Solar Technology Nuts and Bolts

Erin Whitney, Moderator
April 30, 2015

Panelists:
Dr. Daisy Huang, UAF
Greg Egan, Remote Power Inc.
Robert Bensin, Bering Straits Development Company
Photovoltaic Solar Resource: United States and Germany

Annual average solar resource data are for a solar collector oriented toward the south at a tilt = local latitude. The data for Hawaii and the 48 contiguous states are derived from a model developed at SUNY-Albany using geostationary weather satellite data for the period 1998-2005. The data for Alaska are derived from a 40-km satellite and surface cloud cover database for the period 1986-1991 (NREL, 2003). The data for Germany were acquired from the Joint Research Centre of the European Commission and is the yearly sum of global irradiation on an optimally-inclined surface for the period 1981-1990.

This map was produced by the National Renewable Energy Laboratory for the U.S. Department of Energy in May 2008.
Photovoltaic Solar Resource: Flat Plate Tilted South at Latitude

April

Annual average solar resource data is shown for a tilt = latitude collector. The data for Hawaii and the 48 contiguous states is a 10 km, satellite modeled dataset (SUNY/NREL, 2007) representing data from 1998-2005. The data for Alaska is a 40 km dataset produced by the Climatological Solar Radiation Model (NREL, 2003).

This map was produced by the National Renewable Energy Laboratory for the U.S. Department of Energy. December, 2008.
Bottom-up Modeled System Price of PV Systems by Sector, Q4 ’09 - Q4 ‘13

NREL
OFF-GRID SYSTEM

SOLAR ARRAY

CHARGE CONTROLLER

BATTERY BANK

DC TO AC INVERTER

NO GRID REQUIRED

AC CURRENT

AC POWER OUTLET

DC POWER LOAD
Grid - Tied

Array or PV Power Source

Panel
Module

Combiner Box
DC (PV) Disconnect

DC Breaker Panel

Kilowatt Hour Meter
AC Breaker Panel
AC Disconnect

Inverter

Utility

to Household Loads

to DC Loads
Panelists

- Dr. Daisy Huang, UAF
- Greg Egan, President, Remote Power Inc.
- Robert Bensin, Bering Straits Development Company
Panel Topics

• Resource assessment and array placement (Daisy)
  ▫ Performance optimization

• System design (Greg)

• Choosing your PV modules (Greg)
  ▫ Balancing capital costs with performance and O&M

• Insuring proper installation of systems (Rob)
  ▫ Code requirements, training, and certification

• Mounting/racking of systems (Greg)
  ▫ Tracking systems, sub-arctic and arctic environments

• Inverters and other system components (Rob)

• System monitoring and O&M (Daisy)
  ▫ Balancing capital costs with performance and O&M
Resource assessment and array placement

Dr. Daisy Huang
UAF
Why solar in the Arctic at all?

- Cold weather performance
- Albedo
- Exceptionally clear air
- No moving parts
- Peak load doesn’t necessary match peak production, but that’s okay as long as penetration levels are low.
PV output vs. temperature

image source: http://www.solarpower2day.net/solar-cells/efficiency/
Resource assessment and array placement

• Why is resource assessment and array placement important?
• Why can’t we just use weather data or projections?
• Placement of arrays to maximize production through the day (i.e., NWAB)
• Tracking doesn’t necessary work well
• Array placement for serviceability
PV Watts

SYSTEM INFO

Modify the inputs below to run the simulation.

- **DC System Size (kW):** 4
- **Module Type:** Standard
- **Array Type:** Fixed (open rack)
- **System Losses (%):** 14
- **Tilt (deg):** 20
- **Azimuth (deg):** 180

**Advanced Parameters**

**INITIAL ECONOMICS (Optional)**

Modify the inputs below to provide an initial rough estimate of the cost of energy produced by the system. Note that complex utility rates and third-party financing can significantly change these values.

- **System Type:** Residential
Solar data collection at UAF
Circular Array on Deering Water Tower, NWAB

(July 2014)

image credit: Robert Bensin
Nearly Constant Production in Noatak, NWAB

(July 2014)

image credit: Robert Bensin
System Design

Greg Egan
Remote Power Inc.
PV System Design

• Contact the utility as early as possible
  ▫ Find out local requirements
  ▫ System size limits
  ▫ All permits, paperwork submitted first
Design for long term value

- 30 + year PV module service life
- Rugged.
- Quality components
- Climate appropriate
- Safe and secure
- Ease of maintenance
Variability of Latitude Fixed-Tilt Radiation

Monthly Radiation (kWh/m²/day)

1961-1990 Average

Mid Apr. - Mid Oct.  
28.5 / 6 = 4.75

Annualized  
28.5 / 12 = 2.4 Avg. Sun Hrs/day
Mid Apr. - Mid Oct. = 28.5
Mid Oct. - Mid Apr. = 12.6
41.1 / 12 = 3.4 Avg Sun Hrs/day
Choosing your PV modules

Greg Egan
Remote Power Inc.
PV Modules – Information overload!

- Over 1000 crystalline PV module manufacturers
  - 544 in China alone!
  - 100+ companies fail each year
  - No warranty, no customer service

- Well established companies may be the smartest choice for the long term investment
Rugged & reliable

- Mono or Multi-crystalline
- Strong frames
- Lighter=better?
- Cell efficiency
- Panel efficiency
- Marketing efficiency?
Design Improvements
Insuring Proper Installation of Systems

Robert Bensin
Bering Straits Development Company
Insuring Proper Installation

- Code requirements
- Training
- Certification
Mounting/racking of systems

Greg Egan
Remote Power Inc.
PV array mounting systems

- Robust & reliable
- Wind loading
- Adjustable
- Security/Safety issues
- Roof mounting not always best
- Custom installations are the norm
Wall Mount
Non-penetrating, adjustable roof mount

©2010 Remote Power Inc.
Top of pole, ground mounts
Dual axis tracking arrays
Inverters and other system components

Robert Bensin
Bering Straits Development Company
System monitoring and O&M

Dr. Daisy Huang

UAF
System Monitoring

- What kind of data collection is valuable?
  - Performance data
  - Shade data
  - Snow-cover data
O&M

- Ice/frost accumulation
- Snow accumulation vs. removal
- Mechanical damage from wind, humans, etc.
Snow Shedding Study

- Four each of simulated solar panels: one set actively cleared, the second left to shed naturally.
  - Mean time between active clearing: 7 days
- Extrapolation to a 1-MW array (4200 panels), per winter season:
  - Extra solar power generation by actively clearing panels: $18,800, 3.7% more than panels left to self-clear
  - Labor costs of actively clearing panels: $49,200
- Observations:
  - Panels often naturally shed.
  - Occasional frost accumulation naturally sublimated within days.