Solar Insolation: Alaska ≈ Germany
What’s Unique About Solar PV

• NO MOVING PARTS!
• 25 year warranty
• Operates only when the sun is shining
  – Can extend this with trackers or energy storage, but then you have moving parts, hazards, etc.
• Clouds have very significant, and rapid, impact on power production (difficult integration)
• Always direct current (but so are batteries)
• Policy Incentives...
What’s NOT Unique About Solar PV

• Policy Incentives
• Prices for modules are plummeting
• Grid integration can be a major challenge
• Modern inverters produce high quality power, but are subject to the weakest link in the system
• It’s difficult (or at least expensive and inefficient) to store the energy
• In rural Alaska, except for small applications (fish camps, hunting cabins, etc), power systems are not built around PV (diesel is still king)
• No “silver bullet” solutions, but each technology & resource can contribute to diesel savings
Community Solar in China

China, Yushu Valley, 2 MW PV Plant – Courtesy of Lu Fang.

IEA – PVPS Report, 2013
Community Solar in Kaltag, AK

- Utility (AVEC) ownership, construction, O&M

- The first year of operation (2013) produced approximately 8,200 kWh—fuel cost savings of ~$1,800

- Performance prediction (prior to installation) was correct
High Latitude Adaptation: “Rooftop” Solar?
Steady March of Progress

Best Research-Cell Efficiencies

Multijunction Cells (2-terminal, monolithic)
- Three-junction (concentrator)
- Three-junction (non-concentrator)
- Two-junction (concentrator)
- Two-junction (non-concentrator)
- Four-junction or more (non-concentrator)

Single-Junction GaAs
- Single crystal
- Concentrator
- Thin-film crystal

Crystalline Si Cells
- Single crystal
- Multicrystalline
- Thick Si film
- Silicon heterostructures (HT)
- Thin-film crystal

Thin-Film Technologies
- Cu(In,Ga)Se_2
- CdTe
- Amorphous Si:H (stabilized)
- Nano-, micro-, poly-Si
- Multijunction polycrystalline

Emerging PV
- Dye-sensitized cells
- Organic cells (various types)
- Organic tandem cells
- Inorganic cells
- Quantum dot cells

Efficiency (%) vs. Year

Institutes and Companies
- IBM (T.J. Watson Research Center)
- Sandia National Lab
- Westinghouse
- ARCO
- UNSW
- Stanford
- Varian
- NREL
- SunPower
- Spire
- UNSW
- Georgia Tech
- NREL
- Varian
- UNSW
- UNSW/EuroSolare
- University of So. Florida
- Boeing
- ARCO
- AMETEK
- Photonic Energy
- ARCO
- United Solar
- EPFL
- EPFL
- University of Maine
- Toshiba
- Boeing
- Kodak
- Solar Systems
- United Solar
- University of Linz
- University of Toronto
- NREL
- Konarka
- Konarka
- UCLA-Sumitomo Chemical
- UCLA
- NREL (CfTe/CIS)
- Sharp (large-area)
- Sharp (small-area)
- Sharp (45 µm thin-film transfer)
Solar & Diesel Cost Trends, 2001 - 2011

Source: Navigant Research
Village of Ugashik

Hybrid Performance Monitoring Project

- Working with ACEP at UAF, AEA
- Monitoring performance of wind-diesel-battery hybrid system to determine relative contribution of various RE inputs and diesel savings for system optimization
- Results replicable for other projects in region and beyond
- Very windy site (class 5), but PV performed as well as wind on kWh/kW installed basis, and better on a $/kW installed basis with current pricing
Ugashik Hybrid Power: Wind, Solar, Diesel, Battery
Supply & Demand – Do They Match Up?

Monthly Solar Radiation for Select Alaska Communities

- Kake, AK (Fixed Tilt)
- Barrow, AK (Fixed Tilt)
- Anchorage AK (Fixed Tilt)

Monthly Peak Electricity Demand for Select Alaska Fishing Communities, 2011

- Cordova
- Dillingham, Aleknagik
- Unalaska
To Track or Not to Track?

Cold Climate Housing Research Center – 4 different PV arrays

<table>
<thead>
<tr>
<th>Solar array type</th>
<th>kWhrs 2009</th>
<th>kW</th>
<th>Trking</th>
<th>Si</th>
<th>kWhrs norm’ed</th>
<th>Annual Cap Factor</th>
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<td>SB3000/A1/JXC 180</td>
<td>2156.52</td>
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<td>N</td>
<td>Mono</td>
<td>968.6969697</td>
<td>11.06%</td>
</tr>
</tbody>
</table>

In Fairbanks, dual axis tracking results in ~ 40% increase in capacity factor, all else being equal

Data courtesy CCHRC; Analysis courtesy Rich Stromberg, AEA
Differing Perspectives (Kodak vs. ATT)

March 25th, 2014

http://www.rmi.org/electricity_grid_defection
PATH 1 INTEGRATED GRID

One path leads to grid-optimized smart solar, transactive solar-plus-battery systems, and ultimately, an integrated, optimized grid in which customer-sited DERs such as solar PV and batteries contribute value and services alongside traditional grid assets.

Pricing & Rate Reform
New Business Models
New Regulatory Models

PATH 2 GRID DEFECTION

Another path favors non-exporting solar PV, behind-the-meter solar-plus-battery systems, and ultimately, actual grid defection resulting in an overbuilt system with excess sunk capital and stranded assets on both sides of the meter.

Solar PV and batteries play an important role in the future electricity grid, but decisions made today will encourage vastly different outcomes.
Issues to Consider for a Successful Project

• **First Things First: Save before you spend!**
  – Diesel Efficiency
  – End use efficiency
  – Education

• **Reasonable Expectations**
  – Resource Availability
  – Load
  – Technology
  – Existing Infrastructure
  – Ownership structure
  – Grid Integration
  – Fixed vs. Variable costs
  – CapEx; O&M
  –Aggregate/Economies of Scale
  – Integrate with new Housing

• **People**

• **Money**
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