

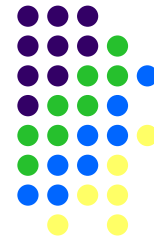
Natural Gas and Renewables: Bridge to the Future or Death Knell?

BIT's 1st Frontier Industrial Forum - 2013
24 October 2013
Qingdao, China

Lori Smith Schell, Ph.D., ERP
2013 USAEE President

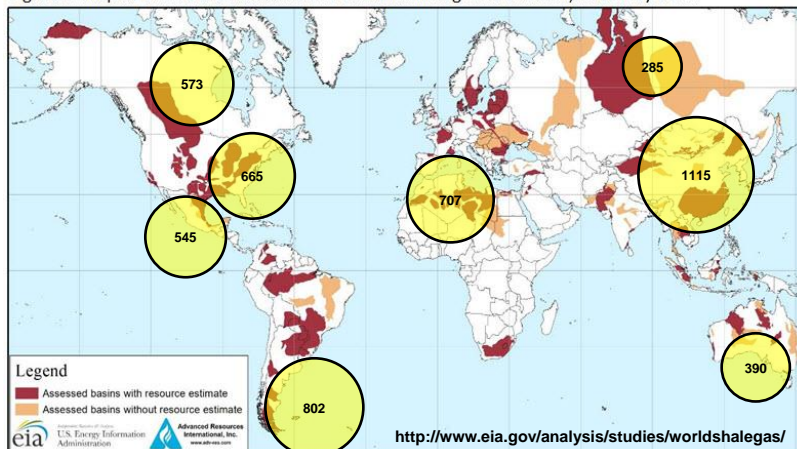


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Shale Gas and Oil Basins are Globally Disperse & Widespread

Figure 1. Map of basins with assessed shale oil and shale gas formations, as of May 2013



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U.S. Shale Gas “Revolution” – The Supply Side



Figure 91. Natural gas production by source, 1990-2040 (trillion cubic feet)

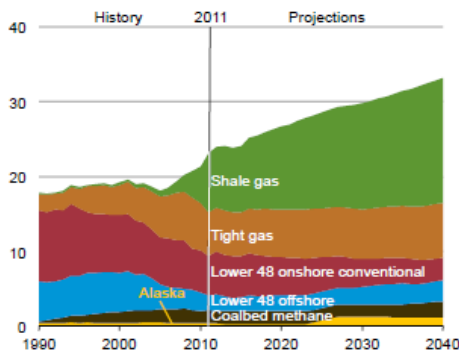
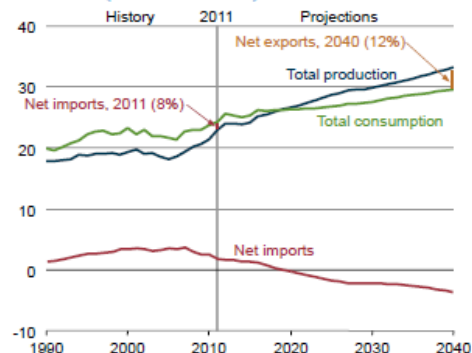


Figure 2. Total U.S. natural gas production, consumption, and net imports in the Reference case, 1990-2040 (trillion cubic feet)



Source: U.S. Energy Information Administration, *Annual Energy Review* 2013.

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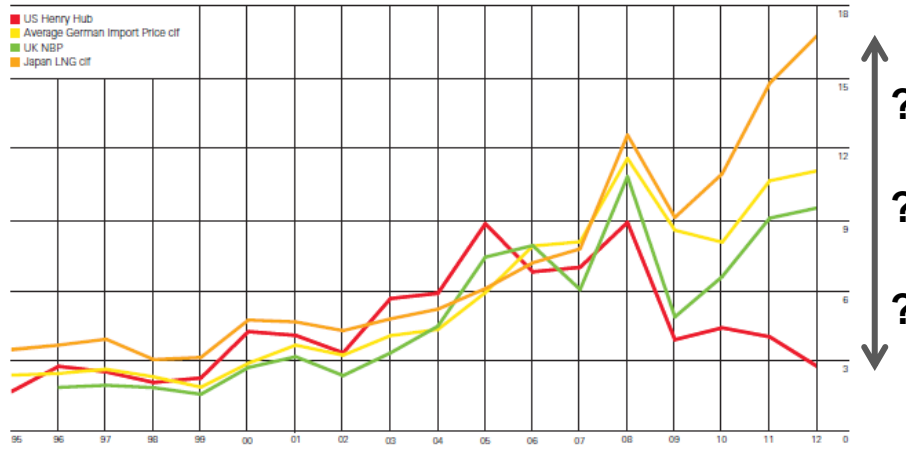
3

Differing Natural Gas Prices Create Opportunity, but Whose?



Prices
\$/Mmbtu

Source: BP Statistical Review of World Energy, June 2013.



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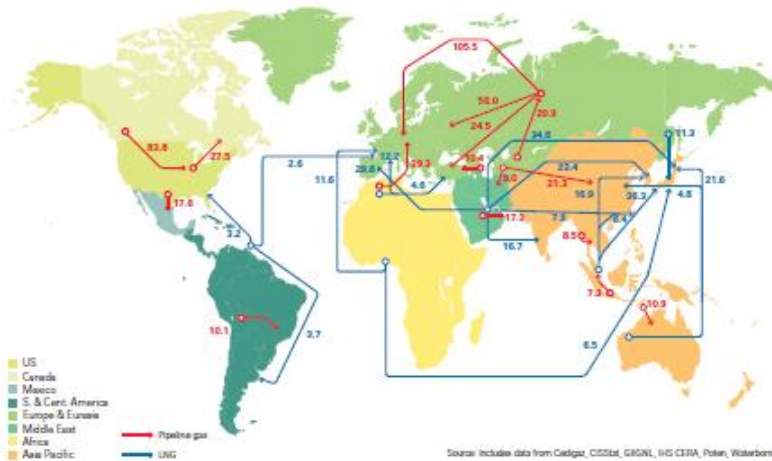
4

What if North America Becomes a Major LNG Exporter?



Major trade movements 2012
Trade flows worldwide billion cubic metres

Source: BP Statistical Review of World Energy, June 2013.



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U.S. Shale Gas “Revolution” – The Demand Side



Figure 86. Annual average Henry Hub spot natural gas prices, 1990-2040 (2011 dollars per million Btu)

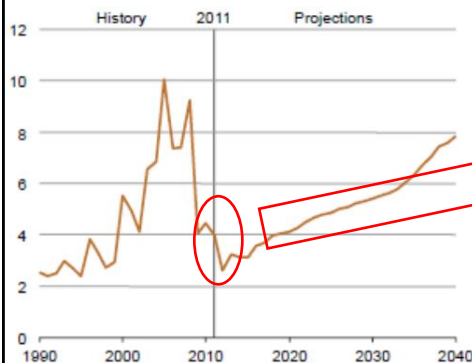
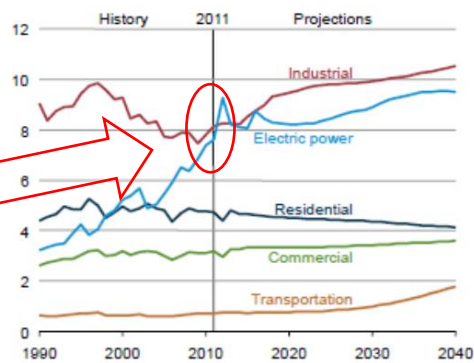


Figure 85. Natural gas consumption by sector, 1990-2040 (trillion cubic feet)



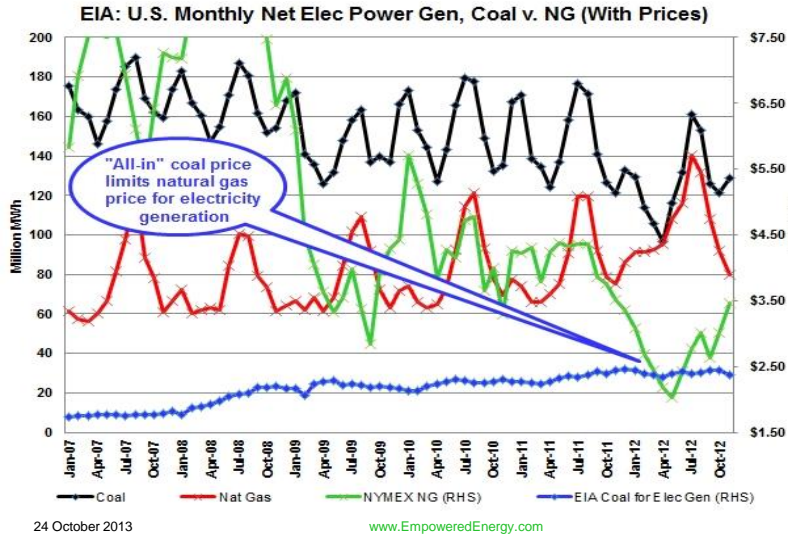
Source: U.S. Energy Information Administration, *Annual Energy Review* 2013.

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In April 2012, U.S. Natural Gas-Fired Power Gen = Coal-Fired

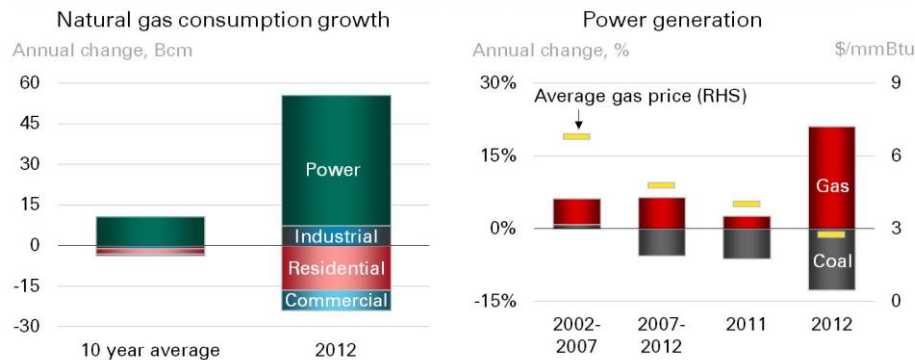


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Fortuitous Entry of U.S. Shale Gas as Coal Exits...



US coal to gas switching Source: BP Statistical Review of World Energy, June 2013.



In Increasing Volumes to China.

Table 1: China's coal imports by source, 2007-2011

Million tons	2007	2008	2009	2010	2011
Indonesia	14,1	11,6	30,5	56,3	101,2
Australia	4,5	3,5	44,6	37,0	32,6
Vietnam	24,6	16,9	24,1	18,1	22,1
Mongolia	3,2	4,0	6,0	16,6	20,2
North Korea	3,7	2,5	3,6	4,6	11,1
Russia	0,3	0,8	11,8	11,6	10,6
South Africa	0,0	0,0	0,8	7,0	10,5
USA	0,0	0,2	0,8	4,5	4,9
Canada	0,2	0,6	4,1	5,5	4,5
Others	0,3	0,7	0,4	5,1	4,9
TOTAL	51,0	40,8	126,6	166,3	222,4

Note: Chinese coal imports data include "lignite" imports supplied by Indonesia mainly. Whereas lignite is not usually traded on the international market due to its very low calorific value, Indonesia exports large quantities of low calorific coal falling under this sub-category.

Source: National Development and Reform Commission (NDRC), China's Customs Statistics

Source: IFRI, *Global Coal Trade: From Tightness to Oversupply*, Sophie Cornot-Gandolphe, February 2013, p. 21.

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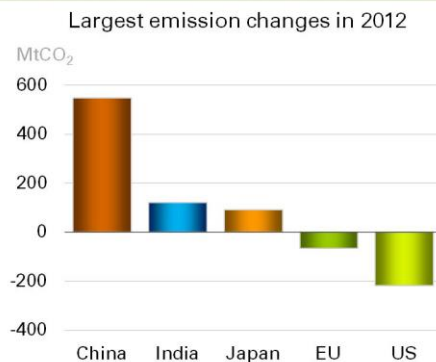
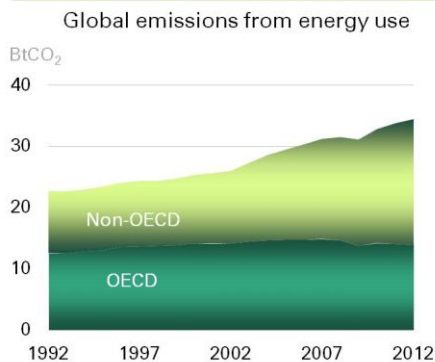
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U.S. CO₂ Emissions Fall Thanks to ~~K~~to Shale Gas...

Carbon emissions

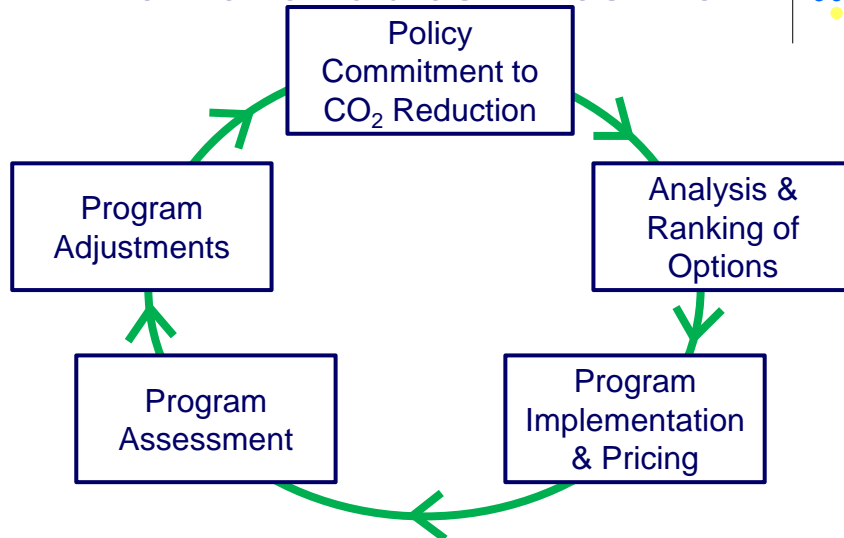
Source: BP Statistical Review of World Energy, June 2013.



BP Statistical Review of World Energy

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Renewable Portfolio Standards Drive Renewables Investment



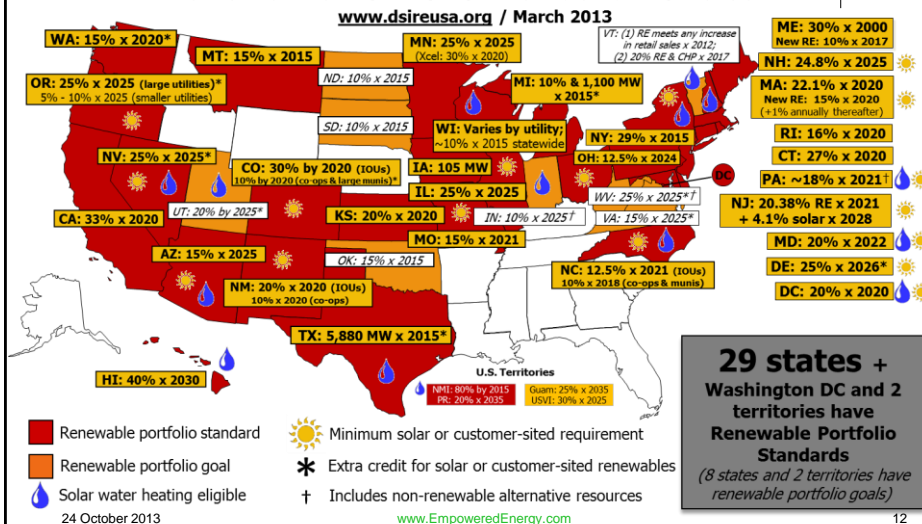
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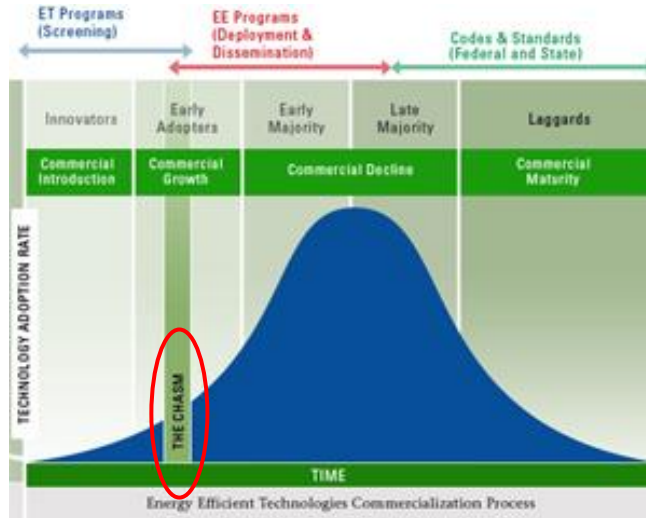
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U.S. Policies Similar to Global but Implementation Differs

Renewable Portfolio Standard Policies



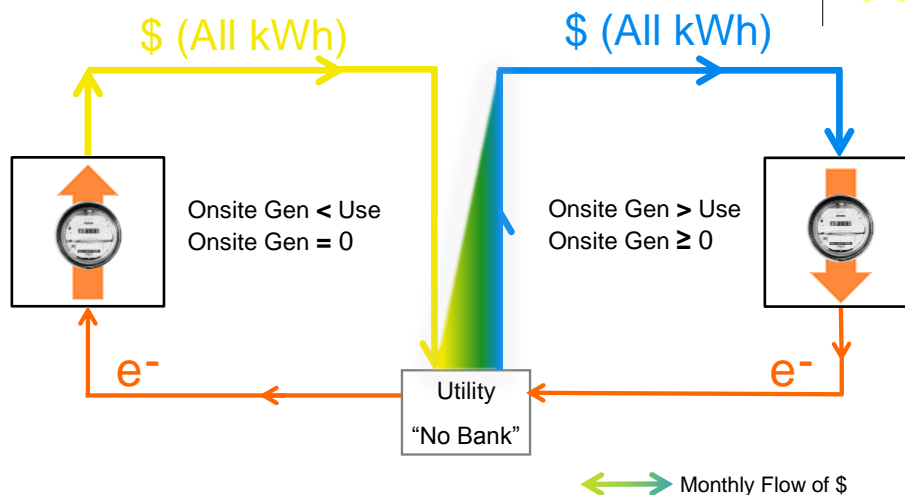
RPS Policies Designed to Drive Market Transformation.



Source: American Council for an Energy-Efficient Economy, <http://aceee.org/portal/market-transformation>.
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Europe Favors Feed-In Tariffs: 2 Meters (Locations May Differ)

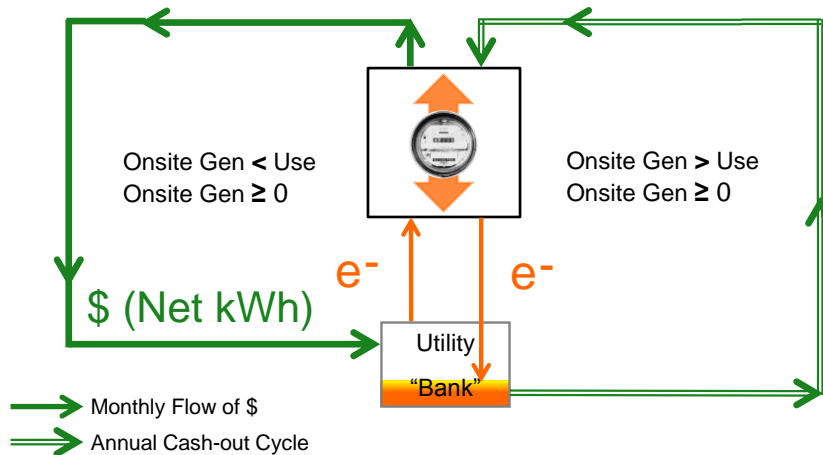


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U.S. Favors Net Metering: One Bidirectional Meter, Cash Settle



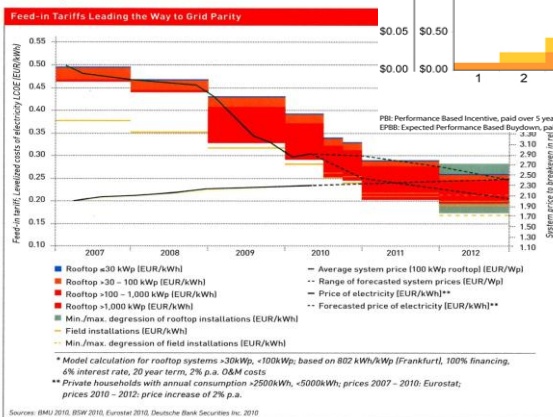
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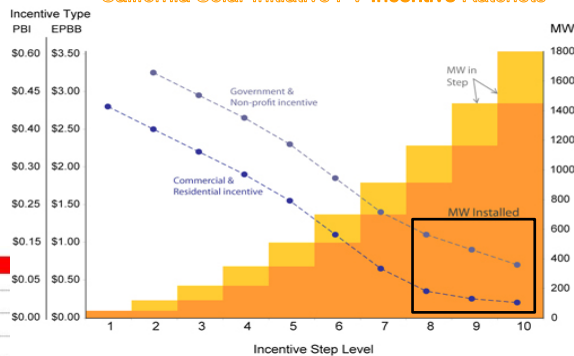
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Must Ratchet Prices Down Over Time

The German Solar PV Experience



California Solar Initiative PV Incentive Ratchets



Source: California Public Utilities Commission, "About the California Solar Initiative," Figure 1. Overview of the CSI Step Level Changes, <http://www.cpuc.ca.gov/PUC/energy/Solar/aboutsolar.htm>

Source: Germany Trade & Invest, "The Photovoltaic Industry in Germany," Issue 2010/2011, p. 4.

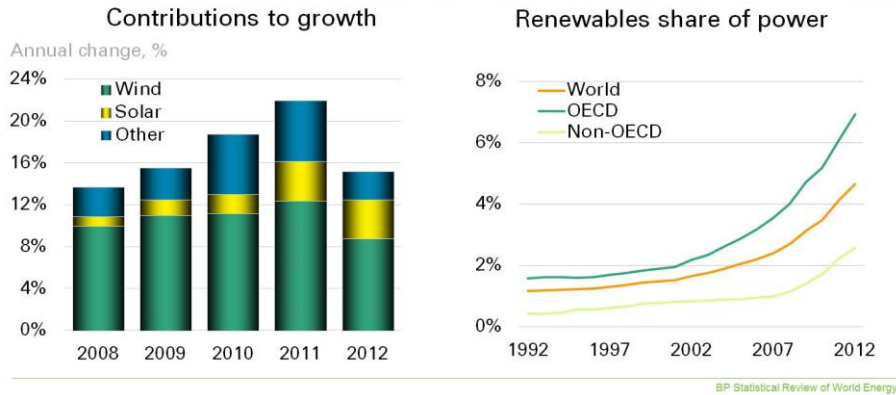
Policy Support ➡ Increased Renewables in Power Gen



Source: BP Statistical Review of World Energy, June 2013.



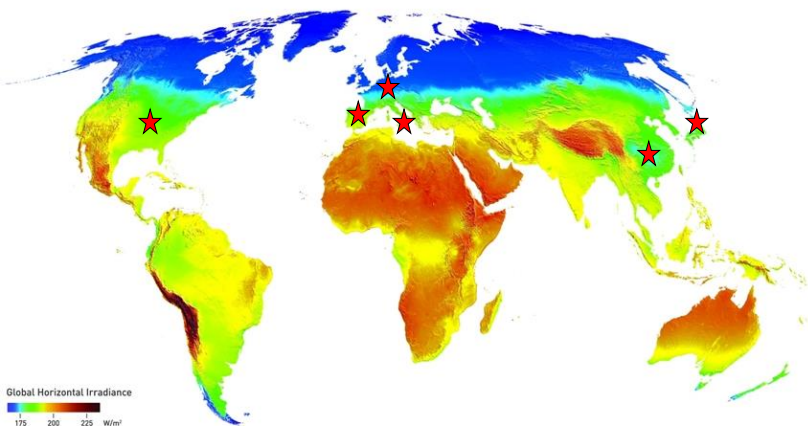
Renewables in power generation



Solar Potential Varies by Location, Time of Day, Season



Global Mean Solar Irradiance

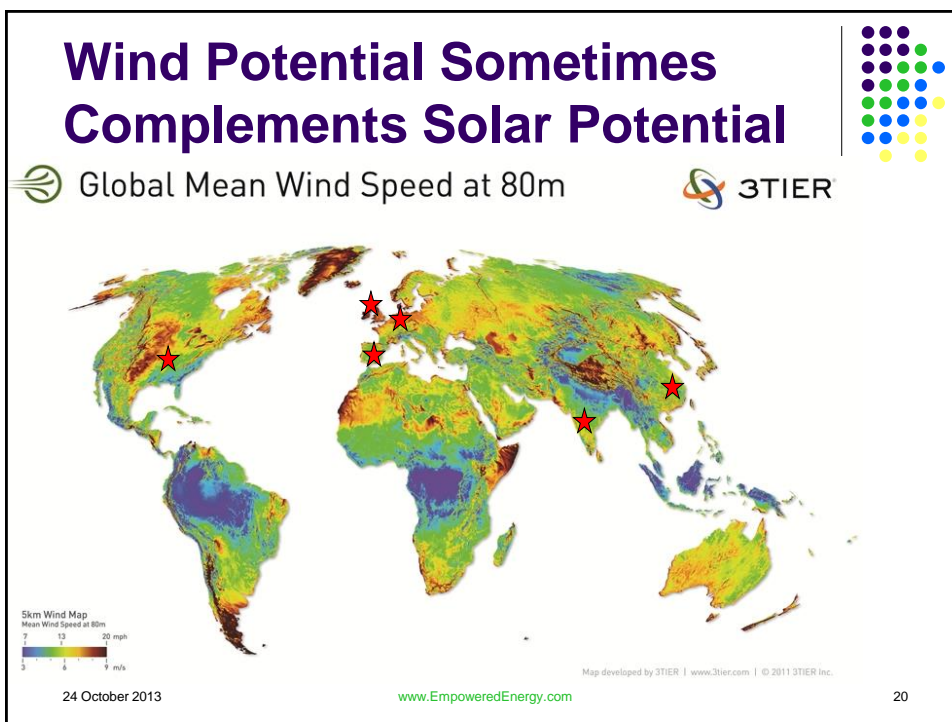
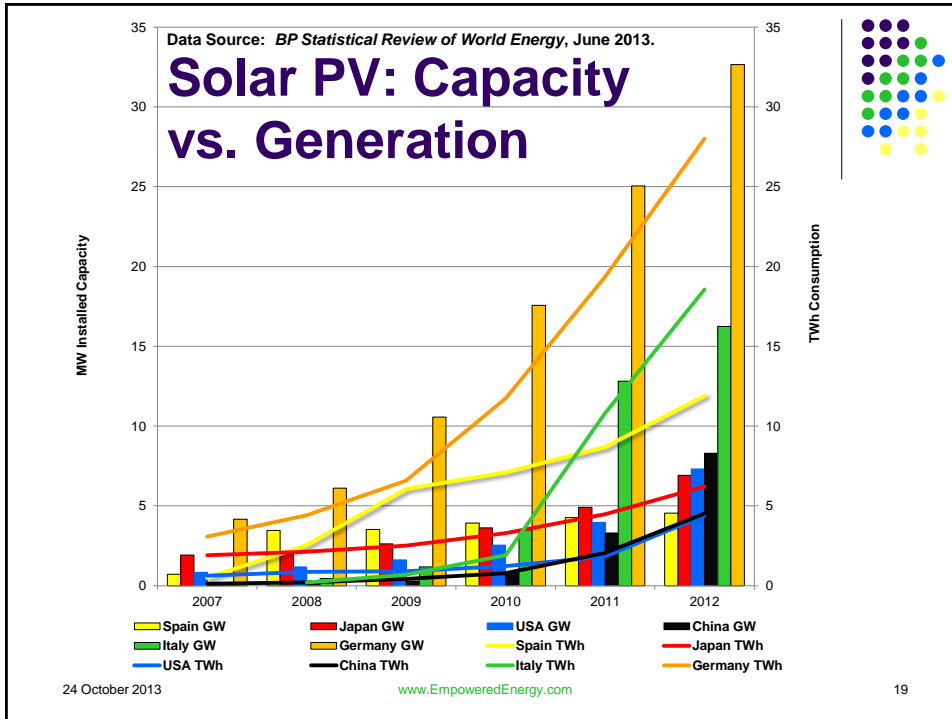


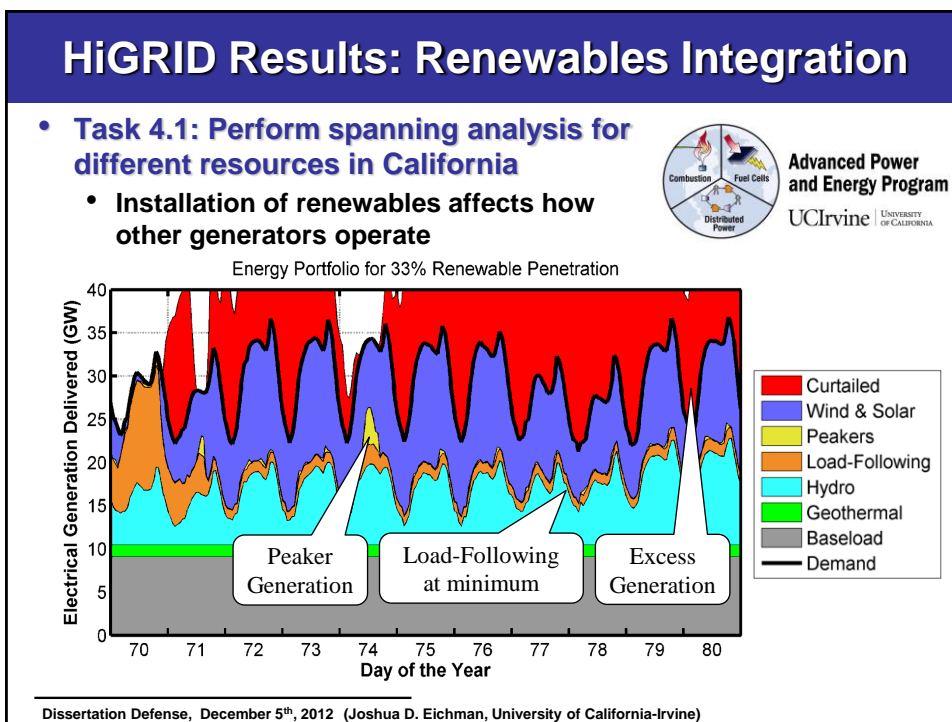
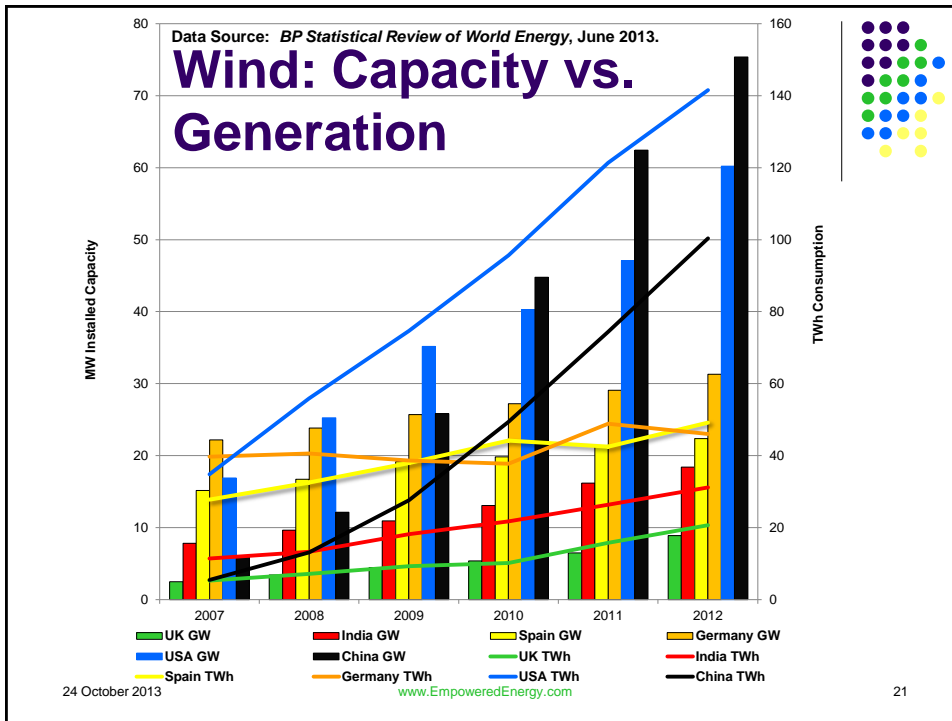
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Complementary Technologies Aid Renewables Integration



- Demand Response
 - Peak Shaving
 - Load Shifting
- Energy Storage (Speed vs. Capacity)
- Plug-in Electric Vehicles (“Smart” Charging)
- Off-peak H2 Production (Minimizes Curtailment; “Free” Vehicle Fuel?)

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Conclusions: Competing Forces Create Uncertainty/Opportunity



- Cheaper natural gas will:
 - Provide the flexible generation required to support intermittency of renewables
 - May actually increase natural gas-related CO₂ emissions as natural gas-fired generators ramp up and down, operating as less than optimal levels
 - Potentially reduce policy support for renewables
- Need to think “outside the box” to combine technologies that have not traditionally been thought of as natural partners.

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