Solar Power – What’s Happening

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Solar Power with SEI

Renewable Energy Education for a Sustainable Future
RE = solar, wind, and water power.
SEI’s R.E.E.P.

Renewable Energy Education Program

- Photovoltaics
- Wind Power
- Micro-Hydro Power
- Solar Home Principles
- Natural House Building
- Biodiesel
- Alternative Fuels
- RE for the Dev. World
Solar Energy International (SEI)
Charitable Programs

• Solar In Schools - SIS
• Women’s RE Training
• International - INVEST
SEI’s Women’s Program
SEI’s International Program - INVEST

• Education
• Training
• Volunteer Opportunities
Solar Electricity – Photovoltaics (PV)
ADVERTISEMENT PHOTOS, SUCH AS THIS ONE THAT APPEARED IN A 1956 ISSUE OF LOOK MAGAZINE, SHOW OFF THE "BELL SOLAR BATTERY" TO THE AMERICAN PUBLIC.

Courtesy of Solar Today
It is an exciting time for solar electricity!
Photovoltaics = PV

Down to earth...
PV Rural Electrification...

Water, lights, refrigeration +
1st Priority - PV Water Pumping
Two billion people in the developing world don’t have access to electricity...
A better source of ‘light’…

…for 1/3 of the world!
Solar Home Systems (SHS)

US $500 - $1,500
Chauganphaya Village in Humla NEPAL
(Latitude 30° North, Longitude 81.77° East, Altitude 2643 m)

What is needed?
• Light
• Stove
• Pit Latrine
• Drinking Water

Village situation in 2003:
• 62 homes, and 365 peoples
• No house had light
• All homes cooked on open fires
• No home had a toilets
• All drank dirty river water

Photo courtesy of Alex Zahnd
At altitude of 3,000 meter (9,443 feet) above sea level, lies the KU-RDC High Altitude Research Station in Simikot.
How do... PV **SYSTEMS**...work?

A COMPLETE PHOTOVOLTAIC SYSTEM

- **SOLAR CELL ARRAY**
- **CONTROLS**
- **STORAGE**
- **LIGHT BULB**
Electrical end use equipment…
pumps, lights, tools, appliances…

LOADS…
DAY USE SYSTEM

Simple, elegant, and lowest cost PV system.
**DC SYSTEMS WITH BATTERIES**

*Stand-Alone* (utility independent) systems... require battery storage.
Stand-Alone systems must have batteries.
Stand-Alone PV System
(with only AC loads)
INVERTERS…

- Change Direct Current (DC) to Alternating Current (AC).
Stand-Alone PV systems are often cost-effective for remote electrical energy off-grid independence.
PV SYSTEM COMPONENTS
(Stand-Alone with both DC & AC loads)
UTILITY-INTERACTIVE PV SYSTEM (NO BATTERIES REQUIRED!)

Diagram showing a PV array connected to a synchronous inverter, which in turn supplies electricity to AC loads and the utility grid.
Utility-Interactive PV Systems – Grid-Tie / Line-Tie (without batteries)
UTILITY-INTERACTIVE WITH BATTERY BACK-UP

Charge Controller → Storage Battery → Synchronous Inverter → AC Load Center → Main Service Panel

Branch Circuits to AC Loads → Utility Grid
Grid-Connected PV System with battery back-up
DC SYSTEM SCHEMATIC

PV Array:
Four panels wired in parallel for 12 Volts

Battery Bank:
Four 6 Volt batteries wired in series/parallel for 12 Volt

Charge Controller

Branch Circuits to DC Loads

DC Load Center
PV SYSTEM WITH GENERATOR BACK-UP
PV Technology & Terminology

**Cell**

**Module**

**Array**
How a solar cell works...

Magnified Cross Section

P-N Junction

N-Layer (phosphorous)

P-Layer (boron)

wire

electron flow
MONOCRYSTALLINE SILICON MODULES

- Most efficient commercially available module (11% - 14%)
- Most expensive to produce
- Circular (squarround) cell creates ‘wasted space’ on module
- 1.5 volts per cell (nominal)
POLYCRYSTALLINE SILICON MODULES

- Slightly less expensive to make than single crystalline modules
- Cells slightly less efficient than a single crystalline (10% - 12%)
- Square shape cells fit into module efficiently using entire space
- Also called multi-crystalline
AMORPHOUS THIN FILM
SILICON MODULE

- Most inexpensive cell technology to produce.
- Vacuum deposition applies silicon on a substrate.
- Amorphous silicon can be made monolithically (as a single unit).
- Metal grid replaced with transparent oxides that conduct electricity.
- Efficiency = 6-8%
- Can be deposited on flexible substrate.
WATTAGE/SIZE COMPARISON

**Monocrystalline** *(Single-crystalline)*
- 75 Watts

**Polycrystalline** *(Multi-crystalline)*
- 80 Watts

**Amorphous Thin Film**
- 43 Watts
JUNCTION BOXES
MODULE FRAMES
TYPICAL CURRENT-VOLTAGE (I-V) Performance Curve

25°C (77°F) cell temperature and 1000 W/m² insolation

Important Points:
- Maximum Power Point ($V_{mp}, I_{mp}$)
- Open Circuit Voltage ($V_{oc}$)
- Short Circuit Current ($I_{sc}$)
The Extreme Effects of Shading

<table>
<thead>
<tr>
<th>% of One Cell Shaded</th>
<th>% Loss of Module Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 %</td>
<td>0%</td>
</tr>
<tr>
<td>25 %</td>
<td>25%</td>
</tr>
<tr>
<td>50 %</td>
<td>50%</td>
</tr>
<tr>
<td>75 %</td>
<td>66%</td>
</tr>
<tr>
<td>100 %</td>
<td>75%</td>
</tr>
<tr>
<td>with 3 cells shaded</td>
<td>93%</td>
</tr>
</tbody>
</table>
Sunlight intensity **dramatically** affects **CURRENT**.
EFFECT OF CELL TEMPERATURE

Higher cell temperature reduces voltage.
SELECTING THE ‘CORRECT’ MODULE

Practical Criteria – ‘Best Supplier’*

- Size
- Voltage
- Availability
- Warranty
- Mounting Characteristics
- Cost (per watt)
BIPV – Building Integrated PV
Roofs and Walls
Daylighting & Electricity
SUNSLATES™

Roof ‘tiles’
Sunslates™
Two Mile Ranch – Wyly Project
Woody Creek, Colorado

SEI/Fenton Construction

Atlantis Energy Inc. - Sunslates™
Atlantis Energy Systems – SunSlates
LARGE ROOF INSTALLATION – 20+ year warranty
Large wall applications in Europe…
SOUND BARRIER
SHADING ELEMENT
BUTLER BUILDING
BIPV on CA Toyota Roof

‘Ballasted’ mount – no roof penetrations
Uni-Solar Inc.
*(Thin-film PV)*

Roofing Shingles

Standing Seam
13 NEW HOMES IN COMPTON, CA
2.5 kW SYSTEM EACH
12.5 kW UNI-SOLAR SHR-17 solar shingle roof
Fairfield University, Connecticut
Santa Clarita Service Station
Los Angeles, CA 20kW
Net Metering with your utility

Buying Green Power——
You Really Can
Make a Difference
Choice… *Payback vs. Value*…?
Choose *RE* for a sustainable future!

Time: 10,000 BC to 10,000 AD
The Solar Cat

A cat sunning himself in the doorway of a barn knows all about solar energy. Why can't man learn? — E. B. White

THE RETURN OF THE SOLAR CAT BOOK

Mixing cat wisdom with science and solar politics

JIM AUGUSTYN

with illustrations by Hildy Paige Burns

SUN

STRAIGHT HEAT

SQUIGGLY HEAT

DASHED HEAT

CAT
Figure 1.14 Person solving the same problem in more than two steps.
“If we can’t learn to live intelligently and powerfully on earth in the most beautiful places on earth, what hope is there for us?”

George Sibley - Gunnison, CO
Thank you!

Johnny Weiss

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