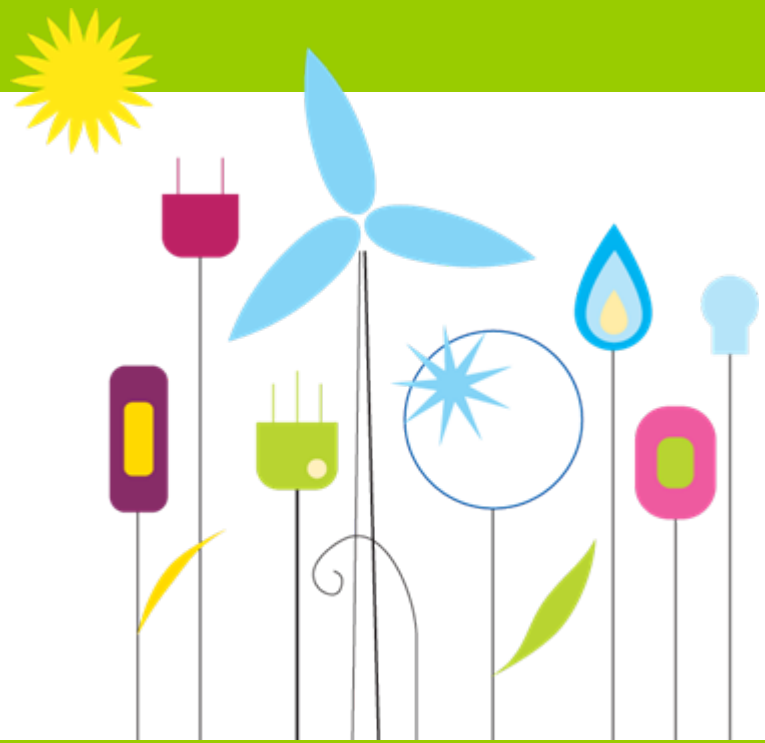

PV Manufacturing in the US

National Academy of Sciences 23 April, 2009

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BP Alternative Energy: BP Solar

- >35 years of history
- Global presence
- Vertically integrated
- Crystalline technology

- DOE's Solar America Initiative participant
  - ~14 partners
  - University and industry

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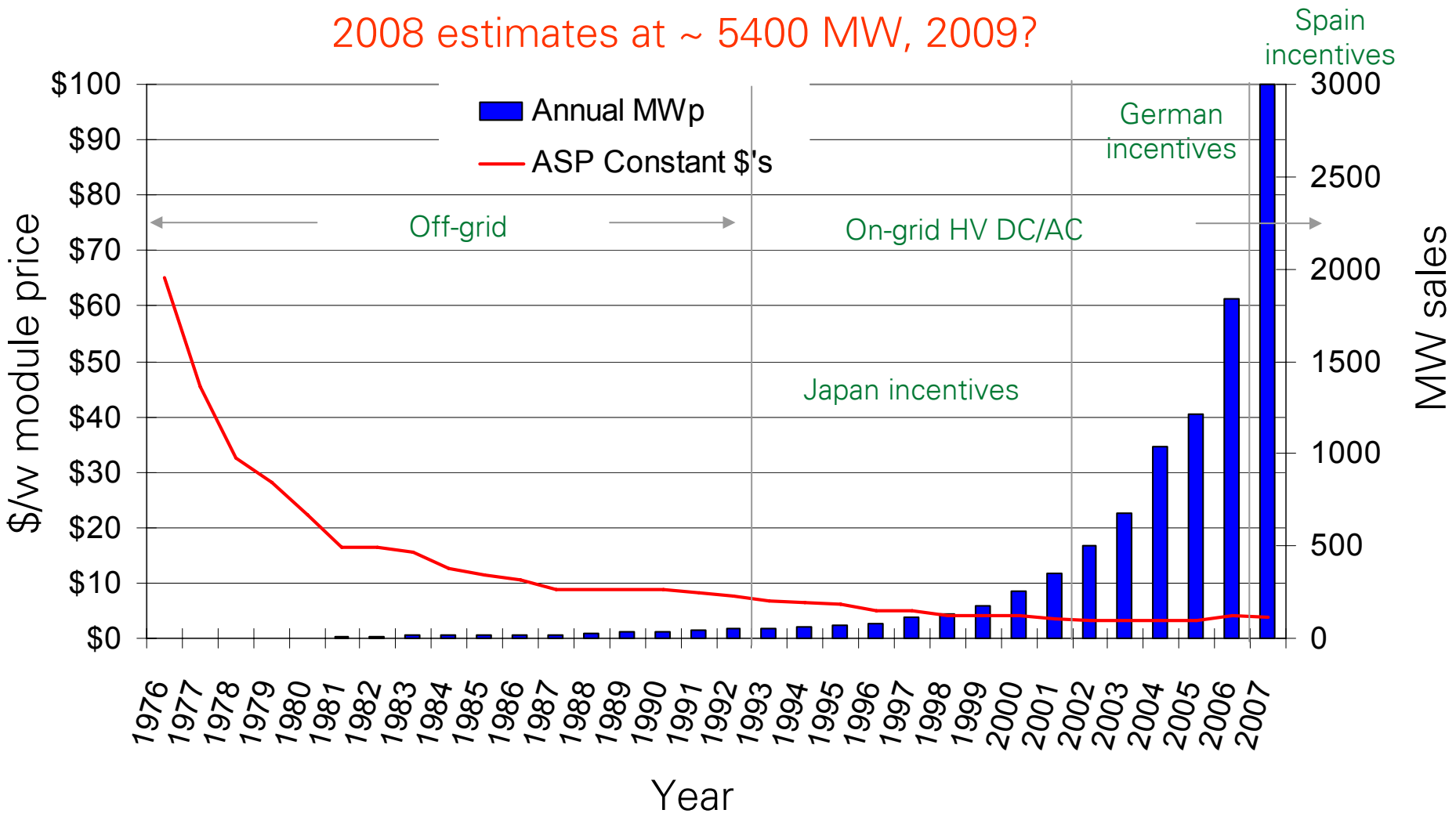
Solar Eras



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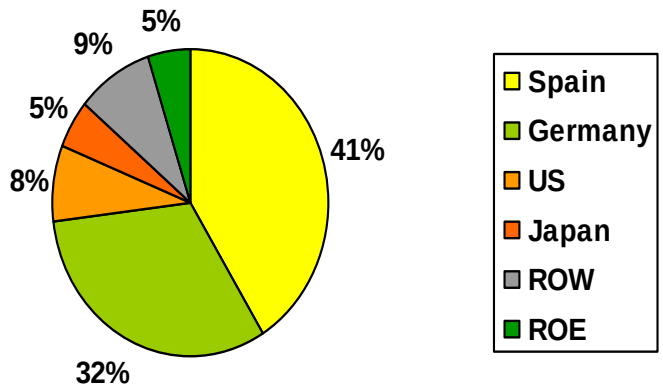
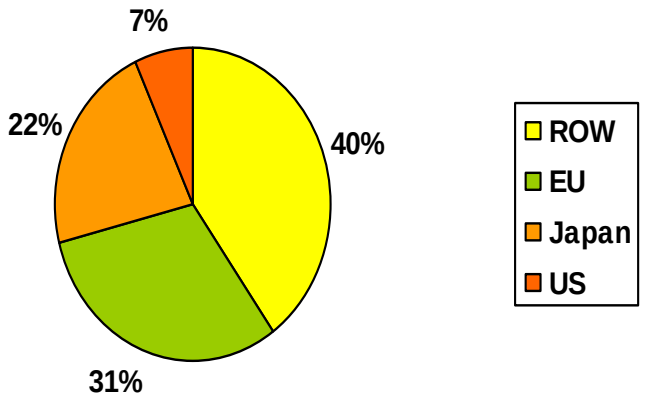
Current observations

- Japan and Germany had dramatic growth in local manufacturing infrastructure
  - Japan transitioned to exports following decline in local incentives
  - Germany beginning to move off-shore? EEG transitioning to favor residential
- ~>70% of 08 industry shipments to Spain
  - ~2.5 GW down to ~300 MW in 09
  - Growth capped
  - Capacity stranded
- Price declines of >15% moving in to 09

2008 Installations %



2008 Supply %



Source: Navigant SO2009-1

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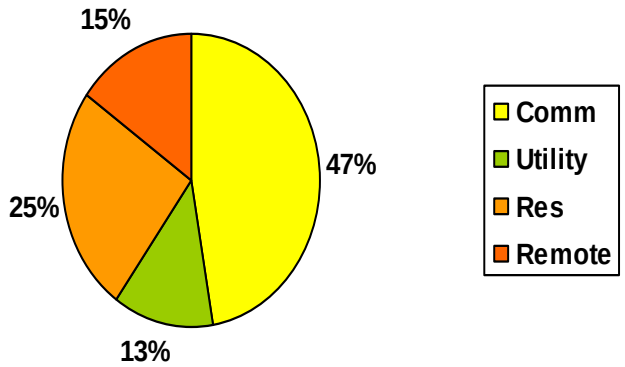
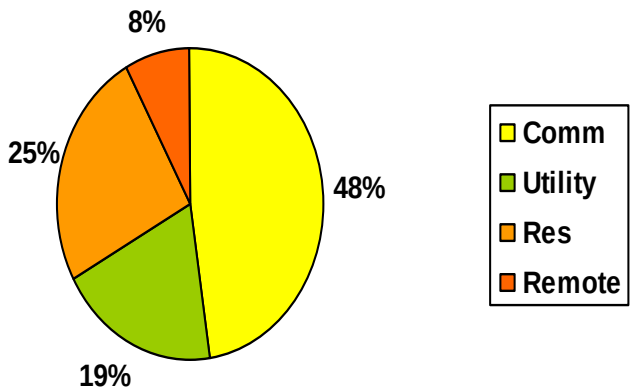
Current observations

- 3 of every 4 jobs are in downstream, installation vs. manufacturing (EPIA)
  - ~200k remote and residential systems per one large utility project for EPC
  - ~>2:1 residential vs. large project jobs for installation, greater ratio if ancillary jobs are considered
  - Near term growth forecasted in large projects
- Current incentives seem to favor larger projects based upon forecasts

2008 US Market Mix %



2011 US Market Mix %



Source: Paula Mints Navigant consulting PV Services program

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Today's PV kWh Costs

Location	Residential Retail Peak (US ¢/kWh)	PV retail amortized cost (before rebate)	Residential PV Rebates
PG&E (Northern CA)	35 ¢/kWh (noon to 6 PM)	~20 ¢/kWh	One time rebate ($2.20/W in 2007)
Hawaii	24 ¢/kWh	~18 ¢/kWh	30%
Tokyo (Japan)	23 ¢/kWh	~23 ¢/kWh	Almost gone
Italy	21 ¢/kWh	~20 ¢/kWh	Suggested 60 ¢/kWh
Spain	24 ¢/kWh	~20 ¢/kWh	~70 ¢/kWh
Germany	25 - 30 ¢/kWh	~45 ¢/kWh	Up to 85 ¢/kWh
LADWP (Los Angeles CA)	14 ¢/kWh	~20 ¢/kWh	One time rebate
France	24 ¢/kWh	~25 ¢/kWh (South)	Up to 85¢/kWh

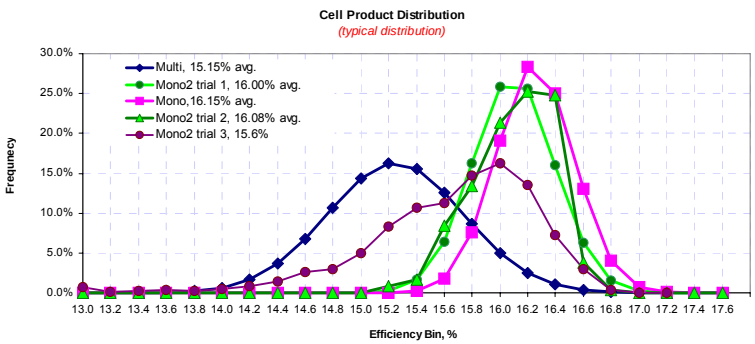
Notes: *- Assumes cost of ~$8.00/W installed*
- Green shaded cells are locations where grid-parity is already a reality

Manufacturing challenges: Silicon - wafers

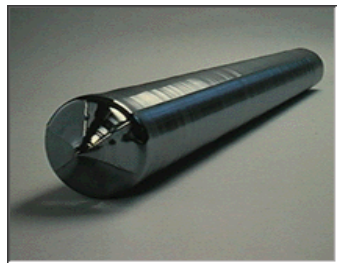
- Very high capital outlay required for UMG experimentation
- New tool concepts offer potential for 40X increase in capacity, 250 MW per station
- Requires access to low-cost energy, metallurgical silicon and transport
- eg Mono2
- *Need market scale and stability to minimize risk of stranded assets*

BP Solar Mono^{2TM} wafer technology

- Introduced in 2006
- Benefits of Mono CZ
  - Higher efficiencies
  - Better crystal uniformity
- Benefits of Multi crystal
  - No LID
  - Lower capital intensity
  - Better module packing efficiencies
- ~200kW in 07, 1.2 MW in 08, > 2MW in 09
- >17% efficiency with cell partners



Ingots



Wafers

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Manufacturing challenges: Modules

- NREL, JPL, Sandia "Block" programs are the basis for today's module designs and standards
  - Focus on longevity and reliability
  - Certification standards derived from these
- Industry is transitioning from watts to watt hours, horsepower to miles per gallon, or entering the energy business!
- *Industry assistance needed for energy evaluation and valuation, otherwise little benefit to differentiation*
- *At 1 GW, import model would require ~$200 million in working capital just for transit times, will lead to local assembly*
- eg ThermoCool™ and micro-circuitry as demonstrated in New Jersey

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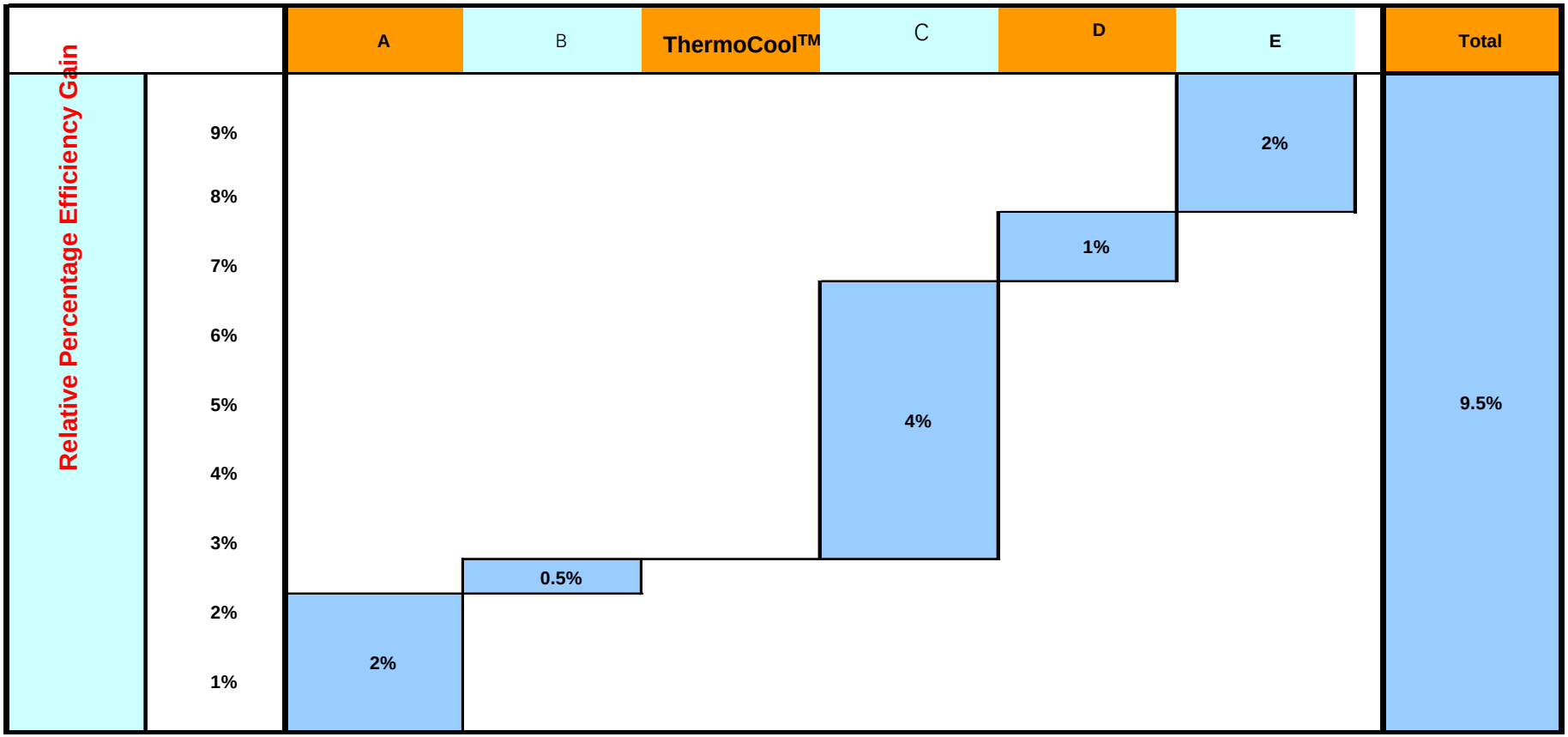
BP Solar module programs: watts



Some improvements may not effect changes in watts or efficiency

Horsepower*?*

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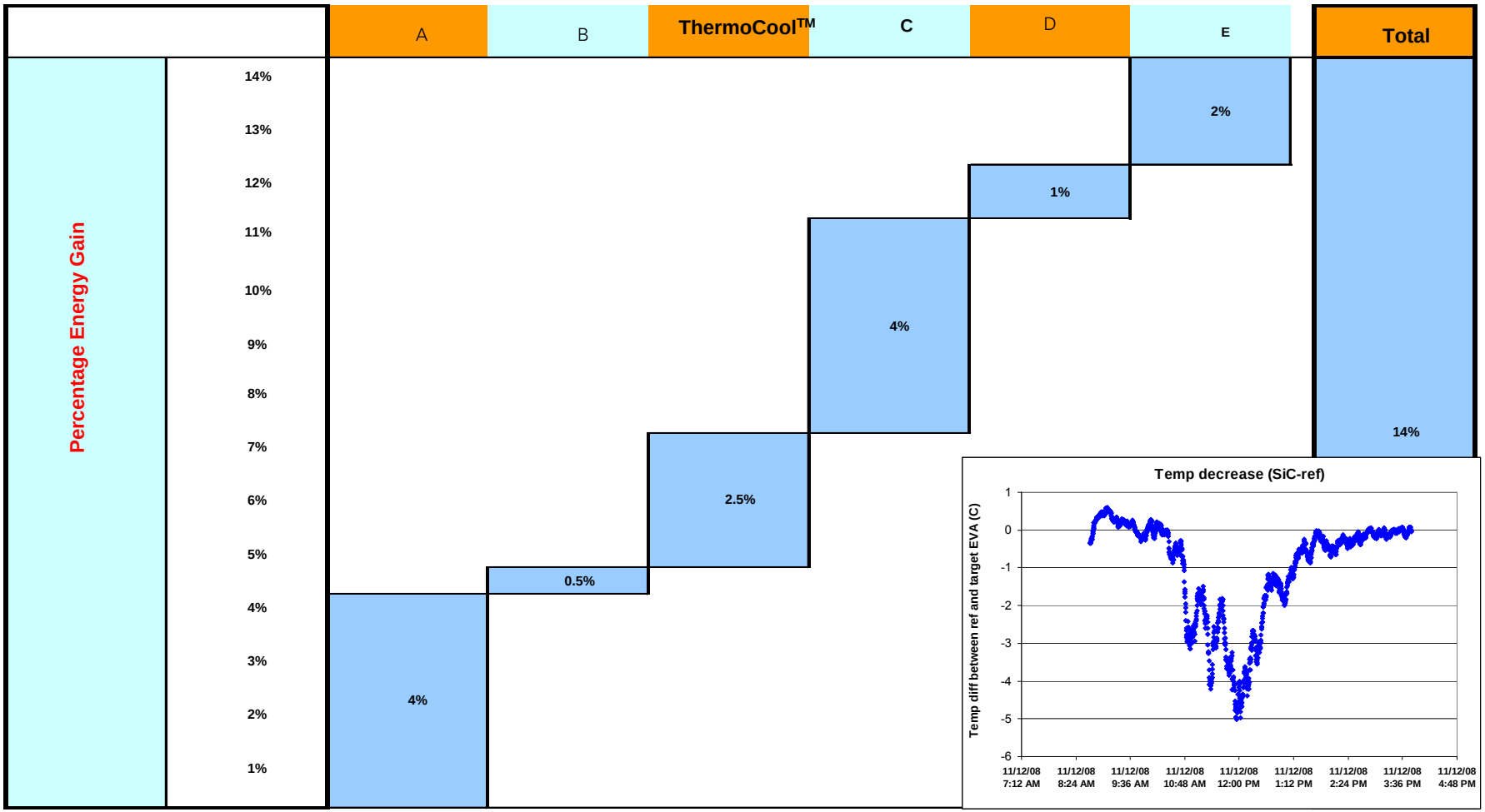
BP Solar module programs: kWhrs



However, results in improved kWh

Miles per gallon?

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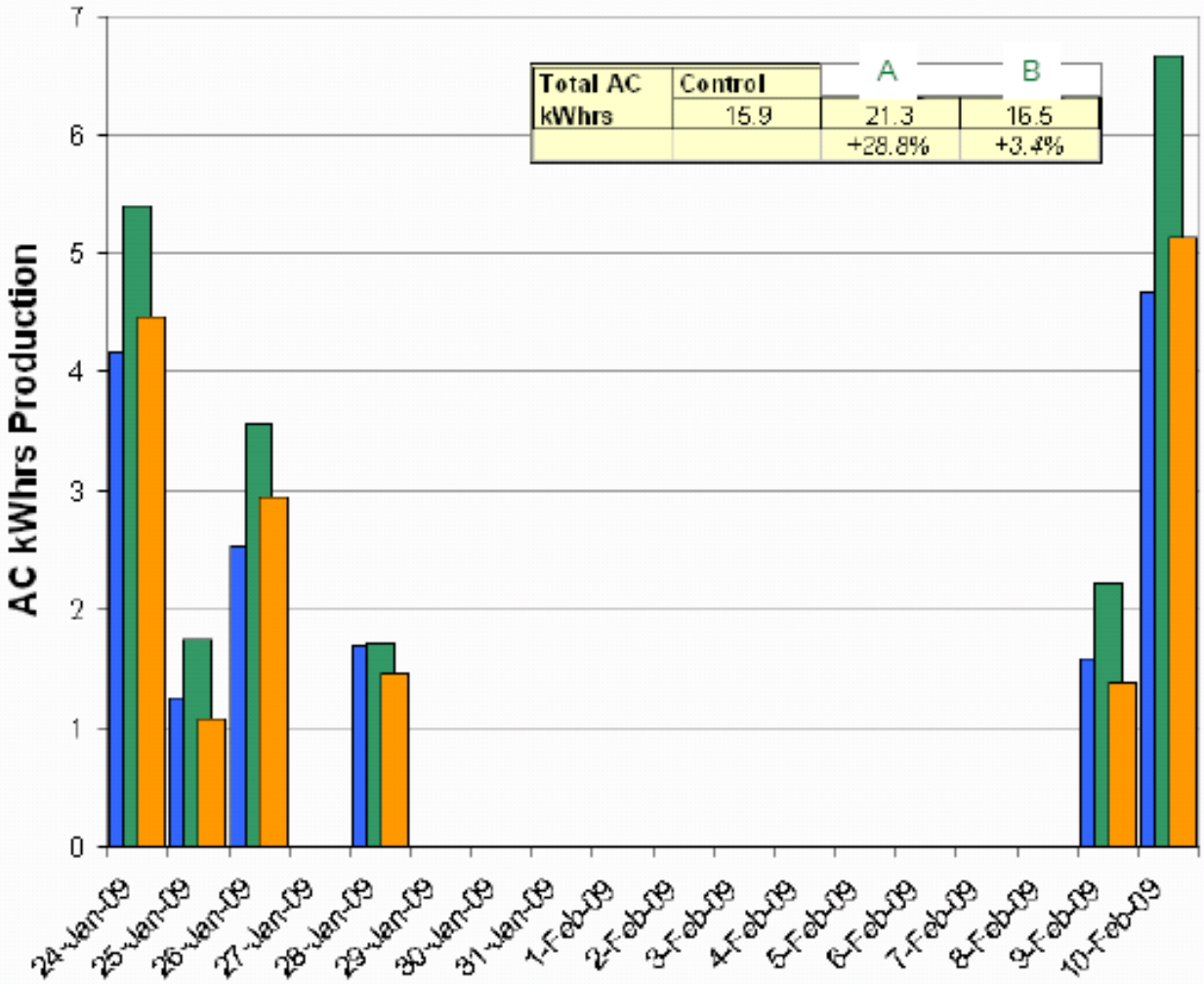
AC kWhrs Production by Array - Shaded



Total AC kWhrs	Control	A	B
	15.9	21.3	16.5
		+28.8%	+3.4%

- Preliminary data
- Residential array
- Further testing in progress

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Manufacturing challenges: systems

- Solar is:
  - Variable output
  - Can be predicted on average
  - Systems can achieve high availability
  - Can be deployed on wholesale and retail side of distribution
  - High capital/low O&M, except for micro circuitry
  - A wireless power supply for a new power model beyond SmartGrid
- Solar isn't:
  - Dispatchable

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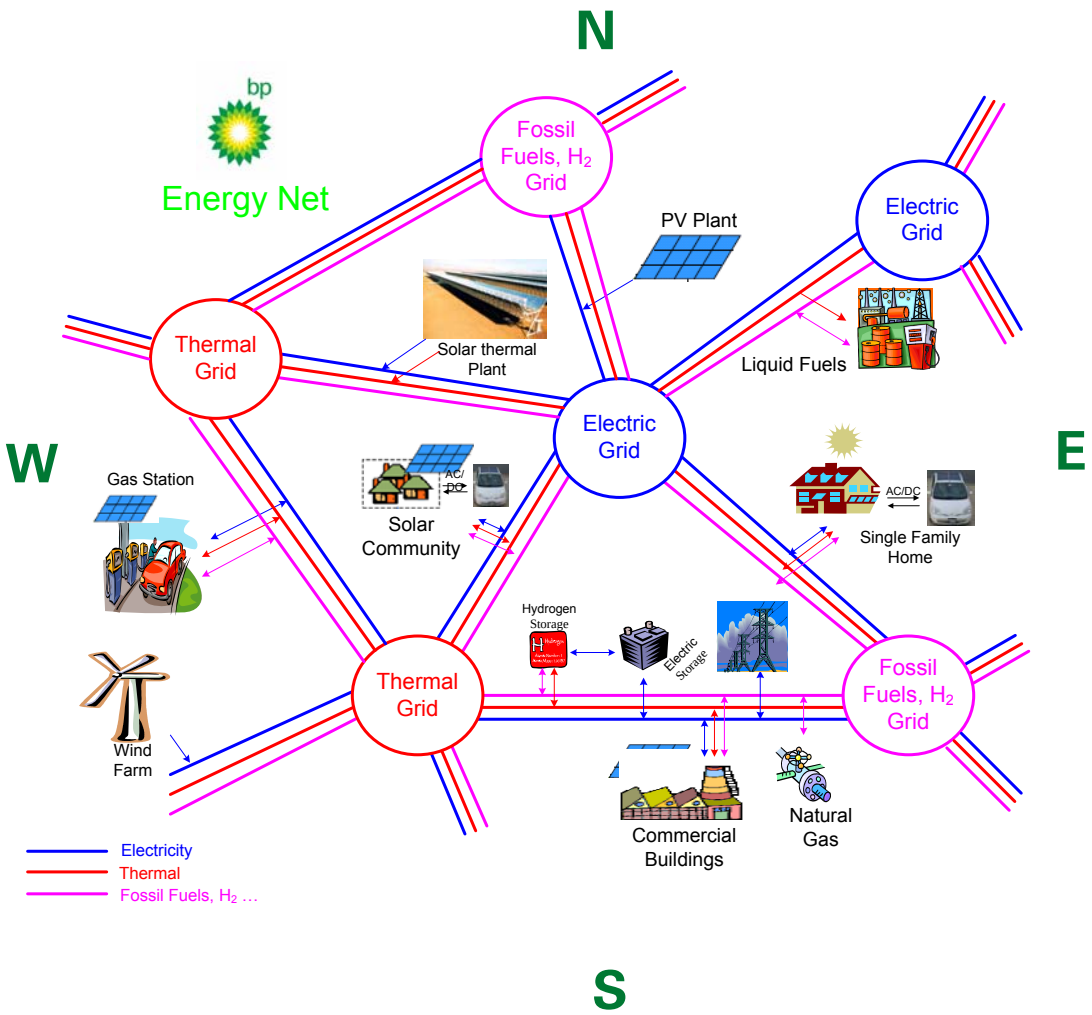
SmartGrid/EnergyNet opportunity

- SmartGrid:
  - Demand management
  - Attack/outage resistant
  - Improves planning
  - Based on traditional distribution infrastructure
- EnergyNet:
  - Modeled after wireless communications
  - Allows far broader participation in CleanTech
  - Emphasis on solar strengths



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EnergyNet: Municipalities

- Solar powered treatment plants but grid tied
- Can accommodate variable nature of solar
- Can reduce distributed power need through deployment at site
- Applies to irrigation

Source: SolarBee, Inc.

EnergyNet: industrial and lighting

- Lighting systems
  - obstacle beacons
  - warning lights
  - message boards
  - traffic signals
- Usually already have storage on board
- Take advantage of LED bulb technology & wireless communications

EnergyNet opportunities

- Industrial
  - Communications
    - Private radio
    - Telephony
    - VSAT
    - Radar
  - Cathodic protection
  - Instrumentation
    - Telemetry SCADA
  - Beacons, transportation
- ***Utility***
  - ***Central station grid***
  - ***Residential roof top systems***
    - ***On and off grid***
  - ***Commercial roof top systems***
- Remote Habitation (off grid)
  - Lighting, schools
  - TV
  - Water
    - pumping, purification
    - Aeration, ice making
  - Village power systems
    - Central plant, PU
    - Battery charging
- Consumer
  - Recreational vehicles, Boating
  - Attic fans
- Emerging applications
  - BIPV
  - AC motor drive
  - Industrial lighting (LEDs)
  - Result through enabling technologies

Summary

- Good local market growth will lead to local manufacturing
- Not all technical jobs need to be device oriented, could benefit from greater applications and energy modeling support
- No reason to limit clean tech to SmartGrid
  - Allows a broader industry engagement & support
  - Will lead to an improved grid
- Leverage the technology's natural attributes
- Leverage utility, commercial and residential markets to drive scale while creating incentives for broader particiation

Q&A

Thank you for your attention!