Integrating Solar PV with the Grid

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IEA Report (2014) Predicts Solar Power Domination by 2050

- PV could generate as much as 16 percent of the world's electricity by mid-century
- Solar thermal electricity generated by CSP could account for another 11 percent
- PV and CSP could cut annual carbon dioxide emissions by more than 6 billion tonnes with worldwide installation of 4,600 GW of PV capacity by 2050
- Worldwide PV capacity had surpassed 150 GW and the IEA reports an estimated 100 MW of capacity being installed on a daily basis throughout 2014
- IEA predicts the cost of PV decrease of 50-65% by 2050

Solar News

- UL has published a new inverter standard, expected to help solar/grid integration (UL 1741 Supplement A (SA), (Sep. 8, 2016)
  - Testing and certification of inverters and DGs
  - UL 1741 SA specifies the test methods for DGs to stay online to stabilize the grid during disturbances, rather than disconnecting
  - California planning to merge its own Rule 21 grid interconnection requirements with UL 1741 SA
  - UL says Rule 21 is a source requirement document (SRD) to be used with UL 1741 SA

US Energy Storage Market Growing

- U.S. deployed 41.2 MW of energy storage in the second quarter of 2016, an increase of 126% over the first quarter of the year.
- New deployments in MISO territory rather than in traditional market leaders CAISO/PJM
- Big boost from the White House (1.3 GW of new storage deployments)

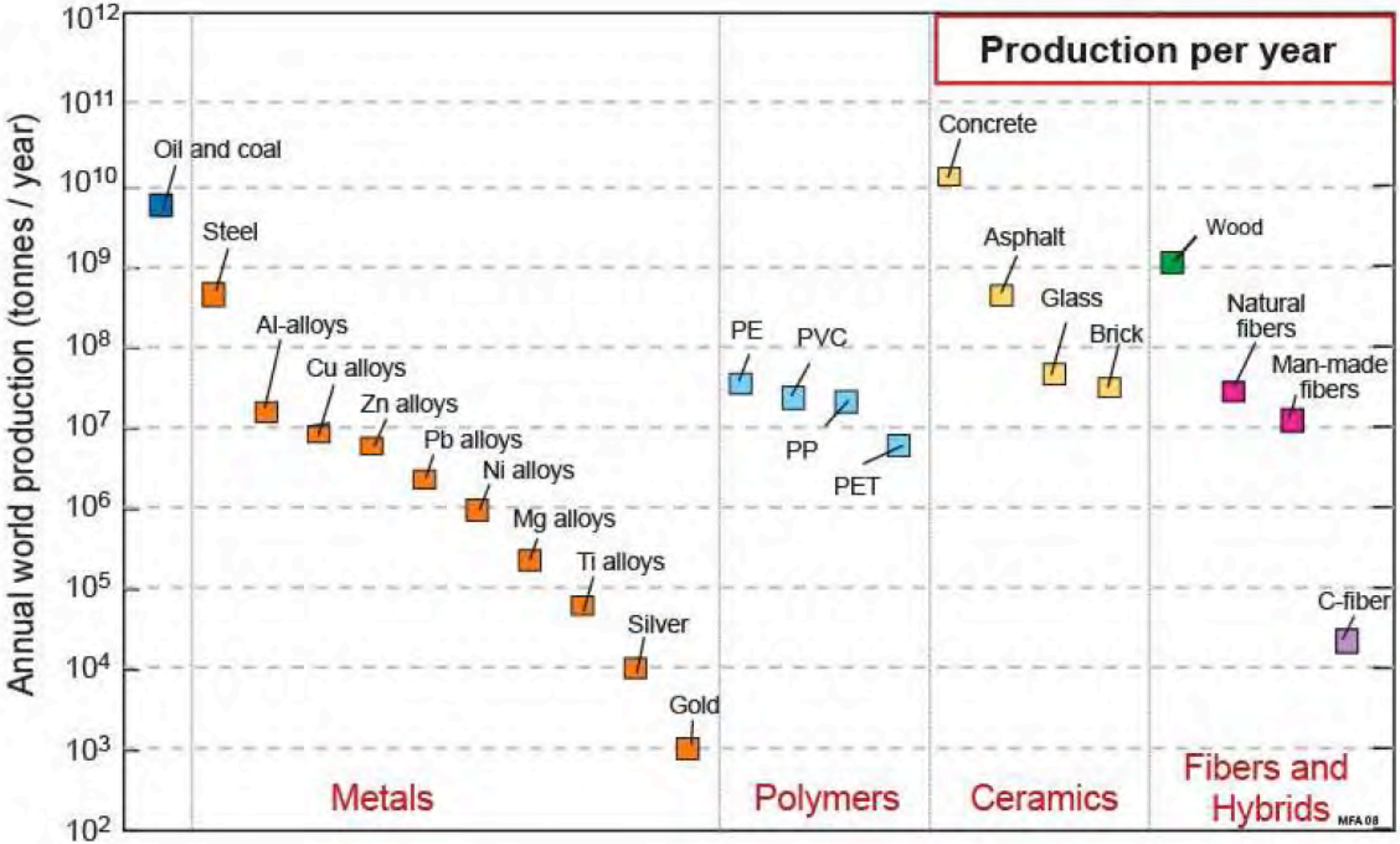
Energy Related Issues

- Large Cities in Europe Produce –
  - 80% of EUs GDP,
  - 68% of population, 85% by 2050
  - 70% of energy consumption,
  - 75% OF GHG emission
- USA: avg. home in pacific Region consumes 35% less electricity than South Central homes
  - NY has the lowest per capita energy use, Wyoming the highest (500% of NY, or 1 billion BTU/yr)

Source: www.worldcoal.org

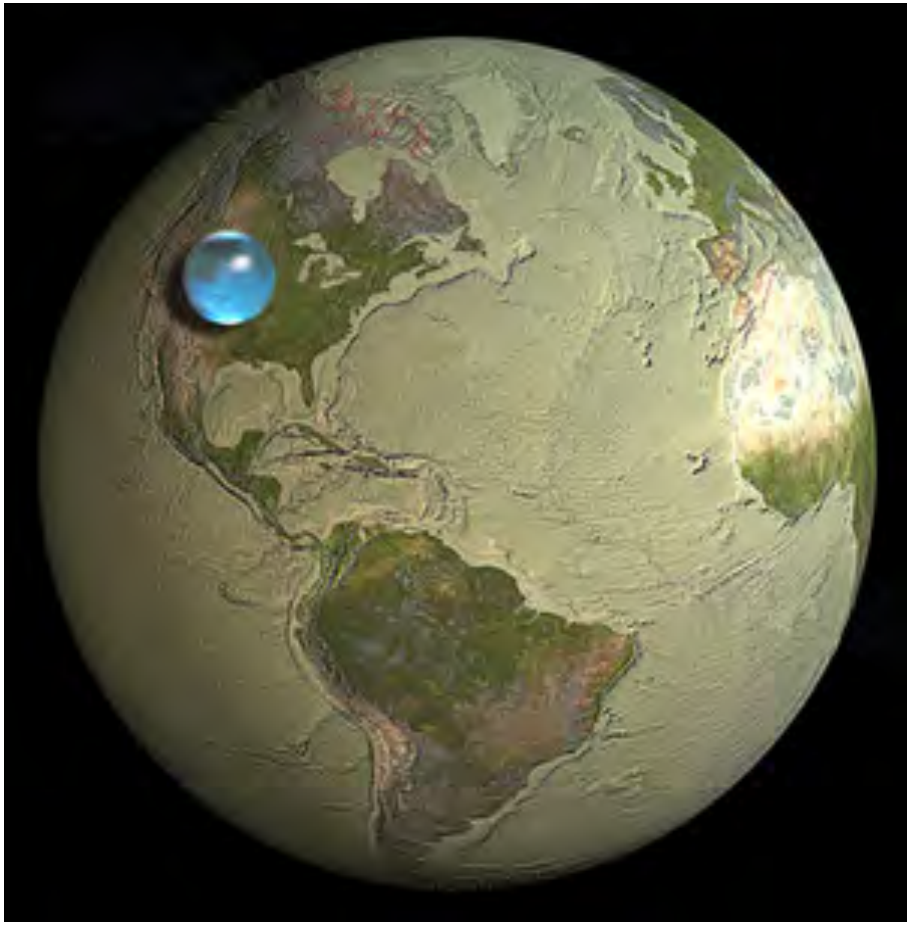
Resource Consumption for Material Production…

(Energy Required for Top 7 Materials: 1.5 TW – 10% of Global Energy)



Credit: Mike Ashby

…but the resources (and energy) are finite!



Source: http://toostep.com/debate/how-to-solve-the-energy-crisis---conservation-or-innovation

Could PV electricity be cheapter than new nuclear ?

109 EUR/MWh

Hinkley Point - UK

80 EUR/MWh

Fraunhofer ISE – Central Germany – Cheapest utility-scale

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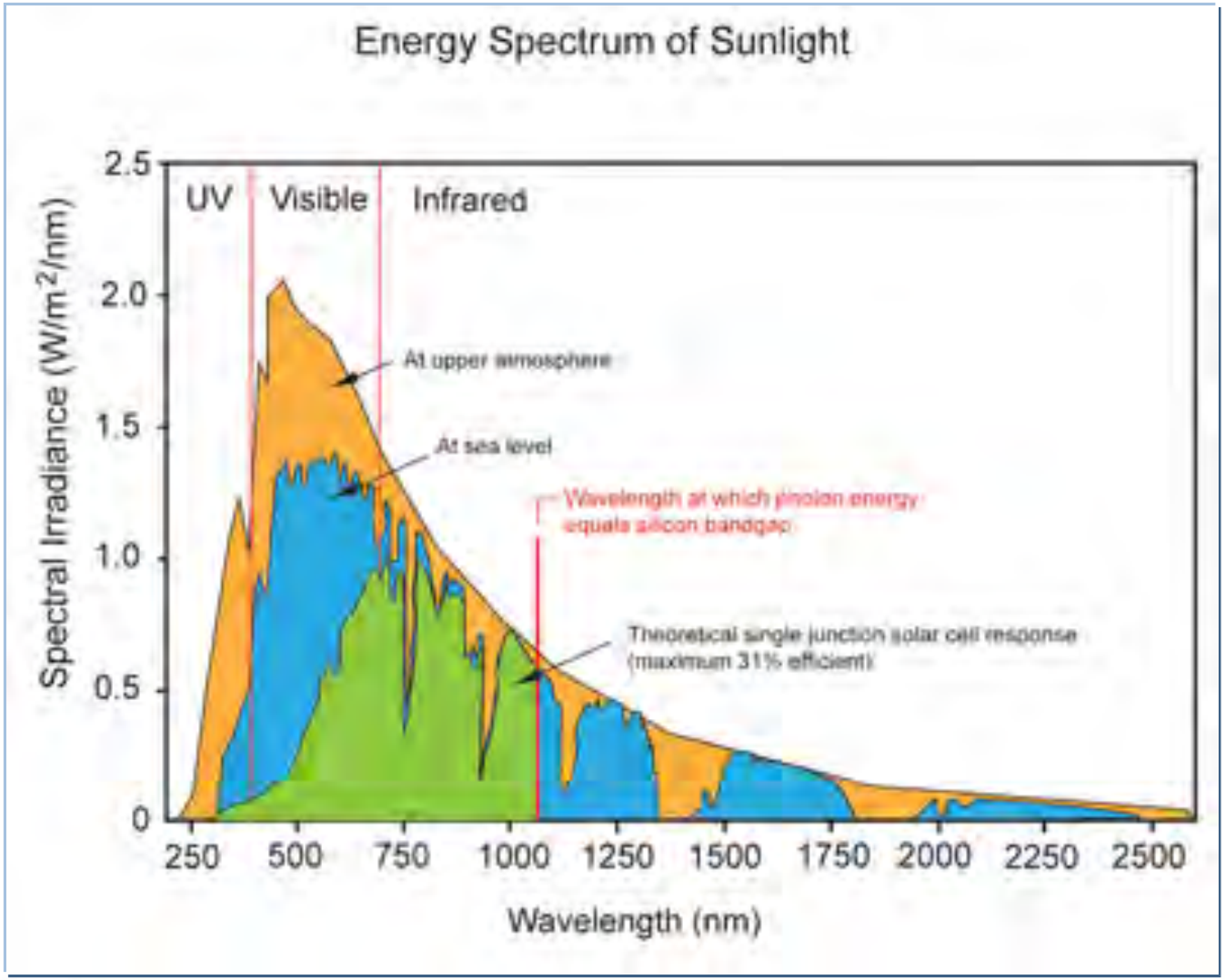
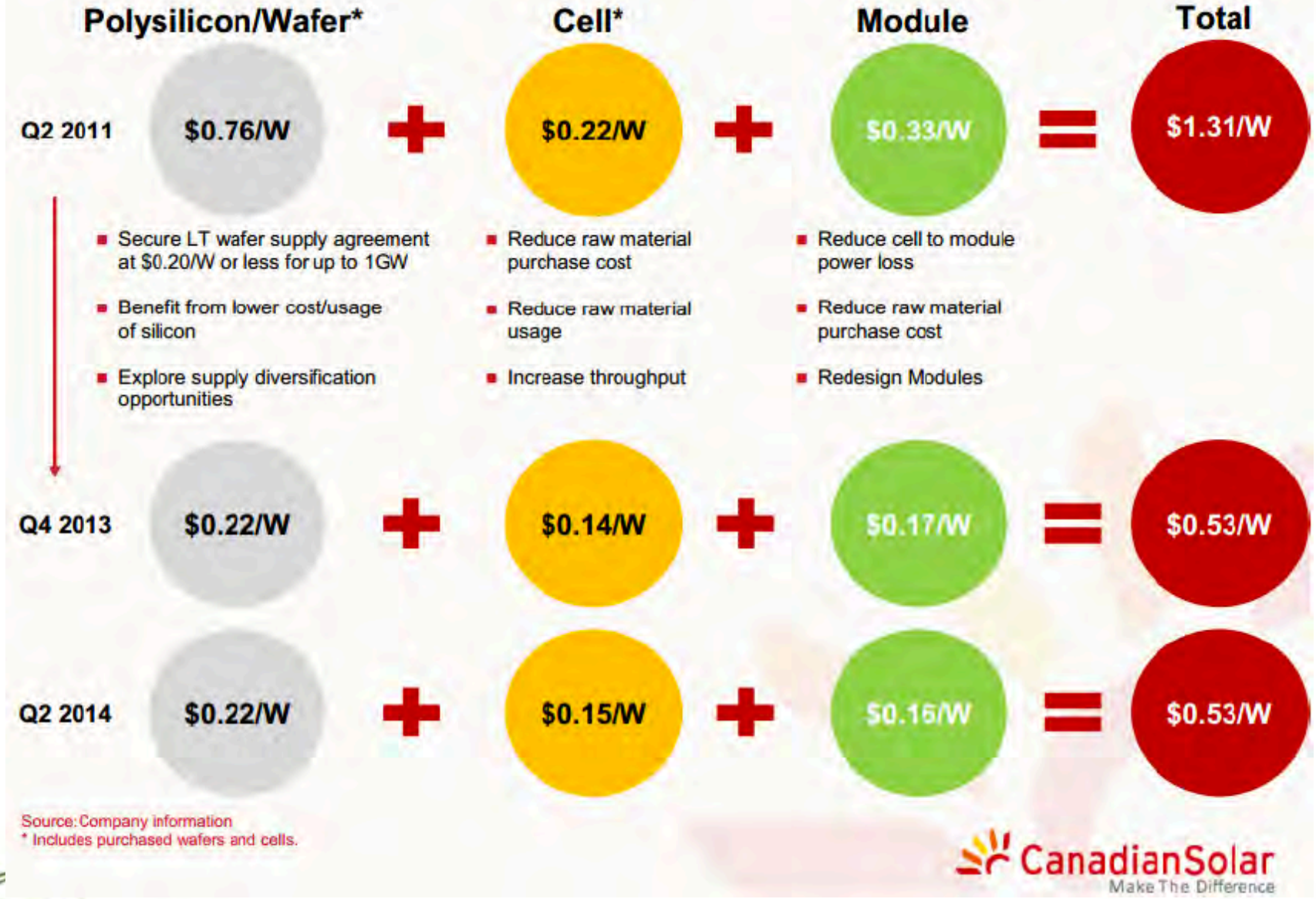
Energy of Solar Spectrum and PV Cell Efficiency



Source: http://www.rfcafe.com/references/electrical/ASTM%20G173-03%20Reference%20Spectra.htm

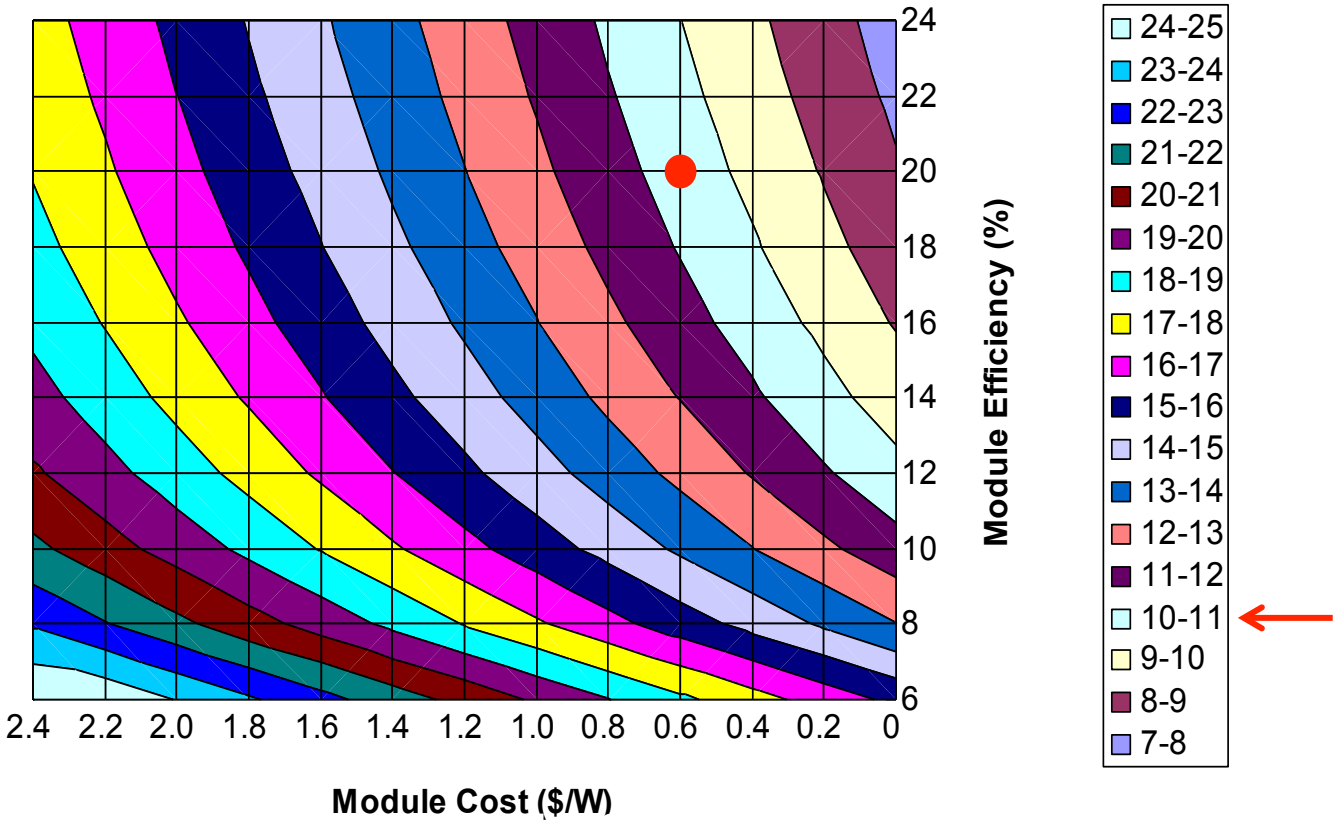


Source: Company information
* Includes purchased wafers and cells.

CanadianSolar
Make The Difference

Why Solar Energy and Solar Cells?

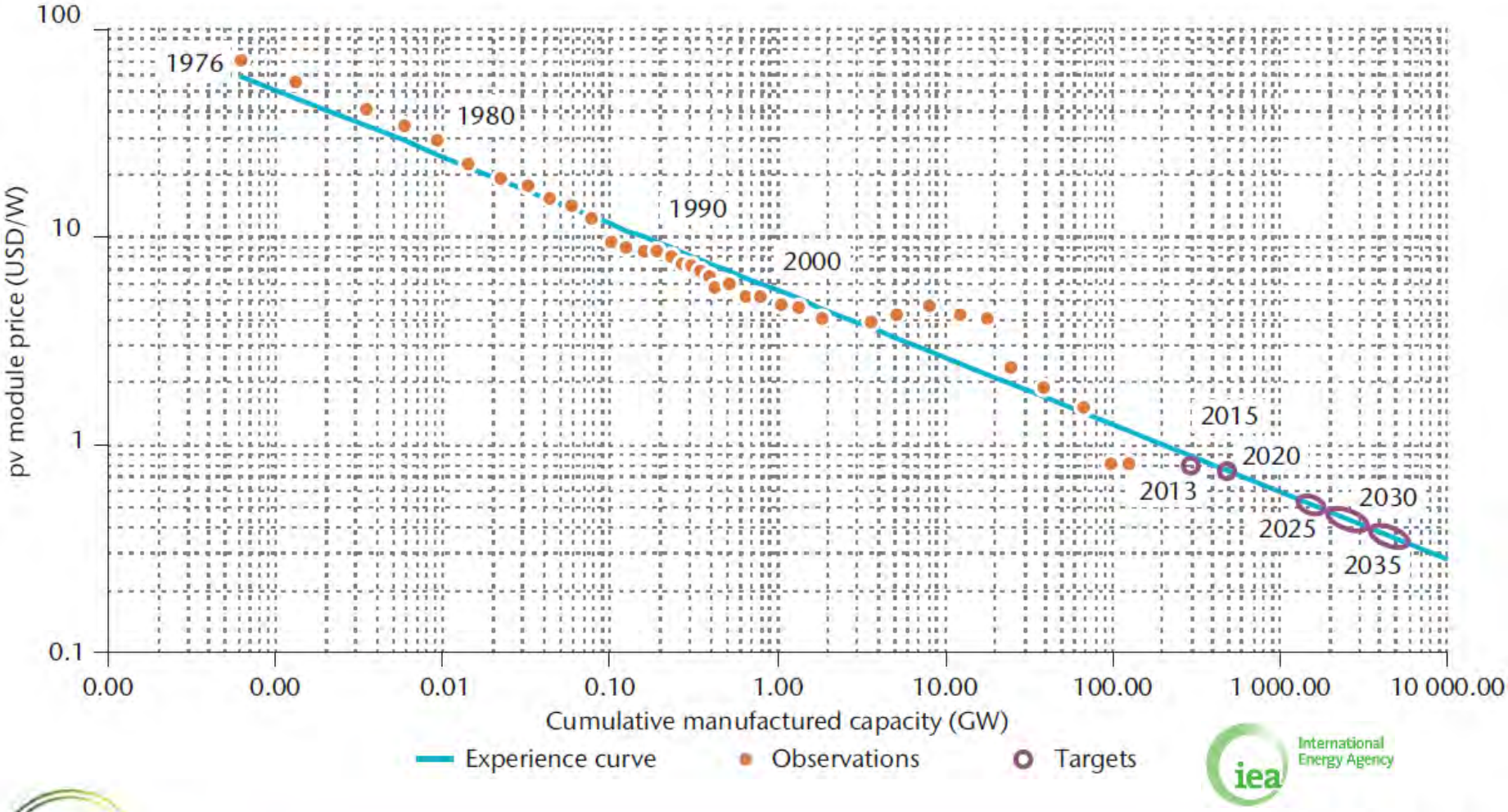
- Model of LCOE [cents/kWh] VS Module cost and efficiency



Assumption for chart preparation: 25 year lifetime, 20% derate, 7.69% WACC, No ITC, 50% debt fraction, 7% loan rate, and 5 year loan term

Plot courtesy Moon-Hee Kang, UCEP, GaTech

Projected Economies of Scale



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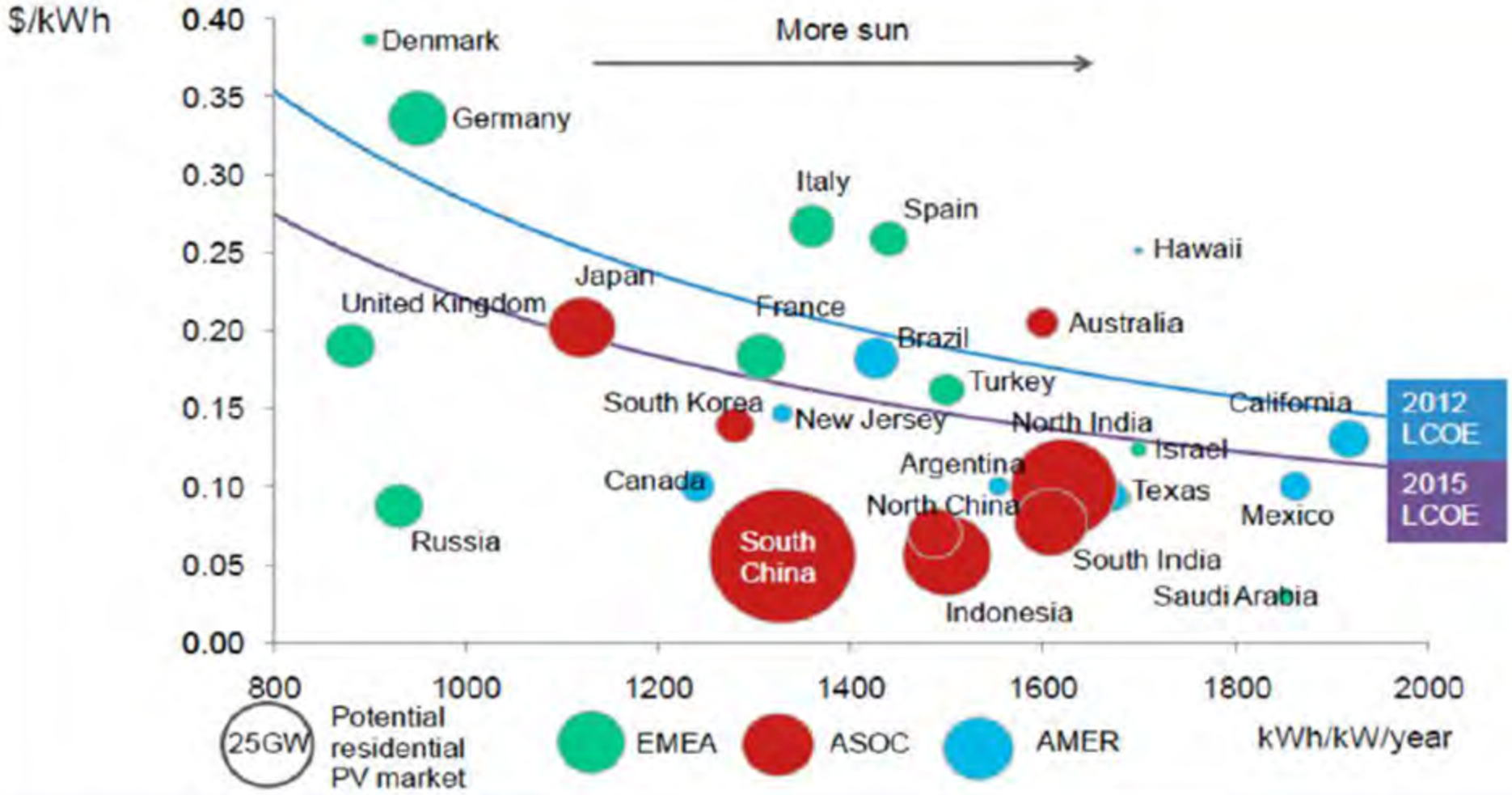
High Cost: *LCOE and Grid Parity*

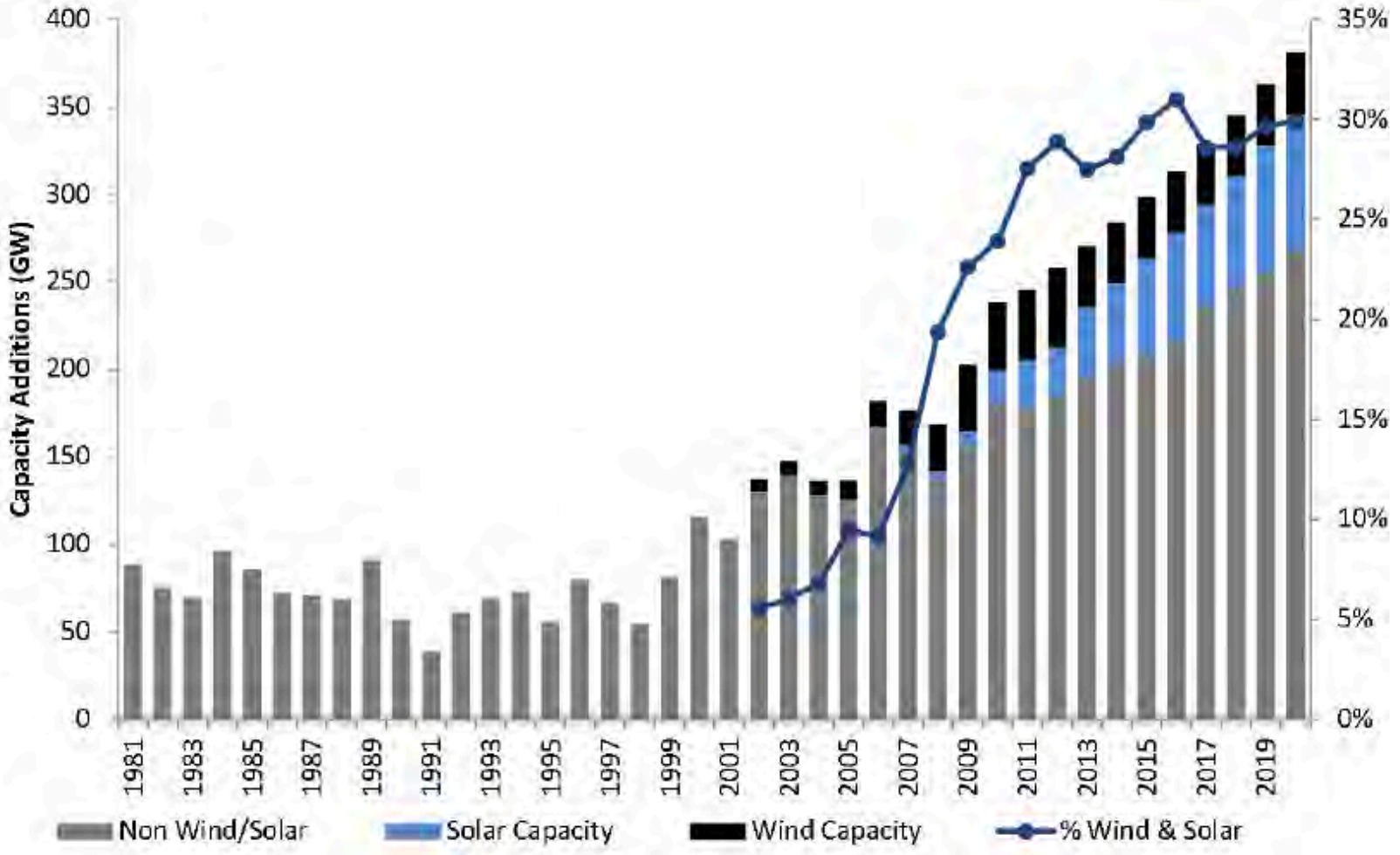


Powered by SunShot U.S. Department of Energy

Source: Bloomberg New Energy Finance. May 2012. *Reconsidering the Economics of Photovoltaic Power*

(from The Solar Foundation's *Solar Powering Your Community…*)

Global Capacity Additions



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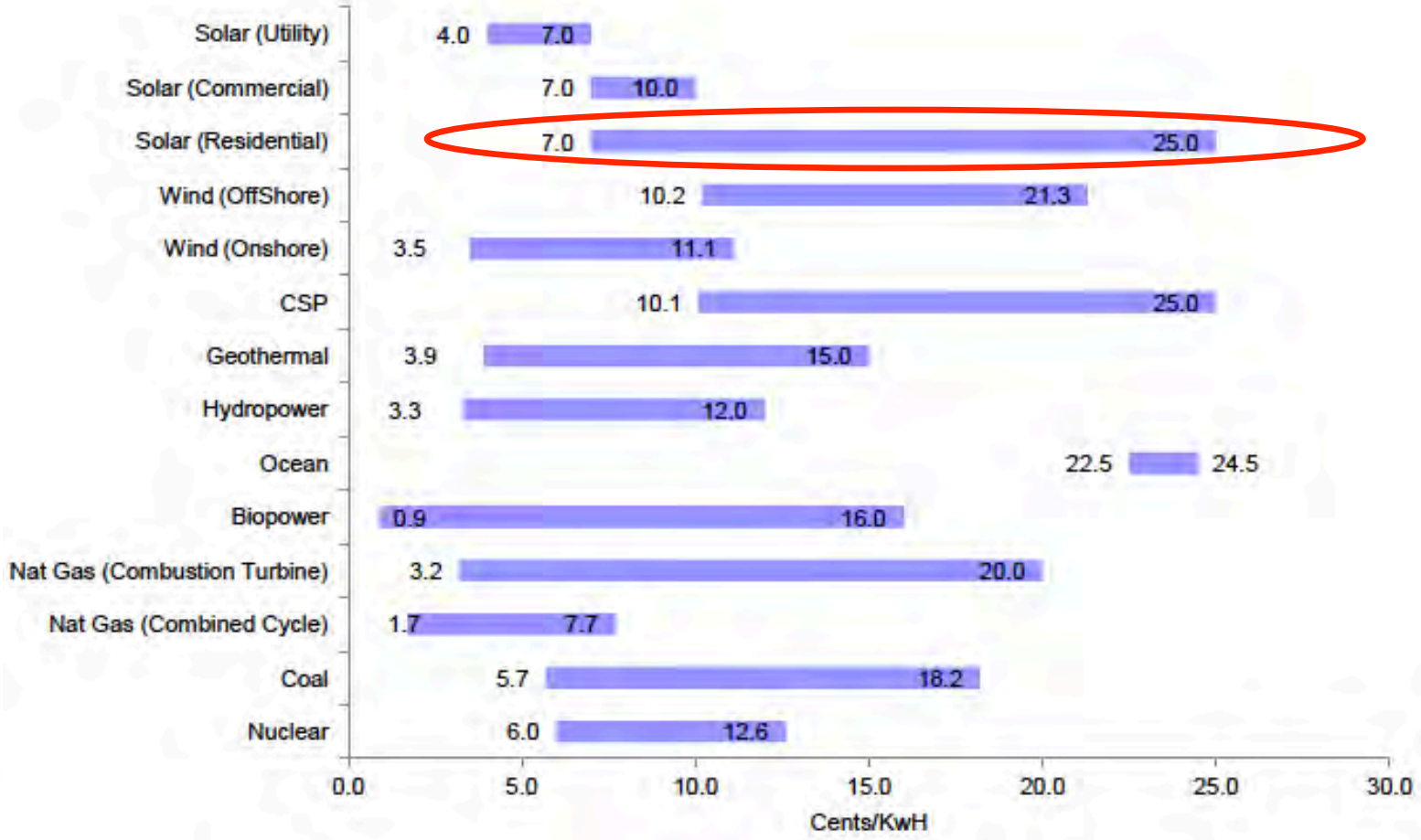
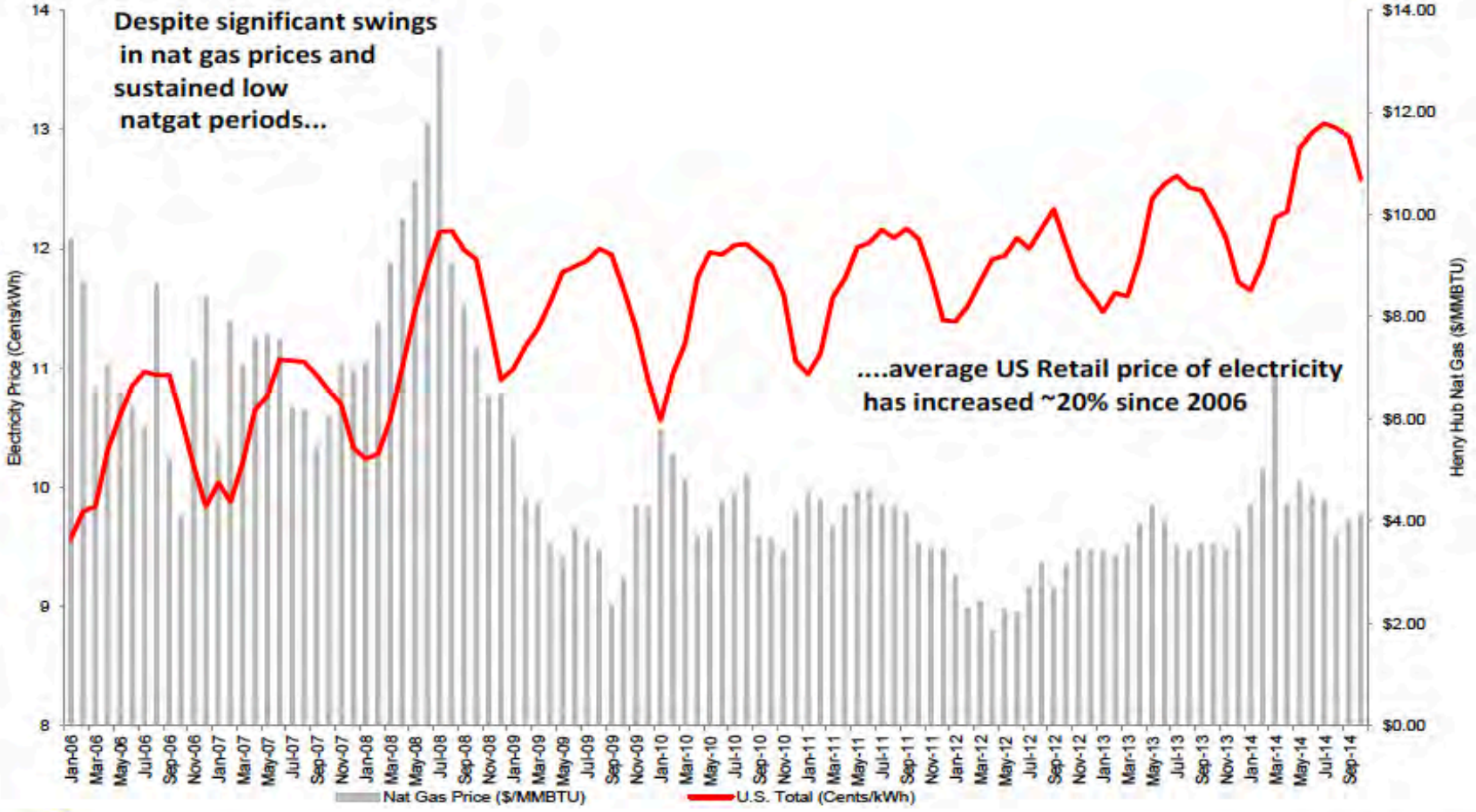
Comparative Costs of Energy Production



Source: Deutsche Bank Securities Inc. 2015

Evolution of Electricity Prices



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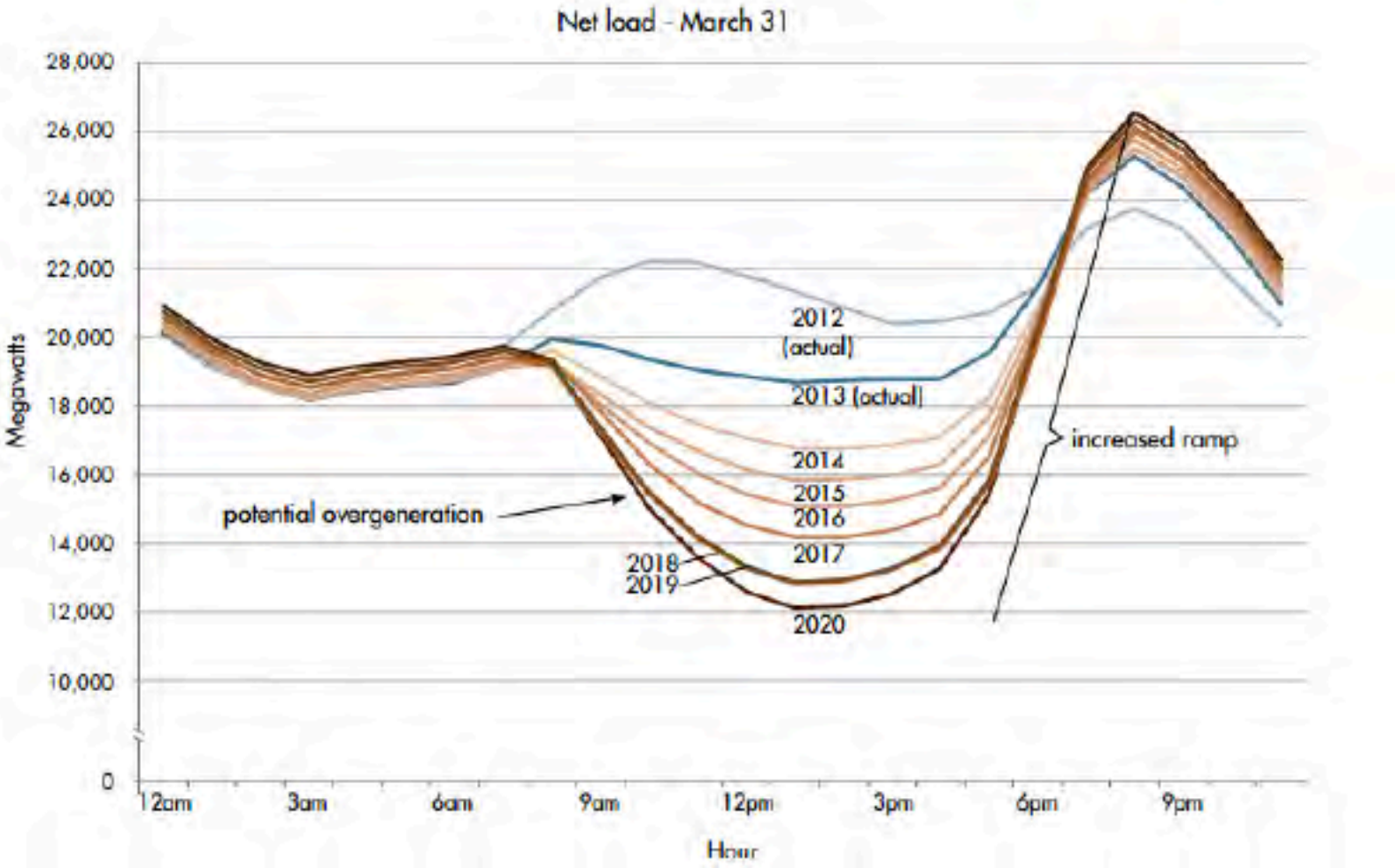
The Duck Curve (Net Load Chart)



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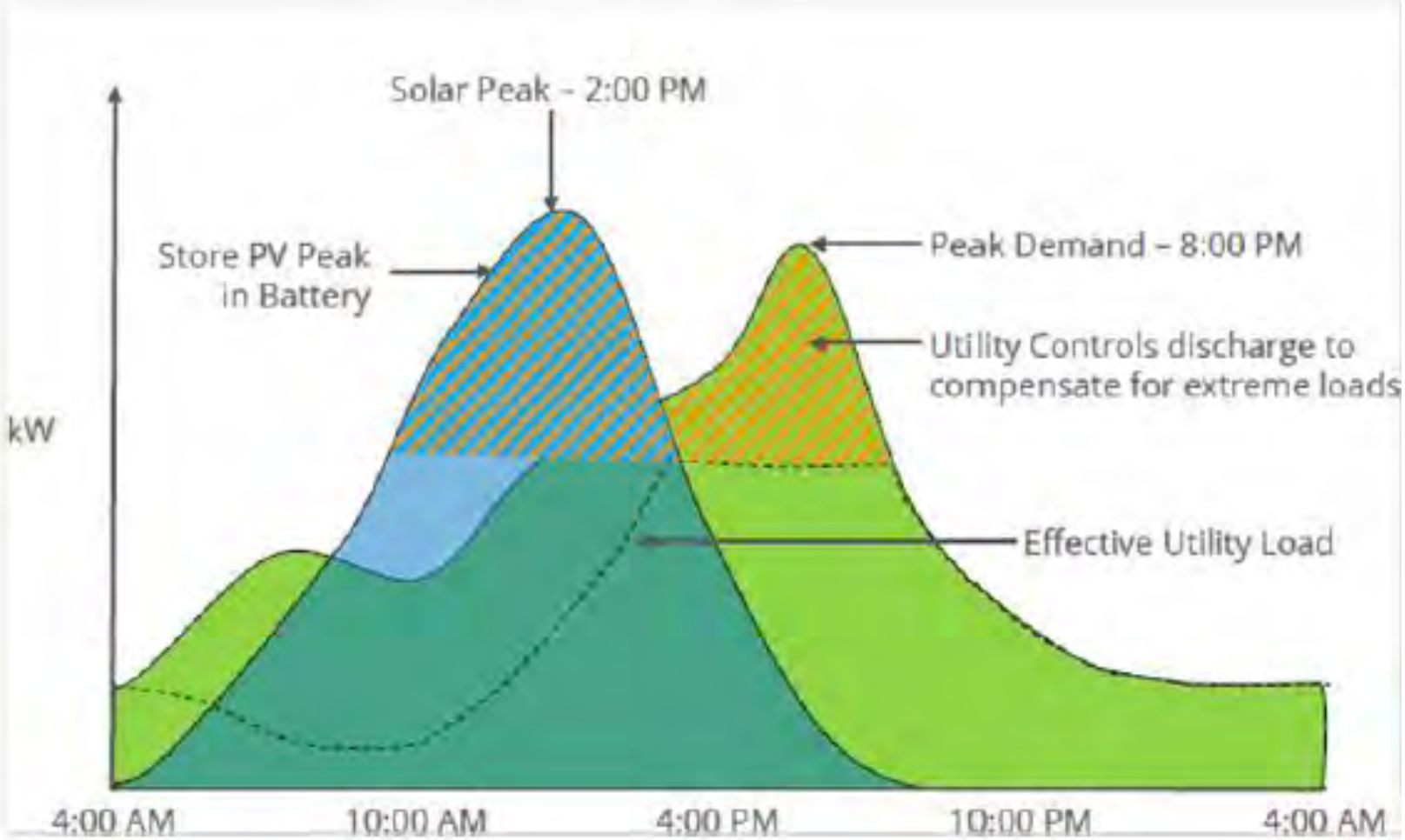
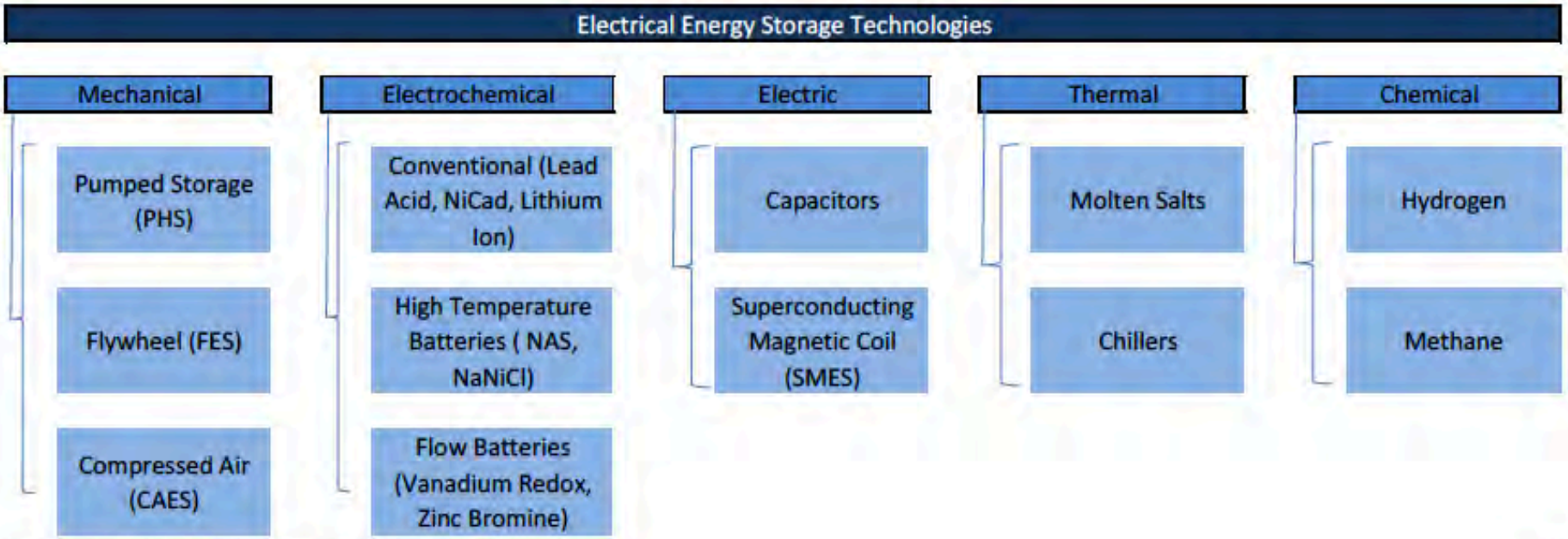
Impact of Storage



Source: Sunpower Analyst Day - 2014

Storage Technologies



Source: Deutsche Bank, State Utility Forecasting Group

Storage Incentives

- California AB2514 – CPUC storage procurement mandate for the utilities
- Plan: 1.3 GW of energy storage by 2020
- NY Battery and Energy Storage Technology (BEST) consortium – grants for thermal and battery storage units incr. to $2,600/kW and $2,100/kW
- Washington - premium prices for energy storage output and requirement for utilities to include storage in planning

Largest Solar Photovoltaic (PV) Power Plants in the World

1. “Topaz Solar Farm” in USA — 550 MW
2. “Agua Caliente” in USA — 290 MW
3. “California Valley Solar Ranch” in USA — 250 MW (completed in 2013)
4. “Antelope Valley Solar Ranch” in USA — 230 MW
5. “Charanka Solar Park” in China — 221 MW
6. “Golmud Solar Park” in China — 200 MW (completed in 2011)
7. “Imperial Solar Energy Center South” in USA — 200 MW (completed in 2013)
8. “Centinela Solar Energy Project” in USA — 170 MW (almost complete)
9. “Meuro Solar Park” in Germany — 166 MW (completed in 2012)
10. “Mesquite Solar I” in USA — 150 MW (completed in 2012)

Read more at http://solarlove.org/largest-solar-power-plants-world/#SEh1hFXv7MMmwCQK.99

Takeaways

- Global solar PV demand: up to 25 percent growth in 2016
- Distributed PV in China falls behind expectations, but continues to grow
- Grid-connected PV energy storage installations to grow rapidly
- Emerging markets mature – Chile follows South Africa to reach 1 GW of installed PV capacity
- Monocrystalline technology to increase market share in 2015
- Systems up to 100 kilowatts account for 30 percent of global installations
- California is becoming global leader in solar power penetration


Ga Tech Center of Excellence for PV