The Inevitable Solar School: Building the Sustainable Schools of the Future, Today

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Presented by:
Mark Hanson
Why is the massive implementation of solar energy in our schools portrayed in media and social media as daunting?

- PV solar systems technology is developed and already affordable
- Supply chain is developed and explosively growing
- Financial tools are there
- Educational programs are emerging to support renewable energy
- Investors have entered the market

- Myths and Fears?
Declining Module (panel) Price

Source: Haegel et al., Science April 2017
Photovoltaic Solar Resource: United States - Spain - 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 1989-1991 (NREL, 2003). The data for Germany and Spain were acquired from the Joint Research Centre of the European Commission and is the yearly sum of global radiation on an optimally-tilted surface for the period 1981-1990. States and countries are shown to scale, except for Alaska.
What are the procurement options for solar PV systems, and how do they vary by state?

- **Direct Purchase**

- **Third Party Investors for on-site PV systems**
  - Energy Services Agreement
  - Equipment loan
  - Power Purchase Agreement
  - Rent-a-Roof (utility may be provider)
  - Remote PV system site (sleeve tariff)

- **Third Party Investors with option to purchase**
  - Available for some of options noted above
  - Performance contracting
Five Case Studies of Zero Energy Schools

- Northland Pines HS/MS – Eagle River, WI
  - Part way to zero energy
- Discovery Elementary – Arlington, VA
- Jeffrey Trail MS – Irvine, CA
  - Part way to zero energy
- Newcastle Elementary – Newcastle, CA
- Richardsville Elementary – Bowling Green, KY
Solar PV Systems at Northland Pines School District, Eagle River, WI

HS/MS (Energy Services Agreement)
• 250,000 sf school completed in 2006 with solar PV added in 2017
• Site EUI 66.5 kBtu/sf/year in 2013
• 160 kW-dc roof
• 70 kW-dc ground mount

Eagle River Elementary (Energy Services Agreement)
• 100 kW-dc ground mount added in 2017

Land O’ Lakes Elementary (Rent a Roof)
• 100 kW-dc ground mount added in 2020
Northland Pines Procurement Process and Timeline

Planning Phase 1 - Site and Financial Analysis: December 2016 to April 2017 (cash flow positive required)

Planning Phase 2 – Incentives, Competitive Bidding, and Financing: April to July 2017

Implementation Phase 3 – Contracting, Installation, and Start-up: July to November 2017

Interconnection (November 2017)

Interconnection with We Energies at Land O’ Lakes Elementary using Rent a Roof in January 2020
HS/MS PV System Arrays on Northland Pines Field House
Eagle River Elementary School – Ground Mounted 100.2 kW DC:
Rent a Roof Solar at Land O’ Lakes Elementary School
Northland Pines HS/MS & Eagle River Elementary Cash Flow

Cash Flow Estimate

Northland Pines HS/MS & Eagle River Elementary Cash Flow

- Annual Cash Flow
- Cumulative Cash Flow

YEARS

YEARS

$900,000
$800,000
$700,000
$600,000
$500,000
$400,000
$300,000
$200,000
$100,000
$-

$100,000
$(-100,000)
$(200,000)
# Impact of Solar PV and Energy Efficiency at Northland Pines HS/MS

<table>
<thead>
<tr>
<th></th>
<th>2016</th>
<th>2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Electricity Use (MWh)</td>
<td>1509</td>
<td>1015</td>
</tr>
<tr>
<td>Annual Utility Electricity Cost ($)</td>
<td>$160,718</td>
<td>$84,736 plus $27,200 for solar agreement</td>
</tr>
<tr>
<td>Average Monthly Peak (kW)</td>
<td>468</td>
<td>365</td>
</tr>
</tbody>
</table>
Solar PV and Zero Energy at Discovery Elementary, Arlington, VA

98,600 sf school opened in 2015

496 kW-dc roof
  • Sized for zero net energy for a ground sourced heat pump HVAC

Direct purchase as part of school design and construction
  • PV system was bid as an alternate if budget allowed

Installed PV system cost in 2015 was $1.5 million or $3,044/kW-dc
  • Contrast to Northland Pines PV systems at $1,519/kW-dc in 2017
  • Solar PV for zero energy was a goal regardless of financial optimization

Site EUI is remarkable at 15.4 kBtu/sf/year

Virginia has a 500 kW-ac net metering threshold
  • 22 states allow net metering of 500 kW or more
Direct Purchase Cash Flow Estimate for a 250 kW-dc PV System for a High School in the Upper Midwest
### Solar PV at Jeffrey Trail Middle School, Irvine, CA

<table>
<thead>
<tr>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>75,200 sf school completed in 2013</td>
<td></td>
</tr>
<tr>
<td>423 kW-dc parking canopy</td>
<td></td>
</tr>
<tr>
<td>• Power purchase agreement with SunEdison</td>
<td></td>
</tr>
<tr>
<td>• No ownership of solar PV</td>
<td></td>
</tr>
<tr>
<td>California net metering threshold at 1,000 kW-ac</td>
<td></td>
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<tr>
<td>Plans to add battery storage under Southern California Edison incentive program</td>
<td></td>
</tr>
<tr>
<td>Site EUI is 29 kBtu/sf/year</td>
<td></td>
</tr>
<tr>
<td>• Includes natural gas heating</td>
<td></td>
</tr>
<tr>
<td>• Net site EUI of 17 including solar</td>
<td></td>
</tr>
<tr>
<td>No known date for transition to full zero energy</td>
<td></td>
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</tbody>
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Solar PV and Zero Energy at Newcastle Elementary, CA

- 31,500 square foot school built in the 1950’s
- Significant renovations
- Leveraged incentive programs with a very limited budget
  - California Prop 39 ZNE (zero net energy) Pilot Program through PGE
  - Required site EUI of up to 20 kBtu/sf/year
  - Anticipates site EUI of 14 kBtu/sf/year
- Performance contracting
- 108 kW-dc ground mount
- On New Buildings Institute’s Emerging Zero Net Energy List
Energy Meter
Data-logger Web server

Features and Benefits:
- Measures electric power on up to 12 conductors:
  - Building demand/consumption
  - Renewable energy production
  - Sub-metering
- Built-in web server
- 16, 64 or 128 recordable register options.
- Multi-layered password protection and information hiding
- Fully web-configurable
- CSV export & data API
- Built-in solid-state memory and data logger:
  - 1 second granularity for 10 minutes (volatile)
  - 1 minute granularity for current year
  - 15 minute granularity for 30 years
- URI data push available / open API
- Internet-enabled or stand-alone operation
- Remote device support
- Team multiple eGauge units
- Weather station & inverter direct readout
- Air temperature
- BACnet/IP compatible
- Windows, Mac, Linux & smartphone compatible
- For residential, commercial, municipal, and industrial use
- See real-time devices at http://www.egauge.net/

For more information:
Sales@eGauge.net -

Revenue Guarantee
ANSI C12.1 - 1% Accuracy Class

Hardware Options
eGauge3 Series
EG3010
Powerline communication
EG3000
Ethernet hardware only

New Features:
- Remote device additions
- Accu-CT integration (raw)
- Factory reset button
- Automatic Homeplug pc
- eGuard Manager update
- Production/consumpt
- Mapping of install pt

Summary for time-period shown in graph:

<table>
<thead>
<tr>
<th>Energy Used</th>
<th>29.5 kWh</th>
<th>(approx. $3.83 used)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Generated</td>
<td>58.3 kWh</td>
<td>(approx. $7.58 saved)</td>
</tr>
<tr>
<td>Net</td>
<td>28.8 kWh sold</td>
<td>(approx. $3.75 sold)</td>
</tr>
</tbody>
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Summary over last 30 days:

<table>
<thead>
<tr>
<th>Energy Used</th>
<th>869 kWh</th>
<th>(approx. $113.03 used)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Generated</td>
<td>1.30 MWh</td>
<td>(approx. $168.49 saved)</td>
</tr>
<tr>
<td>Net</td>
<td>427 kWh sold</td>
<td>(approx. $55.46 sold)</td>
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“I’d put my money on the sun and solar energy. What a source of power! I hope we don’t have to wait till oil and coal run out before we tackle that.”

- Thomas Edison

We are like tenant farmers chopping down the fence around our house for fuel when we should be using Natures inexhaustible sources of energy — sun, wind and tide. ... I'd put my money on the sun and solar energy...

In conversation with Henry Ford and Harvey Firestone (1931); as quoted in Uncommon Friends : Life with Thomas Edison, Henry Ford, Harvey Firestone, Alexis Carrel & Charles Lindbergh (1987) by James Newton, p. 31
So, what do we do to make Solar Schools commonplace?

<table>
<thead>
<tr>
<th>Understand</th>
<th>Understand your context (community and school)</th>
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<tbody>
<tr>
<td></td>
<td>• Utility providers and their net metering rules</td>
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<td></td>
<td>• Incentives</td>
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<thead>
<tr>
<th>Consider</th>
<th>Consider funding options and optimize financial performance</th>
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<tbody>
<tr>
<td></td>
<td>• Promote educational benefits</td>
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<td></td>
<td>• Consider a deliberate planning process and competitive bidding</td>
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<td></td>
<td>• Don’t leave money on the table</td>
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</table>

<table>
<thead>
<tr>
<th>Anticipate and use</th>
<th>Anticipate and use technological advancement</th>
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<tbody>
<tr>
<td></td>
<td>• Solar PV systems</td>
</tr>
<tr>
<td></td>
<td>• Battery systems</td>
</tr>
<tr>
<td></td>
<td>• Smart grids and micro-grids</td>
</tr>
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<table>
<thead>
<tr>
<th>Zero</th>
<th>Zero Energy Schools is the destination for many schools</th>
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<tbody>
<tr>
<td></td>
<td>• Plan the transition where feasible</td>
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</tbody>
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| Do   | Just do it!                                            |
What questions do you have?