Consulting in the Solar Power Age

Miguel Gomez

mgomez@actsolar.com
miguelgomez@aya.yale.edu
Overview

- Green Markets
- Technology
- Money
- Focus on Solar.
- Review consulting options for engineers.
Green Market Drivers

- **Global Warming**
  - The debate is over.
  - Sea change in social, political and cultural attitudes.

- **National Security.**
  - Need less dependence on foreign energy.
  - Saudi Arabia, Iran, Iraq, Venezuela, Russia hold most of the world’s oil.
  - Alarming trade imbalances and intensifying competition for energy.

- **High Energy Costs**
How viable are the Green Markets?

- It looks good...

- Factors driving green energy
  - Energy costs going up.
  - Technology costs going down.
  - Trade imbalances get worse.
    - Devaluation of the dollar is driving the cost of foreign energy up.

- Factors that can work against green energy
  - Attitude on global warming could change.
  - Technology costs don’t come down fast enough.
  - Incumbent technologies stay competitive.
  - Political attitudes change
Government Programs

- **United States 1997 Million Solar Roofs Initiative**
- **Germany 1999 Renewable Energy Sources Act (Feed-In Tariff).**
- **Japan 2003 Renewable Power Portfolio Standard:**
- **China 2004 Allocation of $1.21 billion for solar and wind power generation.**
Current Political Initiatives

- Political initiatives
  - Senate is moving to propose a carbon tax bill.
    - $5.00/Ton -> $50.00/Ton
  - California Solar Initiative
  - California “Community Choice” law (AB117).
    - Communities can choose their power providers and have access to transmission facilities
Today Solar Energy Production is Miniscule

- The U.S. consumes 4000 GW of electrical energy each year.
- Total Solar installed base is .06% of that amount.
- In 2007 Solar production of cells/modules will increase by electrical capacity by 0.1%. By 2011 Solar production will grow to 20+GW.
- Solar production is growing by 8%/year.
Revenue Opportunities

- Green revenue reaching $500 billion by 2020, $1 trillion by 2030.
- The solar industry – $50 billion in revenue by 2010.

World Photovoltaic Shipments, 1971-2003

Source: Paul Maycock
Capacity Growth Rate

Solar cell/module production 2005-2010 (GW)

Source: Photon Consulting. Note: Preliminary
Solar Markets

- **Residential**
  
  Less than 100 panels per install.

- **Small vs Large Commercial**
  
  - Google, eBay, City of San Francisco, Cupertino Schools, Wal-Mart.

- **Wholesale Power Generation**
  
  - Mostly in Germany.
Commercial Install

- Google Solar Installation in Mountain View, CA
Wholesale Install

Waldpolenz Solar Park, Brandis Germany.
Market Challenges to Solar Energy

- Incumbent technologies
- Cost of Goods
- Time and Cost to Market
- A regulated industry.

![Solar Panels](image-url)
Incentive Requirements

- Proof-of-performance is becoming an important method for incentive payments.
  - California Solar Initiative – requirement for systems over 100KW.
  - Meter must be approved.
  - Meter must be installed and read in an approved manner.

- New opportunities in systems management and metering.
Next Generation of Grid Connect.

- Grids today are one way flow systems.
- Grids of tomorrow will better accept two way flows.

Measurement and Communications will provide:

- Improved Safety
  - Command and control of Anti-Islanding, fire protection.
- Local generation of power to reduce transmission burden.
- Improved communications to reduce probability of cascading power outages
- Improved communications to help reduce spin reserves.
Solar Market Needs

- **Grid Connection**
  - Capabilities beyond simple net metering
  - Sophisticated grid connection

- **Higher System Reliability**
  - New and more reliable circuit components
  - Better thermal dissipation

- **Higher Efficiency – Lower Cost.**
  - Cells, Panels
  - Reduction in silicon needs.
Component Reliability

- Solar cells are very reliable.
- Solar panels are not.
  - By-pass diode failures (Heat related)
  - Cell cracking due to thermal stress.
  - Electrical connections fail over time.
Solar Panel Failure Modes

Reversible damage

Non-reversible damage
Inverters

- Biggest failure components
  - Electrolytic capacitors
    - A 10 degree rise in temperature reduces lifetime by 50%.
    - Typically fails in 3-5 years.
  - Other thermal stresses.
  - Power Transistors
  - Power Electronics.
ActSolar Example

- Voltage and current metering of each panel.
- Zigbee communications of all data to an array data aggregator.
- Transmission of data to servers via the internet.
- Business systems software reports
  - Revenue: for tax or government incentive reports.
  - Diagnostics: Minimizes installer costs. I.E. truck rolls.
ActSolar Power Manager

Components

Inverter

Internet

Server

Performance, Diagnostics, Control
Wireless to/from Module
Opportunity

Difficult DC Wiring
Small Local Problems Degrade Whole Array

Inverter Poor Reliability, Efficiency

Overbuild 120kw Modules

100kw Array 100% Power
Technology Innovations

- **Photo-voltaic**
  - Mono-crystal Silicon
  - Multi-crystal silicon
  - Thin Film
    - Amorphous silicon
    - Cadmium Telluride
    - Copper Indium and Gallium Selenide.

- **Panels**
  - Flat arrays
  - Concentrators

- **Power Conversion**
  - DC-AC inverters

- **Communications and Control.**
How Does an IT engineer Get involved in Solar Energy?

- Communications is going to be part of the next two generations of Solar Energy.
  - Metering and Management of large arrays.
  - Command and control of array trackers
  - Sophisticated communications between micro-power generators and the grid.

- Digital control of the "balance of systems" components will become more prevalent.
Skills for the Next Generation of Solar Systems

- Network Communications
- Operating systems, DSP, FPGAs
- Business applications (Server technologies)
- Power systems design
- Thermal management
- Mechanical design
- Optics development
- Certification skills (CEC, UL, FCC)
- Component development
  - Batteries, Capacitors
- Solar cell design
Top Solar Companies

- **First Solar**
  - Received 100 Million investment in 2006

- **SunPower**
  - Cypress Semiconductor Spin off.
    - Heavy participation by TJ Rogers.

- **Qcell**
  - Largest manufacture of solar silicon cells.

- **Applied Materials**
More

- Conergy
- Hemlock
- LDK
- Motech
- REC
- SolarWorld
- Suntech
- Wacker
- ActSolar
Learn More

- National Renewable Energy Lab (NREL)
- Google
- SolarBuzz
- Solar Electric Power Association
- www.gosolarcalifornia.ca.gov
Training

- PG&E Training classes
- University of Delaware Solar Training CD
- Square 1 Wiki