Gathering Summary, June 23, 2010: Alternative & Renewable Energy Part 1

A Presentation by Jeff Arcel

Summary *[and additional text]* by Catherine Haug.

This summary has been divided into two parts to minimize file size. See Alternative Energy Gathering Summary Part 2.

A 2 MB pdf version of Jeff's slide presentation is available: Renewable Energy Solutions.

[NOTE: Urls for all links shown in References section].

Introduction

(Photo of rooftop solar, above, from Mothers' Power; original source unknown)

Jeff's business, Mothers' Power, specializes in renewable energy system design & installation for residential, commercial and community use. *[NOTE: not all alternative energy schemes are 'renewable' in a strict sense.]*

He opened with a bit of history of solar and wind energy applications. The harnessing of solar energy for electricity production by use of photovoltaics (PV) was invented in the 1940s and perfected during the 1960s space race. He notes that DaVinci predicted solar industrialization in 1447. [*However, solar energy applications go back much farther; for example, the use of glass or reflective objects to spark a fire by concentrating solar rays on a point dates back to 7th century BC. The first solar collector (as for cooking) was invented in the 1700s. For a more detailed history of solar milestones, see US Department of Energy, The History of Solar. (1)*]

The harnessing of wind power for generating electricity was promoted in the US by Charles F. Brush, in the late 1800s. [*Harnessing wind energy for mechanical use such as grinding grain dates back to 500-900 AD. For a more detailed history of wind energy, see Telos.com or US Department of Energy, The History of Wind Energy. (3.4)*]

Many alternative energy applications are currently being used for 'point of use' or local power generation, to support off-grid and remote power needs. And as costs for the equipment come down, this becomes even more feasible.

The most common types currently deployed are:

- Solar power (PV cells)
- Solar thermal (heat and hot water systems)
- Wind power (mechanical or electrical applications)
- Hydropower (see part 2)
- Geothermal (see part 2)

Harnessing the Sun's Energy

The total solar energy absorbed by Earth's atmosphere, oceans and land masses is approximately 3850 zettajoules (ZJ) * per year. In 2006, this was more energy in one hour, than the world used in a year! There is tremendous potential here - more energy in one year than we can ever obtain from all of Earth's non-renewable fossil fuels. *[However, life itself consumes much of this energy, and of what remains, our attempts to harness it are inefficient.]*

** a Joule is a measure of energy in the international system of units. To put things in perspective, one Joule is the energy required to lift a small apple straight up a distance of one meter (about 1 yard). A 'zettajoule' is a huge amount of energy, equal to 10^{21} Joules.* (5)

Solar Power: Photovoltaics

PV works by utilizing the 'photon effect' that happens when an energy particle from the sun hits silicon (or other substances such as thin film solar), and releases an electron, thus producing electricity.

While the US accounts for only 5% of the world's population, we consume 26% of the world's energy. Today about 2 billion people world-wide live without electricity. Shell Oil predicts that by 2040, 50% of the world's energy will come from renewable sources.

Solar Insolation*

(Map image from Wikipedia (5))

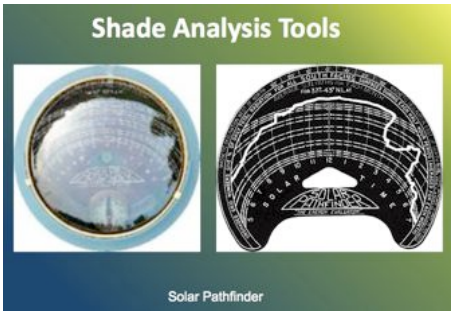
**Insolation is "a measure of solar radiation energy received on a given surface area in a given time." (5) "By knowing the insolation levels of a particular region we can determine the size of solar collector that is required." (6).*

The amount of insolation varies by geographic region; average insolation tables & maps are available from the National Renewable Energy Laboratory (NREL (7)). On average, Montana has about 30% more solar irradiance than Germany or Japan. *[The Solar Insolation Map of the US (shown above), and a similar map for Europe are available on Wikipedia (5).]*

Average Cost for a Residential System

Right now the cost starts at about $6 per watt for a grid-tie system, or $10-$12 per watt for off-grid use, including battery backup. Thus a 1 KW grid-tie system costs about $6000 installed. The average home uses about 1000 KW Hours per month (use spans 600 - 10,000 KW Hours/month). Your use will depend upon your home's load; there are things you can easily do to decrease your load about 20%.

Using solar gives a real appreciation for what electrical items to use and when.



Shade Analysis

(*Image of Solar Pathfinder from Mothers' Power, originally from Solar Pathfinder: How it Works*)

Solar efficiency depends upon the sun's path relative to the PV panel and the horizon.

Obviously, shade over a solar device limits the amount of energy that can be harnessed. Ideally, you want no shade over the panel between 9 AM and 3 PM. the solar pathfinder tool is used to determine the effect of shade. You can view a video of the tool in action on the Solar Pathfinder website (8).

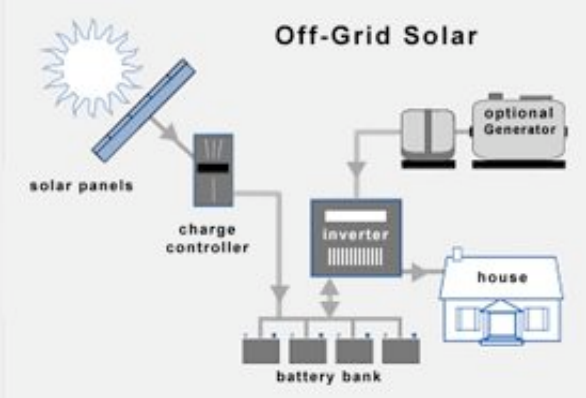
Rapid PV Solar Growth

While PV production has been doubling every 2 years since 2002, the cost has dropped 90% in the last 20 years, and is predicted to drop another 50% in the net 5 years. The US is the third largest world market, growing 36% last year.

Typical Solar Systems

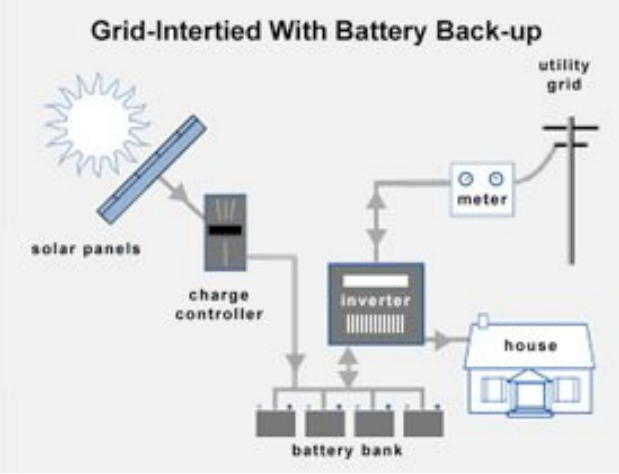
Off-grid system

(Image, right, from Wholesale Solar (9))



A typical system consists of:

- Solar Module: PV cells to collect the sun's energy and covert it to DC power;
- Charge Controller: regulates power to the batteries so they don't over-charge;
- Battery Bank: stores power for evening hours;
- Inverter: converts DC power from the PV cells to AC Power for use in the home;
- Backup Generator: standby power when battery bank is low (optional).



Grid-tie system

(Image, left, form Wholesale Solar (9))

Connects to local power company at the meter, allowing supplementation by grid power on as-needed basis. It consists of:

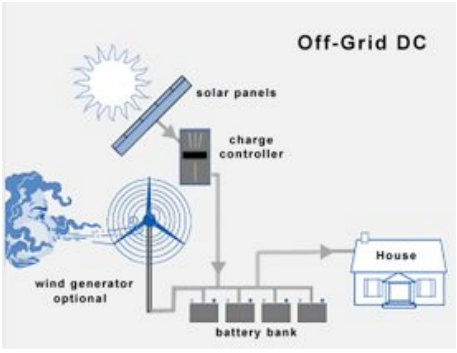
•Solar Module: PV cells to collect the sun's energy and covert it to DC power;

•Inverter: converts DC power from the PV cells to AC Power for use in the home;

•Power meter from local power company and their utility grid;

•Optional battery pack.

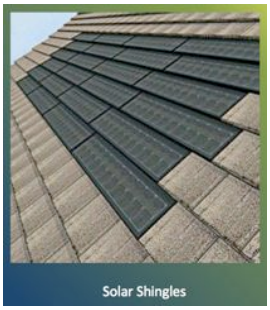
Hybrid system



(Image, right, from Wholesale Solar (9))

Hybrid systems utilize power generated from multiple sources such as wind and solar, to optimize available power during different conditions.

PV Options



(Image, left) from Mothers' Power; original source unknown)

Newer technologies incorporate PV into roof shingles or metal roofing, but these are less efficient than traditional panels.

Jeff provided several photos of different solar and hybrid installations; see his slideshow pdf.

Solar Thermal

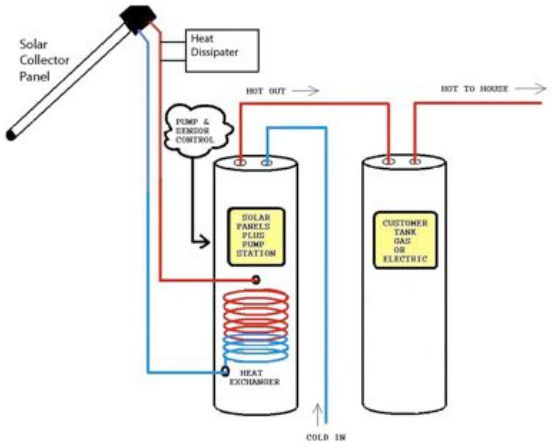
(image, right from Mothers' Power; original source unknown)

Solar thermal systems are typically used to provide heat and/or hot water. Jeff discussed only the closed-loop hot water systems.

Solar Hot Water

(Image, below, from Solar Panels Plus)

These systems come in both open-loop and closed-loop types. Open loop systems cycle the water through the solar panels to heat it directly; closed loop systems heat an intermediate medium such as glycol (antifreeze), which in turn heats water through a heat exchanger.



The panels for a closed loop system (shown above) are comprised of glass tubes with a copper heat transfer mechanism. See Solar Panels Plus: How Solar Hot Water Heaters Work for a great description; their diagram is shown, left (10).

These systems will typically heat water to 160° F, and provide about 80% of hot water need. Cells must be less than 100' from the tank.

See also: How to Build a Solar Hot Water System, by John Canivan. (10)

Sources & References

1. US Dept. Energy, The History of Solar: www1.eere.energy.gov/solar/pdfs/solar_timeline.pdf
2. Alternative Energy Sources, History of Solar: www.alternate-energy-sources.com/history-of-solar-energy.html
3. Telos.com: History of Wind Energy: www.telosnet.com/wind/
4. US Dept. Energy, The History of Wind Energy: www1.eere.energy.gov/windandhydro/wind_history.html; Geothermal Heat Pumps: www1.eere.energy.gov/geothermal/heatpumps.html and www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12640
5. Wikipedia on 'Joule': en.wikipedia.org/wiki/Joule; on 'Insolation' en.wikipedia.org/wiki/Insolation;
6. Apricus Solar Hot Water, on Insolation: www.apricus.com/html/solar_collector_insolation.htm
7. NREL: www.nrel.gov; PV Solar Radiation maps: www.nrel.gov/gis/solar.html
8. Solar Pathfinder: How it works: www.solarpathfinder.com/works; video: www.solarpathfinder.com/video
9. Wholesale Solar: Off-grid solar diagrams: www.wholesalesolar.com/products.folder/systems-folder/OFFGRID.html; Grid-Tie diagram: www.wholesalesolar.com/products.folder/systems-folder/GRIDTIE.html
10. Solar hot water closed loop: www.solarpanelsplus.com/thermal-how-it-works/ and diagram: www.solarpanelsplus.com/thermal-how-it-works/closed-loop-solar.html
11. Build Solar Hot Water System: www.jc-solarhomes.com/how_to.htm
12. Riverstar In-Stream Hydro System; www.bourneenergy.com/future.html
13. Geothermal Energy Office (GEO): geothermal.marin.org/
14. CBS 60-Minutes Feature on the Bloom Box: www.cbsnews.com/stories/2010/02/18/60minutes/main6221135.shtml
15. Celsias on Geothermal Power: www.celsias.com/article/world-geothermal-power-generation-nearing-eruption/
16. Renewable Energy World on geo-electricity: www.renewableenergyworld.com/rea/tech/geoelectricity
17. The EssentiaList: Rail Transit in the Flathead: essentialstuff.org/index.php/2010/04/15/Cat/rail-transit-in-flathead/
18. Who Killed the Electric Car?: trailer: www.youtube.com/watch?v=nsJAlrYjGz8; summary: en.wikipedia.org/wiki/Who_Killed_the_Electric_Car%253F
19. Alternative Energy News: on Nanosolar: www.alternative-energy-news.info/nanosolar-solar-power-lower-cost; on Thin Film PV: www.alternative-energy-news.info/press/printed-thin-film-photovoltaics-batteries/