Consulting in the Solar Power Age

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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

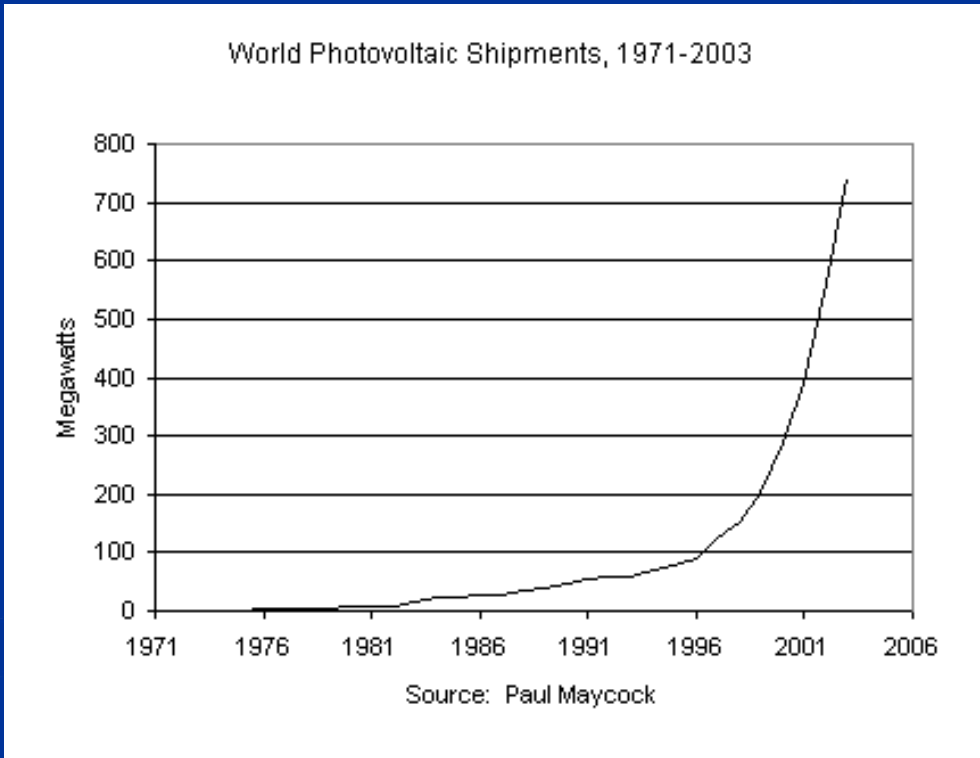
- Political initiatives
  - Senate is moving to propose a carbon tax bill.
    - ~$5.00/Ton -> $50.00/Ton
  - California Solar Initiative
  - California "Community Choice" law (AB117).
    - Communities can choose their power providers and have access to transmission facilities

Today Solar Energy Production is Miniscule

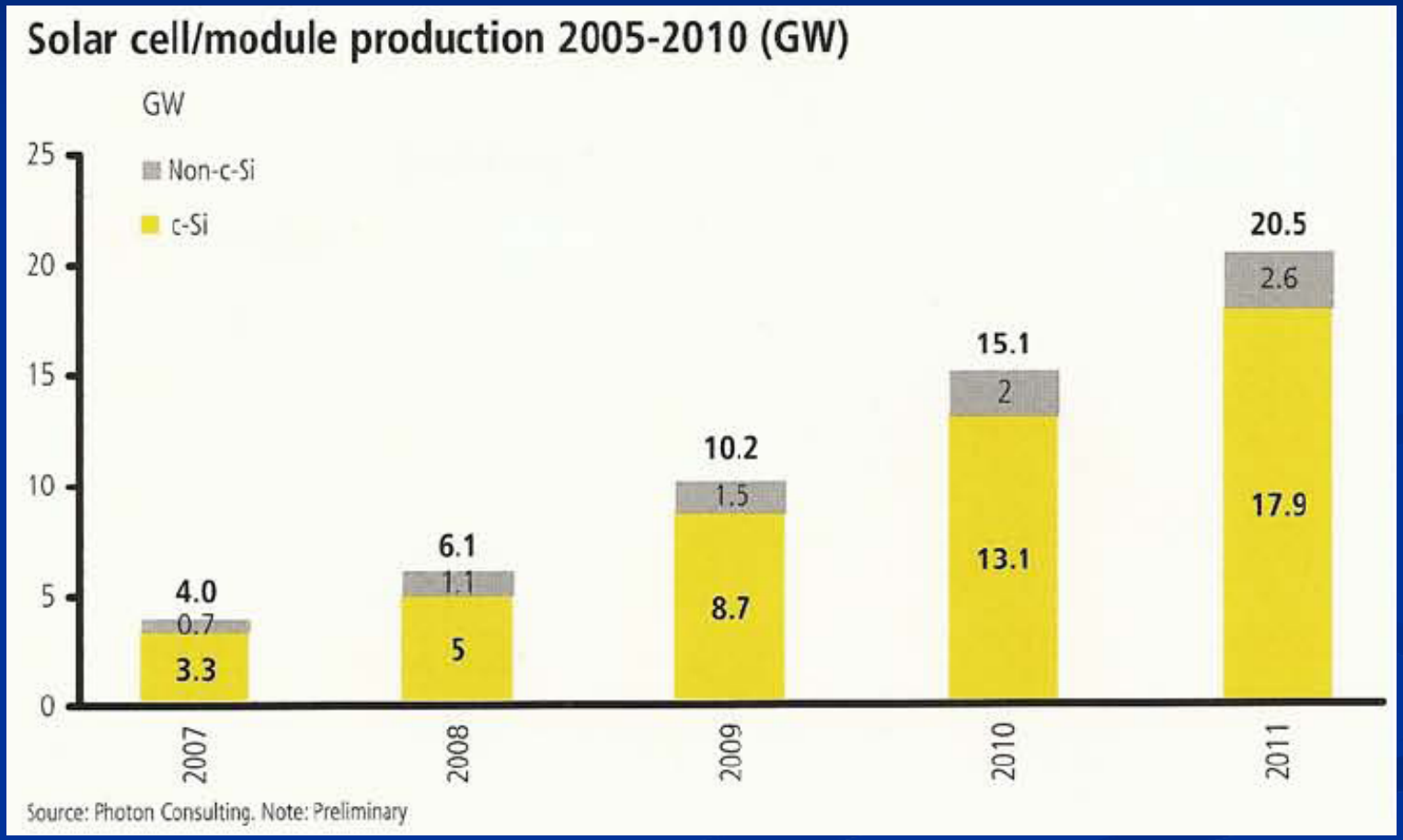
- The U.S. consumes 4000 GW of electrical energy each year.
- Total Solar installed base is .06% of that amount.
- In 2007 Solar production of cells/modules will increase by electrical capacity by 0.1%. By 2011 Solar production will grow to 20+GW.
- Solar production is growing by 8%/year.

Revenue Opportunities

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



Capacity Growth Rate



Solar Markets

- Residential

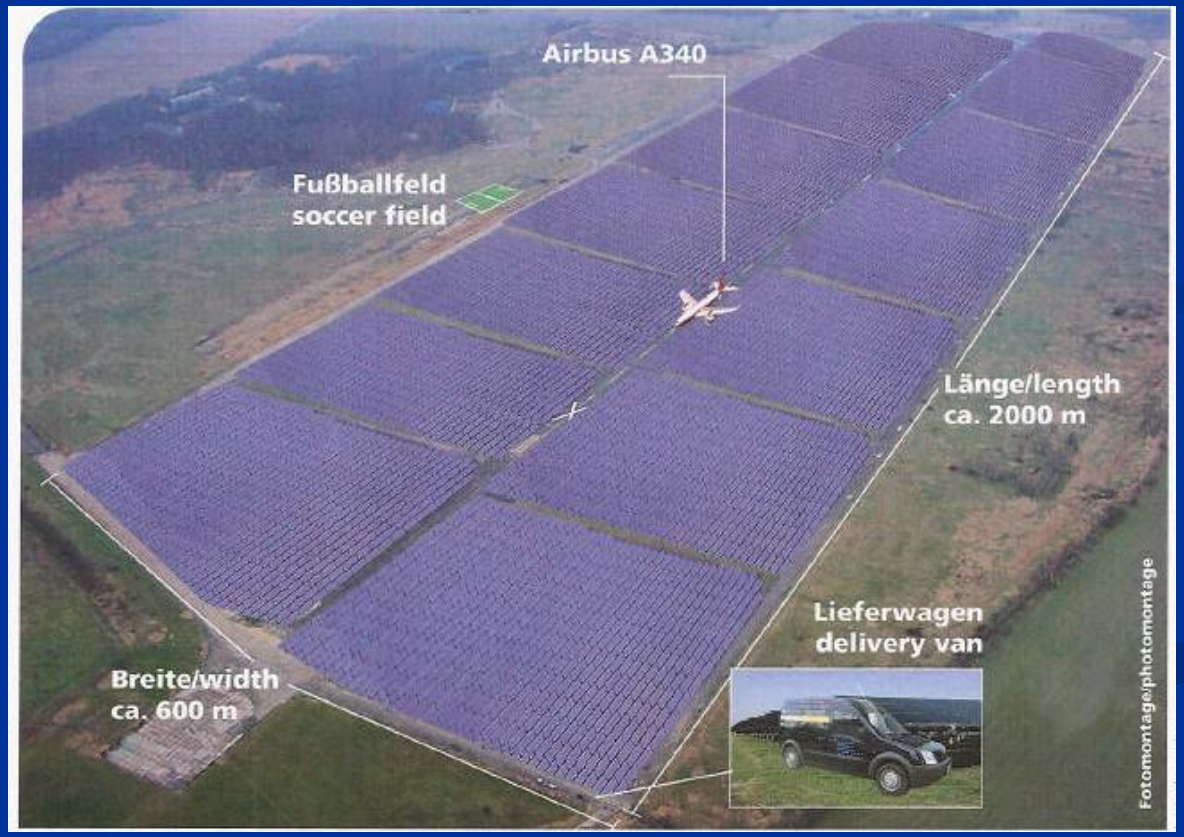
  Less than 100 panels per install.
- Small vs Large Commercial
  - Google, eBay, City of San Francisco, Cupertino Schools, Wal-Mart.
- Wholesale Power Generation
  - Mostly in Germany.

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.

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

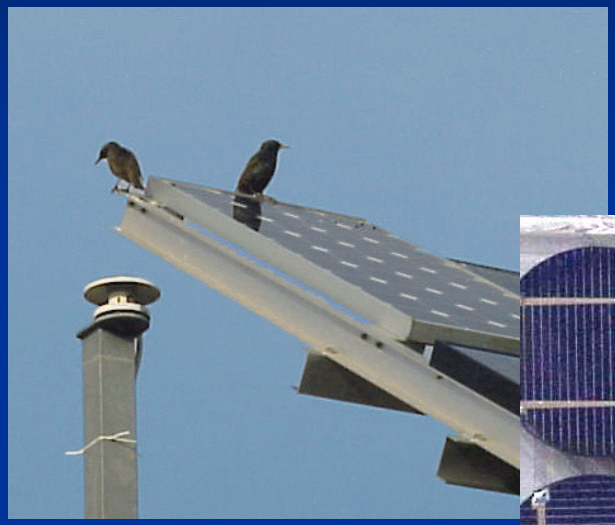
- Grid Connection
  - Capabilities beyond simple net metering
  - Sophisticated grid connection
- Higher System Reliability
  - New and more reliable circuit components
  - Better thermal dissipation
- Higher Efficiency – Lower Cost.
  - Cells, Panels
  - Reduction in silicon needs.

Component Reliability

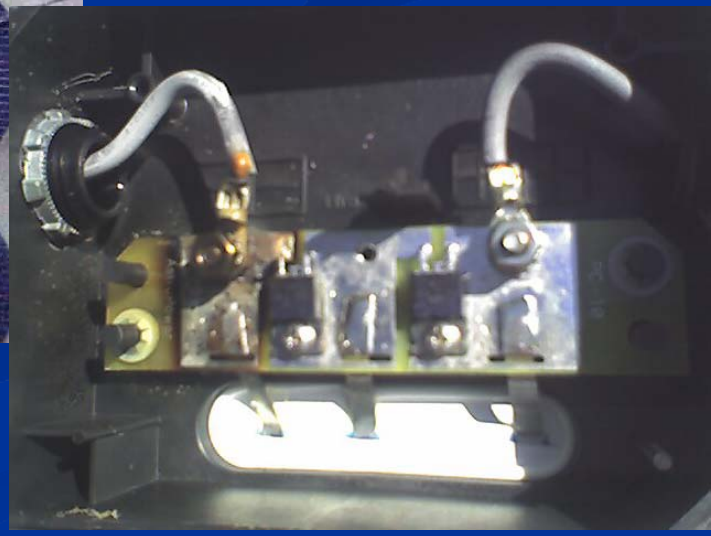
- Solar cells are very reliable.
- Solar panels are not.
  - By-pass diode failures (Heat related)
  - Cell cracking due to thermal stress.
  - Electrical connections fail over time.

Solar Panel Failure Modes

Reversable damage



Non-reversable damage



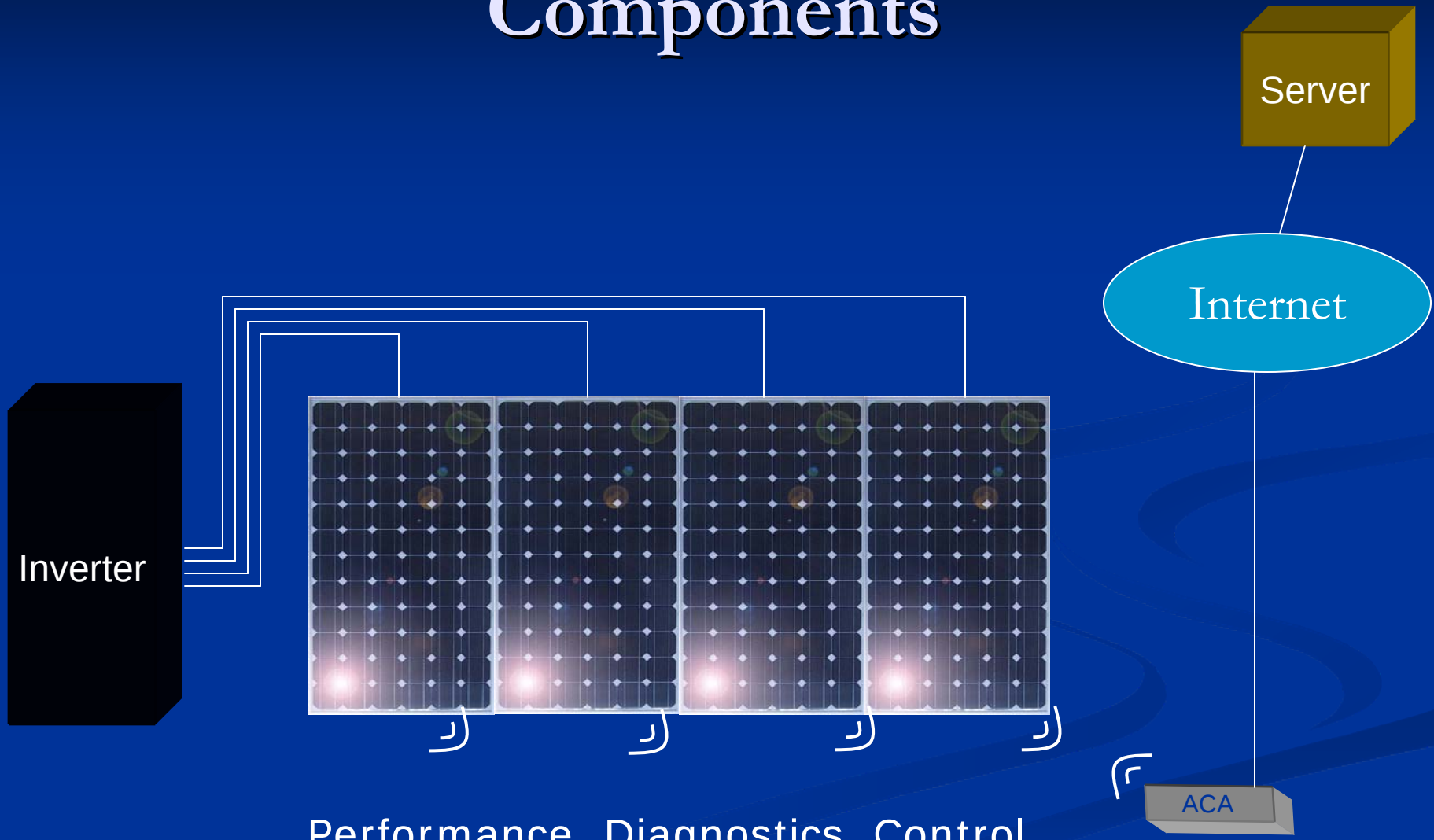
Inverters

- 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



Performance, Diagnostics, Control
Wireless to/from Module

Opportunity

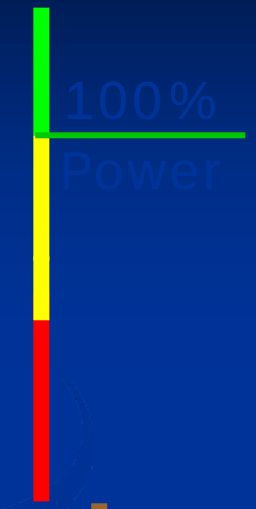
Difficult
DC Wiring

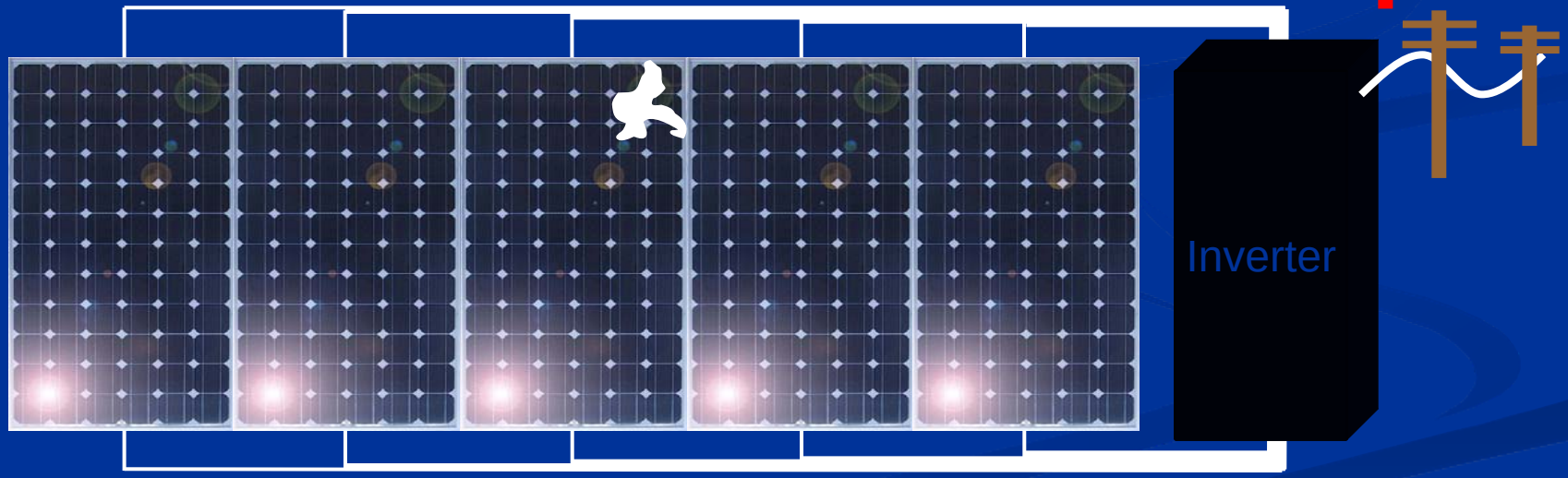
Small Local Problems
Degrade Whole Array

100kw Array

Inverter Poor
Reliability, Efficiency

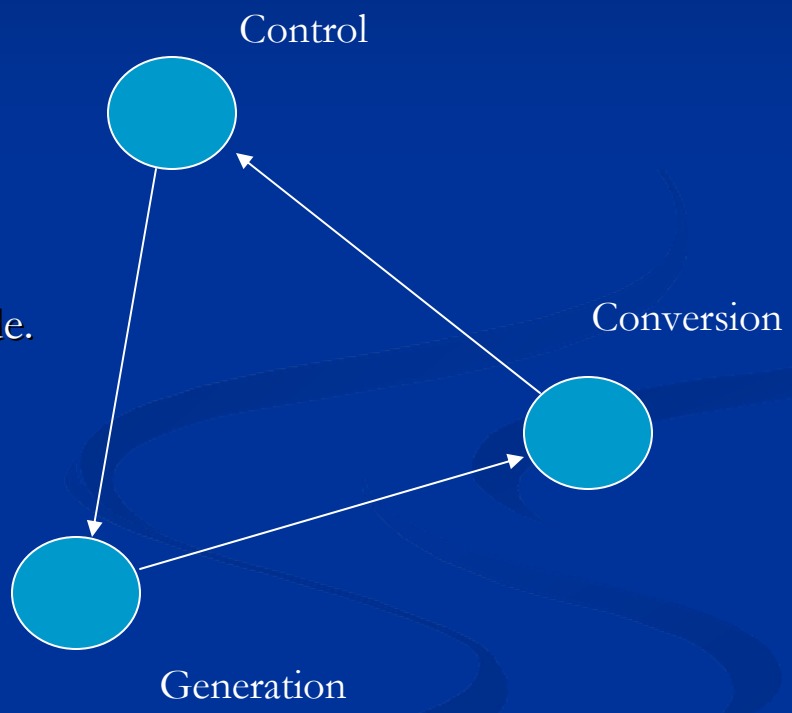
Overbuild
120kw Modules





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

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