De Anza ES 79 Renewable and Alternative Energy Systems

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Instructor

Course Objectives

- Understand basic renewable technology terminology
- Discuss life-cycle costs of alternative energy options
- Explore the technology and applications of renewable and alternative energy systems as they apply to commercial buildings.
- Examine existing and potential applications of photovoltaic (PV) power systems.
- Examine existing and potential applications of wind power.
- Examine potential applications and types of fuel cells.
- Analyze opportunities for buying green power.

Logistics

- http://bhs.deanza.edu/faculty/sGould/index.htm
- Field Trip…
- Reading assignments
- Homework assignments
- Journal
- Grading
- Sign up for "empt" listserve
- Email is scott.gould@stanford.edu

Homework Assignments

- Homework Assignment – "Fill in"
- Field Trip Report
- Current Event or brief project description in class (5 min)
- Small Scale Renewable Design Project with class discussion

Reading Assignments

- 'Solar Energy Resource Guide'
  - Read articles before next class
- Review Articles on Website
- Optional – 'Solar Living Source Book'
  - Chapters 2,3,5,&7

Introduction

- What are renewable energy sources when compared with non-renewable?
- Remember it is more cost efficient to manage your "demand" before sizing a new "supply" system.
- We want lighting, heating, and cooling not kW and kWh.

·Renewable energy: an energy source that news itself without effort: fossil fuels, once consumed, are gone forever, while solar energy is renewable in that the sun we harvest today has no effect on the sun we can harvest tomorrow.

"Solar Living Sourcebook" (p. 493)

Renewable Sources Include:

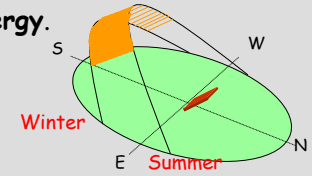
- Solar
- Wind
- Biomass
- Hydrogen
- Geothermal
- Hydroelectric
- Ocean Energy

Solar Orientation

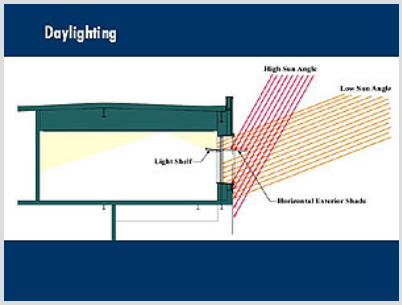
- Sun Location
  - Longitude/Latitude
    - DeAnza approx. 37.5 degrees Latitude & 122 degrees Longitude
  - Seasonal
  - Daily
- Building Design & Orientation

Area, Tilt and Orientation

- Area and efficiency determines **Power**.
- Tilt and orientation determines **Energy**.



Light Shelf Winter/Summer

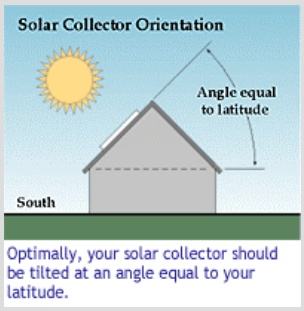


Basic Terminology -- Review

- Solar constant ---
- Insolation or (Incident Solar Radiation)
- "One Sun" = 1000 W/meter^2
- Azimuth
- Altitude Angle

Solar Panel Orientation

- True south is best
- Can deviate from south with some losses
- West is better than east for most coastal locations and time-of-use rates
- Consider shade



http://www.eere.energy.gov/consumerinfo/makeelectricity/eval_pv_resource.html

Net Metering

- No Federal law, but 33 states allow renewable power producers to "sell" excess power
- E-Net program – PG&E
  - Annual True-up
  - Utilities need safe, reliable power
  - Works for PV,wind, etc
- Rebates

Photovoltaic Power

- Issues
  - Where is the sun intense enough to make photovoltaics practical?
  - Are PVs competitive with other renewable energy sources?
  - What about codes & community acceptance?

Photovoltaic Basics

- Electron "pump"
- Thin semi-conductor sandwich is coated with boron and phosphorus
- Sunlight hits the cell and creates a voltage difference between the two sides
- Creates about .5 volts per cell

PV Basics Continued

- Cell – basic unit
- Module – collection of cells (with glass)
- Array – collection of Modules

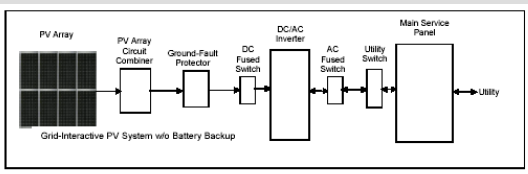
PV Types

- Stand Alone
  - Solar Pump – PV direct
  - Communication Satellites
  - Solar Powered Buoys (NOAA)
  - Stand Alone with batteries
    - Rural Electrification
- Grid intertie – Meter goes backwards!
  - Grid intertie with batteries

PV Types

- Crystalline silicon
  - Single Crystalline
  - Poly or Multicrystalline
- Thin film (amorphous) systems
- Concentrators
- Tracking devices
- BIPV – Building Integrated PV

Typical PV Set-up



CEC report "A Guide to Photovoltaic (PV) System Design and Installation" June 01

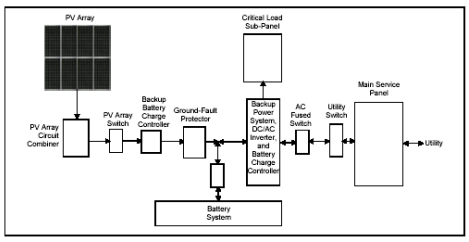
Battery Backup Systems

- Do you need back-up power?
- If so, for how long?
  - Consider climate and sun (or wind) conditions
  - 3 to 5 days back-up is typical
- Advantages
- Disadvantages

Battery Components

In addition to components listed in 2.1.1., a battery backup system may include some or all of the following:

1. batteries and battery enclosures
2. Battery charge controller
3. separate subpanel(s) for critical load circuits



CEC report "A Guide to Photovoltaic (PV) System Design and Installation" June 0

Sizing a Photovoltaic System

- Estimate load both kW and kWh
- Implement Conservation/Energy Management.
- Determine load type (when do you need power?)
- Consider reliability
- Batteries
- Estimate available sun light

Factors Affecting Output

- STC – Standard Test Conditions -- 95%
- Temperature -- 89%
- Dirt – 93%
- Wiring Losses – 95%
- DC to AC conversion – 90%

Solar Issues

- Your location relative to the sun
- Orientation of the solar panels
- Tilt angle of the solar panels
- Insolation
- Local Shading
- Available room for panels

Estimating Peak Demand

Peak demand (kW) =
Largest monthly bill in (kWh/mo)/
(Load factor x days on bill x 24)

Residential load factor = .48
Small Commercial load factor =.47

PV Sizing Cont.

- Consumer Energy Center
http://www.consumerenergycenter.com/renewable/estimator/

- 'PV Watts' online sizing program
http://rredc.nrel.gov/solar/codes_algs/PVWATTS/

Annual Energy Production

CITY	kWh/kWstc (range)
Arcata	1092 - 1365
Shasta	1345 - 1681
San Francisco	1379 - 1724
Sacramento	1455 - 1819
Fresno	1505 - 1881
Santa Maria	1422 - 1778
Barstow	1646 - 2058
Los Angeles	1406 - 1758
San Diego	1406 - 1758

Table 2: Annual Energy Production by City per kW_{STC} array rating

CEC report "A Guide to Photovoltaic (PV) System Design and Installation" June 0

Correction Factor - Orientation

	Flat	4:12	7:12	12:12	21:12	Vertical
South	0.89	0.97	1.00	0.97	0.89	0.58
SSE,SSW	0.89	0.97	0.99	0.96	0.88	0.59
SE, SW	0.89	0.95	0.96	0.93	0.85	0.60
ESE,WSW	0.89	0.92	0.91	0.87	0.79	0.57
E, W	0.89	0.88	0.84	0.78	0.70	0.52

Table 1: Orientation Factors for Various Roof Pitches and Directions

CEC report "A Guide to Photovoltaic (PV) System Design and Installation" June 0

Quick Calculation Based on Consumption

- Size Your PV System
  - Need annual energy consumption
  - Energy production factor
  - Orientation-tilt factor
  - (Battery loss factor)

Quick Calculation– Based on Production

- How much will your PV system produce?
  - Need System size (kW)
  - Energy production factor
  - Orientation-tilt factor

PTC v STC

- STC -- Standard Test Conditions are defined by a module (cell) operating temperature of 25o C (77 F), and incident solar irradiance level of 1000 W/m2 and under Air Mass 1.5 spectral distribution. Since these conditions are not always typical of how PV modules and arrays operate in the field, actual performance is usually 85 to 90 percent of the STC rating.
- PTC -- PTC stands for "PVUSA Test Conditions." PTC watt rating is based on 1000 Watt/m^2 solar irrandiance, 20 degree Celsius ambient temperature, and 1 meter/second wind speed. The PTC watt rating is lower than the "Standard Test Conditions" (STC), a watt-rating used by manufacturers.

Solar Thermal

- Potential Uses Include:
  - Heating hot water
  - Space heating
  - Pool heating
- Benefits
  - California -Replaces natural gas consumption & associated pollution

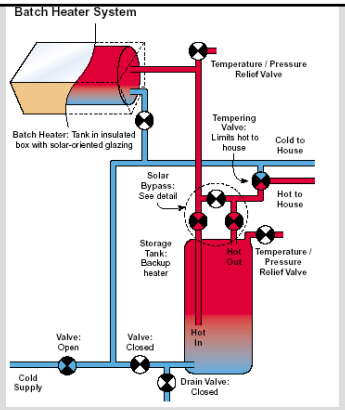
Solar Thermal Applications

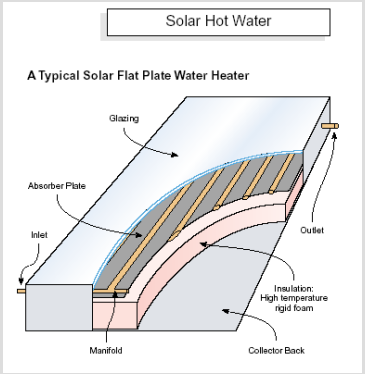
- Residential Example
  - Conservation first!
    - Turn down water heater (125F?)
    - Water heater blanket
    - Fix drips
    - Flow restrictors and aerators
    - Insulate pipes

Solar Thermal System Types

- Batch heaters (breadbox)
  - Collection and Storage together
  - Inexpensive & Simple
  - Compromise full benefits?
- Flat Plate Collectors
  - Separate Storage and Collection
  - Closed loop (in-direct) and open loop (direct)
  - Freeze Protection
  - Active v Passive Systems

A 40 gallon batch heater.





Solar Thermal Pools

- Ideal Solar Application?
  - Size to ½ the pool area
  - $2 to 4 K –
- Components
  - Solar collector
  - Filter
  - Pump
  - Flow control valve

Homework Assignment

Size your own Renewable Energy (RE) system

1. Estimate load (kWh)
   1. PG&E bill
   2. Home Energy Article
2. Size system kW
   1. Consumer Energy Website
   2. Self Generation Rebate technique
   3. Orientation and Production Slides
3. List Assumptions!!!!!

Review

- Course Objectives
- Basic terminology
- Homework assignment
- Reading material