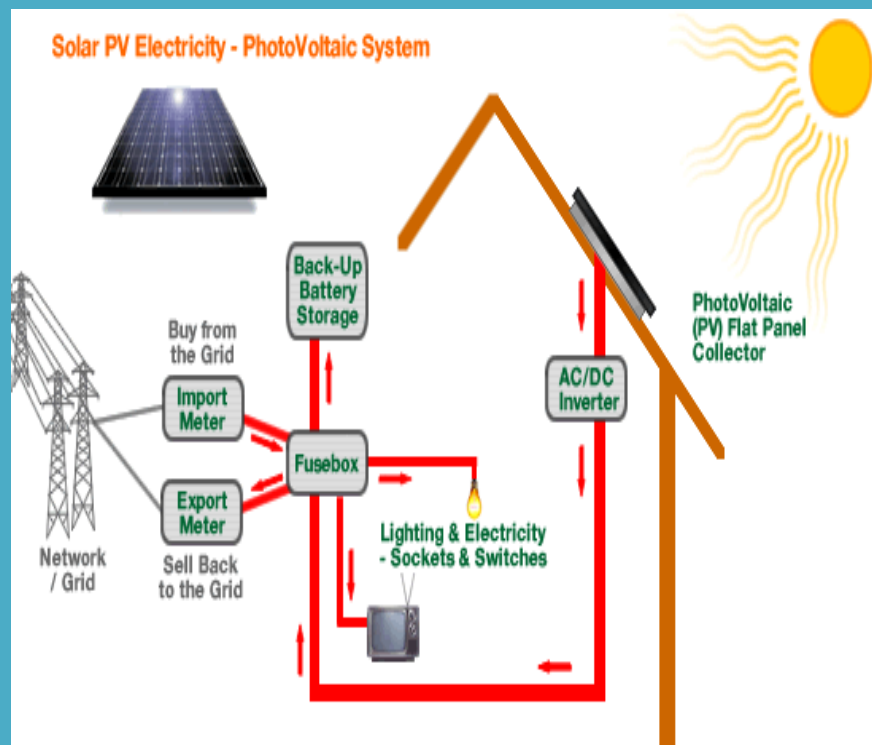
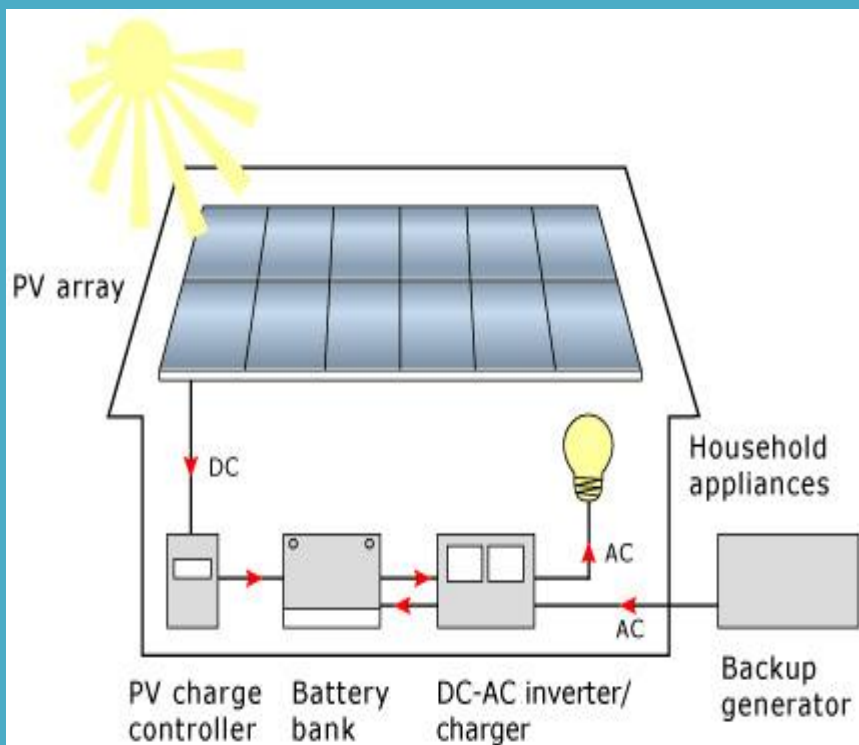
PV System Types

■ Off-Grid PV System

- also Stand Alone PV Sys
- not connected to grid
- loads can be ac or dc

■ On-Grid PV System

- also Utility Interactive PV Sys
- connected to grid
- may (or not) have local load
- Local load can be ac or dc



PV System Key Components

- PV Module: converts sunlight into DC electricity
- Racking: mount to hold PV module/array in place
- Cables: to carry charge (or current) & ground the system
- Fuses: for safety (Circuit Breakers)
- Combiner Box: brings all cables into one box
- DC Disconnect: disconnects PV module/array from PV Sys
- Charge Controller: controls charge flow
- MPPT Controller: maximize power transfer from PV module(s)
- Battery: stores energy for later usage
- Inverter: converts DC to ac electricity
- AC Disconnect: to disconnect PV Sys from utility grid/Load
- Meter: measures energy being generated (kWh) [1 or 2 meters]
- Load: to convert electricity into useful work
- Sun-Tracker: tracks sun to maximize conversion
- Energy Software: for monitoring system & energy yield

Thank You



Questions ?

www.solartraining.ca

Irtaza Syed --- syed@solartraining.ca --- Lead Trainer/Design Engineer