Renewable Energy

Presented by Sean Flanagan

Background

- Flanagan and Sun since 2004
- Solar electric (PV) off grid and grid tie, solar thermal, pool heating, solar air heating, small wind turbines, microhydro in theory
- First several years off-grid installation

Background

- 2009 Ontario passed GEA
  - Put in law ability for RE system owners to sell energy to grid
  - Offer high tariff initially, reduce over time as installation costs decrease
  - 2009 to 2014 80% of business from FIT
- 2015 90% of business is off-grid

Topics Covered

- Electrical Basics
- Photovoltaics (PV, or “solar electricity”)
- Wind energy
- Micro hydro
- Off grid and grid tied systems
- Micro-FIT and Net Metering
- Doing an energy audit
- Living with renewable energy

Goal for Course

- At the end of the course today we will build this off-grid house

Electrical Basics

- Current
  - Symbol is I
  - Units are amperes or amps (A)
  - Movement or flow of electrons in conductor
- Voltage
  - symbol is V
  - units are volts (V)
  - Think of it like electrical “pressure”

Electrical Basics

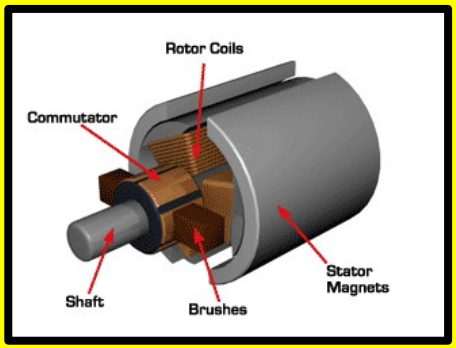
- Power
  - Symbol is P
  - Units are watts or kilowatts (W or kW)
  - Directly related to I and V
  - It is the “oompf” at a particular point in time
- Example
  - A small light has 12.4V across terminals and 0.5A of current flowing
  - P = I x V = 0.5 x 12.4 = 6.2W

Electrical Basics

- Energy
  - Symbol is E
  - Units are watt-hours (Wh)
  - How much work was done? What was accomplished? How much fuel was used?
- Example
  - If a light using 6.2W of power is on for 5 hours, how much energy is consumed?
  - $E = P \times t = 6.2 \times 5 = 31Wh$ (0.031kWh)

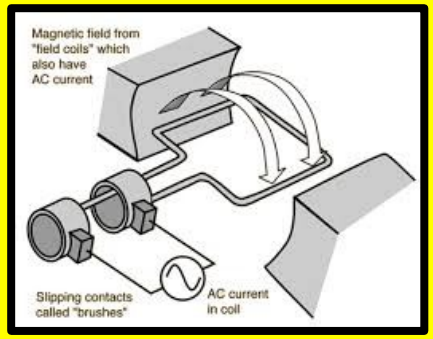
Electrical Basics

- Electricity flowing in one direction only is called direct current (DC)
  - Batteries
  - PV modules (solar panels)
  - DC motors



Electrical Basics

- Electricity that alternately flows in one direction, then the other is called alternating current (AC)
  - Normal house current from grid
  - AC motors
  - Microhydro and wind turbines



Electrical Basics

- Multimeters

Analog (needle)

Digital (screen)

Electrical Basics

- Multimeters

Symbol	Meaning
V ⎓	V DC
V ∿	V AC
mV	millivolts (.001V or 1/1,000V)
A	Amps
mA	milliamps (.001A or 1/1000A)
µA	microA (.000001A or 1/1,000,000A)
Ω	Resistance (Ohms)
kΩ , MΩ	kilo-Ohms, Megohms
))))	Continuity beeper
Hz	Frequency

Electrical Basics

- Multimeters
  - Measure DC voltage of various batteries
    - Pay attention to polarity (+ and -)
  - Measure AC voltage at a receptacle

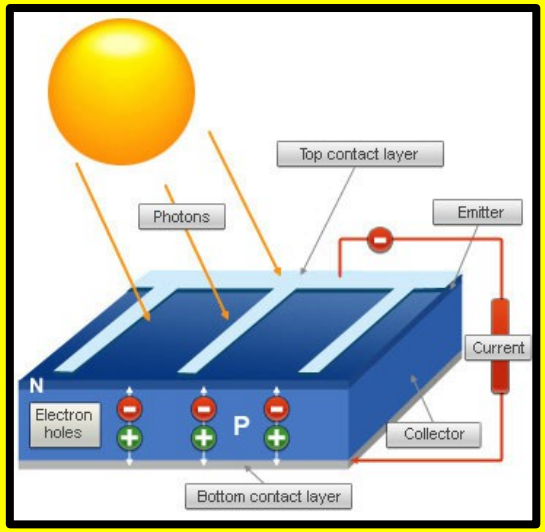
Electrical Basics

- Build a basic DC off-grid system
  - Energy storage (battery) & appliance (light)
  - Add protection / convenience (breaker)
  - Need way to replace energy (PV module)
  - Control charge process (charge controller)

Electrical Basics

- Build a basic AC off-grid system
  - Start with basic DC off-grid system
  - Need a way to change DC to AC (inverter)
  - Add ability to charge from AC source (3 stage battery charger)

Photovoltaics

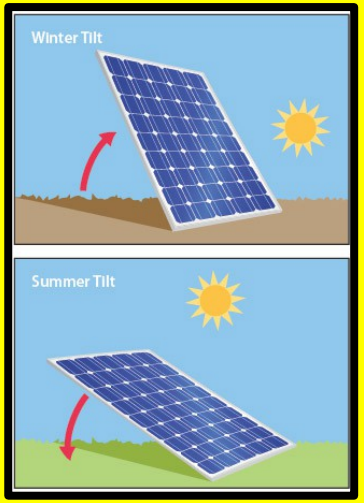


- Photo + Volt = light + electricity
  - PV, solar electric, solar
  - Photovoltaic effect discovered by Einstein (Nobel Prize for Physics in 1921)
  - Sunlight strikes silicon, electrons absorb energy & jump into top contact layer, follow circuit back to bottom contact layer
  - Solar panels are typically 12V or 24V nominally (can be connected in series to make higher voltage arrays)

Photovoltaics

- Why use PV?
  - Cost is falling rapidly (now 1kW = $1000, 10 years ago 1kW = $10,000)
  - Once installed, zero carbon emissions
  - Safe, easy to install, almost no maintenance, 25 year + life span, scalable, proven technology

Photovoltaics



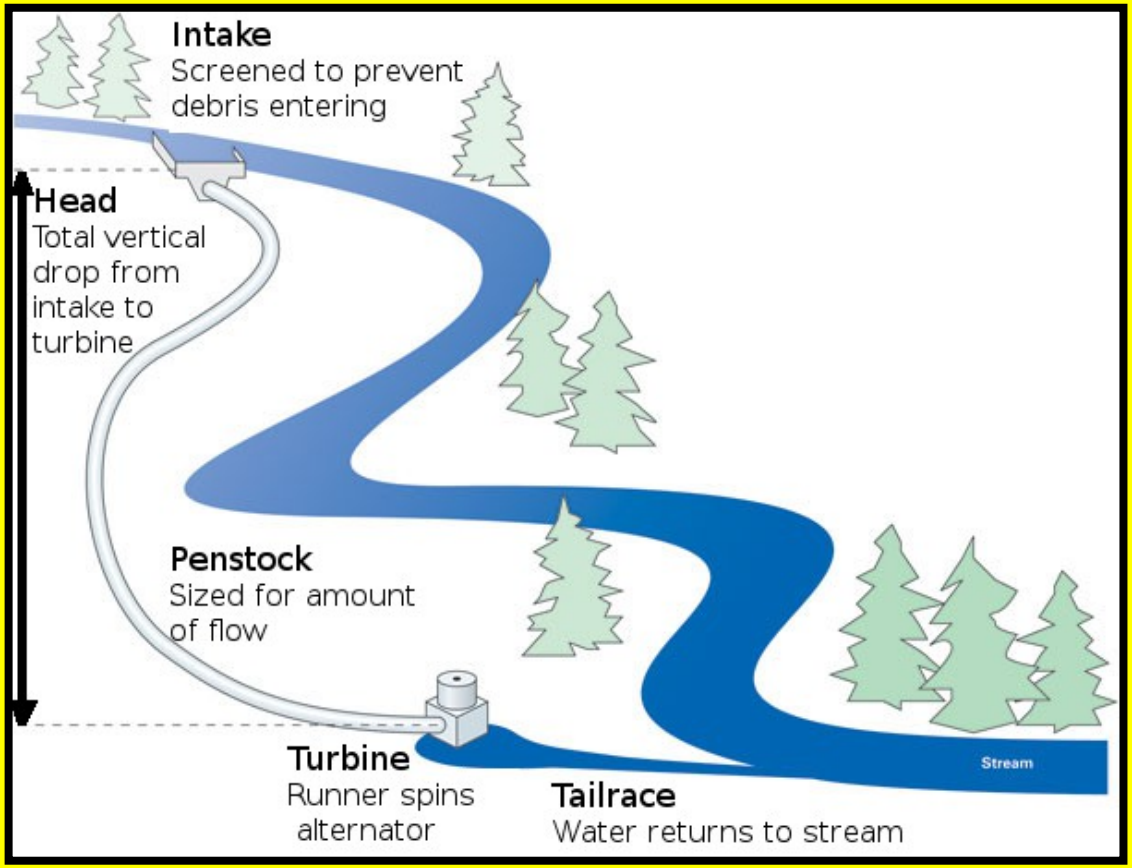
- Dos and Don'ts?
  - Ideally south facing (azumith)
  - For fixed arrays, to maximize annual output at our latitude, tilt 35 degrees from horizontal
  - Off-grid systems typically favour winter sun
  - Seasonally adjustable & trackers are options
  - Shading is a big problem for PV (not linear)
  - e.g. 3 panels connected in series … entire string output drops to level of shaded panel

Wind Energy

- Can be mechanical or to produce electricity
  - Mechanical systems for pond aeration and water pumping
  - Electrical wind systems consist of tower and turbine with blades
  - Height is critical - at least 20 feet above nearest object within 300 feet radius (otherwise turbulence)
  - Small scale wind typically impractical

Microhydro

- Not very common
  - Power a function of “head” and “flow”



Off-grid and Grid-tie Systems

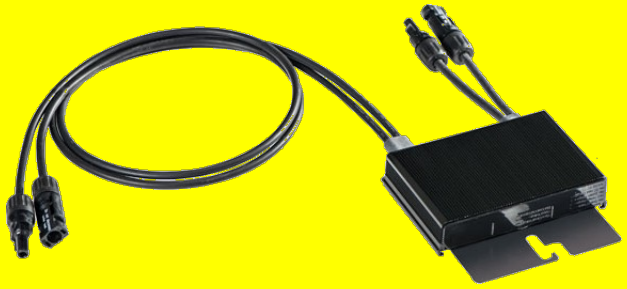
- Off-grid
  - Almost always because connection to grid is too expensive ($20,000 +)
  - Angry Hydro One customers “paying too much” … grid is still relatively inexpensive and conservation is best money spent
  - Batteries are achilles heel (expensive, prone to failure if abused, bulky) … lithium ion helps to address failure and bulk
  - Difficult to make an existing home off-grid
  - Requires a change in attitude, not comfort

Off-grid and Grid-tie Systems

- Grid-tie Systems
  - Allow use of renewable energy without batteries and maintain security of grid
  - During grid failure, RE system shuts down
  - Can add batteries to allow use of renewable energy during grid failures (hybrid off-grid)
  - Distributed generation (less line loss)

Off-grid and Grid-tie Systems

- String inverters, microinverters, power optimizers
  - String inverters prone to shading issues due to many modules in series
  - Microinverters and power optimizers allow solar modules to behave independently
  - Every solar module is connected to its own mi-croinverter or power optimizer on the roof

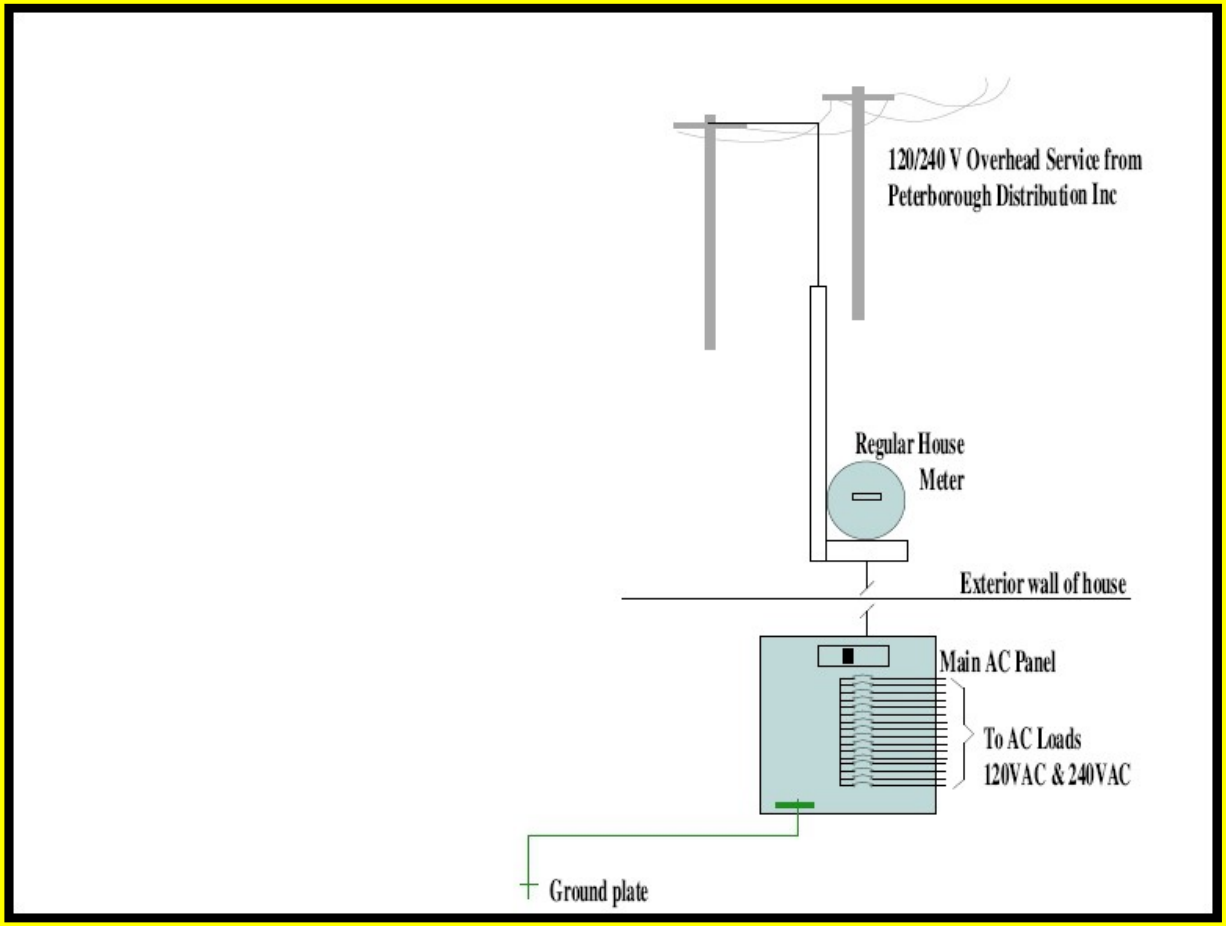


Off-grid and Grid-tie Systems

- Microinverters versus power optimizers
  - Microinverter converts DC to AC on the roof
  - Power optimizers adjust voltage and current to maximize output of each PV module and tie in to a central inverter
  - When devices fail, solar panel needs to be removed to access unit for replacement
  - Microinverters typically use electrolytic capacitors (fluid) whereas power optimizers use ceramic capacitors (solid)

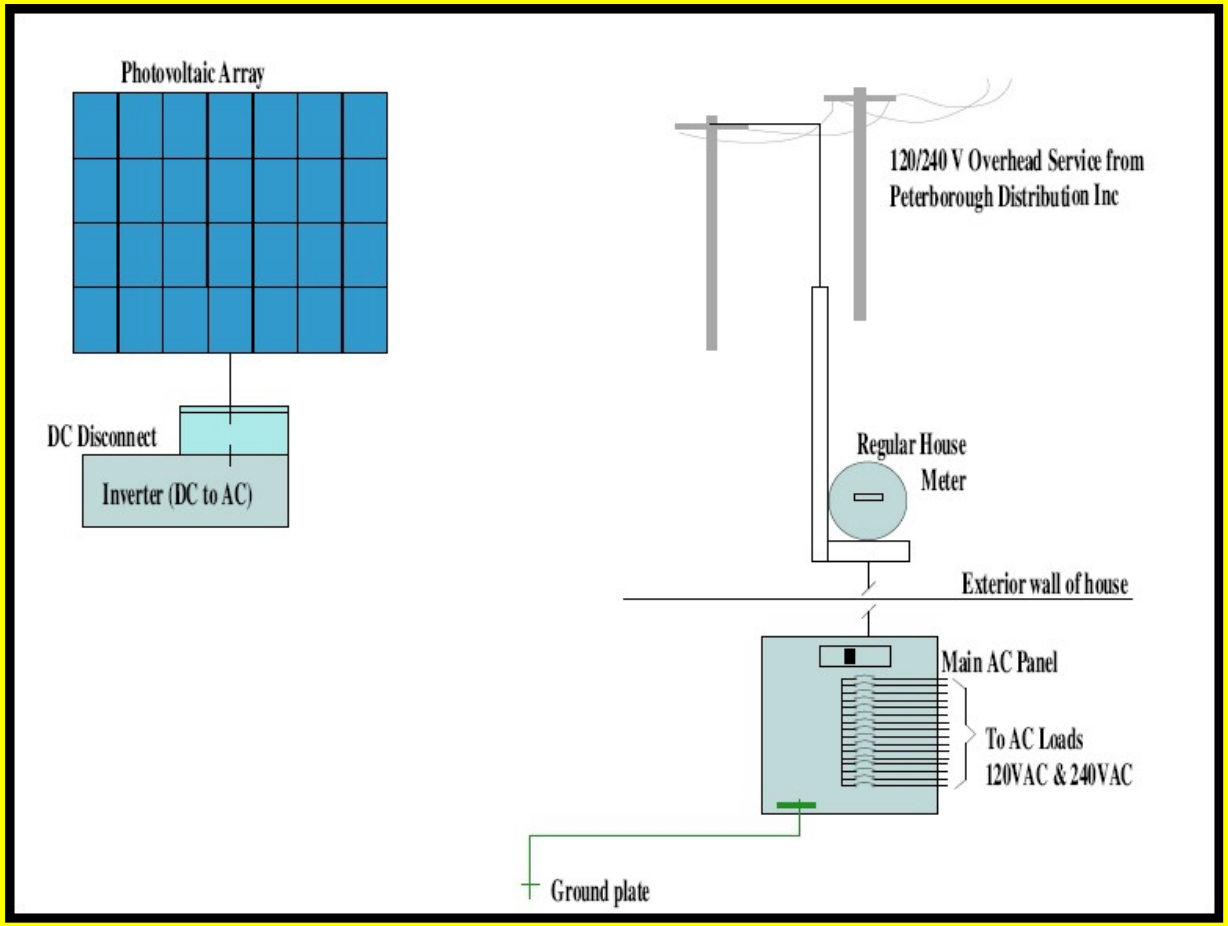
microFIT and Net Metering

- microFIT
  - 20 year fixed price contract to sell RE to grid



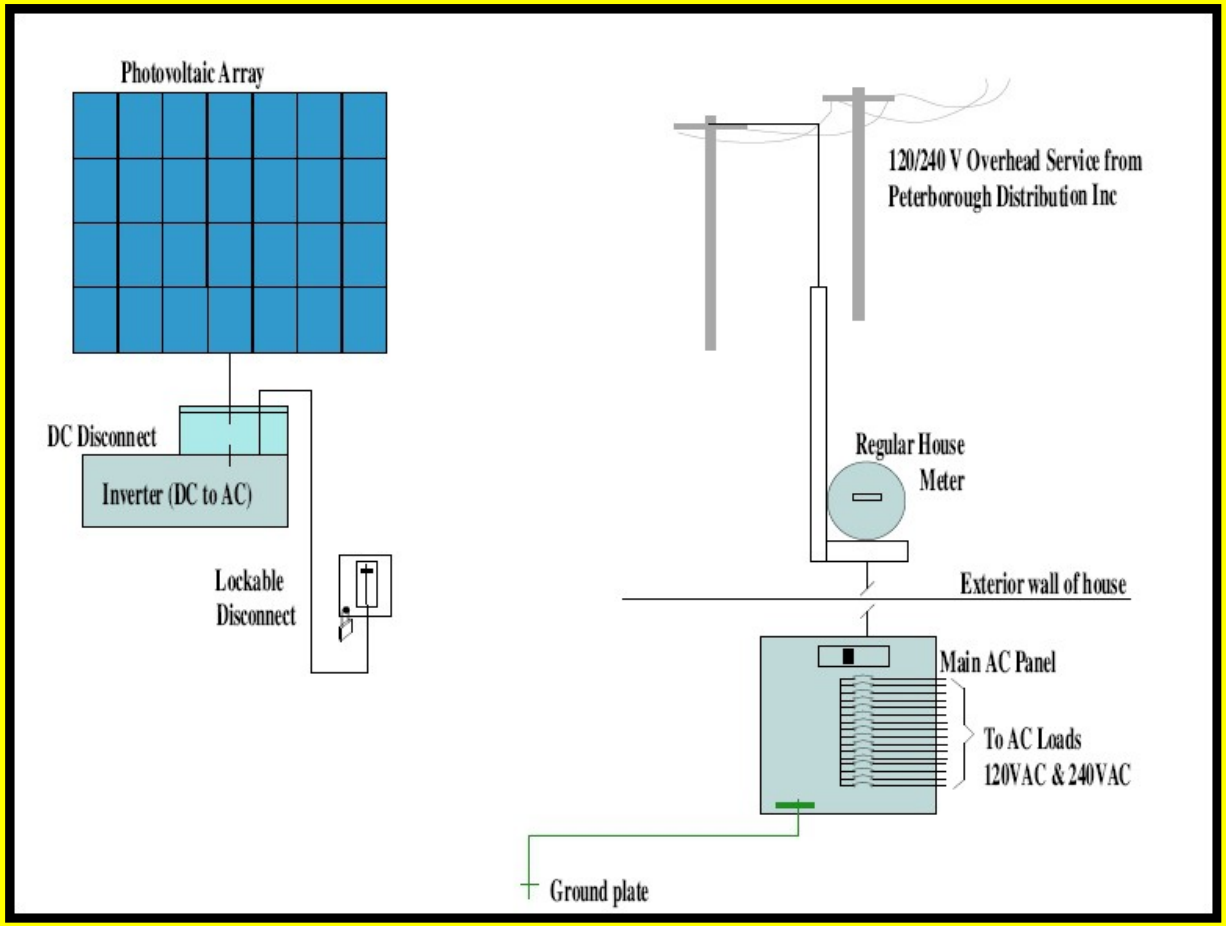
microFIT and Net Metering

- microFIT
  - Solar array feeds a grid-tie inverter



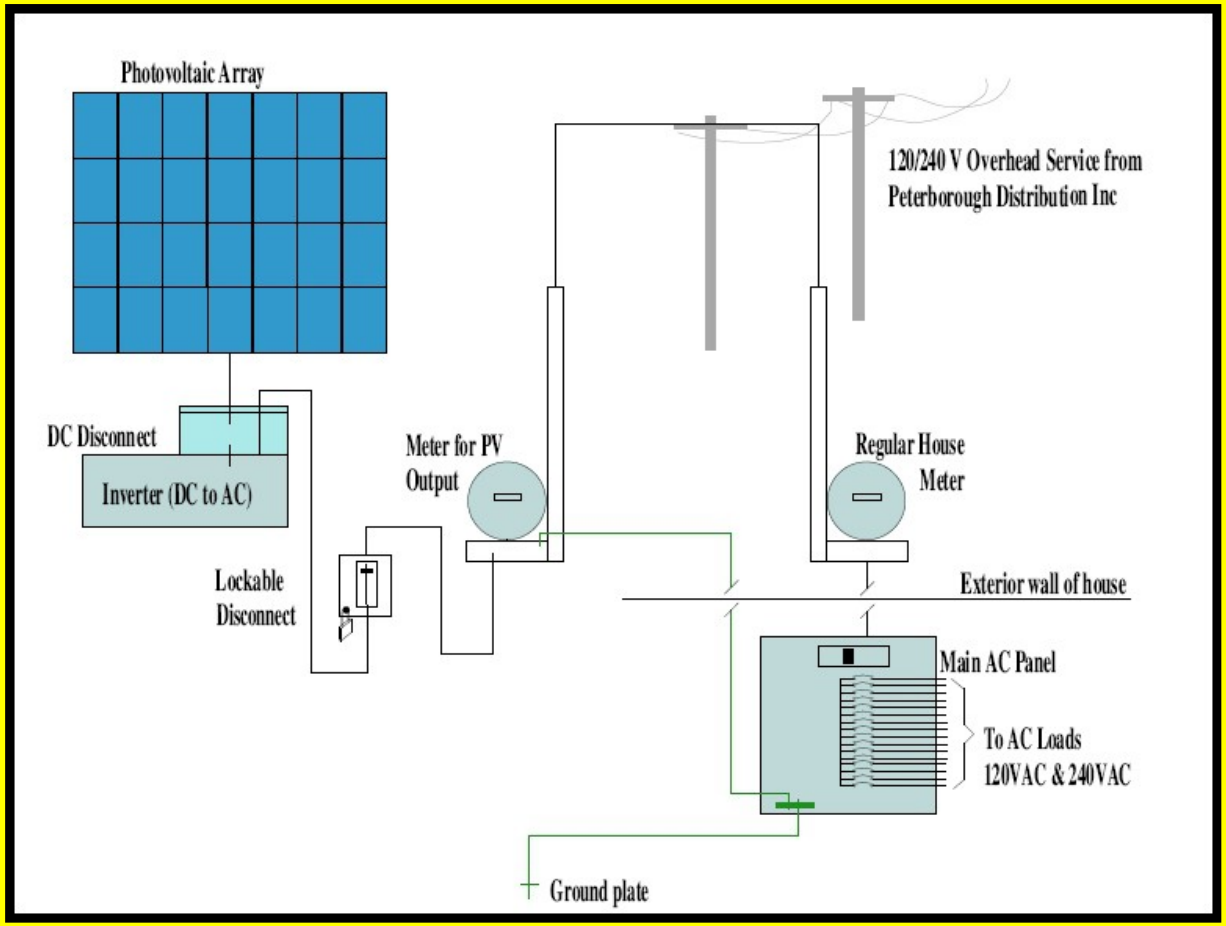
microFIT and Net Metering

- microFIT
  - Lockable disconnect for safety



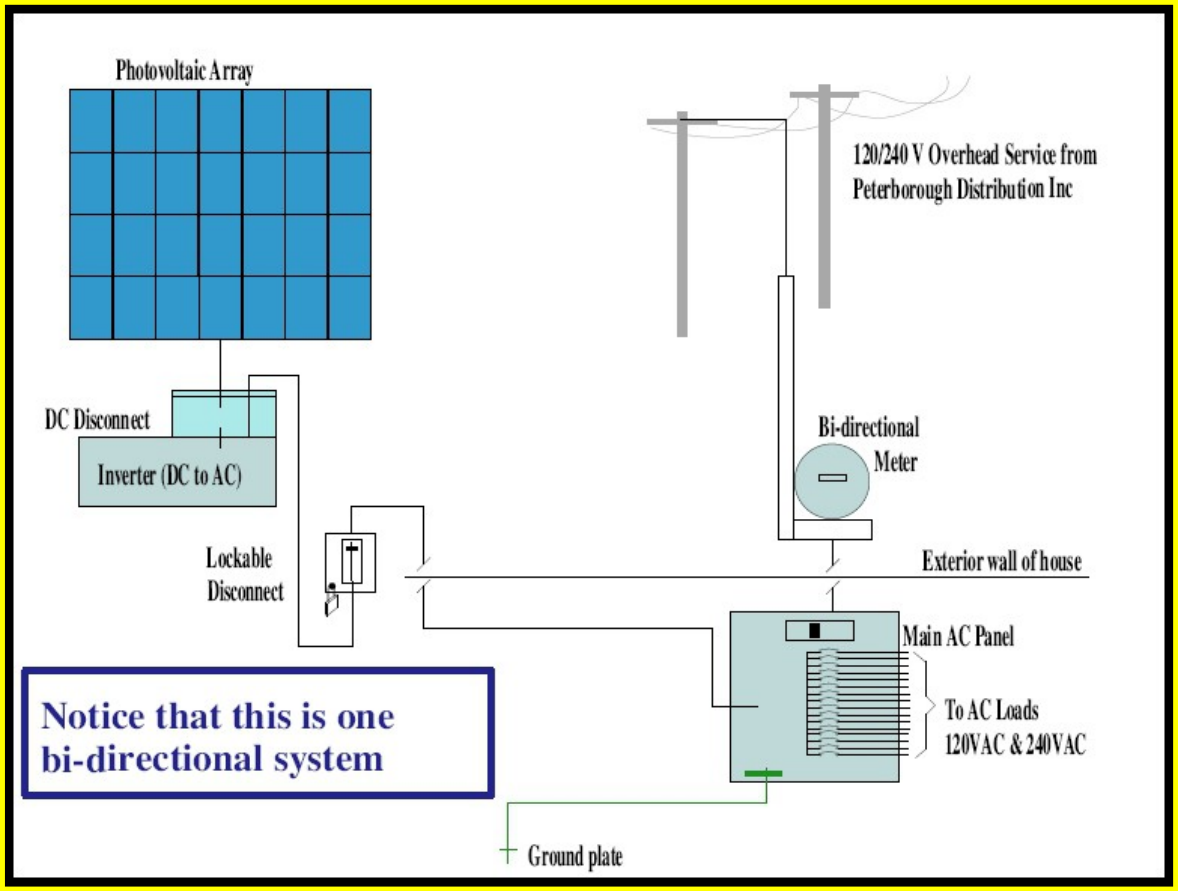
microFIT and Net Metering

- microFIT
  - Output metered separately (all goes to grid)



microFIT and Net Metering

- Net Metering
  - RE used by house – extra reverses meter



microFIT and Net Metering

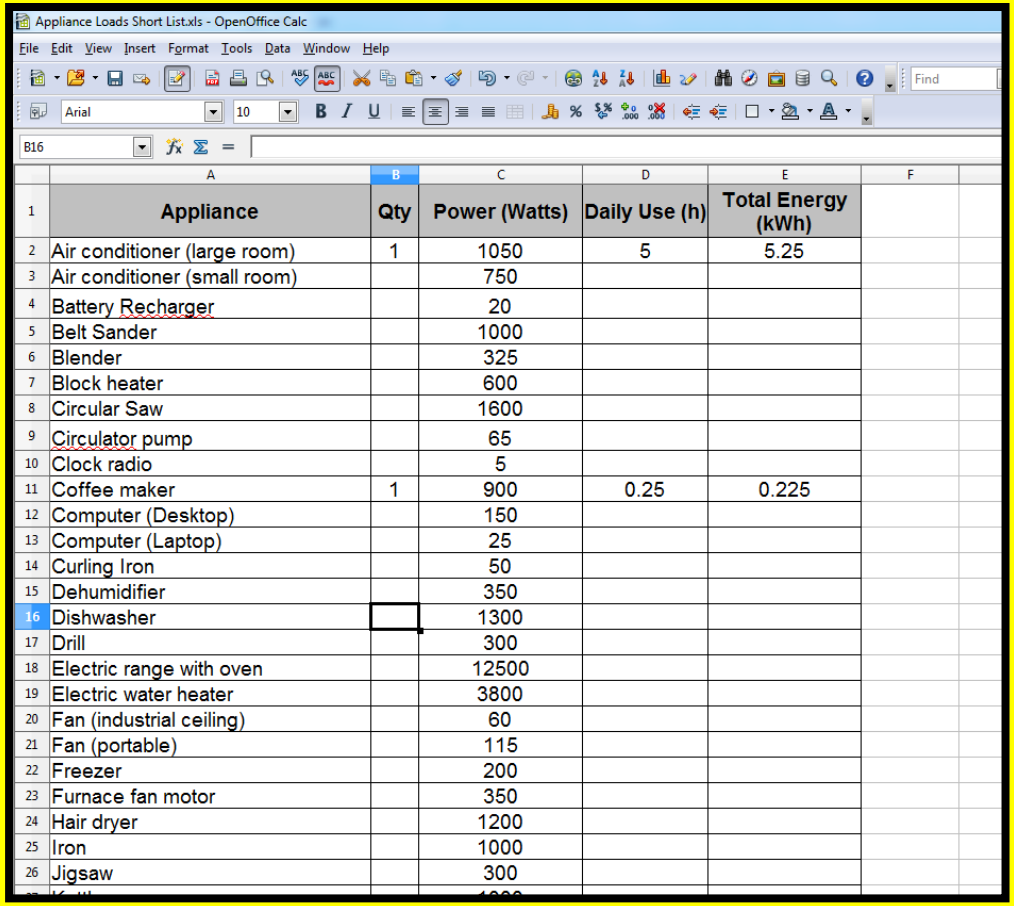
- Net Metering
  - RE used by house – extra reverses meter
  - Monthly credits carried forward effectively annualizing solar output
  - Size system to be no more than expected annual kWh consumption
  - As price of electricity increases, benefit of initial investment increases

Energy Audit

- Full Energy Audit
  - New Energy, Ptbo GreenUp
  - Typically $400 or $500
  - Look at insulation, windows, lighting, heating system, blower door test for leakage
  - Full report recommending upgrades
  - Best money spent is on conservation

Energy Audit

- Basic Electrical Energy Audit
  - Take stock of your electrical loads
  - Get a kill-a-watt meter
  - Look for phan-tom loads
  - Review electrical bills and look for patterns



Appliance Loads Short List.xls - OpenOffice Calc

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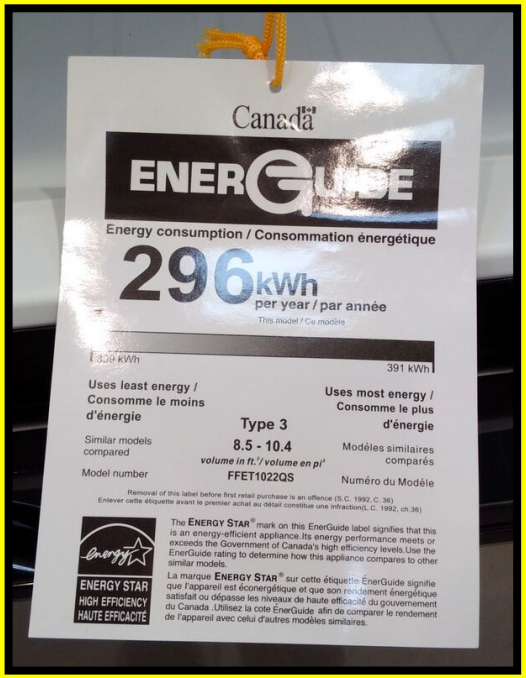
	A	B	C	D	E	F
1	**Appliance**	**Qty**	**Power (Watts)**	**Daily Use (h)**	**Total Energy (kWh)**	
2	Air conditioner (large room)	1	1050	5	5.25	
3	Air conditioner (small room)		750			
4	Battery Recharger		20			
5	Belt Sander		1000			
6	Blender		325			
7	Block heater		600			
8	Circular Saw		1600			
9	Circulator pump		65			
10	Clock radio		5			
11	Coffee maker	1	900	0.25	0.225	
12	Computer (Desktop)		150			
13	Computer (Laptop)		25			
14	Curling Iron		50			
15	Dehumidifier		350			
16	Dishwasher		1300			
17	Drill		300			
18	Electric range with oven		12500			
19	Electric water heater		3800			
20	Fan (industrial ceiling)		60			
21	Fan (portable)		115			
22	Freezer		200			
23	Furnace fan motor		350			
24	Hair dryer		1200			
25	Iron		1000			
26	Jigsaw		300			

Energy Audit

- What to do?
  - Low hanging fruit – LED lighting, phantom loads (use power bars), shift to off-peak usage, clothes line, timers, jacket for water heater
  - When buying new appliances find most energy efficient models



Living with Renewable Energy

- As an installer my goal is to make it is seamless as possible
- For off-grid customers
  - Maintenance free batteries
  - Automatic generator start
  - Basic voltages to watch for
- For grid-tie customers
  - Monitor system output regularly

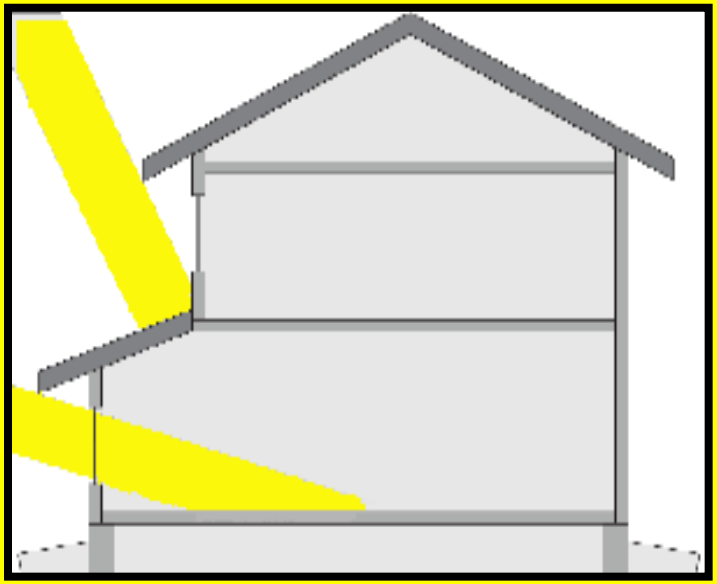
Living with Renewable Energy

- What to expect
  - For grid-tie solar
    - more money in your pocket
    - a warm fuzzy feeling
  - For off-grid solar
    - closer monitoring of system
    - unplanned power outages
    - the feeling that no matter how many times you ask people to turn off lights you will never get them to fully comply
    - eventual battery replacement
    - deeper understanding of energy use

Assemble Portable System

Bonus Tracks

- Passive solar as part of the building design
  - consider roof overhang, location & quality of windows, types of glazing
  - cost is minimal, savings are annual & increase as fuel prices increase



Bonus Tracks

- Solar Air Heaters
  - Relatively inexpensive and simple
  - Easy to heat air quickly, but no thermal mass
  - $ / Btu produced is not great (unless DIY)
  - Windows are generally better