PREPARED BY

The Oregon Center for Non-Partisan Policy Studies
A Project of OESTRA: Oregon Energy Systems, Technology, and Research Alliance

ENERGY AT THE CROSSROADS

New energy economy trends toward a paradigm for renewable energy and associated technologies in coming decades

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PURPOSE OF THE STUDY

The purpose is to provide an ongoing base of background information for Oregon policy makers as they allocate public resources toward energy related purposes. Data will be updated at regular intervals such that material changes in pricing, technology, and other factors can be considered in relevant context.

This White Paper is part of a series of studies and policy publications undertaken by OESTRA beginning in 2008. Other publications by OESTRA include:

> OREGON'S RENEWABLE ENERGY ADVANTAGE, Investing in Talent, Creating Family Wage Jobs, Measuring Outcomes, 2010 (first White Paper)
>
> A ROLE FOR ENERGY AND HIGHER EDUCATION IN OREGON'S PRIVATE SECTOR JOB GROWTH, February 2012 (a policy document)
>
> POWER OREGON, June 2012 (a Proposal to Oregon Innovation Council with attachments that includes recommendations to the Governor)

OESTRA projects underway for future publication include:

> Prioritizing Economic Development Expenditures: Considering the New Energy Paradigm
>
> Optimizing Oregon's Public Investments: Energy Conservation and Energy Efficiency

ENERGY USE, TECHNOLOGY AND ECONOMIC DEVELOPMENT

OVERVIEW

This study is a part of ongoing research relating to energy policy, economic development, and related job growth by the Oregon Center for Non-Partisan Policy Studies (OCNPS). OCNPS grew out of a privately funded initiative: Oregon Energy Systems, Technology, and Research Alliance. OESTRA set the stage for the successful passage of HB3507, 2011 (Honorable Tobias Read), by publishing a White Paper entitled: "Oregon's Renewable Energy Advantage, Investing in Talent, Creating Family Wage Jobs, Measuring Outcomes." HB3507 had bipartisan support in both houses of the Legislature and was signed into law by Governor Kitzhaber in 2011.

Our work has been validated by two recent studies: "A Business Plan for America's Energy Future," authored by the American Energy Innovation Council; and, "Leveraging State Clean Energy Funds for Economic Development," authored by the Brookings-Rockefeller Project on State and Metropolitan Innovation. Both studies recognize a need for public/private partnerships and for collaboration in setting goals for government planning, higher education, and energy policies. They also urge that states make higher education a priority due to the dwindling pool of engineering and technical talent available to lead the emerging economy.

Global warming, energy scarcity, national trade security interests, peak oil, environmental concerns, joblessness, and corporate investments provide a sense of urgency for planners and policy makers. Energy is the foundation for economic development. Oregon has an opportunity to position itself for high wage job growth within the new energy paradigm.

Historically, economic development, and thus growth in jobs, relied on fossil fuel (natural gas, petroleum, and coal) and with hydroelectric energy generation. However, the cost, availability, and environmental problems associated with fossil fuel sources threaten economic development and job growth going forward. The cost of these sources of energy is rising. Fossil fuels, especially coal and petroleum, are a major source of environmental degradation.

Oregon's hydroelectric power generation, which has been essential to the economic development of Oregon and the Northwest, is at or near its limit. The United States now imports 50% of its petroleum from other nations. In 2011, 43% of electricity output in the U.S. came from coal, 24% from natural gas, 19% from nuclear, 8% from hydro, and 5% from renewable energies.

Our studies show that a clean, affordable, and sustainable energy supply will be a critical foundation for economic development and job growth going forward. The studies further conclude that establishing a clean, affordable, and sustainable energy supply requires a technologically trained workforce. While Oregon and the Northwest enjoy high quality indigenous sources of renewable energy (hydro, wind and wave for example), there is no programmatic commitment to match technology training with energy policy.

The need for new energy paradigm, based on indigenous resources and technology training to create high wage jobs, makes it imperative that Oregon examine current policies and prioritize energy and job skills in its job growth strategy. Oregon is spending hundreds of millions of tax dollars annually on programs that are energy related.

An earlier Policy Paper prepared by OESTRA entitled "A ROLE FOR ENERGY AND HIGHER EDUCATION IN OREGON'S PRIVATE SECTOR JOB GROWTH: Optimizing Outcomes from Public Investment in Economic Development" evaluates the evidence and makes suggestions for public policy based on this and other studies. One thing is clear; the needs of economic development and job growth have changed dramatically with the shift to the new energy economy. With it, Oregon's public policy must shift to enable it to plan for and participate in a new energy paradigm to fuel economic development and job growth in the coming decades.

The authors identify the elements of a successful economic development and job growth program in the new energy economy. As a part of the evaluation, an examination of programmatic gaps in existing policies and programs that affect Oregon's ability to attract and maintain high wage jobs and offers alternatives is included.

The evaluation of the components of a successful new energy paradigm requires consideration of native advantages in the context of both business and public interest rationales. The availability and cost of energy is central to the requirements of both business and the public interest.

Our studies test the thesis that Oregon's natural advantage in renewable energy resources, and significant investment in technology and innovation, provide an opportunity that will lead to rapid economic development and job growth. Accordingly this study addresses energy use, energy supply, and the pace at which renewable energy may be expected to contribute toward electricity output in the future. Of particular interest is the pricing parity of renewable energy with fossil fuels for electric power generation. We identify policies that can be implemented by public/private partnerships, including those that are already established like Oregon Inc. and ETIC, that will accomplish the goal of near term engagement in a serious, focused program of sustainable job growth in Oregon. This study concludes that a successful economic development and high wage job growth program can occur within the parameters of existing tax dollar funding by adjusting funding priorities, including higher education, and attention to the need for technology training.

The OESTRA studies, and related Policy Papers, may be considered tools to evaluate strategic investments in terms of energy and economic development policies. The studies can also help to examine programmatic gaps in existing policies and programs that affect Oregon's ability to attract and maintain high wage jobs.

To the extent available, the Appendix will include information on energy subsidies, technology advances, and energy sources that affect energy use. One thing is abundantly clear; the need for economic development and job growth policies have changed dramatically in the 21st Century.

OESTRA and The Oregon Center for Non-Partisan Policy Studies strive to be a resource for legislative leaders, Executive Branch (Gov. Treasurer, Attorney Gen), OEDD (Energy), OUS, ETO, DOE, the Oregon Innovation Council, and Business Oregon on questions relating to policy, job growth, and strategic investments in economic development.

A SHORT HISTORY OF ELECTRICITY GENERATION

Materials abridged from a report by: *Jeff Bladen, Mark Group, Philadelphia, PA.*

Power generation was originally set up to provide a source of energy to businesses that wanted to generate and use their own power. In 1883 the Edison Electric Illuminating Company had 334 operating generators in cotton mills, grain elevators, manufacturing plants, newspapers and theaters. When central power plants did emerge, they were neighborhood affairs. Edison's Pearl Street Station in lower Manhattan served 59 customers with a 72 kilowatt demand.

It is clear that generating electricity has undergone significant changes over the past 100 years. What began as a local business, evolved to become large regulated monopolies serving an entire region. Regulation is steadily shifting toward a federal planning system after a long period of encouraging size and vertical integration at the state level. The introduction of renewable energy introduces a major debate about how to return to a model of distributed power generation that is based on local need.

Economies of scale that fossil fuel power plants and larger grid systems could provide became increasingly evident. Bigger plants operating at higher pressures and temperatures could produce more kilowatt-hours (kWh) per unit of fuel burned. The more customers connected to a grid, the fewer power plants needed to reliably provide them with electricity on demand. Metropolitan and then regional utilities arose. In 1900, 60 percent of electricity was generated on- site. From 1919 to 1927 some 52,000 small steam engines and another 18,000 internal combustion engines were scrapped. By 1930 only 20 percent of electricity was generated on-site.

In the first quarter of the 20th century the political question was one of ownership and of control the new utilities. Eventually a compromise was reached. State regulatory commissions would oversee vertically integrated private monopolies that owned the power plant, the transmission and distribution lines and sold directly to the customer. (Municipally owned, self- regulating utilities also proliferated, and in the 1930s, spurred on by federal intervention, rural electric cooperatives also spread).

State regulatory agencies guaranteed utilities a profit. In return utilities had a legal obligation to serve all customers and to maintain a high level of reliability and performance.

It was a tidy system that worked reasonably well for about 70 years. Regulatory commissioners had an easy job: deciding how fast rates would drop. By 1965, the average price of electricity had declined to 1.5 cents per kWh, down from more than 30 cents in 1910.

In the 1970s, the context for energy planning changed dramatically. A ten-fold increase in the price of oil destabilized the economy, generated high inflation, and pushed borrowing costs higher. The price of new power plants rose sharply. For the first time in two generations, the price of electricity rose.

The bigger-is-better principle that began in the early 1900s reached its peak in the 1970s when utilities, urged on by the federal government aggressively embraced huge nuclear power installations that individually could serve as many as 4 million households. By 1980 demand leveled off and began to fall for the first time since the Depression. Surplus electrical generating capacity reached 39 percent. Several utilities declared bankruptcy. State regulatory commissions began to discourage utility expansion.

In the 1980's, prodded by environmental activists, state regulatory commissions began to develop new decision making rules and tools. A utility that *wanted to build a new power plant or a new transmission line had first to prove a need. And it had to evaluate whether alternatives like improved efficiency or smaller power plants located nearer the final customer could meet that need more effectively. By the early 1990s, a number of states began to account for the environmental damage of power plants in this new least-cost planning process. By the mid 1990s, some states were already giving a priority to renewable energy. In 1993, California issued the first request for bids restricted only to clean power. The response was overwhelming. Other states began to enact renewable energy mandates.*

By the mid 1990s, the economy and the price of energy had stabilized. The country had soaked up the electricity surplus of the early 1980s. States had put in place a more sophisticated and proactive planning process. However, Congress responded to the twin oil shocks of the 1970s by encouraging more efficient electricity generation and renewable electricity. To achieve this goal Congress abolished the 60 year-old monopoly utilities had over electricity generation.

The 1978 Public Utilities Regulatory Policy Act (PURPA) prohibited utilities from obstructing onsite power generation and required them to purchase power from independent power producers (IPPs) if the producer used renewable energy or captured a significant portion of the waste heat generated by a fossil fueled power plant. The independent power industry was born.

From 1979 to 1992, independent producers built 30 percent of all new electrical capacity and began to jockey for a much larger market for their product. In 1992, after intensive lobbying led by Enron, the leader of the pack of new IPPs, Congress added a new category of non-utility generator, "Electric Wholesale Generator", that enabled larger producers to qualify for federal regulatory benefits. Congress also deregulated the wholesale electricity market. By 1994, IPPs accounted for almost three quarters of new capacity.

With the deregulation of the wholesale electricity market, Congress gave independent producers access to the nation's high voltage transmission lines on an equal basis with existing utilities. This created a problem because the transmission system was built to transmit electricity from a utility-owned power plant to a utility customer usually within the same area. Suddenly Congress made the transmission system a common carrier.

The Energy Policy Act of 2005 enabled the federal government to approve the site and location of new electric transmission projects. The new law required the Department of Energy (DOE) to designate selected geographic areas as "National Interest Electric Transmission Corridors." Applicants for electricity transmission projects proposed within these "corridors" could request FERC to exercise federal authority if state regulators had not acted within 12 months

Recently a new rationale for extra high voltage transmission lines has emerged. For 15 years the driving force behind the initiative for new lines has been independent owners of fossil fueled power plants. But in the last two years a new national extra high voltage transmission network is increasingly justified as necessary to expand our production of renewable electricity.

It is clear that generating electricity has undergone significant changes over the past 100 years. What began as a local business, evolved to become large regulated monopolies serving an entire region. Regulation is steadily shifting toward a federal planning system after a long period of encouraging size and vertical integration at the state level. The introduction of renewable energy introduces a major debate about how to return to a model of distributed power generation that is based on local need.

TRENDS IN FUEL SOURCES, USES, AND COSTS

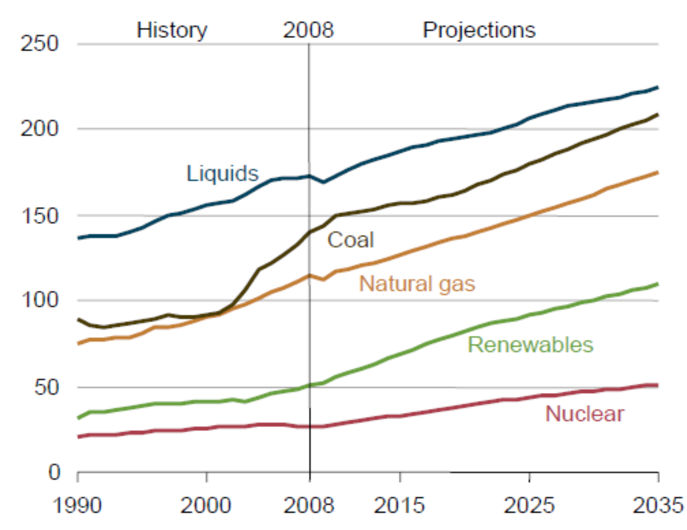
This section will discuss fuel consumption patterns world-wide, but will primarily focus on fuels used by the electricity sector. The analysis will include cost data pertaining to fuels, electricity, and production. Historical data for renewable energy are difficult to find, but are included and discussed as available.

FUEL CONSUMPTION

Data pertaining to energy use and pricing for fossil fuel, coal, hydro, biomass, and nuclear has been maintained since the Second World War. However, data for alternative energy sources were not collected on a regular basis until the late 1990's. Exhibit I shows world marketed energy use from 1990 through 2035 (data and projections by the U.S. Dept. of Energy). From 1990 to date the dominant fuels for energy use of all kinds have been fuel oil, nuclear, coal, and natural gas. Renewable energies (Geothermal, Solar, Wind, Hydro) provide a minor, albeit increasing, role in total energy use. Nuclear energy's share of worldwide energy use has been declining.

It will be interesting going forward to see the impact of technology and renewable energy in the mix of energy use. Grid planners forecast that wind and solar will input 60% of the energy needs to produce electricity by 2020.

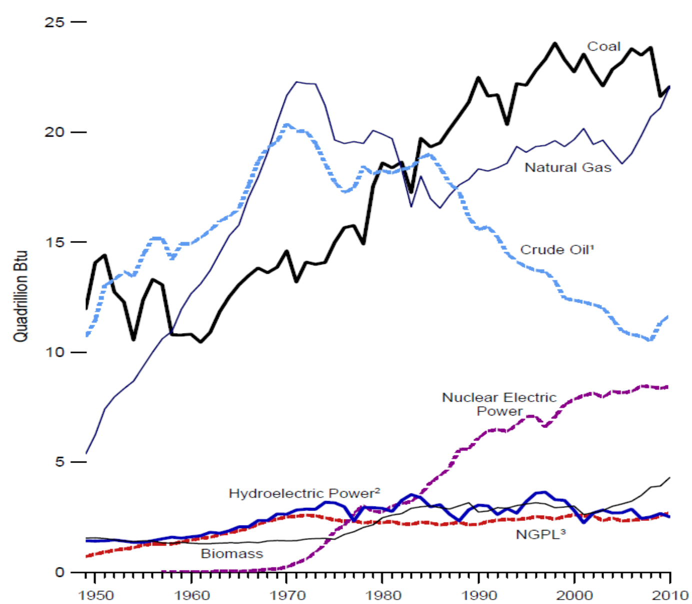
Exhibit I: World Marketed Energy Use by Fuel Type (Quadrillion Btu), 1990-2035



Source: *EIA International Energy Outlook 2011 (p. 2)*

Exhibit II shows that the U.S. does not fit world-wide energy use patterns, in every respect with relation to electricity production. Nuclear power use is higher than hydro and renewable combined. Coal provides nearly half of the energy needs for electricity. It will be interesting going forward to see the impact of technology and renewable energy in the mix of energy use. Grid planners forecast that wind and solar will input 60% of the energy needs to produce electricity by 2020. The EIA forecasts do not reflect the same pace for renewables going forward. Exhibit I shows that 12 – 13% of the energy needs will be met from all renewables by 2020.

Exhibit II: US Energy Use by Source (Quadrillion Btu), 1949 - 2010



Source: *EIA Annual Energy Review 2010 (p. 6)*

Exhibit III: US Energy Production and Consumption (Quadrillion Btu), 1949-2010

	Production				Trade					Stock Change and Other [8]	Consumption			
					Imports		Exports		Net Imports [1]					
Year	Fossil Fuels [2]	Nuclear Electric Power [3]	Renewable Energy [4]	Total	Petroleum [5]	Total [6]	Coal	Total [7]	Total		Fossil Fuels [9]	Nuclear Electric Power [3]	Renewable Energy [4]	Total [10]
1949	28.748	0.000	2.974	31.722	1.427	1.448	0.877	1.592	-0.144	0.403	29.002	0.000	2.974	31.982
1950	32.563	.000	2.978	35.540	1.886	1.913	.786	1.465	.448	-1.372	31.632	.000	2.978	34.616
1955	37.364	.000	2.784	40.148	2.752	2.790	1.465	2.286	.504	-.444	37.410	.000	2.784	40.208
1960	39.869	.006	[R]2.928	[R]42.803	3.999	4.188	1.023	1.477	2.710	-.427	42.137	.006	[R]2.928	[R]45.086
1965	47.235	.043	[R]3.396	[R]50.674	5.402	5.892	1.376	1.829	4.063	-.722	50.577	.043	[R]3.396	[R]54.015
1970	59.186	.239	[R]4.070	[R]63.495	7.470	8.342	1.936	2.632	5.709	-1.367	63.522	.239	[R]4.070	[R]67.838
1975	54.733	1.900	[R]4.687	[R]61.320	12.948	14.032	1.761	2.323	11.709	[R]-1.065	[R]65.357	1.900	[R]4.687	[R]71.965
1976	54.723	2.111	[R]4.727	[R]61.561	15.672	16.760	1.597	2.172	14.588	[R]-.175	[R]69.107	2.111	[R]4.727	[R]75.975
1977	55.101	2.702	[R]4.209	[R]62.012	18.756	19.948	1.442	2.052	17.896	[R]-1.946	[R]70.991	2.702	[R]4.209	[R]77.961
1978	55.074	3.024	[R]5.005	[R]63.104	17.824	19.106	1.078	1.920	17.186	[R]-.339	[R]71.854	3.024	[R]5.005	[R]79.950
1979	58.006	2.776	[R]5.123	[R]65.904	17.933	19.460	1.753	2.855	16.605	[R]-1.650	[R]72.891	2.776	[R]5.123	[R]80.859
1980	59.008	2.739	[R]5.428	[R]67.175	14.658	15.796	2.421	3.695	12.101	[R]-1.210	[R]69.828	2.739	[R]5.428	[R]78.067
1981	58.529	3.008	[R]5.414	[R]66.951	12.639	13.719	2.944	4.307	9.412	[R]-.257	[R]67.571	3.008	[R]5.414	[R]76.106
1982	57.458	3.131	[R]5.980	[R]66.569	10.777	11.861	2.787	4.608	7.253	-.723	63.888	3.131	[R]5.980	[R]73.099
1983	54.416	3.203	[R]6.496	[R]64.114	10.647	11.752	2.045	3.693	8.059	[R].798	[R]63.152	3.203	[R]6.496	[R]72.971
1984	58.849	3.553	[R]6.438	[R]68.840	11.433	12.471	2.151	3.786	8.685	[R]-.892	[R]66.506	3.553	[R]6.438	[R]76.632
1985	57.539	4.076	[R]6.084	[R]67.698	10.609	11.781	2.438	4.196	7.584	[R]1.110	[R]66.093	4.076	[R]6.084	[R]76.392
1986	56.575	4.380	[R]6.111	[R]67.066	13.201	14.151	2.248	4.021	10.130	[R]-.549	[R]66.033	4.380	[R]6.111	[R]76.647
1987	57.167	4.754	[R]5.622	[R]67.542	14.162	15.398	2.093	3.812	11.586	[R]-.074	[R]68.521	4.754	[R]5.622	[R]79.054
1988	57.875	5.587	[R]5.457	[R]68.919	15.747	17.296	2.499	4.366	12.929	[R].861	[R]71.557	5.587	[R]5.457	[R]82.709
1989	57.483	5.602	[R]6.235	[R]69.320	17.162	18.766	2.637	4.661	14.105	[R]1.361	[R]72.911	5.602	[R]6.235	[R]84.786
1990	58.560	6.104	[R]6.041	[R]70.705	17.117	18.817	2.772	4.752	14.065	[R]-.284	[R]72.332	6.104	[R]6.041	[R]84.485
1991	57.872	6.422	[R]6.069	[R]70.362	16.348	18.335	2.854	5.141	13.194	[R].882	71.880	6.422	[R]6.069	[R]84.438
1992	57.655	6.479	[R]5.821	[R]69.955	16.968	19.372	2.682	4.937	14.435	[R]1.392	[R]73.396	6.479	[R]5.821	[R]85.783
1993	55.822	6.410	[R]6.083	[R]68.315	18.510	21.273	1.962	4.258	17.014	[R]2.094	[R]74.836	6.410	[R]6.083	[R]87.424
1994	58.044	6.694	[R]5.988	[R]70.726	19.243	22.390	1.879	4.061	18.329	.037	[R]76.256	6.694	[R]5.988	[R]89.091
1995	57.540	7.075	[R]6.558	[R]71.174	18.881	22.260	2.318	4.511	17.750	[R]2.105	[R]77.259	7.075	[R]6.560	[R]91.029
1996	58.387	7.087	[R]7.012	[R]72.486	20.284	23.702	2.368	4.633	19.069	[R]2.468	[R]79.785	7.087	[R]7.014	[R]94.022
1997	58.857	6.597	[R]7.018	[R]72.472	21.740	25.215	2.193	4.514	20.701	1.429	[R]80.873	6.597	[R]7.016	[R]94.602
1998	59.314	7.068	[R]6.494	[R]72.876	22.908	26.581	2.092	4.299	22.281	-.140	81.369	7.068	[R]6.493	[R]95.018
1999	57.614	7.610	[R]6.517	[R]71.742	23.133	27.252	1.525	3.715	23.537	[R]1.373	82.427	7.610	[R]6.516	[R]96.652
2000	57.366	7.862	[R]6.104	[R]71.332	24.531	28.973	1.528	4.006	24.967	[R]2.516	[R]84.731	7.862	[R]6.106	[R]98.815
2001	58.541	8.029	[R]5.164	[R]71.735	25.398	30.157	1.265	[R]3.771	26.386	-1.953	82.902	8.029	[R]5.163	[R]96.168
2002	56.894	8.145	[R]5.734	[R]70.773	[R]24.674	[R]29.408	1.032	[R]3.669	25.739	[R]1.181	[R]83.747	8.145	[R]5.729	[R]97.693
2003	56.099	7.959	[R]5.982	[R]70.040	[R]26.219	31.061	1.117	4.054	27.007	[R].931	[R]84.014	7.959	[R]5.983	[R]97.978
2004	55.895	8.222	[R]6.070	[R]70.188	[R]28.197	[R]33.544	1.253	[R]4.434	29.110	[R].850	85.805	8.222	[R]6.082	[R]100.148
2005	55.038	8.161	[R]6.229	[R]69.427	[R]29.248	[R]34.709	1.273	[R]4.560	30.149	[R].701	[R]85.790	8.161	[R]6.242	[R]100.277
2006	55.968	8.215	[R]6.608	[R]70.792	[R]29.169	[R]34.679	1.264	[R]4.872	[R]29.806	[R]-.974	84.687	8.215	[R]6.659	[R]99.624
2007	56.447	8.455	[R]6.537	[R]71.440	[R]28.781	[R]34.703	1.507	[R]5.482	[R]29.221	[R].703	[R]86.251	8.455	[R]6.551	[R]101.363
2008	[R]57.482	8.427	[R]7.205	[R]73.114	[R]27.685	[R]32.992	2.071	[R]7.060	[R]25.932	[R].222	[R]83.540	8.427	[R]7.190	[R]99.268
2009	[R]56.644	[R]8.356	[R]7.603	[R]72.603	[R]25.082	[R]29.706	1.515	[R]6.965	[R]22.741	[R]-.869	[R]78.416	[R]8.356	[R]7.587	[R]94.475
2010[P]	58.527	8.441	8.064	75.031	25.290	29.792	2.101	8.173	21.619	1.352	81.425	8.441	8.049	98.003

Source: EIA Annual Energy Review 2010 (p. 5)

Exhibit III shows primary energy production and consumption by source in the U.S. from 1949 to 2010. Renewable energy includes Hydro, Geothermal, Solar/PV, Wind, and Biomass. It is interesting to note that renewable energy provided less than 10% of the consumption in 1950 (almost entirely from hydro and biomass). This percentage dropped to under 7% by 1980. Geothermal, solar/PV and wind have come on-line since 1990, but the share of renewable energy consumption in the U.S. remained at 8% in 2009. Hydro and biomass continue to be the dominant producers in this sector. These trends are changing rapidly as large solar and wind projects come online.

Exhibit III makes a comparison of consumption with production that is useful. During the period 1950-1970 both energy consumption and production expanded at a rapid, but balanced, pace. However, after 1970 energy consumption continued to rise (albeit at a slower pace), while production leveled to near steady state resulting in a larger and larger need for imported liquid petroleum. Recessions tend to close the gap somewhat, but economic recovery leads to higher energy demand without offsetting fossil fuel supply. Will renewable energies come on line fast enough? Probably not. Natural gas seems like the best domestic source of fossil fuel in the intermediate future.

Exhibit III also shows U.S. consumption by energy source. The data show that, beginning in 1970 natural gas and coal began to reflect some cross elasticity of demand. The use of coal increased greatly after 1970 while natural gas experienced a 25% drop. This would suggest a relative price advantage for coal during that time. Since 1985 consumption of coal and gas have followed parallel growth patterns. However, new supplies of natural gas will increase supply and keep downward pressure on natural gas prices over the next several years. Consequently, investment in coal and other new generating resources will likely decrease.

Hydro, nuclear and biomass have remained relatively constant over time. This is true in spite of the fact that the fossil fuel indices reflect the influence of the 1980's, 2002, and 2008 recessions.

Among all energy sectors (e.g., electricity, transportation, thermal) in the EIA May 2012 Monthly Energy Review, production of renewable energy, including hydropower, has increased by 1.8% in a sample space of the first 2-month total from 2012 compared to the same timeframe in 2011, and by 16.8% when compared to 2010. This seemingly low increase in production results from a reduction in hydroelectric generation. Renewable energy production, excluding hydropower, has increased by 8.7% in the primary 2-month totals from 2011 to 2012. Among the renewable energy sources, biomass and biofuels accounted for 50.17% in 2012 (57% from biomass and 43% from biofuels), followed by hydropower (29.19%), wind (16.23%), geothermal (2.54%), and solar (2.00%).

Whether these shifts in alternative energy investment and growth will continue is dependent on production costs and cross-elasticity of demand with liquid petroleum. The latter can be a huge problem. A recent report by McKinsey Researchers shows the nature of the dilemma:

> *"...Going forward, barring prolonged economic stagnation, demand growth for liquids is likely to chug ahead at around 1.5 percent a year. The pace would be even faster without the steady improvements in energy efficiency that we and other energy analysts foresee, particularly for cars and trucks as a result of technology improvements and stiffening regulatory standards that are already on the books.*
>
> *Could supply growth accelerate to keep pace? Many industry analysts and our own supply model suggest that it won't be easy. Despite high oil prices for much of the past decade and surging investment outlays by many major private and national oil companies alike, capacity has risen by only slightly more than 1 percent a year during that time. The logistics, supply systems, and political alignment needed to extract new oil supplies make that a complex, expensive, and time- consuming business. And coaxing more output out of existing oil fields, which typically have high production-decline rates, also is costly and challenging.*
>
> *Our current projections suggest that in a "business as usual" scenario, the world could reach a realistic supply capacity of around 100 million barrels a day by 2020, up from 91 million or 92 million today. That, however, would barely suffice to meet the roughly 100 million barrels of liquids the world would consume each day in such a scenario, up from 88 million or 89 million today ..."*

The major problem that McKinsey researchers caution about is the almost inevitable spikes in oil pricing due to supply/demand imbalances, supply disruption, self-serving national policies, war, investment practices, and natural disaster:

> *"... A prolonged price spike also could prompt investments in infrastructure needed to support the use of electric vehicles or other alternatives (such as natural gas and hydrogen) to traditional fuel sources. Such investments could have an impact on oil demand for trucking, light vehicles, and shipping. What's more, very high oil prices would intensify energy efficiency efforts up and down the supply chain and reduce the amount of plastics used in packaging, thus shrinking demand for oil in chemicals. Additional government action, in the form of either more stringent regulation on the use of plastics or subsidized financing that reduced the up-front cost to consumers of switching away from fuel oil in residential heating, could play an important role in this transition.*
>
> *All along the way, of course, these reactions, plus slower global growth, would do their part to exert some downward pressure on oil prices. Expanded supply would also play a role. From now to 2020, OPEC could increase its capacity by, say, two million barrels a day above currently assumed increases, and new investments in mature assets could slow*

decline rates, leading to an additional one million to two million barrels of daily production. Furthermore, additional investments in unconventional oil sources, such as oil sands, could increase supply by, say, one million to two million barrels a day. Bio fuel, too, would have room to grow. But given the time it would take to pursue some of the available opportunities—and the danger that they could quickly become uneconomic once oil prices fell—the supply response is likely to be slower and more muted than that of demand. In the end, once all the efficiency gains and supply expansions described above kicked in, the world could again wind up in balance and with significant excess capacity, so that eventually—perhaps by 2020, perhaps later—prices fell below the $80 to $100 range. Until then, however, given how slowly many of the demand changes would unfold, it's only prudent to imagine the possibility that the world could experience a prolonged period of both significant volatility and generally much higher prices …"

SECTOR USES FOR ENERGY

Exhibit IV is taken from DOE data and reflects the use of fuel by broad sectors of the US economy. It is clear from the data that fossil fuel technologies are major impediments to rapid transition from fossil fuels to renewables. Nonetheless, the chart shows that there will be substantial pressure for coal to produce energy that is as clean as natural gas and also be price competitive. It is assumed that natural gas prices will remain low for the next several years.

FUEL CONSUMPTION FOR ELECTRICITY GENERATION

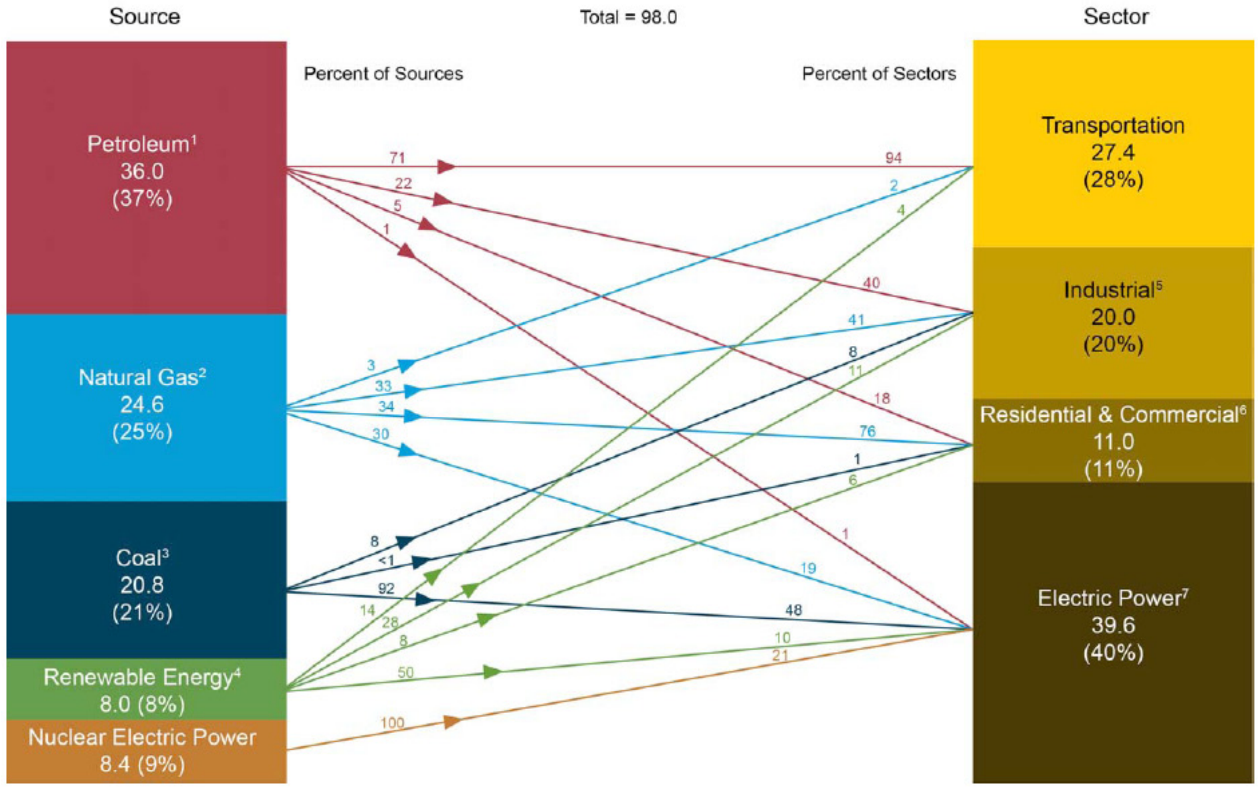
Exhibit V reflects the current and projected distribution of energy use for electricity production in the U.S. The makeup of fuel use for electricity production has not changed significantly until recent years when renewables began to come online. According to the U.S. Energy Information Administration (EIA) the annual production of renewable energy is now greater than that of nuclear power and continues to close in on oil. During the first 2-month total of 2012, renewable energy sources (biomass & biofuels, geothermal, solar, hydro, wind) provided 1.497 quadrillion Btu of energy or 11.39% of U.S. energy production. (On the consumption side, which includes oil and other energy imports, renewable sources accounted for 8.76% of total U.S. energy use). Energy production from renewable energy sources in 2011 was 17.91% more than that from nuclear power. Energy from renewable sources is now equal to 79.83% of that from domestic crude oil production, with the gap closing rapidly.

The U.S. Energy Information Administration estimates that the cost of producing electric energy will plateau for the next several years and then begin a gradual rise. The assumptions that underlie these projections are based on a variety of factors unique to each energy source. However, ongoing and significant research with smart grid, storage, geothermal, solar, wind, biofuel, and wave could change these assumptions significantly.

Looking at just the electricity sector, according to a recent issue of EIA's "Electric Power Monthly," renewable energy sources (biomass, geothermal, solar, water, wind) accounted for 12.71% of net U.S. electrical generation in a rolling 12 month average, ending March 2012. Hydropower accounted for 7.70% of U.S. electrical generation, followed by wind at 3.16%, biomass at 1.40%, geothermal at 0.41%, and solar at 0.05%. Thus, non-hydro renewables accounted for 5.01% of net U.S. electrical generation.

Comparing the first quarter of 2012 to the first quarter of 2011, solar-generated electricity expanded by 81.6%, wind by 29.3%, hydropower by -14.0%, and geothermal by -0.7%; only biomass showed no changes in net generation.By comparison, nuclear power's contribution to net U.S. electrical generation totaled 19.29% representing a decline of 2.6% compared to the quarter of 2011 and a drop of over 5% compared to the quarter of 2010. Similarly, coal-generated electricity dramatically fell by 21.4% from its first quarter 2011 level, while natural gas

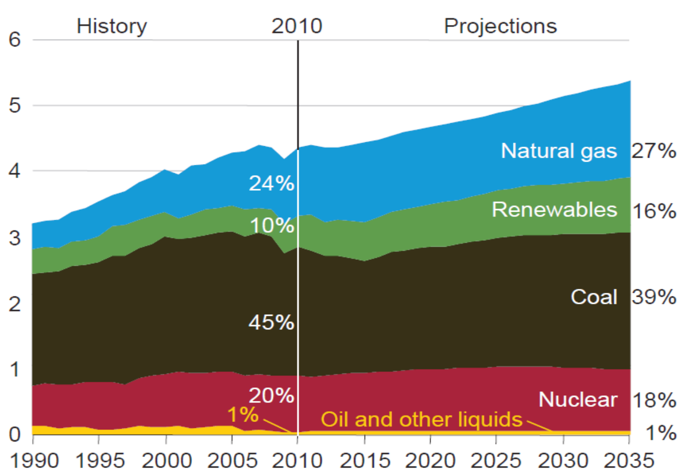
Exhibit IV: Fuel Use by Broad Sectors of the Economy



Source: EIA Annual Energy Review 2010 (p. 37)

increased by 33.3%. This was accompanied by a 29.9% drop in petroleum liquids and a 30.7% decline in petroleum coke.

Exhibit V: Electricity Generation Mix (Trillion kWh/yr), 1990 – 2035



Source: EIA Annual Energy Outlook 2012 Early Release Overview (p. 2)

The exhibit shows that the natural gas share of generation, at 24% in 2010, is rising as natural gas prices fall. This trend may continue, but the EIA forecast indicates that, with slow growth in electricity demand, completion of coal plants under construction, and addition of new renewable capacity, the share of natural gas to total production will fall. Some analysts speculate that natural gas prices will continue to remain at historic lows and that coal generation will be replaced by natural gas. This may be true, but it will take time for existing coal plant investments to be amortized and natural gas production investments to go online. Renewable generation, supported by Federal and State tax incentives and American Recovery and Reinvestment Act funding, shows the strongest growth going forward. EIA predicts that the renewable share of generation will grow from 10% in 2010 to 16% in 2035. Although generation from nuclear plants is expected to increase by 11 percent, the nuclear share of total generation is expected to fall from 20% in 2010 to 18% in 2035.

Technology choices for new generating capacity typically are made to minimize costs while meeting local and Federal emissions standards. Capacity expansion decisions consider capital, operating, and transmission costs. Coal-fired, nuclear, and renewable plants are capital-intensive, while operating (fuel) expenditures make up most of the costs for gas-fired capacity. Capital costs depend on such factors as equipment costs, interest rates, and cost-recovery periods. Fuel costs can vary according to fuel prices, plant operating efficiency, resource availability, and transportation costs. Regulatory uncertainty also affects capacity planning decisions. For example, new coal-fired plants will be required to install Carbon Capture Storage equipment, resulting in higher material, labor, and operating costs.

Use of renewable energy resources in the electric power sector is expected to increase sharply between 2011 and 2035. EIA estimates that non-hydroelectric renewable generation will account for 33% of the growth in total electricity generation from 2010 to 2035 and that wind power and biomass provide the largest share of the growth. A large portion of the increase in biomass generation comes from increased co-firing—a process in which biomass is mixed with coal or natural gas in existing coal-fired plants, displacing some of the fossils that would otherwise be burned.

For large scale energy production the development of smart grid technologies, combined with advances in storage technologies, will make it possible for the electric power and manufacturing sectors to integrate a mix of natural gas, solar, wind, hydro, biomass, and geothermal to significantly reduce carbon emissions and provide a secure supply of power. However, large-scale power generation is not the only place where smart grid technologies will lead to reduced carbon emissions. Distributed (rooftop and neighborhood array) solar PV generation is rapidly growing and is expected to play an important role in power generation during the next decade and beyond.

The U.S. Energy Information Administration estimates that the cost of producing electric energy will plateau for the next several years and then begin a gradual rise. The assumptions that underlie these projections are based on a variety of factors unique to each energy source. However, ongoing and significant research with smart grid, storage, geothermal, solar, wind, biofuel, and wave could change these assumptions significantly (see Appendix).

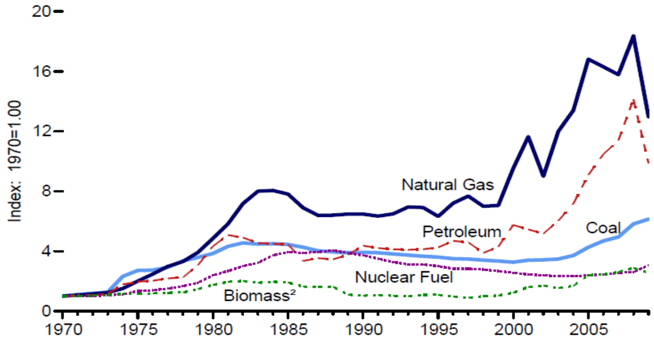
According to the Energy Information Administration (EIA), installed wind capacity grew by 19 gigawatts from 2003 to 2008. That trend is scheduled to continue through 2013, more than doubling wind capacity in the U.S. in 10 years. Geothermal capacity has been restricted to a relatively small number of suitable sites. However, as mentioned elsewhere, new technologies could increase the use of this resource significantly. Until recently, solar capacity has been too costly for widespread implementation. Solar PV and Concentrated Solar Production are now competitive with utility grid costs in some parts of the US. Energy crops are the subject of intensive research to find an efficient conversion process for biofuels. Biomass resources that could be used for electric power generation are used instead to produce biofuels in order to meet the Federal Renewable Fuel Standards (RFS), leading to a small increase in electricity generation at bio refineries.

ELECTRICITY SECTOR FUEL COSTS

As stated in the Appendix section of this report, electricity rates to the consumer were high in the early 1900's; nearly $.30/kWh. However, wholesale electric power costs dropped for over 70 years to under $.01kWh. Beginning in the 1970's the downward trend in pricing reversed due to inflation. Distillate fuel oil costs began to rise with U.S. dependence on foreign oil. Natural gas prices began a period of volatilit y. Coal and wood/waste costs have remained low. Exhibit VI reflects these trends from 1970 through 2009. The data do not reflect the cost of hydro which has remained stable.

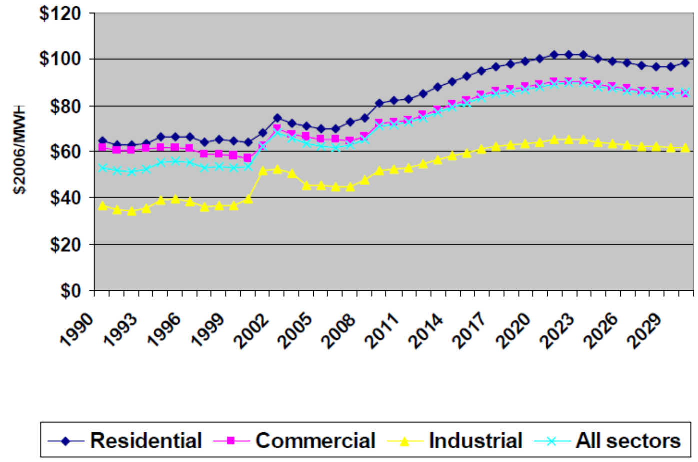
Exhibit VII provides a picture of the impact that energy costs have had on utility costs over the past decades; as well as projections into the future. It is important to note the effects of externalities in resource costs on the price of generation. The most recent spike in utility costs result from spikes in fuel costs, rising technology costs, and renewable portfolio standards.

Exhibit VI: Wholesale Energy Prices ($/Million Btu), 1970 - 2009



Source: EIA Annual Energy Review 2010 (p. 72)

Exhibit VII: Average Retail Electricity Costs and Projections ($/MWh), 1990 – 2030



Source: NWPCC Sixth Power Plan 2010 (Appendix B, p. 37)

The effect of these fuel cost shifts on consumers is reflected with a low of around $.02/kWh in 1970. Due to inflation and fuel source shifts, the unadjusted cost of electricity has since quadrupled for the industrial user. For the residential user it rose five-fold. For the commercial user the increase was nearly six-fold.

Cost increases over the past decade have been one of the major causes for conservation and energy saving technology. The price volatility is also favoring fuel sources that are stable and not affected by exogenous factors. Hydro, biomass, solar, wind, geothermal, and wave meet this requirement. Hydro and biomass are already stable and low cost energy sources. Renewable energy costs are falling and are predicted to meet levelized energy costs within the next several years.

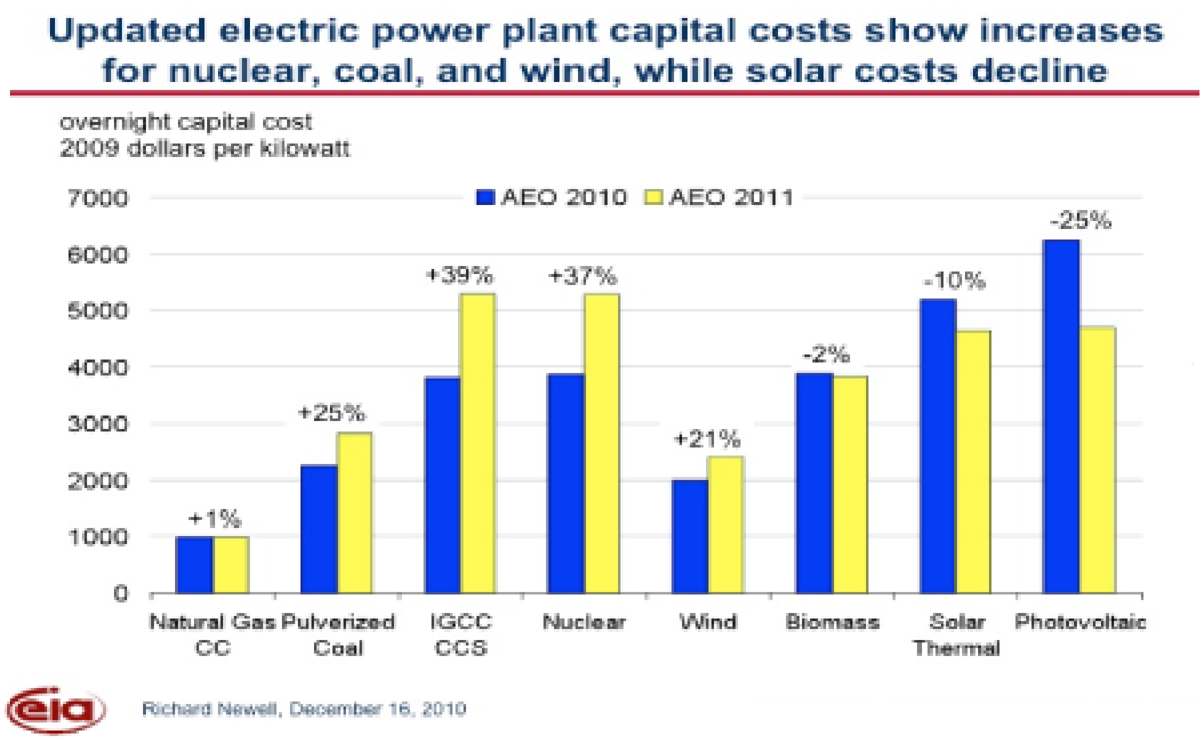
Exhibit VIII: Capital Costs by Type of Production (2009 Dollars, $/kW)

	Overnight Capital Cost ($/kW)			Nominal Capacity KW's[1]	
	AEO 2011	AEO 2010	% Change	AEO 2011	AEO 2010
Coal					
Advanced PC w/o CCS	$2,844	$2,271	25%	1,300,000	600,000
IGCC w/o CCS	$3,221	$2,624	23%	1,200,000	550,000
IGCC CCS	$5,348	$3,857	39%	600,000	380,000
Natural Gas					
Conventional NGCC	$978	$1,005	-3%	540,000	250,000
Advanced NGCC	$1,003	$989	1%	400,000	400,000
Advanced NGCC with CCS	$2,060	$1,973	4%	340,000	400,000
Conventional CT	$974	$700	39%	85,000	160,000
Advanced CT	$665	$662	0%	210,000	230,000
Fuel Cells	$6,835	$5,595	22%	10,000	10,000
Nuclear					
Nuclear	$5,339	$3,902	37%	2,236,000	1,350,000
Renewables					
Biomass	$3,860	$3,931	-2%	50,000	80,000
Geothermal	$4,141	$1,786	132%	50,000	50,000
MSW - Landfill Gas	$8,232	$2,655	210%	50,000	30,000
Conventional Hydropower	$3,078	$2,340	32%	500,000	500,000
Wind	$2,438	$2,007	21%	100,000	50,000
Wind Offshore	$5,975	$4,021	49%	400,000	100,000
Solar Thermal	$4,692	$5,242	-10%	100,000	100,000
Photovoltaic	$4,755	$6,303	-25%	150,000	5,000

1 Higher plant capacity reflects the assumption that plants would install multiple units per site and that savings could be gained by eliminating redundancies and combining services.

Source: EIA Updated Capital Costs for Electricity Generation Plants 2010 (p. 8)

Exhibit IX: Electric Power Plant Capital Costs by Fuel Type (2009 Dollars, $/kW)

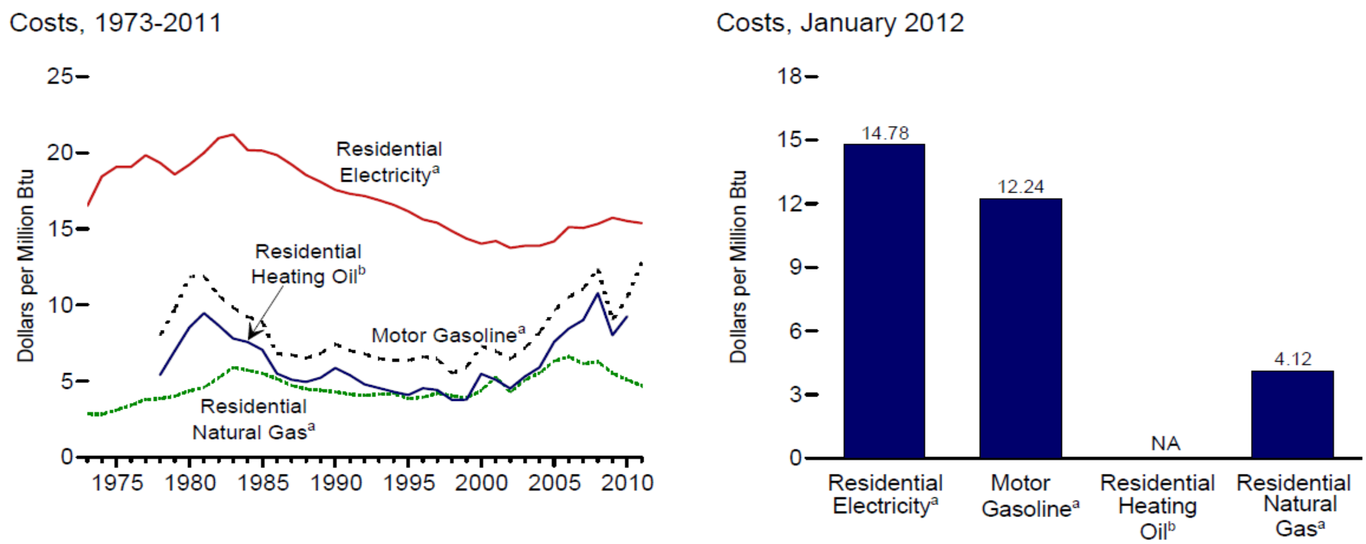


Source: *EIA Annual Energy Outlook 2011 (p. 17)*

POWER PLANT COSTS

Exhibits VIII and IX reflect electric power plant costs for 2010 and 2011 as prepared by the U. S. Energy Information Administration. Exhibit VIII reflects AEI estimates of the capital costs for electric energy production during 2010 and 2011. Exhibit IX shows that capital costs for nuclear, coal, and wind are rising. Clean coal is expected to rise 39% and nuclear 37%. However, biomass, solar/thermal, and solar/pv capital costs are falling. The capital cost for solar/pv fell 25% from 2010 to 2011; a trend that is expected to slow as solar incentives expire.

Exhibit X: Cost of Fuels to End Users (1982-1984 Dollars, $/Million Btu)



Source: *EIA Monthly Energy Review April 2012 (p. 14)*

CURRENT USER COST COMPARISONS FOR FUEL

Comparative costs for fuel sources to the consumer for fossil fuels are provided by the U.S. Department of Energy. However, estimates of alternative energy fuels are somewhat more difficult; especially for recently emerging technologies. Exhibit X compares fossil fuel costs with residential electricity for the period 1973 – 2011.

FUEL COST COMPARISON FOR ELECTRIC ENERGY

Exhibit XI was prepared using the National Energy Modeling System (NEMS) in as a reference case for the EIA Annual Energy Outlook 2011. It reflects current cost estimates for selected fossil and alternative energy sources. The lowest fuel costs are from solar, wind, hydro and geothermal followed by nuclear, coal, and natural gas. However, when direct and indirect costs are added, the rankings shift dramatically. This type of cost comparison is somewhat speculative, but it is interesting to note that overall natural gas ranks lowest, along with hydro. This comes as a shift from recent low cost trends for nuclear and wind. While wind prices are still low; nuclear has garnered negative attention from the recent Fukushima disaster and increased production of natural gas has lowered investment expenditures.

Historically, electricity demand increased in response to population growth and economic growth and fluctuated in the short term in response to business cycles, time of day, and weather trends. However, according to the U.S. Energy Information Administration, electricity demand growth has slowed progressively in each decade since the 1950s. After growing by 9.8 percent per year in the 1950s, electricity demand (including retail sales and direct use) slowed to increase by 2.4 percent per year in the 1990s, and from 2000 to 2008 it grew on average by 0.9 percent per year. As reflected in Exhibit XII, a slower growth is projected to continue as increased demand for electricity services will be offset by efficiency gains from new appliance efficiency standards and investment in energy-efficient equipment.

As seen from previous exhibits, however, lower growth has not meant lower energy costs. Inflation adjusted electricity prices vary, depending on the economy, fuel

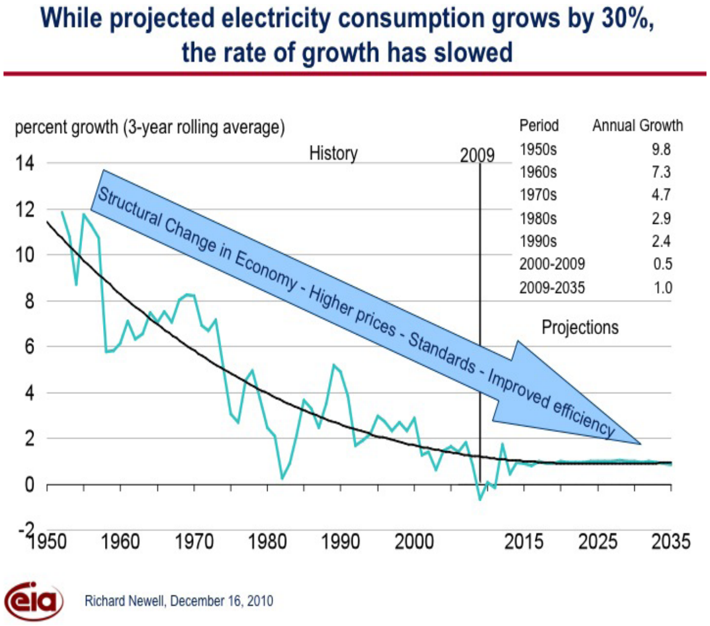
Exhibit XI: Estimated Levelized Cost of New Generation Resources ($/MWh)

Plant Type	Capacity Factor (%)	U.S. Average Levelized Costs (2009 $/megawatthour) for Plants Entering Service in 2016				
		Levelized Capital Cost	Fixed O&M	Variable O&M (including fuel)	Transmission Investment	Total System Levelized Cost
Conventional Coal	85	65.3	3.9	24.3	1.2	94.8
Advanced Coal	85	74.6	7.9	25.7	1.2	109.4
Advanced Coal with CCS	85	92.7	9.2	33.1	1.2	136.2
Natural Gas-fired						
Conventional Combined Cycle	87	17.5	1.9	45.6	1.2	66.1
Advanced Combined Cycle	87	17.9	1.9	42.1	1.2	63.1
Advanced CC with CCS	87	34.6	3.9	49.6	1.2	89.3
Conventional Combustion Turbine	30	45.8	3.7	71.5	3.5	124.5
Advanced Combustion Turbine	30	31.6	5.5	62.9	3.5	103.5
Advanced Nuclear	90	90.1	11.1	11.7	1.0	113.9
Wind	34	83.9	9.6	0.0	3.5	97.0
Wind – Offshore	34	209.3	28.1	0.0	5.9	243.2
Solar PV[1]	25	194.6	12.1	0.0	4.0	210.7
Solar Thermal	18	259.4	46.6	0.0	5.8	311.8
Geothermal	92	79.3	11.9	9.5	1.0	101.7
Biomass	83	55.3	13.7	42.3	1.3	112.5
Hydro	52	74.5	3.8	6.3	1.9	86.4

[1] Costs are expressed in terms of net AC power available to the grid for the installed capacity.

Source: EIA Levelized Cost of New Generation Resources in the Annual Energy Outlook 2011 (p. 3)

Exhibit XII: Rate of Growth Trend for Electricity Consumption

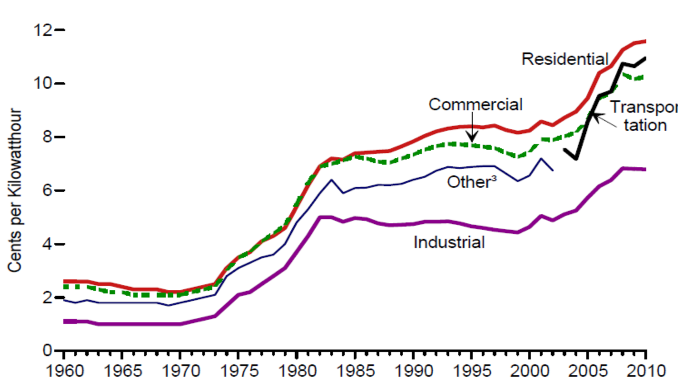


Source: EIA Annual Energy Outlook 2011 (p. 15)

prices, regulations, competition in wholesale and retail markets, and costs of new generation. In the Annual Energy Outlook study prepared by the U.S. Energy Information Administration, Exhibit XIII graphs the rise in nominal (not adjusted for inflation) electricity costs from 1960 – 2010 by sector of use.

Electricity prices are also based on generation, transmission, and distribution costs. Fuel costs account for most of the generation costs for natural-gas- and oil-fired plants but much less for coal and nuclear plants. There are no fuel costs associated with wind and solar plants.

Exhibit XIII: Average Nominal Electricity Prices by Sector (Cents/kWh), 1960-2010



Source: EIA Annual Energy Outlook 2011 (p. 15)

In competitive wholesale markets, natural gas and liquid fuel costs often set hourly prices. Natural-gas-fired generation is likely to have the greatest impact on electricity prices going forward.

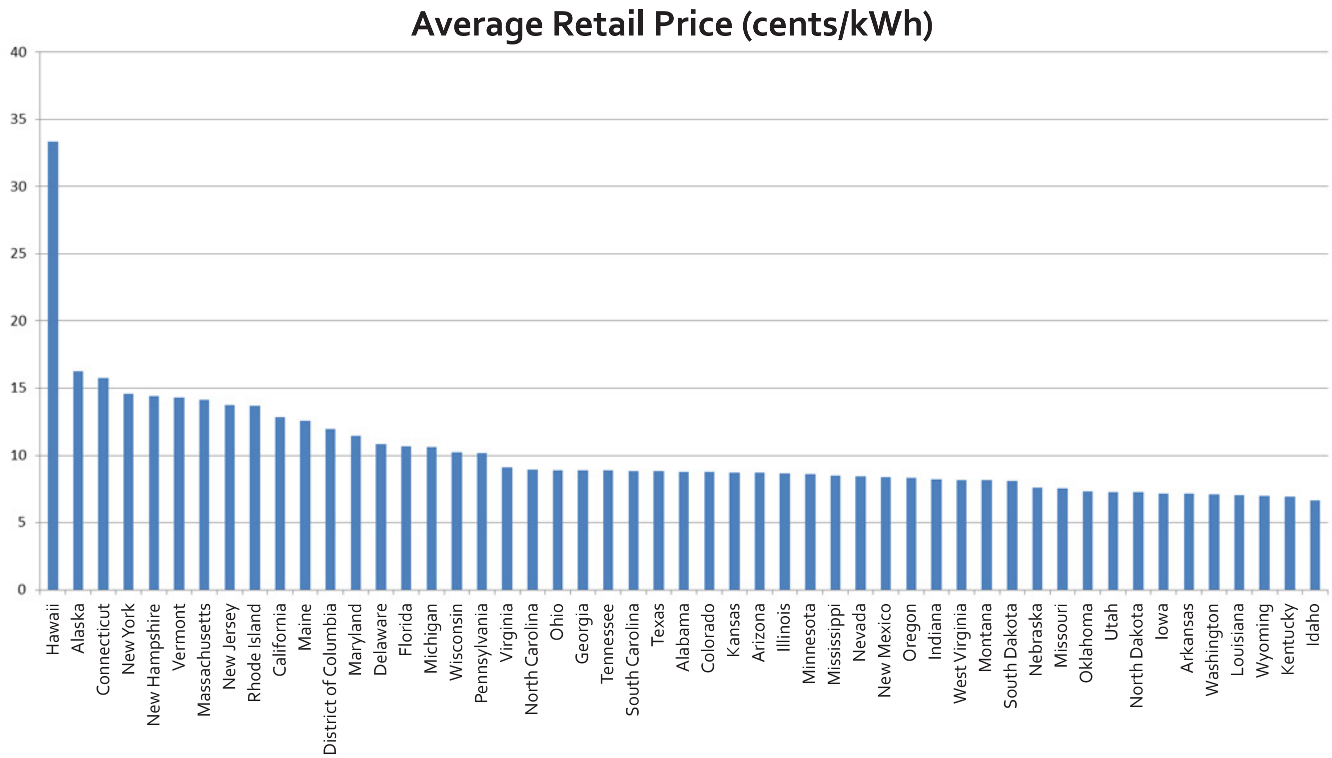
Transmission costs are projected to rise by 33 percent from 2008 to 2035, as new infrastructure is built.

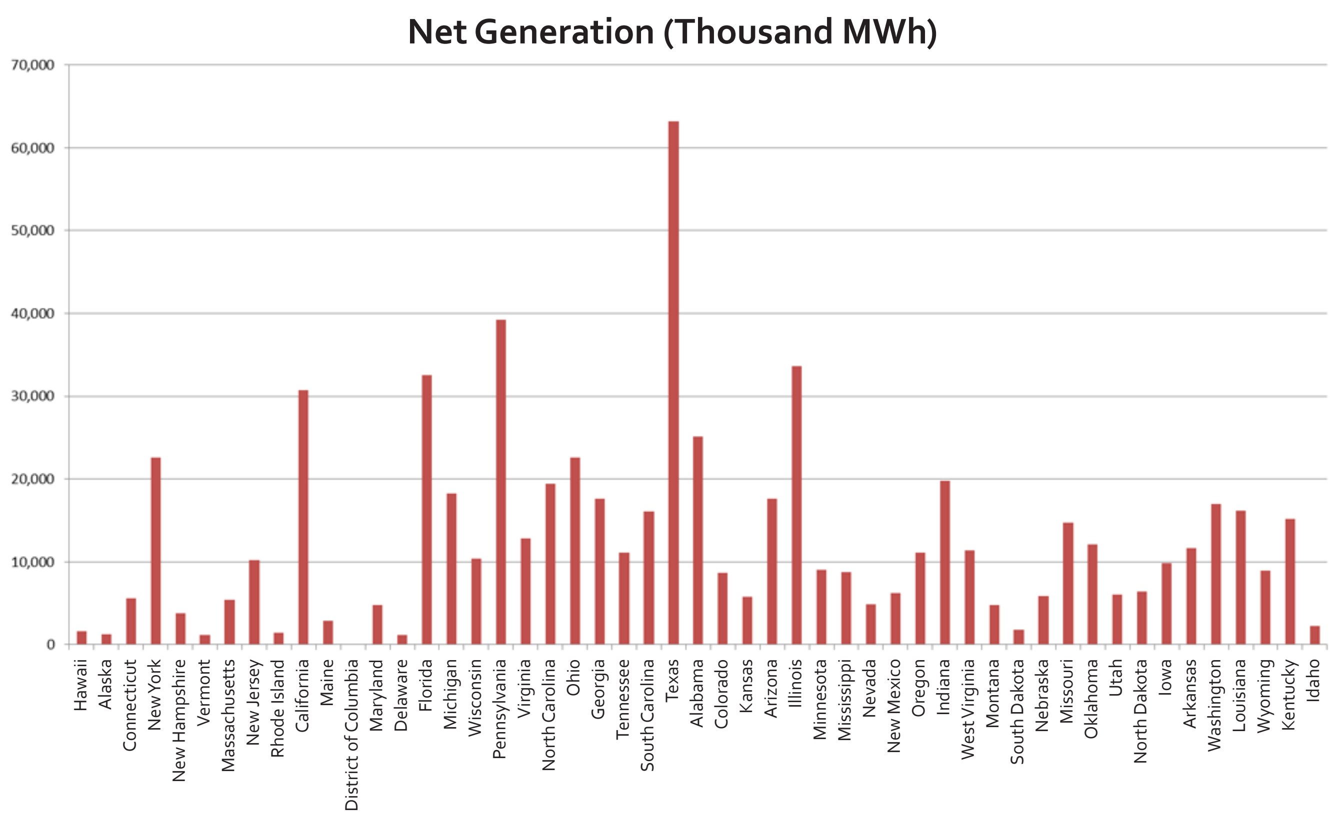
CURRENT ELECTRICITY COSTS BY STATE

> Retail prices in Oregon are at the low end of the spectrum ($.0832/kWh), but higher than the neighboring states of Idaho and Washington. California has an average retail price/kWh of $.1284. These compare with the U.S. average of $.0965.

Exhibit XIV shows net generation of electricity in all states for 2012 together with average retail price. Texas produces nearly 65 million megawatt hours of electricity and the average retail price is $.0881/kWh. Washington DC is the lowest producer with 1,000 megawatt hours of electricity and an average retail price of $.1196/kWh. Retail prices in Oregon are at the low end of the spectrum ($.0832/kWh), but higher than the neighboring states of Idaho and Washington. California has an average retail price/kWh of $.1284. These compare with the U.S. average of $.0965.

Exhibit XIV: State Electricity Average Retail Prices, 2012





Source: EIA Electricity Data May 2012

A NEW PARADIGM FOR ENERGY

BACKGROUND

There are many important reasons for entrenched energy use to rapidly embrace advanced energy technologies and incorporate renewables into their generation profile:

- Global Climate Change and its impending impact on economic development worldwide
- Fossil fuel scarcity as worldwide demand outpaces supply
- Negative trade and national security issues associated with security of fossil fuel demand, including military and trade spending related to energy supply protection
- Man-made natural disasters like the Gulf oil spill and the Fukushima nuclear disaster in Japan
- Rising public health costs relating to coal and petroleum
- Rapidly falling renewable energy costs

This report has been researched and written at a time when National and State concerns are focused on scarcity, security, energy supply, environment, and job growth. The title of this section broadly outlines those concerns. Pick up any serious journal or policy publication and you will read about the problem of "peak oil" and renewable energy as a policy path for addressing fossil fuel shortages and national security concerns.

It cannot be seriously disputed that the United States is in the early stages of transition from a fossil fuel economy to an economy based on information technology, communications, power electronics, semiconductor materials, data aggregation, and clean fuels. Continued transition will require that entrenched interests, especially those associated with traditional energy producers, remain flexible. In any fundamental long-range historical sense, change from entrenched interests can take a very long time. Nonetheless, Oregon has been a leader in supporting policies that encourage innovation and new ways to govern. Oregon's continuation on this path will require that all of the stakeholders remain flexible and patient.

According to Tam Hunt, an attorney who is deeply involved with energy policy in California, there are many important reasons for entrenched energy use to rapidly embrace advanced energy technologies and incorporate renewables into their generation profile:

- Global Climate Change and its impending impact on economic development worldwide
- Fossil fuel scarcity as worldwide demand outpaces supply
- Negative trade and national security issues associated with security of fossil fuel demand, including military and trade spending related to energy supply protection
- Man-made natural disasters like the Gulf oil spill and the Fukushima nuclear disaster in Japan
- Rising public health costs relating to coal and petroleum
- Rapidly falling renewable energy costs
- The immediate need for technology and innovation shifts to grow jobs that support family security

Advancements in communications, information, power electronics, embedded systems and other technologies are helping to create a power grid that could very well become a platform for large-scale innovation. Loosely bundled under the banner of 'smart grid,' these new advanced technologies will provide the means by which new energy services will be delivered and renewable energy sources will be integrated.

Much of the literature we evaluated expressed interest in finding where and when the tipping points will be with regard to conversion to renewable energy and new technologies. Most of the factors pushing change (scarcity, cost, sustainability) are inter-related. So far the factors that are pulling change (technology, portfolio standards, tax incentives) are stronger than the factors that push change (user demand and scarcity). Innovation and new technologies are needed to make renewable energy more cost-effective and reliable.

Economic development and jobs will depend on private sector growth. However, the private sector relies on federal, state, and regional strategies that build stable, sustainable energy economies and provide training for a workforce with advanced technological skills.

Energy is fundamentally a technology business, in its extraction, production, transformation, storage, and use. Advanced technologies can improve every one of these phases, sometimes radically. States, working in concert with the Federal Government, private sector, research and teaching universities, can assure sustained economic development by achieving the following goals:

1. Work toward advanced industries with modern jobs that are fueled by a new energy paradigm.

2. Complete the task of an economy with clean affordable energy.

3. Protect our employment base and public health with a long-term strategy for helping families achieve a living wage.

4. Build an educated workforce that will provide the innovation necessary to transform our energy infrastructure.

5. Expand research universities that partner with industry to create research laboratories that stress renewable energy innovation and advanced engineering training.

CLIMATE CHANGE

Although not always included in discussions about renewable energy, the issue of global warming and fossil fuel consumption is usually a major underlying consideration. If the world is to limit global warming to 2 degrees Celsius — thought to be the minimum safety level before devastating effects of climate change set in — emission volumes in the atmosphere must not have more than 450 parts per million (ppm) of carbon dioxide. With emissions already at 390 ppm of CO_2, time is running out for action.

Information about climate change has been responsible for much public debate over the past two decades. For some the debate has been about blame and greed. For others it has been about scientific hubris and a misreading of natural evolution. Regardless of where we stand in the stream of these arguments, it is clear from empirical evidence that it is prudent to take action toward self-preservation when considering the fact of global warming.

Recent polls show that 47% of the U. S. public take global warming seriously; down from 57% three years ago. However, public belief or disbelief in climate change may not be relevant. There are many very positive trends with respect to energy that are here today and will only increase in the future. The following trends will mitigate climate change, enhance energy independence, reduce traditional air pollution, create millions of new jobs, and have the potential for saving money through decreased electricity costs:

- An ongoing improvement in global energy intensity leading to fewer emissions per dollar of GDP
- Price induced conservation
- Increase in global renewable energy use
- Rapid growth and lower costs for renewable energy use and technology

The impacts from climate change make it necessary for us to address our personal, community, corporate, and business way of doing business. Questions of economic viability going forward arise. Questions of political policy arise. Questions of business sustainability arise. Questions of quality of life arise. For some these challenges are a glass half full. For others these challenges are a warning for ultimate demise.

As noted above, the consensus about man-made global warming may not be important. Governments are beginning to adopt policies that will mitigate many of the perceived causes of global warming. This is especially true for energy policy. Corporations are adopting sustainability policies that recognize the need to mitigate global warming. Citizens are changing consumption patterns to lower costs and conserve resources. At the center of all of these actions is an effort to move from a fossil fuel economy to a clean fuel economy.

How we produce and consume energy will play an important (some would say critically defining) role in our ability to sustain life as we know it in a technological society. The history of human behavior suggests that demand will incline toward the greatest value for the least expense. Energy is no exception. For the human condition to improve, the cost of energy must continue to decline in terms of rising GDP. Political democracy, social contracts, jobs, freedom to choose, and continuing prosperity are at stake. For all of these reasons, what we do now will affect our way of life going forward.

SCARCITY, NATIONAL SECURITY

Many costs associated with fossil fuel are not factored in to the retail and wholesale costs. Scarcity of fossil fuels and the need for secure supply of oil and gas are converging to exacerbate problems relating to international relations, national security, balance of trade, and environmental protection (to include flora and fauna). The cost associated with keeping armed forces in foreign oil producing countries is a cost not attributed to the retail or wholesale price of oil. The cost to public health attributed to air pollution is not attributed to fossil fuels. Nor are the costs of environmental degradation of streams, rivers, ocean, and the natural habitat factored in to the cost of fossil fuel.

Oil exploration has largely moved offshore and into deep, often environmentally sensitive areas. Competition for available foreign sources of oil and gas often provides a framework for foreign policy and our defense budget. Efforts to mitigate environmental damage from oil and gas exploration and extraction worldwide are often compromised.

The environmental arguments over whether to explore for oil in the Arctic National Wildlife Refuge and National Petroleum Reserve in Alaska gain new importance in the context of oil pollution from the BP blowout in the Gulf of Mexico where damage to fisheries, tourism, and related economic development will continue for many years. The total affect from offshore oil production on wildlife, coastal and underwater flora, and water quality may never be fully known. One thing is certain; oil is a finite resource. New sources in North America are increasingly hard to find, and resources that have been identified tend to be in areas that are challenging to reach.

Fossil fuel scarcity is described in a recently published McKinsey Research Study:

> *"…It's been a while since the world has been truly preoccupied with the threat of sustained high oil prices. The global economic recovery has been muted, and a double-dip recession remains possible.*
>
> *But that dour prospect shouldn't make executives sanguine about the risk of another oil shock. Emerging markets are still in the midst of a historic transition toward greater energy consumption. When global economic performance becomes more robust, oil demand is likely to grow faster than supply capacity can. As that happens, at some point before too long supply and demand could collide—gently or ferociously.*
>
> *The case for the benign scenario rests on a steady evolution away from oil consumption in areas such as transportation, chemical production, power, and home heating. Moves by many major economies to impose tougher automotive fuel efficiency standards are a step in this direction. However, fully achieving the needed transition will take more stringent*

regulation, such as the abolition of fuel subsidies in oil-producing countries, Asia, and elsewhere, as well as widespread consumer behavior changes. And historically, governments, companies, and consumers have been disinclined to tackle tough policy choices or make big changes until their backs are against the wall.

This inertia suggests another scenario—one that's sufficiently plausible and underappreciated that we think it's worth exploring: the prospect that within this decade, the world could experience a period of significant volatility, with oil prices leaping upward and oscillating between $125 and $175 a barrel (or higher) for some time. The resulting economic pain would be significant. Economic modeling by our colleagues suggests that by 2020, global GDP would be about $1.5 trillion smaller than expected, if oil prices spiked and stayed high for several years.

But like any difficult transition, this one also would create major opportunities—for consumers of energy to differentiate their cost structures from competitors that aren't prepared and for a host of energy innovators to create substitutes for oil and tap into new sources of supply. Furthermore, if we endured a period of high and volatile prices that lasted for two or three years, by 2020 or so oil could face real competition from other energy sources ..."

FOSSIL FUEL CONCERNS

Oil. The major concerns about oil are that, as a nation, we produce too little and consume too much at prices that are sustainable. Additional concerns have to do with employment based on petroleum, environmental degradation relating to production and consumption, and national security issues relating to security of supply from foreign sources. Most of these concerns are centered in the transportation, agricultural, and plastics sectors. Oil does not play a significant role in the production of electricity in the U.S.

A rising concern is the cost of maintaining a military force to protect sources of foreign oil (generally associated with U.S. National Interest). The past ten years make it evident that the U.S. cannot continue to undertake military actions across the globe without raising revenue sources or debt to unacceptable levels. U.S. consumption of oil has outpaced domestic supply for over 30 years. Rising world demand for oil make it unlikely that foreign oil supply can be relied upon to meet U.S. demands.

Coal. Coal is the most abundant and dominant fuel for electricity production in the U.S. However, coal is also the dirtiest fossil fuel in terms of CO_2, SO_2, NO_x, mercury and particulate production. Concerns about greenhouse gases, mine safety, and environmental degradation due to coalmine operations create major uncertainties for the continued use of coal. Now public health can be added to the list of concerns. According to a 2011 report from the American Lung Association, COPD (chronic obstructive pulmonary disease) has surpassed stroke as the third leading cause of death in the United States. The cause is attributed to emissions from coal and diesel.

Natural Gas. Natural gas supplies have been discovered in shale throughout the world, making it a far more abundant source of energy. However, to extract gas from shale requires the controversial method of hydraulic fracturing (fracking), a technique of injecting water and chemicals to facilitate the release of gas. Some are concerned that this practice may compromise the aquifers that overlay the gas deposits. In the U.S., concerns about environmental degradation have slowed development of this resource and may result in closure of some fields. Nonetheless, EIA projects that abundant gas from fracking will be the norm through 2035.

Oil Sands. Oil sand resources are abundant in Canada, and could be available to the U.S. However, concerns about recovery of oil from tar sands, open pit mining, environmental degradation, and excessive use of water resources make the recovery of oil sands problematic. Pipeline transport of tar sand oil is also of concern. The proposed 1179 mile Keystone XL pipeline from Canada to Texas would pass through the Nebraska Sandhills region and Ogallala aquifer, which supplies water to eight states. The pipeline would travel through five states before reaching Texas refineries.

The Keystone XL pipeline would carry as much as 700,000 barrels of oil a day, doubling the capacity of an existing pipeline operated by TransCanada in the upper Midwest. Supporters say the pipeline to Texas could significantly reduce U.S. dependence on Middle Eastern oil while providing thousands of jobs. Those who oppose the project cite environmental degradation in Canada, air pollution due to the 'heavy' nature of tar sand oil, potential contamination of the Ogallala aquifer, and dangers to farm and city life in the heartland of America.

Nuclear. Concerns about security of supply and fossil fuel scarcity were behind renewed efforts to build more nuclear energy capacity after years of debate about safety. However the ongoing crisis at the Fukushima Daiichi nuclear power plant may spell the end of nuclear power in resource-poor Japan. Germany has already implemented a plan to eliminate nuclear plants by 2022. Many other countries, including the U.S., are studying options. Given ongoing concerns in Japan, safe storage of nuclear waste, fear of plant safety following Chernobyl in Russia, and escalating costs, it is unlikely that nuclear will grow as an energy source in the future.

PRIVATE SECTOR BEHAVIOR

When measured by corporate investments, there is evidence that progress in renewable energy is taking place faster than many can see. Corporate investments in renewable energy are rising and, some argue that cost-competitiveness with conventional power sources is in sight. Customer demand is another factor.

One measure of change can be seen in corporate planning and behavior. 81% of CEOs surveyed by The Guardian newspaper stated that sustainability issues are now "fully embedded" in their companies' strategies and operations, with many extending this focus to their subsidiaries and supply chains, specifically including procurement and investment in renewable energy sources.

Sustainable procurement within corporations includes a variety of "greener" purchasing options, one of which is buying into renewable energy, whether a company purchases power straight from the grid through specialized utilities, purchases Renewable Energy Credits (RECs) or produces energy directly.

Achieving reductions in energy usage is one of the many tasks that demonstrate a commitment to corporate sustainability. As competition intensifies to be the greenest brand in the marketplace, an impressive number of companies now voluntarily measure, manage and publicly disclose their carbon emissions; and a collection of high-tech solutions, clean technologies and market tools have evolved in recent years to meet these demands.

For the increasing number of businesses that are choosing to generate their own renewable energy, each could benefit from average returns of 11–12 percent, with the potential for returns in excess of 20 percent, according to a new Carbon Trust Advisory analysis. Factors such as new financial incentives, energy market trends and building regulations contribute to a compelling case for companies to develop their own renewable energy production. Energy prices are estimated to grow by 37 percent by 2020. Businesses that look ahead see an opportunity to reduce huge energy bills going forward.

RECENT INVESTMENT TRENDS IN RENEWABLE ENERGY

MOMENTUM FOR RENEWABLE ENERGY

Global investment in renewable power and fuels set a new record in 2011. Investment hit $280 billion in 2011, up 33 percent from $211 billion in 2010, and five times the figure achieved as recently as 2004.

Financial new investment, a measure that covers transactions by third-party investors, was $206 billion in 2011. Bloomberg, a financial reporting company that measures global trends, reports that renewable energy's investment balance of power has been shifting towards developing countries for several years. The biggest reason has been China's drive to invest: in 2011, China was responsible for $52 billion of financial new investment, up 57 percent from 2010 figures. This upward trend may be temporary, as 2011 saw investors rushing to take advantage of nearly expired incentives. The developing world's advance in renewables is no longer a story of China and little else. India showed the fastest growing renewable energy market worldwide in 2011, at a 62 percent increase with $12 billion of investment. In 2011, financial new investment in renewable energy fell by 18 percent to $5.5 billion in the Middle East and Africa region, and by 35 percent to $7 billion in South and Central America. Falling investments were caused by project delays from governmental funding difficulties. However, many incentive programs are moving forward in the Middle East and Africa, as well as South and Central America; and growth is expected to resume by 2013.

2011 was the first year that overall investment in solar substantially overcame that of wind. For the whole of the last decade, as renewable energy investment gathered pace, wind was the most mature technology and enjoyed an apparently unassailable lead over its rival renewable energy power sources. In 2011, wind received half the financial new investment funds of solar, with $84 billion compared to $147 billion for solar and $11 billion for the third-placed biomass & waste-to-energy. For solar, particularly rooftop photovoltaic installations in Europe, small-scale projects were dominant. Indeed, small-scale distributed capacity investment ballooned to $76 billion in 2011, up from $60 billion in 2010, fuelled by feed-in tariff subsidies in Germany, Italy and other European countries. Germany invested $20 billion in distributed solar and Italy invested $24.1 billion. Major small-scale solar investment was also seen in Japan, the U.S., Australia the U.K. and France during 2011.

Lowered technology investment costs played a major role in the worldwide renewable energy industry during the year of 2011, according to Bloomberg New Energy Finance estimates. The two largest beneficiaries were the solar and wind industries; which saw a 50% drop in photovoltaic module prices and a 10% drop in onshore turbine costs respectively. Industry pressures of 2011 included waning legislative support in developed countries, arising from European austerity pressures and U.S. congressional deadlocks.

RECENT DEVELOPMENTS

> The maturation of technologies, particularly in the waste to energy, biofuel and solar sectors is stimulating new investment. In 2011, public market investment in biofuel was up 37% at $654 million and geothermal rose nearly fivefold at $406 million. Larger energy companies are developing technologies that yield greater efficiencies, including co-generation technologies with cleaner fossil fuels.

The capital markets for renewable energy slowed in 2011. Share prices worldwide were unimpressive, due to solar and wind overcapacity and threats of legislative support loss in Europe and North America. The Global Innovation Index, by Wilder Hill, fell by 40%. Also, the Nasdaq and S&P500 showed no significant growth in the renewable energy market over the course of 2011. Poor performance of clean energy stock led to slowed public financing.

Emergent financing options in the wake of expiring federal incentives and debt crisis in Europe and North America include pension funds, long-term institutional investment, and green bonds.

The maturation of technologies, particularly in the waste to energy, biofuel and solar sectors is stimulating new investment. In 2011, public market investment in biofuel was up 37% at $654 million and geothermal rose nearly fivefold at $406 million. Larger energy companies are developing technologies that yield greater efficiencies, including co-generation technologies with cleaner fossil fuels.

Late in 2010 researchers noted that a shift was beginning to occur in clean energy investments. Venture capitalists and lenders were shifting from start-up companies to existing companies who had previously received institutional capital. The trend has persisted through 2011. This is indicative of a maturing industry and the trend is becoming more prevalent across the sustainable sector. It should also be noted that worldwide investment for renewable energy sector mergers and acquisitions in 2011 rose to a record high of $68 billion due to corporate vulnerabilities, exposed by a weakened market.

Jennifer Kho, a widely respected researcher in the clean energy field, recently wrote:

> *"...There are several dominant trends within the market, leading to increased momentum in the energy sector. These include:*
>
> - ***Increase in single investments:*** *Large growth equity and private equity funds are increasingly comfortable putting more dollars to work in single investments in today's market.*
>
> - ***Greater willingness by investors to accept risk:*** *Investors have demonstrated they are willing to take risk in terms of execution, scale up, and timing; however, they are less willing to take on technology or customer adoption risk.*
>
> - ***Increased M&A activity:*** *Fortune 1000 corporations in a variety of industries including oil and gas, technology, industrial, and power electronics, will continue to actively look for acquisitions in the sustainability sector."*

As the sustainable sector begins to mature, private equity funds and corporate investors comprise a larger percentage of investor activity. These groups see the growing opportunities and are eager to establish a foothold in the market. The business models of sustainable companies are becoming more clear, costs are decreasing with scale, and sustainable technologies are demonstrating that they can become profitable without government support.

Renewable energy companies are a long way from catching up with fossil-fuel energy industry giants. David Jones, editor of the Platts Renewable Energy Report, said:

> *"... until governments set a market price on carbon emissions, companies and other organizations will naturally release carbon because it doesn't cost anything. Once a price gets put on those emissions, renewables will be much more competitive..."*

Data integration with utility planning is beginning to make smart grid (and all of the related IT and equipment technologies) a more important element in the development of renewable energy. With the emerging interest in renewable energy of existing energy companies, including oil companies and major utilities, planning and integration strategies have become a small growth sector.

Utility and energy company interest brings a familiarity of the market dynamics involved, the relationships and the ability to get financing. Large energy company interest in renewable energy also stems from the fact that this segment has higher growth than the overall energy industry. For this reason, many analysts predict that mergers and acquisitions will remain a major part of new investment.

Will these mergers benefit the public? One of the goals — and strengths — of renewable energy is its diversity and the ability to localize its production. The nature of renewable energy technology doesn't require the kind of scale and vertical integration of oil companies and utilities. Large scale consolidation by vertically integrated energy companies could lead renewable energy away from its strength. For example, in the United States, more than 550 companies are involved in 1,300-plus wind energy projects under various stages of development and around 290 companies are involved in 540-plus solar energy projects. However, the speed of renewable energy adoption and its ultimate market share may depend on scale for its economic viability; subsidies and indirect factors, such as carbon costs, may not be sufficient to drive growth in the long term.

CORPORATE INVESTMENT EXAMPLES

Toward the end of 2011 daily reports told of failing economies and employment loss around the world. But we are also beginning to see some leadership in efforts to move from a fossil fuel based economic model to a clean technology model. In 2011 alone, four big deals in particular tell us a lot about this current trend; private sector investments that point toward a future of energy transformation.

- French oil and energy giant Total SA the world's 14th largest corporation, offered to take a 60 percent stake in San Jose-based solar PV stalwart SunPower, for $1.38 billion.

- Japanese computer/electronics icon Toshiba said it will acquire Swiss electricity meter manufacturer Landis & Gyr, an increasingly influential player in smart meters and other smart-grid technology, for $2.3 billion.

- Home improvement retailer Lowe's, a Fortune 50 company with nearly $50 billion in revenue, took an undisclosed minority stake in fast-growing solar installer/leasor Sungevity. Lowe's plans to offer fast rooftop solar price estimates at kiosks to its in-store customers in the eight states where Sungevity operates.

- Warren Buffet's investment company Mid-American Energy Holdings announced plans to purchase the $2 billion Topaz Solar power development project from thin-film PV module maker First Solar. The 550-megawatt Topaz project in San Luis Obispo County, Calif., is among the world's biggest solar farms under development, and many times larger than any project currently in operation. Pacific Gas and Electric will buy the electricity. The project is moving ahead without Federal loan guarantees. According to First Solar, the project will create about 400 construction jobs.

Further investment undertakings during 2011 include:

- Silver Lake, a U.S. technology investor launched a new clean energy fund, called Silver Lake Kraftwerk. They presented $300 million in investment from Soros Fund Management, aiming to reach a final value of $1 billion. The fund will be used to support companies with technology and business models promoting efficiency in energy production.

- A group of 11 U.S. families formed the Cleantech Syndicate. It will invest up to $1.4 billion over five years in renewable generation and energy efficiency.

- Wheb Ventures plans to open a third environment fund, aimed at eventually totaling $342 million.

- Grand River Capital of China aims to raise $100 million for the SinoGreen Fund.

- Origo Partners and Ecofin will work together raising $200 million for a clean energy fund focused on China.

- Next Energy Capital plans to raise $536 million to contribute toward renewable energy and environmental investments in Africa.

VENTURE CAPITAL

Overall, venture capital in North America led the world in all the venture capital invested globally during 2011; but experienced an 11% decrease from 2010, to a total $2.8 billion. China is emerging as a huge energy market with lots of opportunity for renewable energy companies. It has pledged over $7 billion to smart grid and continues to subsidize solar panel manufacturers that have undercut global competition in price. The top IPO in 2011 was the $1.4 billion offering in China by the turbine manufacturing unit, Sinovel Wind Group.

> *"...Building great businesses typically requires three key ingredients: phenomenal people, compelling technology and investment capital. Cleantech companies are no exception. While cleantech venture capital investments have expanded rapidly, averaging an annual growth rate of 65% over the past five years and now representing over 15% of all venture investments, the compelling technologies are mostly early in their development cycles and the human eco-system for early stage cleantech companies is in its infancy."*

Venture capital money is flowing toward safer bets on the energy front according to a report by Ernst & Young. The report notes that investors shifted their money from capital intensive solar and biofuel companies into firms that use technology to reduce or monitor energy use because the funding requirements are lower and the returns are often faster. These types of investments are more like the traditional tech-type investments that the typical venture capitalist is comfortable investing in. According to the report, some renewable projects can cost up to $250 million to build, and many of their technologies are still relatively unproven.

An article by David Gold, who manages venture capital projects for Venture Capital Partner in Texas, commented that, during a recession, it can be a safer bet for venture capitalists to put their money into cheaper, more solid technology. He also observed:

> *"..... that many renewable energy entrepreneurs are engineers or scientists. Many seem to believe that their phenomenal technology and their outstanding technical skills alone should justify an investment in their company. There are certainly good examples of when this is true. Think of Microsoft and Apple. Having compelling technology is a necessary but not sufficient condition for entrepreneurial success. Human Capital must always precede venture capital."*

In Gold's view, Human Capital, Not Venture Capital, is the Biggest Cleantech Challenge:

> *"...Building great businesses typically requires three key ingredients: phenomenal people, compelling technology and investment capital. Cleantech companies are no exception. While cleantech venture capital investments have expanded rapidly, averaging an annual growth rate of 65% over the past five years and now representing over 15% of all venture investments, the compelling technologies are mostly early in their development cycles and the human eco-system for early stage cleantech companies is in its infancy. There is much buzz about the venture capital and government funding that is being invested in cleantech companies, but the immaturity of the cleantech entrepreneurial ecosystem is overlooked as a significant challenge in accelerating the growth of successful cleantech companies..."*

RENEWABLE ENERGY SECTOR DIFFICULTIES

Momentum for clean energy development has waxed and waned over the past thirty years with mixed outcomes. Investments in wind and solar during the 1980's ended when the price of fossil fuels fell to historic lows. Renewable energy investments have reached historic highs over the past ten years in the context of concerns about climate change, national security, fossil fuel cost, and technology leadership issues.

The current growth of the clean energy sector is based on assumptions that oil prices, now over $80/barrel, will continue or rise in the long-term and display volatility in the short-term. An impressive roster of analysts and energy experts support this view and the authors of this white paper tend to agree. However, caution is in order. Biofuels were promising 10 years ago; enthusiasm peaked in 2006-2007 with investments reaching $20.4 billion. However, biofuels have not been able to compete with fossil fuels in an open market and the investment in biofuels dropped to $3.5 billion in 2011. Due to the financial crisis and recession in Europe and North America, financial new investment in renewable energy was significantly lower in 2011 in both Europe and North America, although this setback was more than outweighed by growing investment in China and other emerging economies, and in small-scale PV projects in the developed world.

March 2011 brought a tragic event with potentially far-reaching consequences for energy, including renewables. The Japanese earthquake, and the ensuing crisis at the reactors at Fukushima Daiichi, cast into doubt the future of nuclear power in Japan and also in other countries such as Germany. Initially, this led to a sharp rise in the share prices of renewable energy companies. But it could be that gas-fired generation will be the prime, short-term beneficiary of nuclear problems, rather than the renewable energy sector. The Henry Hub US benchmark for natural gas stayed in a range of $2-$4 per MMBtu for almost all of 2011, far below the $13 peak of 2008 and also below the levels prevailing in most of the middle years of the decade. This gave generators in the US, but also in Europe and elsewhere, an incentive to build more gas-fired power stations and depressed the terms of power purchasing agreements available to renewable energy projects.

The perception that renewable energy investments are only a sideshow to conventional energy sectors such as oil and gas has been outdated for many years. Recall, in 2011 overall new investment in renewable energy of $280 billion was up 33 percent from 2010, and nearly five times the figure for 2004. There is also burgeoning investment in the parallel area of smart technologies - including advanced metering infrastructure, phasor measurement units, highly-networked protection schema, electric vehicles, advanced power electronics, smart appliances, home energy management systems, and energy efficiency devices and systems. Public market investment in these technologies totaled $18.9 billion in 2011.

A major headwind for renewable energy has been outside skepticism. This manifests itself in the stock market where clean energy shares under-perform wider indices by more than 20 percent on pessimism about future profit growth. The perception that renewable energy investments are only a sideshow to conventional energy sectors such as oil and gas has been outdated for many years. Recall, in 2011 overall new investment in renewable energy of $280 billion was up 33 percent from 2010, and nearly five times the figure for 2004. There is also burgeoning investment in the parallel area of smart technologies - including advanced metering infrastructure, phasor measurement units, highly-networked protection schema, electric vehicles, advanced power electronics, smart appliances, home energy management systems, and energy efficiency devices and systems. Public market investment in these technologies totaled $18.9 billion in 2011.

The total shares in funds focused primarily on renewable energy fell by 31% in 2011. This was paired with a

20% drop in shares focused on the environment and climate change. Three new funds were created to open investment options in public equities for renewables and climate change, which pales in comparison to the 2007 height of 45 new funds. Venture capital was not as successful as private equity funds in raising new capital, which highlighted the new trend of private investment and green bonds in clean energy financing. Pension funds are also emerging as a potential financing option, along with the development of project debt with Chinese state-backed financial institutions by Western developers.

GOVERNMENT INCENTIVES

Government incentives have long been used to prime the pump for "infant industries." Moreover, when national interests are at stake, government incentives have been used to promote the national rail and highway systems, food production, fossil fuel exploration and development, research and technology, and health. Add renewable energy to the list.

In addition to the programs outlined in the following exhibits, both Federal and State programs have used a variety of tax, direct cash, and loan incentives to stimulate renewable energy development. The problem with this type of government intervention with the market economy is that these temporary programs tend to become long term subsidies after infant industries mature.

An analysis prepared by Navigant (below) shows that Federal incentive programs are making a difference in renewable energy growth in the U.S. Without them, renewable energy investments would be smaller and would be competing with fossil fuel incentives already in place.

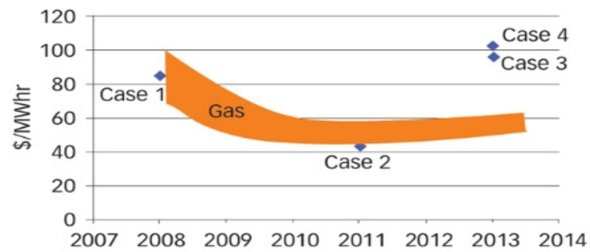
NAVIGANT STUDY

From abridged materials prepared by: *Bruce Hamilton, Director of Energy at Navigant Consulting, Inc.*

"Renewable energy technologies, have benefitted in a variety of ways from federal incentive programs. The Section 1603 cash grant program, the

Exhibit XV: Wind Incentive Project Deadline Schedule

Program	Expiration Deadlines for Wind Projects
Section 1603 Cash Grant	Begin construction by 12/31/11, place in service by 12/31/12
DOE Section 1705 Loan Guarantee	Begin construction by 9/30/11
Bonus Depreciation Schedule	Place in service by 12/31/11 for 100% first-year bonus depreciation, 12/31/12 for 50% bonus
Production Tax Credit and Investment Tax Credit	Place in service by 12/31/12



Source: Navigant Consulting, Inc. What Happens When the Incentives Expire? 2011

Department of Energy Section 1705 Loan Guarantee program and the Bonus Depreciation schedule are among the federal programs that are scheduled to expire by the end of 2012. The Production Tax Credit (PTC) and Investment Tax Credit (ITC) are also scheduled to expire for wind projects at the end of 2012. In today's budget-cutting environment, it's possible that none of these incentives will be renewed.

The Section 1603 cash grant has been a popular and successful program and is generally credited for keeping the U.S. wind industry healthy during the 2009-2010 recession1. Since the program was initiated in 2009 through the first quarter of 2011, $5.6 billion in cash grants has been awarded for wind projects, representing more than 80 percent of all Section 1603 funding to date.

The DOE Section 1705 loan guarantee program has a current allocation of $2.5 billion that can support up to $30 billion of loan guarantees. "

"Under the federal Modified Accelerated Cost-Recovery System (MACRS), renewable energy properties are classified as five-year property for depreciation purposes. Eligible property placed in service after Sept. 8, 2010 and before Jan. 1, 2012

qualifies for 100 percent first-year bonus depreciation, meaning that 100 percent of the project cost can be expensed in the first year. For 2012, a 50 percent bonus depreciation is still available. After Dec. 31, 2012, the allowable deduction reverts to the original five-year MACRS recovery. The 100 percent bonus is estimated to be 40 percent of the value of the Section 1603 cash grant.

To determine the impact of the pending expiration of these programs, Navigant calculated the levelized cost of Energy (LCOE) for a 100 MW wind plant in various time frames with the following project finance structures:

- *Case 1. Circa 2008, using the production tax credit, equity from the project sponsor (20 percent), and a tax equity partnership of (80 percent).*

- *Case 2. Circa 2011, using the cash grant (30 percent), equity from the project sponsor (20 percent), a DOE loan guarantee (40 percent) and a private loan (10 percent). 3*

- *Case 3. Circa 2013, using the production tax credit, equity from the project sponsor (20 percent) and a tax equity partnership of (80 percent), assuming that the production tax credit will be renewed.*

- *Case 4. Circa 2013, using the project sponsor's equity (70 percent) and a private loan (30 percent), assuming that the production tax credit is not renewed.*

Navigant also calculated the range of LCOE prices from natural gas fired power plants during these same time periods. The results of the four cases are shown in the above graph.

The case studies show that wind plants are competitive with gas plants in Cases 1 and 2, which is consistent with the fact that many utilities have installed wind plants well in excess of their Renewable Portfolio Standard (RPS) requirements. In comparing Cases 1 and 2, the combined effect of the cash grant and the DOE loan guarantee cuts the cost of a wind farm nearly in half. In comparing Cases 1 and 3, increased return requirements from tax equity investors are a significant factor in driving wind LCOEs higher. In comparing the wind plant LCOEs of Cases 3 and 4 with their corresponding gas plant LCOEs, wind will not be competitive with gas, either with or without the production tax credit."

Exhibit XVI lists the federal clean energy tax and related incentives and shows most are scheduled to expire soon. With the current cost structures in place, and no federal incentives, the cost of wind energy will be 40% higher when competing head-to-head with natural gas. The impact on solar and other renewable energy projects would be even greater. Natural gas prices are low and are expected to remain low into the foreseeable future.

The calculation demonstrates, in the absence of Federal incentive programs, the importance of state Renewable Portfolio Standard (RPS) requirements to promote development of renewable energy using local resources.

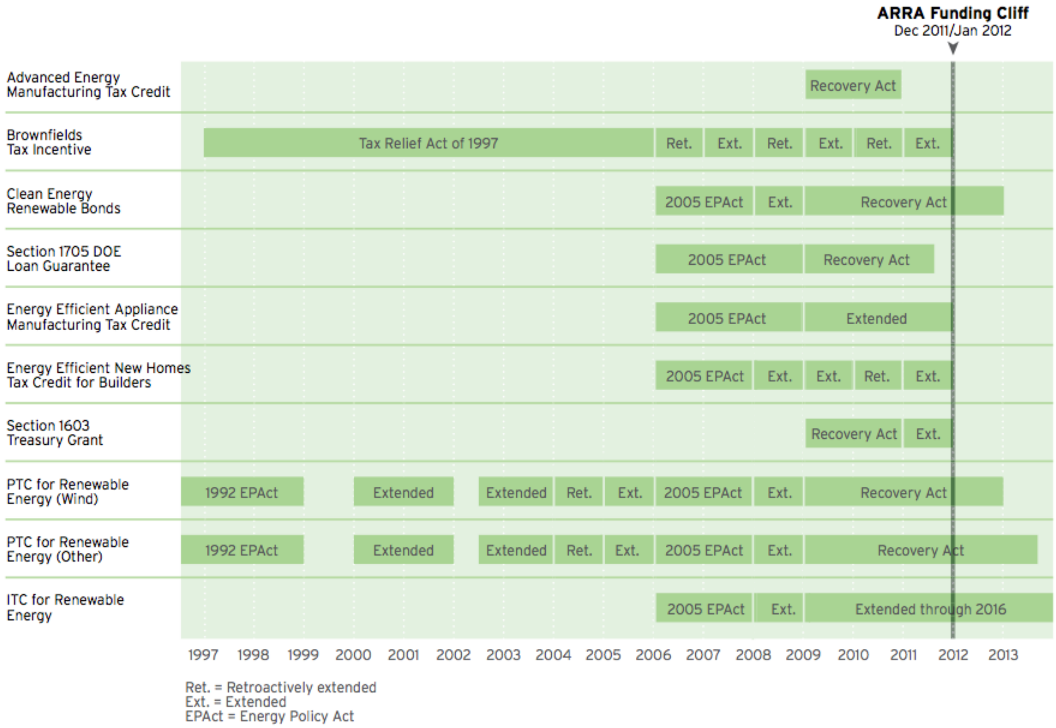
Certain federal incentives for projects which began construction prior to December 31, 2011 have received slight extensions.

According to the Database of State Incentives for Renewable Energy (DSIRE), U.S. Department of Treasury Renewable Energy Grants for eligible property types and renewable technologies have credit termination dates of January 1, 2013, for wind; January 1, 2014, for closed-loop biomass, open-loop biomass, landfill gas, trash, qualified hydropower, marine and hydrokinetic; January 1, 2017, for fuel cells, small wind, solar, geothermal, microturbines, CHP and geothermal heat pumps. These apply with the stipulation that project construction began prior to December 31, 2011.

Business energy Tax credit (ITC) applies to eligible systems placed in service before December 31, 2016.

Renewable Electricity Production Tax Credit (PTC) applies to eligible projects with in-service dates of December 31, 2012, for wind; December 31, 2013, for closed-loop biomass, open-loop biomass, geothermal, landfill gas,

Exhibit XVI: Renewable Energy Tax Incentive Expiration Timeline



Source: Brookings Institution, Sizing the Clean Economy 2011 (p. 36)

municipal solid waste, qualified hydropower, marine and hydrokinetic.

Presently, Green Bonds are emerging as a major replacement funding source for currently dwindling federal incentives. Green bonds may play a vital role in filling the gap introduced by disappearing federal support. MidAmerica holdings, owned by Warren Buffet, received an $850 million bond for a solar photovoltaic project early in 2012.

Throughout 2011, awareness grew over the significance of green bonds for the future of renewable energy investment. Current estimates of outstanding green bonds equate to $243 billion. The division of these bonds is $233 billion of corporate bonds issued in clean energy and efficiency, and $10 billion issued by international financial institutions or project developers to fund projects directly. Though the bond issuance trend is up, the rate at which these bonds are dispersed still falls short of that necessary for the $600 billion annual investment needed for 2020 emissions goals.

Slow growth in green bond investment comes from a lack of standard terms and conditions, which create an atmosphere of risk for investment. This uncertainty is exacerbated by the reluctance of manufacturers to openly reveal device performance data. Attempts to address these issues are being made by the Climate Bonds Initiative, a non-governmental organization that promotes green bonds. They have developed a Climate Bonds Standard, aimed to build investor confidence.

EMPLOYMENT AND ECONOMIC IMPACTS OF RENEWABLE ENERGY INVESTMENTS

JOB GROWTH

According to an analysis of 13 independent reports and studies of the clean energy industry by the Renewable and Appropriate Energy Laboratory (RAEL), renewable energy technologies create more jobs per average megawatt (MW) of power generated, and per dollar invested in construction, manufacturing, and installation when compared to coal or natural gas. Over the course of a 10-year period the solar industry created 5.65 jobs per million dollars in investment, the wind energy industry 5.7 jobs, and the coal industry 3.96.

Studies at the state level also confirm the comparative job creation advantages of renewable energy systems. A Union of Concerned Scientists analysis conducted for the state of Wisconsin found that an 800 MW mix of new renewables would create about 22,000 more full time jobs than would new natural gas and coal plants over a 30-year period. A New York State Energy Office study concluded that wind energy would create 27% more jobs than coal and 66% more than a natural gas plant per kilowatt hour generated. A study by Economic Research Associates in Colorado found that ratepayers saved $1.2 billion with a net gain of 8,400 jobs by investing in renewable energy. The study also assessed nine other states and reached similar conclusions.

> Given the fact that renewable sources of energy are local, have a smaller carbon footprint than fossil resources, and are declining in cost, it seems prudent for states to establish policies that increase the use of renewables in all sectors of the local economy.

These studies do not provide an analysis of the comparative energy rates that would result from a renewable energy investment strategy. However, to be fair, such a study would also need to include the impact on unemployment, retail sales, community tax base, etc. What these studies do show is that renewable energy is more labor intensive than fossil fuel energy to develop. Given the fact that renewable sources of energy are local, have a smaller carbon footprint than fossil resources, and are declining in cost, it seems prudent for states to establish policies that increase the use of renewables in all sectors of the local economy.

From a national perspective, several studies indicate that hundreds of thousands, if not millions of jobs could be created, depending on the aggressiveness of the public policy approach. The California-based think tank Redefining Progress estimates that clean energy can produce 1.4 million jobs by 2025, reducing unemployment rates by 14%. The Redefining Progress Plan proposes to increase renewable energy generation in the US by 1% per year through to 2025 as well as doubling federal research and development dollars to leverage private investment.

A recent study by the Union of Concerned Scientists concluded that if the United States adopted a 25% Renewable Portfolio Standard for its electrical utilities, over 297,000 jobs could be created by the year 2025. Quoting Union of Concerned Scientists, these jobs would be in "manufacturing, construction, operations, maintenance, agriculture, forestry, and many other industries."

This study, from an unbiased and reputable source, suggests that clean energy development not only helps to mitigate the twin challenges of climate change and fossil fuels dependency, it holds great promise in addressing the pressing need for high-quality jobs with pathways to sustainable careers for Americans who have yet to benefit from the burgeoning green economy.

SKILLS SHORTAGES

Leaders in the renewable industry say that one of the factors holding back growth in the renewable energy sector is a shortage of acute skills; especially skills in high wage technology jobs. One company in the offshore wind sector claims that hiring is so competitive that companies are constantly poaching staff from each other.

David Spencer-Percival, of Spencer Ogden Renewables, pointed out that it's not just the renewables sector, but the whole of the energy industry that suffers as a result. Moreover, Spencer-Percival warned that the problem is only going to get worse, as 20% of oil and gas executives are due to retire over the course of the next few years.

In the UK and elsewhere governments are being asked to review curriculums now, right down to secondary school level, and to encourage pupils to pursue subjects that will lead to careers in energy and engineering.

There is significant pent-up demand for energy efficiency education and training programs. A recent survey indicates that most programs have waiting lists. Demand for hiring graduates with energy efficiency education is also strong; respondents at community colleges and universities all report easily placing graduates. However, the challenge of responding to this demand is different for different parts of the workforce. For example: Universities indicate that public funding is not available to add faculty and/or space. Some universities plan to offer distance learning options as a partial solution, though they acknowledge that certain classes and equipment skills cannot be taught well online.

Community colleges are able to more easily ramp up than universities, but many still have waiting lists for their programs. Supporting training for the building and construction industry is especially challenging for those areas lacking an infrastructure for energy efficiency services. An alternative approach could be to integrate building and industrial process system efficiency into existing curricula or union apprenticeship programs. This could be a cost-effective way to train large numbers of electricians, HVAC contractors, mechanical insulators, and green home builders.

TRAINING RECOMMENDATIONS

UC Berkeley's Renewable and Appropriate Energy Laboratory is conducting ongoing studies pertaining to training and job skills in the energy efficiency industry. They make the following recommendations for meeting the demand for training renewable industry workers:

> ***Provide energy efficiency education and support targeted at building and construction contractors and tradespeople.*** *We found a notable lack of awareness on the part of building and construction contractors and tradespeople that energy efficiency is poised for significant growth. Building and construction contractors and trades constitute about 65-75% of the overall workforce in the Energy Efficiency Services Sector (EESS). Thus, it is important to educate and support the building and construction contractors and tradespeople to ensure that they are able to provide a trained workforce to support projected growth. This problem appears more severe in states that do not have long-running ratepayer-funded programs. There is also the issue of limited access to resources in addition to lack of awareness. Even in cases where there is interest, the expertise and training required may not be available in the local area. It will also be important, especially in states that are ramping up energy efficiency, to integrate building and industrial process system efficiency into existing building and construction technical, apprenticeship, and trades curricula*
>
> ***Coordinate and track training efforts within states and share best practices across states.*** *With the influx of ARRA funding, many states are initiating and/or ramping up a range of training and education activities that target workforce development in the "clean energy" sector. However, it was challenging to identify and determine those programs/courses that will provide specific education and training for the energy efficiency services sector. This information needs to be tracked in a systematic way going forward. There also needs to be greater coordination between the various types of EESS training programs within each state. Establishing broad statewide education/training efforts, such as NYSERDA's collaboration with Hudson Valley Community College, may be helpful to avoid duplication of efforts at the local level. This type of training infrastructure can help states that are ramping up energy efficiency*

programs if building and construction contractors and tradespeople are much less aware of energy efficiency specific design and construction practices.

There is significant pent-up demand for energy efficiency education and training programs. A recent survey indicates that most programs have waiting lists. Demand for hiring graduates with energy efficiency education is also strong; respondents at community colleges and universities all report easily placing graduates. However, the challenge of responding to this demand is different for different parts of the workforce. For example: Universities indicate that public funding is not available to add faculty and/or space. Some universities plan to offer distance learning options as a partial solution, though they acknowledge that certain classes and equipment skills cannot be taught well online.

Finally, it is also important to note that similar efforts are happening in a number of states, so increased sharing of best practices and high quality curriculum could help lead to more rapid launch of effective training programs.

Increase short-duration, applied trainings to augment on-the-job training and/or introduce new entrants to a field. *Much of the growth in the EESS will come from new entrants who already have some applicable skills (e.g. building and construction contractors who become efficiency retrofit specialists). There is also a strong demand for up-to-date training for those who are currently employed in the EESS but who need to update or augment their skills. In both cases, short-duration courses on specific, applied topics will be more relevant than a 2 or 4-year degree program. These types of offerings will need to be significantly ramped up in the next few years and could be funded by government and/or utility ratepayer energy efficiency programs.*

Increase funding to "train the trainers." *Our research indicates that there is likely to be a lack of qualified trainers to train the workforce needed to support the projected growth in the EESS. For example, the WAP network estimates they will need 700 additional trainers by summer 2010 to meet their goals. Similarly, many community colleges rely on a small group of key instructors to teach courses, and many are nearing retirement age. The Building Performance Institute, which provides certifications for residential retrofit contractors, experienced 5-fold increase in number of certifications between 2005 and 2008, and believe the number will almost triple between 2008 and 2009. These growth rates strain the capacity of existing trainers; additional resources from government and/or ratepayer energy efficiency program funds could be directed towards training the next generation of EESS trainers.*

Increase access to on-the-job and other formal training for mid- and senior-level engineers and managers. *Our interviews revealed a need for more managers and engineers experienced with energy efficiency. Managers and engineers in potentially related fields need to understand the opportunity in the EESS and have increased access to professional training that they can complete on the job, or if they decide to make a career change. However, most firms report relying on on-the-job and informal training to ensure their staff was skilled and knowledgeable after hiring. Examples of more formal resources that address this need and could be expanded include training offered by the Association of Energy Services Professionals, and; the Certified Energy Manager certificate program offered by the Association of Energy Engineers.*

Prepare the next generation of EESS professionals. *We learned from our interviews that most professional roles within the EESS require at least a four-year degree. However, few colleges or universities offer EE-specific curriculum, and those that do stated that funding to grow these programs was extremely limited in most cases.*

Additional funding is needed to support new energy efficiency-related, inter-disciplinary programs and expand existing programs and course offerings. Four-year colleges, especially in states that are ramping up large-scale energy efficiency programs, need to provide additional courses with multi-disciplinary and system-based approaches to energy efficiency. The Department of Energy Industrial Assessment Centers have been a successful model to provide energy efficiency services to industry and a training ground for engineering students. Similar centers could be developed in conjunction with college and university-based engineering, architecture, planning, and policy-focused programs and could include building science centers for architecture and engineering students and policy/planning centers that emphasize education/training needed for energy efficiency program design and project implementation. Initial support for these centers could come from federal/state energy efficiency program funds.

APPENDIX

STATUS AND OUTLOOK FOR TRADITIONAL AND EMERGING ENERGY SOURCES

OVERVIEW

" … the reason for a long-term consistent drop in clean energy technology costs is a result of hard work for decades by tens of thousands of researchers, engineers, technicians and people in operations and procurement. And it is not going to stop: In the next few years the mainstream world is going to wake up to wind cheaper than gas, and rooftop solar power cheaper than daytime electricity. Add in the same sort of deep long-term price drops for power storage, demand management, LED lighting and so on and we are clearly talking about a whole new game."

Renewable energy provides an answer to concerns about climate change, energy security, and global conflict over energy resources. Much time, energy and thought are going in to finding ways to address concerns about peak oil.

Justin Wu, lead wind analyst at Bloomberg New Energy Finance, said:

> *" … the reason for a long-term consistent drop in clean energy technology costs is a result of hard work for decades by tens of thousands of researchers, engineers, technicians and people in operations and procurement. And it is not going to stop: In the next few years the mainstream world is going to wake up to wind cheaper than gas, and rooftop solar power cheaper than daytime electricity. Add in the same sort of deep long-term price drops for power storage, demand management, LED lighting and so on and we are clearly talking about a whole new game."*

The remainder of the Appendix will provide commentary on various sectors that touch on the viability and timing of renewable energy finding its way into the mainstream. It is important to remember that all sources of renewable energy will be important for energy independence, secure supply, and affordable fuel. While innovative grid management tools will allow us to scale wind and solar without an equivalent megawatt to megawatt backup, there will definitely be a need to better integrate renewable and fossil energies to boost output and maximize current infrastructure.

HYBRID POWER GENERATION

In an ideal world, renewable technologies would be developed on a scale that would phase out fossil-based plants. There are indications that this is beginning to happen. But in order to scale these technologies, drop costs and better utilize power plants that are in operation (or switch from burning coal to far more efficient natural gas), the hybrid approach is a very attractive option.

Hybrid renewable energy plants, which generate electricity from more than one source of intermittent renewable energy together with a hydro or fossil fuel source, have the potential to help developers in their ongoing battle to lower costs and extend operating hours, particularly during periods of cloud cover or inclement weather.

The perceived advantages have led some companies to establish such plants – one notable example being the joint GE, MetCap and eSolar 'Project Dervish' power plant in Turkey, which combines power from a variety of sources, including CSP power towers, wind turbines and a combined cycle gas turbine (CCGT) in a purpose-built 530MW plant.

One concern relating to the establishment of hybrid plants is the idea that they might face greater challenges in obtaining the necessary permits to operate, particularly since they make use of multiple renewable, and sometimes other, energy sources - meaning that developers may sometimes have to deal with more than one permitting agency or authority. Government regulators can mitigate this problem by planning ahead and establishing standards that take into consideration co-generation.

One of the strengths of co-generation is that utilization of several energy sources may help developers to make better use of existing resources. Many timber mills have been operating co-generation facilities for years. By 'bolting on' several sources of energy within a single plant configuration, developers are able to reduce the costs associated with operating hardware, as well as balance of plant, operations and maintenance (O&M) costs.

In the case of co-generation with solar or wind and a fossil fuel like natural gas, the power producer and consumer are protected against market volatility and rising fossil fuel prices.

Hybrid renewable plants currently represent the most competitive approach to the supply of power to consumers. Hybrid renewable plants will ultimately become more and more price competitive – particularly in the context of increasing oil, coal and gas prices coupled with market disruption.

Integrated plants, with their associated economies of scale, can help developers to reduce costs in a variety of ways. They reduce and optimize the amount of fossil fuel being burned - leading to lower fuel costs. Secondly, by helping to reduce CO_2 emissions, they enable operators to cut the carbon levies or taxes they face - or might even help to generate 'carbon income,' perhaps via trading schemes or third wave biofuel technologies. Off grid renewable energy supplying auxiliary power to a generation plant maximizes the electricity pushed onto the grid and shared infrastructure reduces investment costs.

While states are working to increase the share of renewables that generate electricity, combining intermittent renewable resources with hydro, geothermal, or natural gas looks to be one of the best approaches for multi-resource utilization for the next several decades. As the cost pressure on coal, oil or gas fired power plants continues to grow, renewable energy hybrid plants should emerge as an increasingly credible alternative.

OUTLOOK FOR ONSHORE WIND

Wind has been the dominant sector of renewable energy development over the past decade. In 2011 alone, investment in wind energy rose 29.3 percent. The best wind farms in the world are already competitive with coal, gas and nuclear plants. Over the next five years, according to Bloomberg New Energy Finance, continued performance improvements and cost reductions should bring the average onshore wind plant in line with cheap natural gas, even without a price on carbon.

Onshore wind power is in a good place, at least through the end of 2012. Wind power has made up 35 percent of all new generating capacity added to the U.S. grid between 2007 and 2011. That's twice what coal and nuclear combined have added in the last five years, according to the American Wind Energy Association (AWEA). And as U.S. developers take advantage of federal tax credits for renewables through the end of 2012, it's possible that 2012 may result in the largest number of wind projects completed in one year.

As of the end of the first quarter of 2012, 8,900 megawatts (MW) of wind power capacity are under construction in U.S. and cumulative installed wind power capacity stands at 48,611 MW. 2011 saw 6,816 MW of new installed wind capacity in the U.S., which exceeds installations up to the same point in 2010 by 75 percent.

After analyzing the cost curve for wind projects since the mid-1980s, a research team at BNEF showed that the cost of wind-generated electricity has fallen 14% for every doubling of installation capacity. These cost reductions are due to a number of factors: more sophisticated manufacturing, better materials, larger turbines, and more experience with plant operations and maintenance. Those improvements, combined with an oversupply of turbines on the global market, should bring the average cost of wind electricity down another 12% by 2016.

Bloomberg New Energy Finance estimates that manufacture of onshore wind turbines displays a 7% "experience-curve" – that is a 7% cost reduction for every doubling of installed capacity – as economies of scale and supply chain efficiencies reduce costs. In 1984, there were only 0.3GW of installed wind capacity in the world, but by the end of 2011 this grew to over 240GW. A second factor driving down the price of wind-generation is the power output achieved by each turbine as a percentage of nameplate capacity. The capacity factor has been rising steadily. This has been driven by the long-term move to bigger and taller turbines, better aerodynamics, better controls and gearboxes, as well as improved electrical generation efficiency. For each megawatt of wind capacity built on land today, turbines can be expected to deliver 2900 MWh as compared with 1800 MWh in 1984.

Due to structural overcapacity and growing competition in the wind industry, Bloomberg expects turbine prices to continue to fall over the next few years. At the same time, as designers roll out larger turbines with longer blades designed to capture more energy, even in low-wind locations, capacity factors will continue to increase. These two changes will drive the cost of wind energy down further. Wind should become fully competitive with energy produced from combined-cycle gas turbines by 2016 in most regions offering fair wind conditions. Any increase in the cost of gas, which will consequently raise the cost of energy of gas-fired turbines, would bring forward the timing of grid parity for wind.

OUTLOOK FOR OFFSHORE WIND

The U.K and other countries bordering the North Sea are major investors in offshore wind. Offshore wind is another matter in the U.S., however. The potential value of offshore wind in the U.S. is sizeable. According to the U.S. Department of Energy's (DOE's) National Renewable Energy Laboratory, the 28 U.S. coastal states consume 78 percent of the nation's electricity, but only six of these states could meet even one-fifth of their power demand with land-based wind energy. This leaves a clean energy void from wind that could be filled by offshore wind power.

The U.S. Department of Energy recently announced that it is providing funding for a team of leading energy organizations to perform a broad study that will assess the most promising sites for high offshore wind production along all of the U.S. coastal regions. ABB, a Swiss-based company with U.S. offices in Cary, N.C., will lead a team that includes: AWS Truepower (a consulting company headquartered in New York offering high quality data and tools to support wind farm development and asset management), Duke Energy, National Renewable Energy Laboratory (NREL), and the University of Pittsburgh. The team will attempt to determine the expected staging of offshore wind development in each of the coastal regions, develop expected wind generation production profiles, assess the applicability of integration study methods to offshore wind production, assess a variety of offshore wind collection and delivery technologies, and consider regulatory issues that may influence the selection of technologies or the implementation of systems. Additionally, the study will provide the technical and economic viability data necessary to produce a roadmap to the Department of Energy's "20 Percent Wind Energy by 2030" goals for the U.S. This Offshore Wind initiative will help guide the national effort to achieve a 54 gigawatts (GW) of deployed offshore wind generating capacity by 2030.

Electric power generated by wind resources has become an increasingly important part of the energy production portfolio of the U.S. The majority of current wind production, however, is land-based. DOE plans to invest $43 million in 41 projects across 20 states over the next five years to speed technical innovations, lower costs, and shorten the timeline for deploying offshore wind energy systems. The projects are designed to advance wind turbine design tools and hardware, improve information about U.S. offshore wind resources, and accelerate the deployment of offshore wind by reducing market barriers such as supply chain development, transmission and infrastructure. The DOE study is intended to be a landmark study that will provide a road map for offshore wind development in North America. The project team is expected to provide its final report and recommendations to the Department of Energy in September 2013.

OUTLOOK FOR SOLAR/PV

Use of the sun for power generation at scale is a relatively new phenomenon. With the development of photovoltaic (PV) systems installation, solar has been growing at a rapid pace in recent years. In 2011, approximately 27,700 megawatts (MW) of PV were installed globally, up from approximately 16,600 MW in 2010, consisting primarily of grid-connected applications. With 1,855 MW of grid-connected PV capacity added in 2011, the United States was the world's fourth largest PV market in 2011, behind Italy, Germany, and China. Despite the significant year-on-year growth, however, the share of U.S. electricity supply met with PV remains small.

The market for PV in the United States is, to a significant extent, driven by national, state, and local government incentives, including up-front cash rebates, production-based incentives, renewable portfolio standards, and federal and state tax benefits. These programs are, in part, motivated by the popular appeal of solar energy, and by the positive attributes of PV, i.e. modest environmental impacts, avoidance of fuel price risks, coincidence with peak electrical demand, and the ability to deploy PV at the point of use. Given the relatively high historical cost of PV, however, a key goal of these policies is to encourage cost reductions over time.

PV is popular with consumers who want to gain some independence from the grid and favor an approach that is distributive. However, for larger scale needs that are consistent with utility production and distribution, distributive PV presents a break from historic models. Utilities tend to favor large scale Concentrated Solar Production (CSP). An example of CSP is a field of large parabolic dish concentrators that harness temperatures up to 1,000°C. Each dish channels the sun radiation onto a boiler or volumetric receiver, which then produces steam. The steam is delivered to a power plant turbine, generating clean electricity.

Nobel economist Paul Krugman recently wrote an article that cited that solar electricity prices are falling at a rate of about 7% per year, making solar cost-effective. While it may be true that solar costs have fallen dramatically, solar is not yet competitive with other baseload fuels at utility scale.

In terms of utility scale, installed solar costs for have dropped dramatically, from $8 to $10 per Watt just a few years ago to as low as $3.50 per Watt for utility-scale systems. But electricity isn't sold in Watts, but in kilowatt-hours (kWh). So, solar installed at $3.50 per Watt in Minneapolis, MN, will produce electricity for about 23 cents per kWh. In sunny Los Angeles, the same solar PV array would produce power at 19 cents per kWh, because the more abundant and direct sunshine would make 20% more solar electricity over the same time period. In either place, such prices don't compare favorably to average residential retail electricity prices of 8 and 12 cents, respectively. In fact, none of the top 40 metropolitan areas in the country have average prices for electricity as high as 19 cents in 2011.

Nonetheless, solar has some advantages:

- Grid electricity prices are not fixed, but changing. Over the past decade, electricity prices have risen, on average across the United States, 3 percent per year. Solar electricity prices do not rise once the panels are operating.

- Some utilities have time-of-use rates that charge more for electricity during peak times (hot, summer afternoons) that rise as high as 30 cents per kWh. Solar competes favorably against these rates.

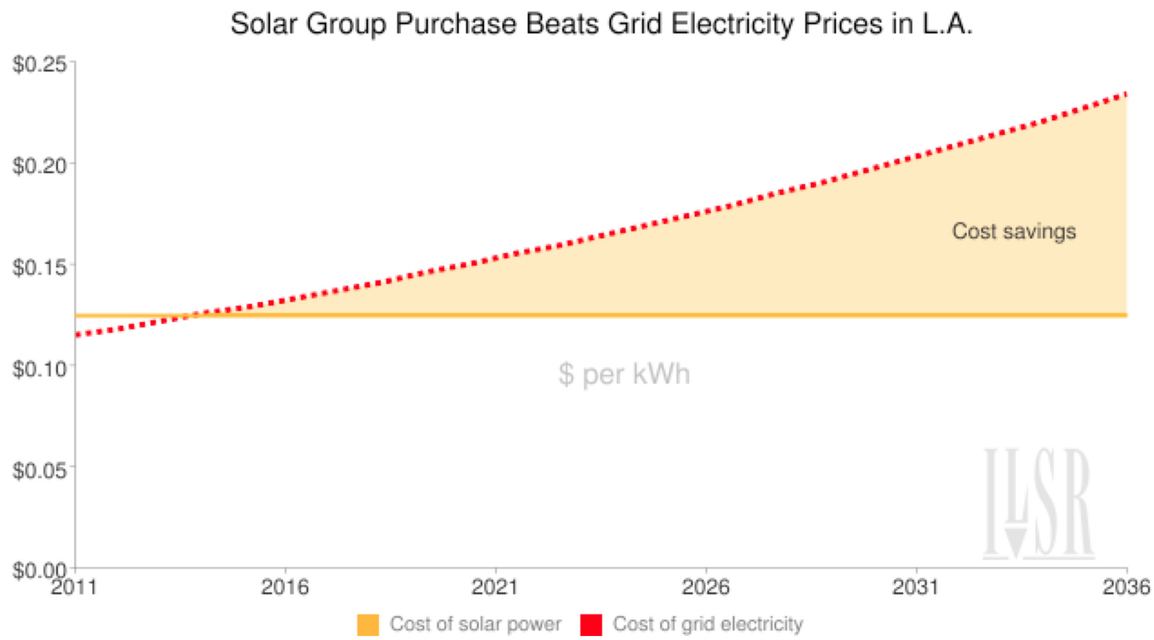
- There are federal, state and utility incentives for solar that reduce the cost. The 30% federal tax credit, for example, is in statute until the end of 2016.

While only 3 million Americans can beat grid prices with $3.50 per Watt solar and no incentives, 41 million Americans can beat grid prices using the 30% federal tax credit. And the market expansion enabled by tax incentives is driving down the cost to install solar (labor and materials).

Exhibits XVII reflects calculations using an assumption that solar prices will decline 7% per year and that grid electricity prices will rise 3%. For group purchases in a sunny climate the cost of solar PV is close to parity with the grid now. However, as Exhibit XVIII shows, residential solar without accelerated depreciation allowances will not break even with the grid until 2023. Both exhibits were prepared by John Farrell, Institute for Local Self Reliance in Minnesota.

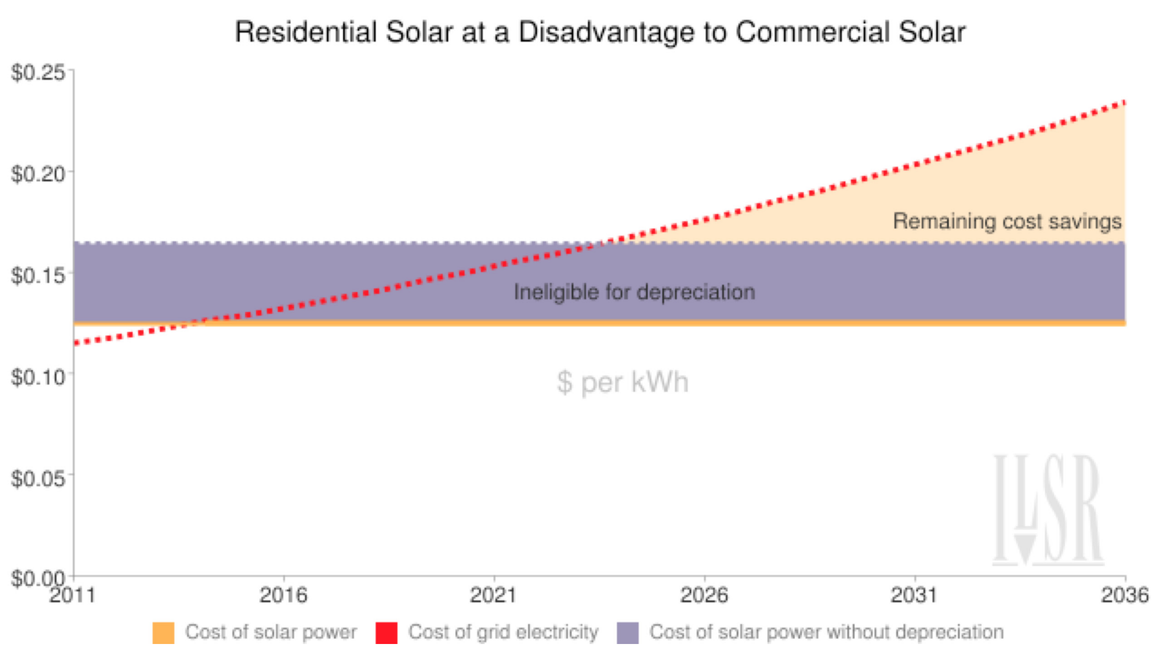
The end of 2011 saw cancellation of the U.S. 1603 treasury program, which will make PV financing more difficult in the future; and also explains the rush for record-setting

Exhibit XVII: Residential Group Purchase vs. Grid Solar



Source: Institute for Local Self Reliance Group Purchase Gets Residential Solar to Grid Parity in Los Angeles 2011

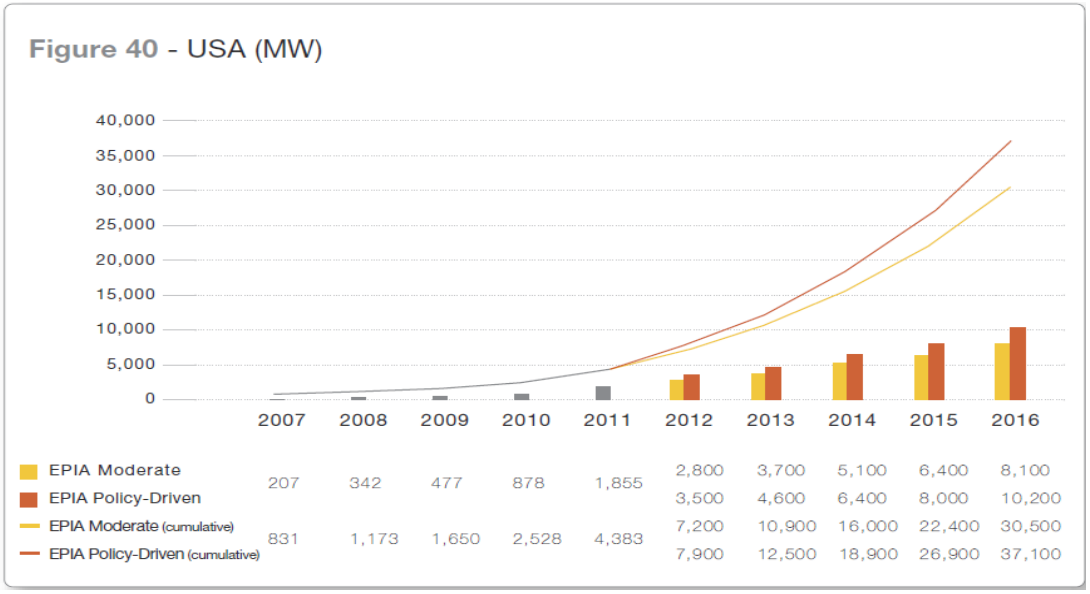
Exhibit XVIII: Residential Solar vs. Commercial Solar in L.A.



Source: Institute for Local Self Reliance Group Purchase Gets Residential Solar to Grid Parity in Los Angeles 2011

installations during 2011. Residential accounted for 15% of new capacity, which was interestingly dominated by third-party ownership and not customer-owned systems. Commercial installations accounted for 45%, and utility-scale installations made up 40% of new installed capacity during 2011. Power purchasing agreements (PPA) are the main driver behind this growth, with 9 GW of utility projects holding PPAs and scheduled for completion

Exhibit XIX: U.S. Installed PV Capacity Forecast (MW), 2007-2016



Source: *EPIA Global Market Outlook for Photovoltaics Until 2016 (p. 55)*

within the next 5 years. Exhibit XIX shows projections by the European Photovoltaic Industry Association (EPIA) for U.S. installed capacity through 2016 for both moderate and policy driven scenarios.

OUTLOOK FOR CONCENTRATED SOLAR (CSP)

With significant government assistance, a solar thermal power (CSP) technology boom seems to be coming in the United States. Regulators have issued permits for about a dozen power plant projects and construction is underway for a few. However, concentrating photovoltaic (CPV) technology is also attracting interest because of a dramatic drop in the cost of PV panels. CSP technology developers are responding by improving efficiencies of their equipment to turn sunlight into electricity and adding storage to make a CSP project operate more like a fossil-fuel power plant.

The CSP market so far has a bright future. Over 20 GW of power projects are under development worldwide, and the United States leads with about 8.67 GW, according to GTM Research. Spain ranks second with 4.46 GW, followed by China with 2.5 GW.

About 1.17 gigawatts of CSP power plants are online. Spain is home to 582 megawatts, followed by the United States with 507 megawatts. Iran is third with 62 megawatts according to GTM Research.

CSP developers share similar profiles: they are staffed with experts in power plant engineering, sometimes specifically in CSP plant designs. They also are able to raise the capital to finance research and development and power plant construction. Some of them already have built projects.

Most of the U.S. CSP projects are in the southwestern region of the U.S., which offers a combination of sunny climate, state mandates for renewable energy use, and public land that is available for energy development leases.

Projects going forward are all more than 100 megawatts in order to reach an economy of scale that keeps the construction and operating costs down. Solar Trust of America is working on the 1,000-megawatt Blythe Solar Project in California, but that project is divided into four power plants of 250 megawatts each.

Power plant designs that use parabolic trough reflectors and power-tower receivers are most common. The parabolic trough design features rows of connected reflectors that focus the sunlight onto tubes that run along the length of the reflectors. These tubes contain synthetic oil that flows to a heat exchanger to heat water and produce high-pressure steam. The steam then powers a turbine, which in turn runs a generator to produce electricity.

Another CSP technology uses a central tower instead of tubes as the receiver. A field of reflectors beams the light to the top of the tower, where a tank of water or molten salt sits. The heated fluid then goes through the similar steps for steam generation and electricity production.

Stirling engines make up the third common CSP technology and, unlike parabolic trough and power tower setups, each Stirling engine embodies both the thermal and electric generation mechanisms and uses gas rather than fluid to transfer the sun's heat. Main components of a Stirling engine include a giant round dish of reflectors that concentrate the sunlight to heat up hydrogen gas or helium inside an engine. The heated gas expands and creates pressure that is then used to run the piston driving the generator to produce electricity.

Storage is a big selling point for CSP; particularly since they are having a harder time competing with PV technologies that have become much cheaper in the last two years. Storing thermal energy for use after the sun goes down means a CSP plant is more flexible in adjusting its power output to meet a utility's demand. CSP power plants with storage already are running in Spain. Although including storage means adding costs, the greater ability to provide power on demand makes a CSP plant more valuable than one without storage.

OUTLOOK FOR GEOTHERMAL

HIGH GRADE HYDROTHERMAL SYSTEMS

Geothermal energy has provided commercial base-load electricity around the world for more than a century. However, it is often ignored in national projections of evolving U.S. energy supply. This could be a result of the widespread perception that the total geothermal resource is often associated with identified high-grade, hydrothermal systems that are too few and too limited in their distribution in the United States to make a long-term, major impact at a national level.

The perception that geothermal energy is only commercially useful where high grade hydrothermal systems exist tends to undervalue the long-term potential of geothermal energy by missing an opportunity to develop other technologies. Direct-use geothermal energy is widely used internationally, including in Iceland, China and Japan. Direct use of geothermal energy for homes is also used in Klamath Falls, Oregon. In Japan, geothermal power developers are competing with spa, hotel, and bath projects to access the direct-use energy resources. Direct use, low gradient heat capture, and sustainable heat mining from large volumes of accessible hot rock anywhere in the United States can significantly expand the use of geothermal as a renewable energy source. In fact, many attributes of geothermal energy, namely its widespread distribution, base-load use without storage, small footprint, and low emissions, are desirable for reaching a renewable energy future for the United States.

There is general consensus that expanding indigenous and renewable resources is a sound approach that will increase energy security. Geothermal energy provides a long-lasting option with attributes that would complement other important contributions from renewable fuels.

2008 was a watershed year for the geothermal industry. The U.S. Department of Energy (DOE) revived its Geothermal Technologies Program (GTP) with new funding that made possible substantial new investments in geothermal research, development and technology demonstration. The U.S. Bureau of Land Management (BLM) also significantly increased the amount of Federal land available for geothermal exploration and development and worked to streamline the complex permitting and leasing process.

Historically, geothermal energy at commercial scale in the U.S. has been limited to California, Nevada, Oregon and New Mexico where heat and water combine near the earth's surface to provide steam. However, there are three types of geothermal power plants, each one differing because of the composition of the geothermal resource and the temperature level of the resource: steam only, steam in combination with water and water only. High temperature reservoirs consisting of steam only can be used directly to drive steam turbines in dry steam power plants. High temperature geothermal resources consisting of both water and steam are first allowed to "flash" so that the mixture is converted to steam: the steam is then used to drive a turbine. In the third type of plant (binary plants), geothermal resources are fed to a heat exchanger to produce steam indirectly. In some areas geothermal steam is laden with caustic minerals. Binary systems are used in these areas to capture the heat in useable form.

Commercial scale geothermal development has been limited to areas where active volcanic activity persists, and areas where tectonic plate activity results in active faults. Low-temperature geothermal direct use applications typically include spas, district space heating, aquaculture, agricultural drying, and snow melting. Though these applications remain only a small portion of total geothermal resource use in the United States, it is still noteworthy that their installed base has doubled in the past 15 years.

As indicated above, the search for geothermal power is no longer limited to volcanism and fault areas. Two promising areas for geothermal development include Enhanced Geothermal Systems (EGS), and Ground Heat Source Pump (GHSP) technologies. Geothermal co-production with oil and gas is another prospect and likely possibility for the near future. These developments, along with the enormous potential of enhanced geothermal systems (EGS) projects, could transform geothermal energy in the United States from a western state-focused energy source into a ubiquitous source of energy.

ENHANCED GEOTHERMAL SYSTEMS

Enhanced Geothermal Systems entails drilling thousands of feet underground into hot, dry rock and hydraulically fracturing the formations to engineer fluid reservoirs into which millions of gallons of water can be pumped. This creates steam that powers turbines. 60% of all geothermal program funds in the U.S. Department of Energy are earmarked for EGS in 2012.

A 2006 MIT study estimated EGS could provide about 100,000 MW of electricity capacity, about 5% of the U.S. power supply, over the next 50 years. The National Renewable Energy Laboratory predicts that EGS could provide up to 16,000 GW of capacity in the U.S., but cautions that available water will be a limiting factor.

One of the largest "hydrolic-fracking" projects is proposed for the Newberry Caldera near Bend, Oregon. DOE recently awarded a $21 million contract to develop an EGS demonstration project there.

The EGS technology is somewhat controversial because it has been shown to cause seismicity … in some cases magnitudes of 3.4. In addition, the importation of scarce water resources for hydrolic-fracking takes water away from other needs. Some believe that the technology has a possibility of polluting local water supply. Industry representatives tend to be positive and argue that EGS has the potential to bridge the divide between renewable energy and fossil fuels by employing the same hydraulic fracturing technology that has been used in extracting oil and gas from shale formations.

GROUND-SOURCE HEAT PUMPS (GSHP)

While geothermal technology itself is not new, only in the past few years has the industry seen explosive growth with smaller systems using closed-loop well systems. The GSHP heating process involves extracting heat from the ground, which is directed into a living space for heating much like air source heat pumps. These devices can also be used for cooling, in which case heat extracted from the living space is injected back into the ground. These heating and cooling modes use electricity to run the compressor and ground loop pump. Since the device itself is not generating heat (instead it is simply moving heat already available) it is able to achieve very high coefficients of performance; one unit of electricity can move five or more units of heat. Consequently, heating and cooling bills are reduced dramatically in both residential and commercial settings.

Ground source heat pumps are one of the most advanced technologies available for space heating, hot water and cooling according to Cementation Skanska. Heat pumps supply more energy than they consume by using a refrigeration cycle to absorb heat from the environment and raise it to a suitable level for heating buildings or providing hot water. The process can operate in a reverse cycle to provide cooling for buildings as well. Even with the electrical demands of the pump and compressor heat pumps can provide a 50% reduction in CO_2 emissions compared to traditional technologies.

As sustainability gains importance, and the cost of home heating and cooling rises, the ability to use the earth as a heat source and sink has become an attractive proposition to consumers. The benefit of an established industry achieving popularity is that the technology has been refined to a high degree of safety and efficiency, and is well placed to respond to the sudden consumer demand. Geothermal heat pumps have been tried and tested and have proven their ability to reduce heating bills dramatically while maintaining a long product life and little environmental impact.

A recent report, "Geothermal Heat Pumps and Direct Use" by Pike Research, cited unfinanced capital cost and lack of consumer awareness as the primary obstacles to increased adoption of geothermal heat pumps. In particular, drilling or trenching for the ground loops are a considerable cost of the system. Nonetheless, the Pike study finds that direct use of geothermal energy using heat pumps is on the rise.

The potential for geothermal heat pumps is high, according to industry analyst Mackinnon Lawrence, but installations currently represent just one percent of the heating and cooling market overall. Growing electricity demand, rising energy prices and increasing regulation around emissions and efficiency are all expected to push demand higher. In the US, analysts at Global Information expect geothermal heat pump shipments to double in volume to 326,000 units annually by 2017, while Pike Research anticipates that geothermal heat pumps will represent a significant majority of the global market for geothermal direct use applications, accounting for some 84 percent of total capacity.

OUTLOOK FOR HYDRO

Hydropower is considered to be a clean, renewable source of energy, emitting a very low level of greenhouse gases when compared to fossil fuels. It has a low operating cost once installed and can be highly automated. An additional benefit is that the power is generally available on demand since the flow of water can be controlled very accurately and quickly. Hydroelectric facilities also provide grid stability because of the massive inertia of the turbines and water columns.

Water has long been used as a source of energy, beginning with the Greeks use of water wheels over 2,000 years ago. For over a century, hydropower has been used to generate electricity from falling water. Hydroelectric power stems from the process of using water's energy as it flows from higher to lower elevation, rotating hydraulic turbines to create electricity. Tidal power, although not widely used, can also generate hydroelectricity by utilizing the same process.

While the use of water to produce electricity is an attractive alternative compared with fossil fuels, the technology is not free of problems. Dams can block fish passage to spawning grounds or to the ocean. The diversion of water can impact stream flow, or even cause a river channel to dry out, degrading both aquatic and streamside habitats. Hydroelectric plants can also have an impact on water quality by lowering the amount of dissolved oxygen in the water, or by raising the amount of dissolved nitrogen. In the reservoir, sediments and nutrients can be trapped and the lack of water flow can create a situation for undesirable growth and the spread of algae and aquatic weeds.

The hydropower resource assessment by the Department of Energy's Hydropower Program has identified 5,677 sites in the United States with acceptable undeveloped hydropower potential. These sites have a modeled undeveloped capacity of about 30,000 MW. This represents about 40 percent of the existing conventional hydropower. A study

Exhibit XX: Navigant Study Findings for U.S. Undeveloped Hydro Capacity

Key Findings

- The U.S. has the second largest installed capacity of hydropower in the world at ~100 GW (including pumped storage).
- Hydropower accounts for approximately 7% of overall domestic electricity production in the U.S. and ranks 10th worldwide in electricity production.
- Over 400+ GW of untapped hydropower resource potential (inland and ocean) exists within the U.S.
- The U.S. hydropower industry currently accounts for approximately 200,000 – 300,000* jobs.
- Developing these untapped hydropower resources could contribute significantly to the emerging green jobs market in the U.S.
- The U.S. hydropower industry could install 23,000 MW – 60,000 MW of new capacity by 2025 depending upon the national RES adopted, representing only 6% - 15% of the total untapped hydropower resource potential in the U.S.
- Total jobs (direct + indirect) required to meet these targets would be in the range of 230,000 – 700,000 jobs
- These total jobs estimates do not include induced jobs (e.g., service sector jobs such as retail, restaurants created by added dollars flowing into the market) that represent an additional upside potential from the growth of the hydropower industry.

* Assumes an average of 2-3 FTE/MW needed to operate, maintain and license compliance of existing 100,000 MW fleet

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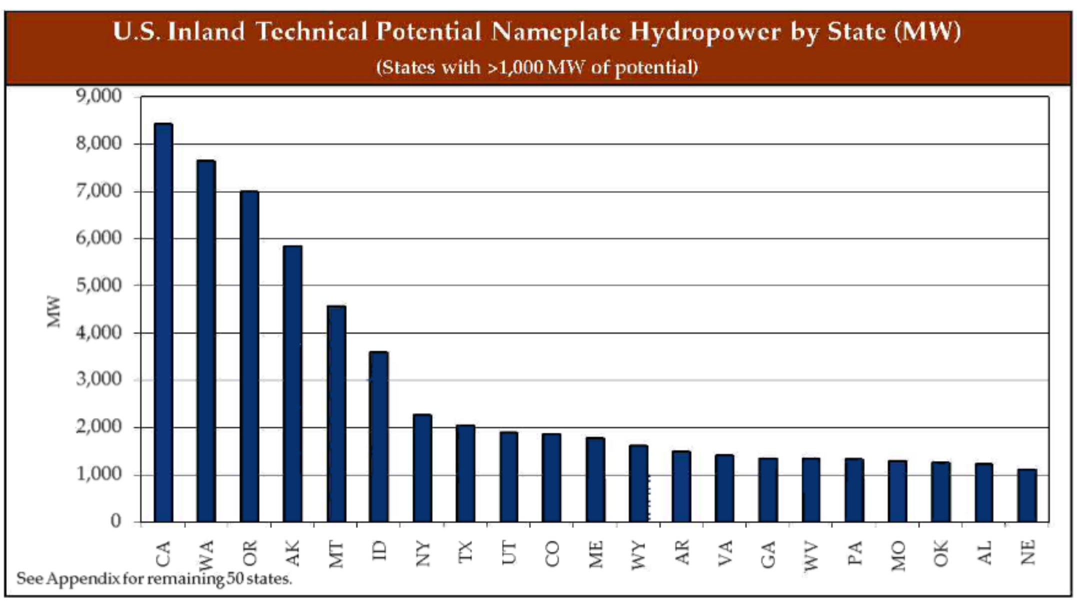
by Navigant Consultants in 2009 concludes that Western States, including Oregon, have in excess of 50% of the undeveloped capacity. Exhibit XX presents the findings from the Navigant study.

The "Technical Potential" (i.e. free of legal or regulatory restraints, but not considering cost) for expansion of hydrogeneration is also greatest in the West as shown on Exhibit XXI.

Exhibit XXI: U.S. Hydro Potential Assessment by State



Source: INL *Feasibility Assessment of the Water Energy Resources of the US for New Low Power and Small Hydro Classes of Hydroelectric Plants* 2006 and *Estimation of Economic Parameters of U.S. Hydropower Resources* 2003. Excludes Capacity Additions and Efficiency Upgrades

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In North America, many of the larger sites for hydropower production have already been developed. The 6800-MW Grand Coulee Dam on the Columbia River is the largest hydroelectric facility in North America. Hydro developers are looking at non-powered dams to add generation as well as new technologies to increase the generating capacity of existing hydro plants.

There is also a significant potential for developing "in stream" hydro power using small scale distributive generation equipment. These devices do not require reservoir or run of river technologies and can be used where there are constant flowing streams and canals. This type of equipment is also being used to generate power in regional water treatment facilities and could be adapted to any water diversion facility as a co-generation technology.

The number of proposals to build new hydropower capacity in the US (United States) is up about 30 % from two years ago according to the Federal Energy Regulatory Commission's Office of Hydropower Licensing; most are at existing federal dams. In addition, there are many small projects that are exempt from licensing. US Energy Secretary Steven Chu has been quoted as saying that:

> *"There's no one solution to the energy crisis, but hydropower is clearly part of the solution and represents a major opportunity to create more clean energy jobs. The US has about 100 000 MW of hydropower capacity."*

A Navigant study measured the impact of additional hydro capacity on job growth and concluded that hydro expansion could generate as many as 725,000 new jobs by 2025. A factor of 2.5 jobs/100,000 MW of operating capacity is used to measure job potential.

OUTLOOK FOR ENERGY STORAGE

Electricity storage is thought to be a prerequisite for high levels of integration of renewable energy. Storage "absorbs" excess generation and delivers it when needed. To "store" excess generation it needs to be converted into mechanical energy (pumped hydropower, compressed air, flywheel), chemical energy (battery, hydrogen), or thermal energy (heat). Stored energy is then used to generate electricity when needed; incurring some losses each time the conversion is made. De facto storage can also be implemented via the smart grid, effectively shifting the load from mainly heating or cooling procedures to boost demand.

Currently, the best large-scale established form of storage is pumped hydro, and it appears unlikely that any other measure will be applied at scale in the near-to-medium future according to a study by a German energy agency.

In the near term, integrated energy policy and planning, rather than storage, will probably be the primary tools, rather than any specific technological solution. A major consideration will be how broadly intermittent renewable energy is used. Improving the grid will be necessary, along with big advances in demand-side management. More efficient and flexible non-renewable solutions have an important part to play, especially natural gas.

Three highly effective technologies for producing quick bursts of high power without much energy storage capacity are flywheels, Superconducting Magnetic Energy Storage (SMES), and ultra-capacitors which are generally too expensive for grid based applications. Among established technologies, Lithium-Ion (Li-ion), Nickel-Metal Hydride (NiMH) and Lead-Acid (PbA) batteries are used in remote grid stability applications where few other options exist.

Demand Response is a suite of smart grid technologies which allows for economic storage. A utility can ask energy users to reduce their energy usage when the utility's generation capacity has trouble meeting current demand. Like transmission, but unlike batteries, flow batteries or thermal storage, the electricity storage provided by demand response technologies is virtual: when a customer temporarily turns up the thermostat in response to a signal from the utility, the use of energy to cool the building is delayed until after the event. This avoids the cost of physical electricity storage, and makes Demand Response the most economical way to meet short-term spikes in energy demand (such as on hot summer days when air conditioning demand is high) and short term supply shortfall.

Another application for which advanced energy storage is showing significant benefits is as spinning reserve. In this application, storage assets can efficiently increase the reliability and improve the responsiveness of the electric power grid. Advanced energy storage can also release traditional generation—otherwise encumbered by an obligation to provide some amount of spinning reserve—to sell more valuable energy output.

To help ensure consistent availability and reliability of electricity, utilities keep generation capacity on reserve that can be accessed quickly if there is a disruption to the power supply. For example, if a base load generator or a major transmission line delivering imported power goes down, the utility and/or grid operator will access its reserve capacity to compensate.

Typically, this reserve capacity is created by generators that are already synchronized with the power grid but are not operating at full capacity. If backup power is needed, utilities will increase the output of these generators, usually by increasing the steam setpoints of the turbine (hence "spinning reserve"). Typically, a 10-minute response time is a minimum requirement to qualify as spinning, or "operating" reserves.

However, leveraging traditional generation assets for creating reserved capacity creates a number of inefficiencies. Generators operating below their rated value mean that the utility is not maximizing power output that could be used for base load supply. Also, it requires the use of additional fuel to ramp these generators up in the event that their reserved generation potential is needed, which increases emissions while reducing the net efficiency of the power system.

Alternatively, energy storage can be implemented onto the power grid as spinning reserve assets. These systems provide a cleaner, more efficient mechanism for utilities to compensate for disruptions to the power supply while enabling them to leverage the full capabilities of their generation assets to deliver base-load power. The most advanced storage solutions are also equipped with sophisticated monitoring and control systems, enabling them to detect disruptions in the power supply and communicate quickly with the grid to near-instantaneously discharge and provide the reserve capacity when it is needed.

Research has shown that there is a direct correlation between speed of response and the amount of capacity needed to mitigate a negative grid operating condition. Essentially, faster response requires less capacity for equally beneficial impact.

Inverters that connect large-scale battery systems to electrical grids can also provide reactive power as an ancillary. Reactive power is used to support bus voltages. Several independent system operators (ISOs) have developed ancillary markets for reactive power, thereby creating an additional revenue stream for facilities that can generate reactive power, including battery banks, solar PV installations and traditional synchronous generators. One utility taking advantage of these benefits is Southern California Edison, which is deploying energy storage systems based on lithium-ion technology at the Tehachapi wind farm.

An important factor to take into account is whether advanced energy storage can provide an economically viable solution. While regulation services using short-duration storage produce measurable return on investment, increasing the duration of storage increases the cost.

When combined with smart grid technologies, energy storage systems are helping to transform intermittent renewable energy from a variable energy source to a strategic grid resource. Development and demonstrations are underway to understand how energy storage systems can work with intermittent energy systems to firm output, shift customer demand, and help maintain distribution reliability and power quality. Along with technology development, utilities and their regulators will need to explore new approaches to electricity pricing that reflect the actual costs and benefits of renewable energy storage systems.

Current efforts to assign a dollar value to the benefits of storage may create two-way markets that are sub-hourly. The smart grid will make this possible at the residential level, necessitating a change in the way the grid operates.

When the markets for energy storage and ancillary services are set and values assigned, storage development technology will become a major growth sector. Storage is going to have a profound effect on transmission development as well. In the end the grid will be more reliable, cleaner, and more secure.

Lux Research recently presented a study on the current state of the grid-based energy storage market and its likely development over the next five years. By 2015, Lux forecasts an annual market for grid-based storage in the $1.5 billion range. Lux took pains to emphasize several key points:

- There is no silver bullet solution for the grid and several technology classes will be important;
- There is no unified mass market for grid-based energy storage technologies;
- The market for grid-based energy storage is highly fragmented and extremely price sensitive;
- The two largest market segments for grid-based storage are behind the meter installations for commercial and industrial facilities and in front of the meter facilities for renewable power generators;
- Most buyers of grid-based energy storage will require several years of reliability data before making a major capital commitment to any energy storage technology; and
- End-users of energy storage systems will try to aggregate as many value streams as possible to maximize the total economic benefit of their energy storage investments.

For energy storage investors, the important question is who will benefit. There are a lot more questions than answers at this point. There is a fairly short list of public companies that are actively involved in developing large scale energy storage systems for the grid connected market including:

6. Japan's NGK Insulators, has built and installed the overwhelming bulk of the high-temperature sodium-sulfur battery systems in the world.

7. General Electric, which has built a new manufacturing facility for a high-temperature molten salt device known as the Zebra battery and is preparing to launch a series of products for large commercial and industrial users.

8. A123 Systems, has a strong working relationship with AES Corporation and is making progress in the renewable power generation market with its high-power lithium-ion battery systems.

9. Altair Nanotechnologies, has demonstrated a high-power lithium-ion battery system for frequency regulation.

10. Enersys, manufactures advanced lead-acid batteries for commercial and industrial power quality, load leveling and uninterruptable power supply systems.

11. Axion Power International, has joined with Viridity Energy to demonstrate a behind the meter energy storage system for commercial and industrial facilities that integrates utility revenue and demand response savings with conventional power quality, load leveling and uninterruptable power benefits to users.

12. Active Power, is a world-leader in flywheel based power quality and reliability systems for data centers and other critical infrastructure facilities that require absolute reliability.

13. ZBB Energy, recently completed a three-year validation test of its flow-battery system in cooperation with Australia's Commonwealth Industrial and Scientific Research Organization.

The Lux study concludes that regulated utilities will be the last to invest heavily in grid-based storage due to aversion and need to justify capital spending to regulators.

Lux notes that, on the power producer's end of the grid, there are significant opportunities for storage systems to smooth and stabilize power output from wind and solar while optimizing revenue streams to the owners of the facilities. At the power user's end of the grid, the most readily quantifiable values will be derived by commercial and industrial customers who can aggregate the internal benefits of power quality and reliability with external monetary benefits from demand response programs.

Energy storage can accelerate the adoption of renewable energy by compensating for variable wind and solar. Energy storage makes these sources more predictable, allowing them to be more seamlessly integrated with the existing power grid. The determining factor for its use will be whether it can be cost effective if deployed at bulk commercial levels.

The business case for deploying advanced energy storage for existing applications is compelling. For example, frequency regulation has historically been provided by traditional generation assets, including gas turbines or coal generation plants, often as a requirement for participation in energy markets. However, this has been an imperfect approach to regulation because traditional generators are slow to respond, often taking as much as 10 minutes to respond to a regulation control signal.

Bulk grid-level generation and demand imbalance is measured by the area control error (ACE), typically on a second-by-second basis, and assets deployed for regulation are instructed to regulate up or down in response to changes in the ACE. Traditional slow moving assets are an imperfect mechanism for minimizing and managing ACE. Traditional assets performing regulation also exhibit increased wear and tear as well as reduced efficiency, which translates directly into higher operating costs and increased emissions.

Advanced energy storage systems are ideally suited for providing frequency regulation services. Since the ACE represents the short-term fluctuations in supply and demand, it is almost energy neutral. Energy markets are typically managed on an hour-by-hour basis, but a storage asset with robust energy management capabilities can successfully provide this hourly market-based service with as little as 15 minutes of energy stored.

Advanced storage assets are also capable of responding significantly faster than traditional generation assets, without the wear and tear or efficiency loss associated with continuously ramping up or down. In fact, with response times measured in milliseconds, advanced storage can provide significantly more value since the correction to the ACE is virtually instantaneous. In turn, traditional generator assets can be utilized at their optimal efficiency, improving asset utilization and reducing emissions.

The return on investment based on revenue generated from providing regulation services is expected to occur in as few as three years given today's market conditions. And when ancillary benefits such as improved asset utilization and emissions are also considered, the payback time is accelerated. For these reasons some argue that advanced energy storage technology is now an economically viable, next-generation substitute for traditional, fossil-fuel generators for frequency regulation.

OUTLOOK FOR BIOMASS

Biomass (plant material and animal waste) is the oldest source of renewable energy, used since our ancestors learned the secret of fire. At the turn of the 21st century biomass supplied far more renewable electricity than wind and solar power combined. If developed properly, biomass can continue to supply increasing amounts of renewable energy. In fact, in numerous analyses of how the U.S. can transition to a clean energy future, sustainable biomass is a critical renewable resource. States that are looking for ways to sustainably utilize waste from their forest product industries would be well advised to include biomass in energy plans.

As long as biomass is produced sustainably—meeting current needs without diminishing resources or the land's capacity to re-grow biomass and recapture carbon—the resource will last indefinitely and provide sources of low-carbon energy. Beneficial biomass includes:

- Energy crops that don't compete with food crops for land
- Portions of crop residues such as wheat straw or corn stover
- Sustainably-harvested wood and forest residues and clean municipal and industrial wastes

Beneficial biomass sources generally maintain or even increase the stocks of carbon stored in soil or plants. Beneficial biomass also displaces carbon emissions from fossil fuels, such as coal, oil or natural gas, the burning of which adds new and additional carbon to the atmosphere and causes global warming.

Energy crops can be grown on farms in potentially large quantities and in ways that don't displace or otherwise reduce food production, such as by growing them on marginal lands or pastures or as double crops that fit into rotations with food crops. Trees and grasses that are native to a region often require fewer synthetic inputs and pose less risk of disruption to agro-ecosystems.

Thin-stemmed perennial grasses used to blanket prairies in the United States before the settlers replaced them with annual food crops. Switchgrass, big bluestem, and other native varieties grow quickly in many parts of the country, and can be harvested for up to 10 years before replanting. Switchgrass is a hardy species—resistant to floods, droughts, nutrient poor soils, and pests—and does not require much fertilizer to produce consistent high yields. Today, switchgrass is primarily cultivated either as feed for livestock or, due to its deep root structure, as ground cover to prevent soil erosion. However, this prairie grass also has promise for biomass energy and biofuel production

Manure from livestock and poultry contains valuable nutrients and, with appropriate management, should be an integral part of soil fertility. Where appropriate, some manure can be converted to renewable energy through anaerobic digesters, combustion or gasification. The anaerobic digesters produce biogass which can either directly displace natural gas or propane, or be burned to generate biomass energy. For instance, dairy farms that convert cow manure with methane digesters to produce biogas can use the biogas on-site as a replacement for the farm's own natural gas or propane use. The biogas can also be cleaned up, pressurized, and injected into nearby natural gas pipelines. A third use would be to burn the biogas to run steam turbines.

Poultry litter, like manure from livestock, can be digested and used to produce biogas, and can be used for combustion to produce renewable electricity, either directly or through gasification.

Timber states can use bark, sawdust and other byproducts of milling timber and making paper. Currently these are the largest source of biomass-based heat and renewable electricity; commonly, lumber, pulp, and paper mills use them for both heat and power. In addition, shavings produced during the manufacture of wood products and organic sludge (or "liquor") from pulp and paper mills are biomass resources. Some of these "mill residues" could be available for additional generation of renewable electricity.

Beyond these conventional types of woody biomass, there are additional sources of woody biomass that could be used for renewable energy. With the proper policy these additional sources could be sustainably harvested and make a significant contribution to renewable energy generation. The ZeaChem demonstration project in Boardman Oregon is a good example of a technology that uses sustainable poplar harvest to generate biofuel from biomass.

Many forest managers see new biomass markets providing opportunities to improve forest stands. Where traditional paper and timber markets require trees to meet diameter and quality specifications, biomass markets will pay for otherwise unmarketable materials, including dead, damaged and small-diameter trees. Income from selling biomass can pay for or partially offset the cost of forest management treatments needed to remove invasive species, release valuable understory trees, or reduce the threat of fires. Removing undesired, early-succession or understory species can play an important role in restoring native forest types and improving habitat for threatened or endangered species.

Thinning plantations of smaller-diameter trees before final harvest can also provide a source of biomass. In addition, thinning naturally regenerating stands of smaller-diameter trees can also improve the health and growth of the remaining trees. With the decline in paper mills, some areas of the country no longer have markets for smaller-diameter trees. Under the right conditions, biomass markets could become a sustainable market for smaller-diameter trees that could help improve forest health and reduce carbon emissions.

Under the right circumstances, there may be a role for short-rotation tree plantations dedicated to energy production. Such plantations could either be re-planted or "coppiced." (Coppicing is the practice of cutting certain species close to the ground and letting them re-grow.) Coppicing allows trees to be harvested every three to eight years for 20 or 30 years before replanting.

When considering biomass as a fuel, energy density is a factor. Green woody biomass contains as much as 50% water by weight. This means that unprocessed biomass typically can't be cost-effectively shipped more than about 50-100 miles by truck before it is converted into fuel or energy.

It also means that biomass energy systems may be smaller scale and more distributed than their fossil fuel counterparts, because it is hard to sustainably gather and process more than a certain amount of in one place. This has the advantage that local, rural communities will be able to design energy systems that are self-sufficient, sustainable, and adapted to their own needs.

However, there are ways to increase the energy density of biomass and to decrease its shipping costs. Drying, grinding and pressing biomass into "pellets" increases its energy density. Compared to raw logs or wood chips, biomass pellets can also be more efficiently handled with augers and conveyers used in power plants. In addition, shipping biomass by water greatly reduces transportation costs compared to hauling it by truck.

Thus, hauling pelletized biomass by water has made it economical to transport biomass much greater distances—even thousands of miles, across the Atlantic and Pacific, to markets in Japan and Europe. In the last few years, the international trade in pelletized biomass has been growing rapidly, largely serving European utilities that need to meet renewable energy requirements and carbon-reduction mandates. Several large pellet manufacturers are locating in the Southern US, where there are prodigious forest plantation resources

Currently, over 50 billion kilowatt-hours of electricity from biomass, providing nearly 1.5 percent of total electric sales, are produced in the U.S. according to the U.S. Department of Energy. Biomass was the largest source of renewable electricity in the U.S. until 2009, when it was overtaken by wind energy. Biomass energy accounted for more than 35 percent of total net renewable generation in 2009, excluding conventional hydroelectric generation. The contribution for heat is also substantial. Better conversion technology and more attention to energy crops could produce much more. Exhibit XXII was prepared by DOE according to 2005 resource assessments.

Exhibit XXII: Electricity Generation Specifications for Various Biofuel Resources

Renewable Resource	*Electric Generation Capacity Potential (in gigawatts)*	*Electric Generation (in gigawatts)*	*Renewable Electricity Generation as % of 2007 Electricity Use*
Energy Crops	83	584	14%
Agricultural Residues	114	801	19%
Forest Residues	33	231	6%
Urban Residues	15	104	3%
Landfill Gas	2.6	19	0.4%

Source: DOE, 2005

Even with potential for the growth of biomass energy, electricity suppliers will probably move forward slowly, and wait to grow their biomass supply chain until after the EPA regulations are announced.

"We don´t see a sudden rush from utilities to expand their biomass generation sources," says Chris Namovicz, a biomass consultant at the U.S. Energy Information Administration. "Rather, I think the move will be gradual as it takes time to bring biomass plants online and utilities will have to establish a reliable biomass supply system."

OUTLOOK FOR BIOFUELS

Biofuels have been around since before the industrial age. At the start of the 20th century, Henry Ford planned to fuel his Model Ts with ethanol, and early diesel engines were shown to run on peanut oil.

Huge petroleum deposits kept gasoline and diesel cheap for the past century, making biofuels uneconomic. However, with the recent rise in oil prices since the 1970's, along with growing concern about global warming caused by carbon dioxide emissions, interest in biofuels for transportation has renewed.

Gasoline and diesel are actually ancient biofuels. But they are known as fossil fuels because they are made from decomposed plants and animals that have been buried in the ground for millions of years. Biofuels are similar, except that they're made from plants grown today.

There are various ways of making biofuels from plants, but they generally use chemical reactions, fermentation, and heat to break down the starches, sugars, and other molecules in plants. The leftover products are then refined to produce a fuel that can be used for transportation and industry.

Since the use of fossil fuels for transportation is a major source of atmospheric carbon dioxide and greenhouse gases that cause global warming, biofuel from plants for transportation is viewed as a path to eliminate the greenhouse gas problem. Unfortunately, it's not so simple. Not all biofuels are created equal. Many, like ethanol from corn, may use as much fossil fuel for production as the increment of biofuel produced.

In addition to cost, there are various social, economic, environmental and technical issues with biofuel production and use, which have been discussed in the popular media and scientific journals. These include: the effect of moderating oil prices, the food vs. fuel debate, poverty reduction, lowering carbon emissions, sustainability, deforestation, and loss of biodiviersity. The International Resources Panel, in its report "Assessing Biofuels", outlined the wider and interrelated factors that need to be considered when deciding on the relative merits of pursuing one biofuel over another. It concluded that not all biofuels perform equally in terms of their impact on climate, energy security and ecosystems, and suggested that environmental and social impacts need to be assessed throughout the entire life-cycle.

These considerations have caused a second wave of biofuel experimentation with grasses and saplings, which contain more cellulose. Cellulose is the tough material that makes up plants' cell walls, and most of the weight of a plant is cellulose. If cellulose can be turned into biofuel, it could be more efficient than current biofuels, and emit less carbon dioxide. Although there are many current issues with biofuel production and use, the development of new biofuel crops and second generation biofuels attempts to circumvent these issues. Many scientists and researchers are working to develop biofuel crops that require less land and use fewer resources, such as water, than current biofuel crops do.

Second generation biofuels are biofuels produced from sustainable feedstock. Sustainability of a feedstock is defined among others by availability of the feedstock, impact on greenhouse gas emissions and impact on biodiversity and land use. Many second generation biofuels are under development such as Cellulosic ethanol, Algae fuel, biohydrogen diesel, mixed alcohols, and wood diesel.

Cellulosic ethanol production uses non-food crops or inedible waste products and does not divert food away from the animal or human food chain. Lignocellulose is the "woody" structural material of plants. This feedstock is abundant and diverse, and in some cases (like citrus peels or sawdust) it is in itself a significant disposal problem.

Producing ethanol from cellulose is a difficult technical problem to solve. Various processes are being explored to release the sugars from cellulose so that they can be fermented to make ethanol fuel. Later in this section we include a list of companies trying to bring a third generation of biofuels to industrial scale using different approaches.

The range of biofuel is impressive and includes, but is not limited to:

1. Methanol is currently produced from natural gas, a non-renewable fossil fuel. However, it can also be produced from biomass as biomethanol.

2. Butanol is the only liquid biofuel product. Butanol will produce more energy and allegedly can be burned "straight" in existing gasoline engines (without modification to the engine or car). It could be distributed via existing infrastructures.

3. Biodiesel is the most common biofuel in Europe produced from oils or fats using transesterification. It is a liquid similar in composition to fossil diesel. Biodiesel feedstocks include animal fats, vegetable oils, and algae. In the USA, more than 80% of commercial trucks and city buses run on diesel.

4. Green diesel, also known as renewable diesel, is a form of diesel fuel which is derived from renewable feedstock rather than the fossil feedstock used in most diesel fuels. Green diesel uses traditional fractional distillation to process the oils, not to be confused with biodiesel which is chemically quite different and processed using transesterification.

5. Biogas is methane that is produced by the process of anaerobic digestion of organic material. Landfill gas is a less clean form of biogas which is produced in landfills in through naturally occurring anaerobic digestion. If it escapes into the atmosphere it is a potential greenhouse gas. Farmers, especially dairy, livestock, and chicken farmers, can produce biogas from manure from their animals by using an anaerobic digester.

6. Syngas is a mixture of carbon monoxide, hydrogen, and other hydrocarbons. It is produced by partial combustion of biomass, that is, combustion with an amount of oxygen that is not sufficient to convert the biomass completely to carbon dioxide and water. Syngas may be burned directly in internal combustion engines, produce methanol, or a diesel substitute.

7. Solid biofuels. Examples include wood, sawdust, grass trimmings, domistic refuse, charcoal, agricultural waste, non-food energy crops, and dried manure. Concentrated solid biofuels include wood pellet, cube or puck.

The third wave of biofuel development includes syngas (see above). Jim Lane, writing in August, 2011 for "Biofuels Digest" identifies the following developments to watch as the third wave of biofuel development moves forward:

Coskata
Technology: *Gas fermentation*

In June, Coskata announced that it has issued a Letter of Intent with Fagen for engineering, procurement and construction services for the construction of its commercial cellulosic ethanol facility in Boligee, Alabama, that will be designed around the Coskata technology. Fagen and Harris Group will lead an EPC process that will include in its scope the project detailed design, procurement, construction and commissioning.

Coskata received a conditional commitment for a loan guarantee from the United States Department of Agriculture, and is working on the details that will be necessary to close the financing for the project. The facility will convert sustainably harvested wood biomass into ethanol, a high-octane renewable fuel, and is expected to bring approximately 300 construction jobs and 700 direct and indirect jobs to Greene County, Alabama.

Coskata has been on the warpath of late to remind the industry, and the broader stakeholders in a future beyond fossil fuels, about why ethanol fuels were developed in the first place, and why they should be considered a superior alternative to drop-in hydrocarbons when refining fuels from biomass.

At the end of June, Coskata CSO Rathin Datta presented at the Fuel Ethanol Workshop that ethanol should be considered "the primary renewable liquid fuel". Though too polite to say it, he leaves us to draw the obvious conclusion that all the companies making renewable gasoline can go home now.

Enerkem

Technology: *Catalytic conversion of gasified biomass*

Last week, Enerkem announced the closing of $30 million in additional financing through corporate equity ($15.3 million) and corporate debt ($15 million) transactions. As part of the equity financing round, The Westly Group, Fondaction CSN and Quince Associates, L.P. join existing investors Valero Energy Corp., Waste Management, Rho Ventures, Braemar Energy Ventures and Cycle Capital, who had each invested in the recently announced $60 million equity tranche.

In June, Enerkem, in partnership with the Government of Alberta and the City of Edmonton, opened The Advanced Energy Research Facility. This facility will consist of a network of top researchers from around the world aligned for the purpose or creating renewable fuels and chemicals through the conversion of waste.

Enerkem enables every city in the world to produce advanced fuels locally, efficiently and cost-effectively using their household garbage. The company manufactures, owns and operates community-based, compact advanced biorefineries. Enerkem's transformative technology converts residual materials, such as non-recyclable municipal solid waste, into clean transportation fuels and advanced chemicals. The multi-feedstock and multi-product process combines green gasification and catalytic synthesis. Enerkem's extensive gas conditioning produces a tailored synthetic gas that is converted into premium products using proven industrial catalysts at the proper temperatures and pressures.

Fulcrum BioEnergy

Technology: *Catalytic conversion of gasified biomass*

Fulcrum BioEnergy most recently announced that it has successfully demonstrated the ability to economically produce renewable ethanol from garbage at its TurningPoint Ethanol Demonstration Plant. The company's 10.5 Mgy Sierra BioFuels Plant, located approximately 20 miles east of Reno, will commence operations in 2011 and will convert 90,000 tons of municipal solid waste (MSW). The company expects to produce fuel for less than $1 a gallon, at a yield of 120 gallons per ton. In a two-step thermochemical process, organic materials recovered from MSW are gasified in a plasma enhanced gasifier – the syngas is then converted to ethanol.

Ineos BIO

Technology: *Gas fermentation*

In June, INEOS New Planet has signed a feedstock supply agreement with the Indian River County Board of Commission which includes plans to import 90,000 tons per year of yard clippings, tree trimmings and other vegetative waste from other counties in order to supply its $150 million plant in addition to the 55,000 tons per year of waste from local household collection.

INEOS Bio's biorefinery will have the capacity to produce 8 million gallons of ethanol and 6 megawatts (gross) of electricity per year—of which approximately two megawatts will be exported to the local community. This renewable electricity will be able to power approximately 1,400 homes. Located at a former citrus processing plant site in Vero Beach, Florida, the BioEnergy Center will provide 380 direct and indirect jobs (including 175 construction jobs) over the next two years and 50 full-time jobs in Indian River County. The project is expected to commence operation in 2012.

KiOR

Technology: *Catalytic pyrolysis*

In May, KiOR finalized a "conditional" offtake agreement for its biocrude-based with Catchlight Energy, the 50-50 joint venture between subsidiaries of Chevron and forest products major Weyerhaeuser, *making it the second deal of its kind following an earlier deal with Hunt Refining.*

Back in April, KBR announced it has been awarded an engineering, procurement and construction by KiOR build a first-of-its-kind biomass-to-renewable crude facility to be located in Columbus, Miss. The facility is designed to process approximately 500 tons per day of wood biomass and produce over 11 million gallons of fuel per year.

KBR will provide engineering and procurement services, as well as direct hire construction for the commercialization of KiOR's proprietary technology, which is designed to convert biomass into drop-in biofuels such as gasoline and diesel blendstocks. The facility is designed to produce renewable fuels from wood biomass. KBR is an engineering, construction and services company.

LanzaTech
Technology: *Gas fermentation*

LanzaTech is talking with Indian Oil and Jindal Steel on how to implement a commercial scale ethanol plant using LanzaTech's technology to process waste gases from a Jindal steel mill. The fuel ethanol produced by the plant would be blended into Indian Oil's gasoline pool. The announcement was made during the state visit to India by New Zealand Prime Minister John Key and Trade Minister Tim Groser. LanzaTech's vice-president, Prabhakar Nair was part of the 25 member delegation accompanying Key and Groser.

In March, LanzaTech, Baosteel Group Corporation, and the Chinese Academy of Sciences (CAS) began construction of a plant that will use LanzaTech's gas fermentation technology for the production of fuel ethanol from steel mill off-gases. Construction of the plant is expected to take six months and production will begin late in the third quarter of this year. The company's commercial plants will have a 50 million-gallon capacity.

In February, LanzaTech and Baosteel signed a joint venture agreement that will see the construction of a 100,000 gallon a year demo plant, with the intention of quickly scaling the model again for the first commercial plant in China.

Rentech
Technology: *Fisher-Tropsch process*

In Canada, Ontario has selected Rentech's Olympiad Project in the Township of White River for proposed supply of up to 1.1 million cubic metres/year of forest waste and unmerchantable wood fibre (1.3 million US tons) to produce renewable RenJet low-carbon jet fuel at the proposed 23 million-gallon Olympiad Project. The Rentech project will also produce 43 million litres (13 million gallons) annually of renewable naphtha, a chemical feedstock.

In addition, Rentech has recently submitted an application for funding to the federal government's NextGen Biofuels Fund, for up to 40 percent to a maximum of C$200 million of eligible project development and construction costs, which would be repaid from a percentage of the project's cash flows. The Government of Canada's Sustainable Development Technology Canada (SDTC) has up to C$500 million in funds.

The Olympiad Project, scheduled to be in service in 2015, will be designed as a state-of-the-art renewable energy facility that will employ the Company's Rentech-ClearFuels biomass gasification system and the Rentech Process to produce the only type of alternative jet fuel certified for use in commercial aviation today. These leading-edge technologies will enable Rentech to turn primarily unmerchantable and underutilized timber into clean, renewable jet fuel, and create up to 400 jobs.

S4
Technology: *Reforming, following gasification*

Last May, Waste Management Inc. annd InEnTec announced a joint venture called S4 Energy Solutions, that will produce renewable fuel, power and *industrial products as well as generate electricity using plasma gasification. In plasma gasification, biomass is fed into a closed chamber and super-heated to temperatures of up to 20,000 degrees fahrenheit. The intense heat transforms biomass into syngas, which is then reformulated into ethanol and green diesel, hydrogen, methanol or methane. A secondary process can convert the base materials into other industrial chemicals.*

Last week, InEnTec converted itself from an LLC to a corporation under the laws of the State of Delaware, and has filed a Form D with the SEC disclosing a $20 million capital raise, with a goal of $69 million.

Karl A. Schoene, InEnTec President and CEO, stated that this was done to fund new commercial projects. InEnTec has a proprietary gasification system that transforms waste streams from municipal, commercial, medical, and most industrial and hazardous wastes into syngas that can be used to produce electric energy, ethanol, methanol and hydrogen.

Solena
Technology: *Fischer-Tropsch process*

In January, Qantas and Solena Group announced that they expect to finalize a partnership in the next two weeks to determine the feasibility of a Fischer-Tropsch based biofuels plant in Australia that will produce aviation biofuels from waste.

Early last year, Solena inked a $309 million partnership with British Airways to construct a 16 million gallon aviation biofuels demonstration plant in East London. The London project would utilize up to 500,000 tonnes of waste as feedstock for the project.

According to Qantas and Solena, the partners expect to complete a business case by year-end as airlines struggle to determine the most cost-effective means of coping with new EU regulations on aviation carbon emissions that will take effect in 2012 under the Emissions Trading Scheme.

According to a report in the Guardian, Solena is also negotiating at an early stage with Lufthansa and for a Dublin-based project with a coalition of airlines including easyJet, Ryanair and Aer Lingus with a prospective price tag of $309 million per project.

Last year, British Airways announced that it will construct a 19-MGY waste biomass gasification plant at one of four sites under consideration in East London, that will produce renewable aviation biofuels. The plant will commence operations in 2014, and will utilize 500,000 tons of waste biomass. The facility will be constructed by US company Solena Group, will use the Fischer Tropsch process and will reduce the airline's annual carbon emissions by 145,000 tons per year, according to consultancy Arcadis that is also working on the project.

SynGest
Technology: *Catalytic conversion of gasified biomass*

The gasification facility is the only new technology in their proposed Cornucopia BioRefinery. The SynGest gasifier, although it has some new characteristics and achieves better performance than prior biomass gasifiers, is based on well-known and understood technologies. The goal with the SynGest system is to convert any form of biomass into clean syngas at the lowest possible cost and simplest operational approach. The ideal scenario would be to convert biomass into syngas in one step. The best way to come close to achieving that goal is to gasify the biomass using almost pure oxygen and the appropriate catalytic fluidized bed. Although the design gets very close to complete conversion in one step, it still contains components of the syngas that need to be handled, such as methane, tars and BTX.

ThermoChem Recovery International
Technology: *Steam reforming, following gasification*

TRI's medium-BTU syngas can be converted into a wide range of downstream and biochemical products. Since 2003, a TRI gasifier has been in commercial-scale operation at Norampac's Trenton (Ontario) containerboard mill, gasifying black liquor *(solid biomass equivalent: 500 dry tons per day). Currently, TRI is the gasification technology provider for two separate DOE-funded biorefinery projects which will convert TRI syngas to Fischer-Tropsch waxes and diesel for market sale, and provide tailgas to offset natural gas use in the lime kiln.*

ZeaChem
Technology: *Hybrid gasification and fermentation technologies*

In Boardman, Oregon, ZeaChem commenced construction of their demonstration plant, designed to prove out a technology at scale that has been producing 2,000 gallons of ethanol per acre in its three-year pilot phase. (Note: that's based on 135 gallons-per-ton of biomass, and a correspondingly large productivity in poplar biomass.)

Three 40,000 gallon fermentation tanks are in place at a site between a massive Cargill processing plant and the Pacific Ethanol's 40 million gallon corn ethanol facility. ZeaChem's footprint looks tiny. But the technology, which processes poplar among a wide variety of cellulosic feedstocks from corn stover to switchgrass, is promising to be anything but small or insignificant.

2,000 gallons per acre? They are numbers that usually are associated with algal biofuels, or a liquid-fuel-from-thin-air project like the Joule Unlimited pilot in Leander, Texas. These are not productivity rates generally associated with cellulosic ethanol, and are approximately four times the productivity of first-generation corn ethanol, without competing with food processors and cattle ranchers for edible starches.

There are two arrows in the ZeaChem productivity quiver.

First, its bacterial acetogen-based process does not produce CO2 as a by-product – it conserves all that carbon for fuels and chemicals. For that reason, the process yields up to 135 gallons-per-ton of biomass, about 30 percent higher than yields from a standard-range 100 gallon-per-ton cellulosic ethanol project.

Second, it uses poplar, which grows like a weed and is one of the primary reasons for the project's location along the Columbia River because it ties in for feedstock to the 30,000 acre GreenWood poplar tree farm. The farm grows the 15-20 ton-per-acre-per-year biomass monster for the solid wood, power and fuel markets".

The U.S. Department of Energy estimates that the share of liquid biofuel to total energy consumption will grow from 1% in 2010 to 3% in 2035. Some observers say that this estimate is far too conservative. Much will depend on cost and scale. For the immediate future, analysts are forecasting that over a billion gallons of liquid biofuel will be produced wordwide during 2012. There are over 200 companies working on liquid biofuels in the U.S. The number is expected to diminish as mergers and acquisitions continue. Feedstock will determine location for many companies. Areas with forest, human, and industrial waste could benefit from a market where biofuel liquid is expanding.

Subsidies for corn based ethanol were not renewed by Congress in 2011. Most analysts expect the Congress to attempt revision of the Renewable Fuel Standards (RFS) in 2012.

No one expects the liquid biofuel sector to grow without massive investment. Oil, chemical, and large feedstock companies are expected to control the size and pace of growth. Aviation biofuels seems like a probable growth area. Traditional producers of ethanol are beginning to switch to higher value molecules like biobutinol, organic acids, and chemicals.

Industry, especially large coal users, have been working on "carbon capture and storage" technologies for some time. New biofuel technologies are developing ways for using the carbon that is captured. Carbon needs to be in the soil, helping to produce food and fuel. Carbon becomes a problem when it is trapped in the atmosphere and in the ground. Technologies that capture carbon emissions for biofuel generation could be interesting productivity possibilities.

Advanced biofuels use plants and by-products that are chosen for the qualities that can maximize the technology. Capital may come from major oil companies, but biofuels will be produced less by vertically integrated giant companies and more like associative industries. A large number of feedstock producers would raise the crop and perhaps be involved with some processing. Chemical plants would process the cellulosic materials into product. Wholesalers, distributors, and retailers would take the product to market.

OUTLOOK FOR WAVE ENERGY

Wave energy is an irregular and oscillating low-frequency energy source that can be converted to electric power and then be added to the electric utility grid. The energy in waves comes from wind inducing surface motion of the ocean resulting in changing heights and speed of the swells. The kinetic energy in waves is significant. An average 4-foot, 10-second wave striking a coast puts out more than 35,000 horsepower per mile of coast.

Waves get their energy from the wind. Wind comes from solar energy. Waves gather, store, and transmit this energy thousands of miles with little loss. As long as the sun shines on a rhythmic cycle, wave energy will never be depleted. It varies in intensity, but it is available twenty-four hours a day, 365 days a year. Further, wave energy is fairly predictable, much more so than wind energy; buoys placed out at sea can register wave movements many hours before the waves arrive at a generation location. Consequently, from the market perspective, integration of wave energy into the grid is much more reliable than other renewable energy resources.

Ocean wave energy technologies rely on the up-and-down motion of waves to generate electricity. The first application for a wave-power patent was in 1799 in France. The applicant, Monsieur Girard wanted to use the technology direct mechanical action to drive pumps, saws, mills, or other heavy machinery. In modern times installations have been built, or are under construction, in a number of countries, including Scotland, Portugal, Norway, the U.S.A., China, Japan, Australia and India. The world's first commercial wave energy plant, .5 MW is located in Isle of Islay, Scotland.

Unlike dams, wave power structures that are equally long-lived promise comparatively benign environmental effects if not used in estuaries. Wave power is renewable, green, and pollution-free. Its net potential (resource minus "costs") is equal to or better than wind, solar, small hydro or biomass power.

It has been estimated that improving technology and economies of scale will allow wave generators to produce electricity at a cost comparable to wind-driven turbines, which produce energy at about 4.5 cents per kWh. However, reports from currently operating systems indicate an average projected/assessed cost of 7.5 cents kWh.

In comparison, electricity generated by large scale coal burning power plants costs about 2.6 cents per kilowatt-hour. Combined-cycle natural gas turbine technology, the primary source of new electric power capacity is about 3 cents per kilowatt hour or higher. It is not unusual to see average costs of 5 cents per kilowatt-hour for municipal utilities districts.

There are three basic methods for converting wave energy to electricity:

- Float or buoy systems that use the rise and fall of ocean swells to drive hydraulic pumps. The object can be mounted to a floating raft or to a device fixed on the ocean floor. A series of anchored buoys rise and fall with the wave. The movement "strokes" an electrical generator and makes electricity that is then shipped ashore by underwater power cable

- Oscillating water column devices in which the in-and-out motion of waves at the shore enter a column and force air to turn a turbine. The column fills with water as the wave rises and empties as it descends. In the process, air inside the column is compressed and heats up, creating energy the way a piston does. That energy is then harnessed and sent to shore by electrical cable.

- "Tapered channel" or "tapchan" systems, rely on a shore-mounted structure to channel and concentrate the waves, driving them into an elevated reservoir. Water flow out of this reservoir is used to generate electricity, using standard hydropower technologies.

Some scientists argue that wave energy is potentially more important than wind and solar. Reasons given for this view are:

1. Because waves originate from storms far out to sea and can travel long distances without significant energy loss, power produced from them is much steadier and more predictable, both day to day and season to season. This reduces project risk;

2. Wave energy contains roughly 1000 times the kinetic energy of wind, allowing much smaller and less conspicuous devices to produce the same amount of power in a fraction of the space;

3. Unlike wind and solar power, power from ocean waves continues to be produced around the clock, whereas wind velocity tends to die in the morning and at night, and solar is only available during the day in areas with relatively little cloud cover;

4. Wave power production is much smoother and more consistent than wind or solar, resulting in higher overall capacity factors;

5. Wave energy varies as the square of wave height, whereas wind power varies with the cube of air speed. Water being 850 times as dense as air results in much higher power production from waves;

6. Estimating the potential resource is much easier than with wind, an important factor in attracting project lenders;

7. Wave energy needs only 1/200 the land area of wind and requires no access roads, infrastructure costs are less;

8. Wave energy devices are quieter and much less visually obtrusive than wind devices, which typically run 100 to 200 feet in height and usually requiring remote siting with attendant high transmission costs. In contrast, 30 foot high wave energy devices can be integrated into breakwaters in busy port areas, producing power exactly where it is needed;

9. When constructed with materials developed for use on off-shore oil platforms, ocean wave power devices (which contain few moving parts) should cost less to maintain than those powered by wind;

OUTLOOK FOR SMART GRID

Smart grid generally refers to a class of technology that is used to bring utility electricity delivery systems into the 21st century using communications technologies, information technology, advanced optimization algorithms, advanced sensors & meters, large-scale data warehousing and power electronics. These systems are made possible by two-way communication technology and computer processing that has been used for decades in other industries. They are beginning to be used on electricity networks, from the power plants and wind farms all the way to the consumers of electricity in homes and businesses. They offer many benefits to utilities and consumers -- mostly seen in big improvements in energy efficiency on the electricity grid and in the energy users' homes and offices.

Since the development of utilities and electrical generation, utility companies have had to send workers out to gather much of the data needed to provide electricity. The workers read meters, look for broken equipment and measure voltage. Most of the devices utilities use to deliver electricity have yet to be automated and computerized. Now, many options and products are being made available to the electricity industry to modernize it.

The "grid" includes how utilities connect with the high voltage grid lines, power production plans, and the networks that carry electricity from the plants where it is generated to consumers. The grid includes wires, substations, transformers, switches and much more.

Smart phone digital connection with computers is a good analogy for utility smart grid. It includes adding two-way digital communication technology to devices associated with the grid. Each device on the network can be given sensors to gather data (power meters, voltage sensors, fault detectors, etc.), plus two-way digital communication between the device in the field and the utility's network operations center. A key feature of the smart grid is automation technology that lets the utility adjust and control each individual device or millions of devices from a central location.

The number of applications that can be used on the smart grid once the data communications technology is deployed is growing as fast as inventive companies can create and produce them. Benefits include enhanced cyber-security, handling sources of electricity like wind and solar power and even integrating electric vehicles onto the grid. The companies making smart grid technology or offering such services include technology giants, established communication firms and innovative start-up technology firms.

In December 2007, Congress passed, and the President approved, Title XIII of the Energy Independence and Security Act of 2007 (EISA). EISA provided the legislative support for the Department of Energy's smart grid activities and reinforced its role in leading and coordinating national grid modernization efforts. The following activities are already underway:

1. **Smart grid demonstrations and deployment** activities take advantage of the catalytic effect of substantial investments in the manufacturing, purchasing and installation of devices and systems. These activities leverage efforts under way in the research and development activity area and will help develop critical performance and proof-of-concept data. This activity area is also developing a framework for analyzing smart grid metrics and benefits, which is necessary to help build the business case for cost-effective smart grid technologies.

2. **Research and development** activities advance smart grid functionality by developing innovative, next-generation technologies and tools in the areas of transmission, distribution, energy storage, power electronics, cybersecurity and the advancement of precise time-synchronized measures of certain parameters of the electric grid.

3. **Interoperability and Standards** activities ensure that new devices will interoperate in a secure environment as innovative digital technologies are implemented throughout the electricity delivery system, advancing the economic and energy security of the United States. The ongoing smart grid interoperability process promises to lead to flexible, uniform, and technology-neutral standards that enable innovation, improve consumer choice, and yield economies of scale. Interoperability and standards activities are not limited to technical information standards; they must be advanced in conjunction with business processes, markets and the regulatory environment.

4. **Interconnection planning and analysis** activities create greater certainty with respect to future generation, including identifying transmission requirements under a broad range of alternative electricity futures (e.g., intensive application of demand-side technologies) and developing long-term interconnection-wide transmission expansion plans.

5. **Workforce development** intends to address the impending workforce shortage by developing a greater number of well-trained, highly skilled electric power sector personnel knowledgeable in smart grid operations. An example of this is OE's involvement with the Consortium for Electric Reliability Technology Solutions (CERTS), a consortium of national laboratories, universities and industry that performs research and develops and disseminates new methods, tools and techniques to protect and enhance the reliability of the U.S. electric power system and the efficiency of competitive electricity markets.

6. **Stakeholder engagement and outreach** activities identify R&D needs for planning, sharing of lessons learned for continuous improvement, and exchanging technical and cost performance data. Information is provided on www.smartgrid.gov to inform decision

makers about smart grid technology options and facilitate their adoption.

7. **Monitoring national progress** activities establish metrics to show progress with respect to overcoming challenges and achieving smart grid characteristics.

The benefits of the Smart Grid are numerous and stem from a variety of functional elements which include cost reduction, enhanced reliability, improved power quality, increased national productivity and enhanced electricity service. In general terms, the Smart Grid will assure that consumers are provided with reliable, high quality digital-grade power, increased electricity-related services and an improved environment.

The Smart Grid will allow the benefits resulting from the rapid growth of renewable power generation and storage as well as the increased use of electric vehicles to become available to consumers. Without the development of the Smart Grid, the full value of many individual technologies like electric vehicles, electric energy storage, demand response, distributed resources, and large central station renewables such as wind and solar will not be fully realized.

For a variety of reasons, utility investment in energy delivery infrastructure has lagged behind other sectors of the economy for decades. In fact, GE estimates that the average age of electric power transformers is 42 years. Couple this with the fact that the utility workforce is rapidly aging gives additional reason for investment in smart grid technologies research and development, and technology training infrastructure.

Energy infrastructure, with increasing volumes of fluctuating renewables in the electricity supply system, raises important issues and questions as to whether the energy supply system can safely sustain high amounts of wind and solar energy. Transmission grid operators face the challenge of balancing the energy system with high amounts of fluctuating renewables. Meanwhile, operators must grapple with how best to forecast wind and solar power for dispatch centers and how to reduce forecast errors. Smart grid technologies will make it possible for these needs to be met.

Most capacity building programs tend to focus on project development, operation of projects or their maintenance and repair, on the technology development or on financing aspects. However, it is also important to have a look at the whole energy system from the grid operators' and dispatch centers' point of view, because they are responsible for the control and quality of the energy supply.

With more fluctuating power sources, measures to control the frequency and the voltage have to change. In detail, this means new methodologies to calculate balancing power, to set up a power station schedule for the next day, to forecast power more precisely, to cover peak load and to plan investments in power stations or to ensure a flexible combination of renewable and conventional power generation.

More renewables also affect the upgrade and the extent of distribution and transmission grids, the requirements for grid codes, grid connection studies and grid simulations. A major need will be for a significant increase in the number of highly trained engineers. All of the above factors require teaching new tricks to experienced and highly qualified engineers and managers.

While Smart Grid technologies will continuously evolve, the fundamental building blocks were put in place during the dot-com era to create a new class of digital technologies that have the potential to transform the analog, electromechanical grid. Solid-state meters are already being installed. Wireless communication and consumer friendly electric devices are becoming available at reasonable prices, and sophisticated sensors can monitor energy use digitally. Smart grid applications for smoothing intermittent power sources, incorporating distributed energy production, utilizing demand response technologies, and much more are already available.

Without the adoption of digital smart grid technologies the goal of building an economy, and hence a sustainable labor force based on the increasing utilization of renewable energy, would be problematic at best. Smart grid has the potential for fundamentally changing the way we produce and distribute electric energy in the U.S. and beyond.

OUTLOOK FOR ENERGY EFFICIENCY AND CONSERVATION

Energy efficiency is using less energy to accomplish the same task. Not to be confused with energy conservation which is reducing energy or going without. Both have a role to play in a sustainable energy economy.

A good example of energy efficiency would be replacing a single pane window with an energy efficient window. The new window prevents heat from escaping in the winter, so you save energy by using your furnace or electric heater less while still staying comfortable. In the summer, efficient windows keep the heat out, so the air conditioner does not run as often and you save electricity.

When you replace an appliance, such as a refrigerator or clothes washer, or office equipment, such as a computer or printer, with a more energy-efficient model, the new equipment provides the same service, but uses less energy. This saves you money on your energy bill, and reduces the amount of greenhouse gases going into the atmosphere. That is the reason for promoting "Energy Saver" appliances.

Energy efficiency and conservation are the low hanging fruit in the energy economy. The technology already exists for saving a third of all electrical energy consumed in the U.S. using energy efficiency and conservation technologies. Energy efficiency offers a powerful and cost-effective tool for achieving a sustainable energy future. Energy efficiency can reduce the need for investment in energy infrastructure, cut fuel costs, increase competitiveness and improve consumer wellbeing. Environmental benefits can also be achieved by the reduction of greenhouse gases emissions and local air pollution. Energy security will benefit from improved energy efficiency by decreasing the reliance on imported fossil fuels.

Over the past forty years energy efficiency has evolved to become recognized as an integral and highly valuable element of utility investments and operations. Energy efficiency programs have yielded significant energy and economic benefits to utility systems and to ratepayers. Energy efficiency programs have also led to job growth in many fields; especially the building trades. In response to both economic concerns and climate change, legislators and regulators have supported energy efficiency and conservation at unprecedented levels.

Some states have supported energy efficiency programs for decades and now have programs that subsidize energy efficiency at the consumer level. Most of these programs rely on rate-payer fees to support energy audits, underwrite equipment purchases, and conduct educational campaigns.

The origin of utility-sector energy efficiency programs traces back to the energy crises in the 1970s and the beginning of the modern environmental movement. Government and utilities were pushed to adopt energy conservation measures to help customers cope with environmental concerns and soaring energy prices. In late 1960's, turning off the lights, putting a brick in your toilet, wearing another layer, turning down the thermostat, or planting a shade tree were the conservation mantras. For the most part today, there are technologies that do those things. In addition to technology, government mandates and energy efficiency programs provided by electric and natural gas utilities work together to encourage (and in some cases subsidize) energy saving practices.

When utilities and other groups discuss energy efficiency as a resource, they are defining efficiency as an energy resource capable of yielding energy and demand savings that can displace electricity generation from coal, natural gas, nuclear power, wind power, and other supply side resources. Investments in energy efficiency and the resulting resource benefits are factored directly into utility energy resource decision making about investing in new resources and operating existing systems. Demand response technologies associated with smart grid are examples of how less energy is used when the consumer is given the tools to use energy only when needed. With demand response, it is the consumer who is able to change energy use without sacrificing productivity. That is why demand response is most useful for business. In the case of demand response, however, there are benefits for both consumer and utility.

Energy savings from customer energy efficiency programs are typically achieved at 1/3 the cost of new generation investments. Efficiency programs can also reduce the need to install, upgrade or replace transmission and distribution equipment. Efficiency can also improve system reliability and allow utilities to reduce or manage the demand on their systems — in some cases offsetting the need to add new peak generation capacity.

Reducing fossil fuel use has many additional benefits including reducing air pollution and greenhouse gases and decreasing the environmental impacts associated with fossil fuel production and use.

The market for energy efficiency technology and equipment is large and growing rapidly. Smart grid technologies are likely to continue this expansion. Almost 70 percent of U.S. electric energy consumption takes place in buildings or homes, and by some estimates, about 50 percent of that energy is wasted. The way buildings are designed and used constitutes the major source of potential for energy conservation. However, the outlook for realizing the benefits from energy efficiency and conservation will require a major shift in human behavior.

Energy audit programs show that only 20% of recommended electric energy saving plans are adopted by homeowners; only 33% are adopted by businesses. This is true even when the cost of modification is small and the payback time is short. The technology is there. Upgrading building systems to save energy often costs a fraction of what it takes to generate the equivalent number of kilowatts from a new fossil-fuel power plant. Experts say many of the lower-cost measures pay for themselves in months.

The rationale behind "Nudge" programs is to offer a subsidy or benefit for changing human behavior. These programs work to a limited extent when the consumer has capital and the freedom to make choices. In the energy efficiency and conservation field this is not always the case. Low income and renter populations already struggle to make their income stretch across many demands. Investing in energy efficiency may be a good aim, but food on the table takes priority. Renters do not have an incentive to invest in energy efficiency technologies on behalf of the owner.

In theory, it makes sense for utilities to invest in the energy efficiency of customers' homes and buildings rather than expand or build new power plants; at least up to the point where the cost surpasses new generation.

In practice, it's not that simple. The hearts and minds of the customers need to be committed. They have to agree that this is a priority worth taking at this time. Many experts say it's important for both building owners and tenants to have money and intellectual capital invested to make sure that savings are a priority and that once established, they endure.

Performance contracting is a third path for energy efficiency and conservation to play a larger role in achieving a sustainable energy economy. At the present time, most energy-efficiency transactions are structured like a subsidized consumer finance or real estate deal, relying on consumers and businesses to take out loans for energy-efficiency retrofits.

Bringing in a third party to make the investment, monitor the performance of the energy efficient technology, and guarantee the energy savings would solve these problems. Performance contracting already exists in the commercial sector, and programs are now being offered by solar PV companies to homeowners. Community Solar Garden programs function like community supported agriculture. They provide direct access to low cost renewable energy. They are managed on behalf of their members. The SolarShare Bond program in Ontario Canada is an example of a community supported renewable energy program that provides low cost energy to stakeholders. State governments would be well advised to recognize these initiatives and expand on methods that will encourage individual and group funding and management of renewable energy projects.

OUTLOOK FOR MANAGEMENT EFFICIENCIES

Constructing the next wave of renewable energy capacity will undoubtedly be a tall order. New technology, system complexity, increasing expectations for operating performance, and an expected shortage of experienced and skilled resources all present challenges and increase the risks of completing these projects on budget and on time.

In this environment, the case for improved project execution is compelling. Project developers that apply cross-industry leading project management practices can achieve total lifecycle cost advantages that significantly outweigh any corresponding benefits from reducing O&M costs.

As already noted in the section on venture capital, management skill and experience may be as, or more, important as compared with technology. There are lessons to be learned from successes in large and complex projects outside the renewable energy industry. If project developers and key suppliers are able to successfully adopt these differentiating practices, the future economic viability of renewable energy generation can be enhanced significantly. If not, the economic justification for future investment likely will be difficult and it will be increasingly challenging to attract growth capital and compete with fossil fuel.

In addition to developing long-term plans for energy supply, job growth, and economic development, governments promoting renewable energy growth should work with proposed renewable energy projects to insure best practices. Large scale projects need to use state of the art technology to insure success, project supervision, training, and management are critical elements to achieve project goals. According to principles at A.K. Kearny, management and operations best practices for renewable energy would include seven key differentiating practices:

Adopting a portfolio view to capital program management: *Planning capital strategy over a multi-year year horizon with a rolling (that is, continually updated) process. This allows for better response to changing market conditions, better aligns capital project management processes with the organization's strategy (based on financial and non-financial criteria) and facilitates cost containment strategies such as developing longer-term relationships with strategic suppliers and embedding complexity management in design practices.*

Creating integrated teams instead of operating in functional silos: *Migrating from traditional functional silos within capital project organizations to utilizing cross-functional teaming will optimize installation, operation and maintenance. Of particular importance in new generation capacity construction is ensuring sufficient, early involvement of the operations team.*

Attracting, developing and retaining required skills and capabilities: *Planning resource continuity to manage scarce personnel on long-term projects and project portfolios. A particular challenge across all capital-intensive industries in North America has been developing suitable career ladders for the most capable and ambitious technical staff. Lessons can be learned from other countries (for example, Germany and Japan) that place an extremely high value on "execution excellence" being the foundation of "business excellence."*

Optimizing around cost rather than schedule: *Understanding the trade-offs between cost and schedule and utilizing flexibility where available to take advantage of market conditions. Lessons can be learned from recent behaviors in the oil and gas industry, where the peak in commodity prices in 2007 to 2008 drove many companies to execute projects "at any cost" based on schedule considerations alone.*

Managing complexity: *Using standard/modular specifications and rigorous interoperability checks. Leading companies are resisting the urge to over-engineer what works well and are aggressively leveraging functional, effective designs time after time. In addition, construction complexity can be reduced by adopting modular design concepts that limit both the activity and workforce required at the operating site during construction.*

Realizing leverage through thoughtful procurement practices: *Employing risk-based contracting strategies and unbundling of spend to create leverage with narrow supply bases, manage cost and guard against escalation. Strategic, long-term relationships with* *key suppliers are a critical enabler of design troubleshooting and continuous improvement. Legacy "bid and buy" strategies have a high correlation with over-budget, late projects.*

Predictive modeling to estimate contingencies: *Utilizing history and Monte Carlo simulations to estimate project budgets and establish contingencies. Poorer performing companies tend to use a single, consistent contingency value when preparing appropriation estimates; leaders understand that uncertainties vary project by project and apply contingency factors accordingly. This is particularly important for renewable energy generation given that initial capital costs represent a significant majority of total lifecycle costs.*

Kearny identifies three key drivers of project performance: scope definition, cost estimation and project execution.

Scope definition and project strategy activities play the most significant role in ultimately determining the success of project execution and can also be critical to successful start-up of operations upon project completion. Poor project performance can impair the lifecycle economics of new renewable energy generation, coupled with ongoing increases in project and technology complexity up-front planning and strategic issues grow in importance.

Cost and schedule estimation has historically been one of the most challenging areas for large generation capital projects, regardless of technology. Historical construction cost reporting is often unreliable, and increasingly irrelevant, given the accelerating pace of change in renewable energy generation technology.

Problems in project execution can be mitigated to a large extent through proper planning, yet scope changes and unforeseen events are inevitable. In particular, an expected future shortage of experienced and skilled talent in the United States (in both engineering and skilled trades) presents a significant risk in project execution.

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Charles has served as Policy and Research Director for OESTRA since 2008. His experiences center on economic analysis, public policy development, project development/management, and government organization.

In 1963 he worked with legislative leaders to design and implement statutes enabling development of the East Wilmington oil field to proceed. The measures established environmental safeguards, designed an economic model to measure field valuation, set standards for maximum field recovery, and implemented a bidding procedure which resulted in $100 million in revenues to support higher education capital outlay.

He was appointed Principal Consultant to the California Senate Government Efficiency Committee in the late 60's where he focused on setting standards for legislative research and policy. Major areas of study included Welfare Reform, Natural Resource Management, Judicial Retirement Policy, Public Employee Collective Bargaining, Public Lotteries, and Alcoholic Beverage Control. Additional consulting roles to the California legislature included preparing the first comprehensive study of tide and submerged lands along California's 1,000-mile coastline and the first comprehensive study of geothermal energy in California. He was appointed to a task force to organize the first United Nations Conference on Geothermal Resources. In addition to serving on numerous boards and commissions, Charles public service includes his role as Aide to California Governor Edmund G. Brown Jr. in the late 70's, Director of the California Office For Volunteerism, Member of the California Council for Humanities, and Member of the California Disabilities Employment Council.

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Josh founded the Oregon Energy Systems, Technology and Research Alliance in 2008 as a privately funded public policy initiative. For the past 21 years, Josh has served multiple roles with Morgan Stanley & Company's Global Wealth Management Group (now Morgan Stanley Smith Barney) including; Regional Vice President, Senior Investment Management Consultant, Wealth Advisor, and Portfolio Manager. In his role as Regional Vice President, Josh was responsible for growing revenue and increasing profitability for fourteen offices in five western states. Prior to joining

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BIBLIOGRAPHY

A Business Plan for America's Energy Future, 2009, American Energy Innovation Council

A Future of Innovation and Growth, Clean Edge, 2009

A Greenprint for the Metro Region, Portland Prosperity Project, 2010

A New Paradigm for Economic Development, How Higher Education Institutions are Working to Revitalize Their Regional and State Economies, Shaffer & Wright, March 2010

A Resource Guide for Technology-Based Economic Development, State Science and Technology Institute, 2010

A Review of Solar Photovoltaic Levelized Cost of Electricity, Brankera, Pathaka, & Pearce, March 2011

A Way to Solve the Problem of Solar on Multi-Tenant Buildings? Clean Tech, 2011

A World of Opportunity: Hydro Energy Around The World, International Electrotechnical Commission, December 2010

Across the Globe, Big Corporate Dollars Aiming at Clean Energy, Clint Wilder, 2011

Advanced Energy Storage: What's the Value of Frequency Regulation? Chris Campbell, May 2011

Advancing Green Chemistry in Oregon, Oregon Green Chemistry Group, July 2010

Alternative Energy: When Catalysts Coalesce, Morgan Stanley Smith, October 2010

Alternative Transportation Fuels and Energy Efficiency, Western States Petroleum Association, November 2011

America's Energy Future: A Battle Between Entrenched Utilities and Clean, Local Power, John Farrell, 2011

An Economic Development and Strategic Plan, Massachusetts Economic Development Planning Council, December 2011

Anatomy of a Solar PV System: How to Continue "Ferocious Cost Reductions" for Solar Electricity, Stephen Lacey, July 2011

Annual Energy Outlook, EIA, 2011

Annual Energy Review, Primary Energy Overview 1949-2010, EIA, 2011

Assessment of Offshore Wind Energy Resources for the United States, National Renewable Energy Laboratory, June 2010

Balancing Act: How Can We Deal With Variability? Renewable Energy News, 2011

Batteries for Energy Storage: New Developments Promise Grid Flexibility and Stability, Tildy Bayar, August 2011

BETC Program Overview, ECONorthwest, 2010

Billionaire Buffet Bets on Solar Energy, Steve Leone, December 2011

Boise Idaho: An Overview of the High-Technology Economy in the Treasure Valley, Heike Mayer, PhD, Clean Edge, A Future of Innovation and Growth, April 2010

Bootstrapping High Tech, Brookings Institute, Heike Mayer, June 2009

Bringing Energy Closer to Home: Why Distributed Generation Works, Jeff Bladen, Mark Group, 2011

California, Oregon, Massachusetts, New York, and Colorado Top the Nation in Clean Energy Leadership, Clean Edge, May 2011

Can Venture Capital Really Influence Environmental Sustainability? Wharton, 2011

Capital Returns to the Energy Sector, Michael Butler, Cascadia Capital, June 2011

Carbon Free Prosperity, Clean Edge, 2008

Catching Up: The Role of State Science and Technology Policy in Open Innovation, Heike Mayer, August 2010

CCA Local Power Begins California Expansion, Mark Braly, June 2011

Centers of Invention: Leveraging the Mountain West Innovation Complex for Energy System Transformation, University of Nevada Las Vegas & The Brookings Institute, September 2010

Charting a Course for Arizona's Technology-Based Economic Development, Milken Institute, December 2009

Clean Energy: Ten Trends to Watch in 2011 and Beyond, Pike Research

Clean Energy Economy 2009, Pew Charitable Trust

Clean Energy Trends 2010, Clean Edge

Cleantech Cluster Profile, Portland Development Commission, 2008

Clean Tech Job Trends, Clean Edge, 2010

Climate Swindle: The Mirage of Carbon Offsets, Cascade Policy Institute, March 2010

Co-Generation and Renewables, International Energy Agency, 2011

Colloidal Quantum Dots Capture Infrared, Dana Blankenhorn, June 2011

Compressed air energy storage: The natural option for Brayton Cycle CSP? Helen Campbell, June 2011

Cost of Generating Electricity, Royal Academy of Engineering, 2004

Creating Our Future, Electric Power Research Institute, 2009

Cross-Industry Project Management Practices, Khemani, Walters, Haischer & Kearney, June 2011

Crossing the Valley of Death, Bloomberg New Energy Finance, June 2010

CSP-PV pricing: Mind the Gap, Bob Moser, June 2011

Democratizing the Electricity System, The New Rules Project, John Farrell, 2011

Distributed Solar Nears Grid Parity with Fair Electricity Pricing, John Farrell, 2011

Does Energy Storage Compensate for Water-thirsty Concentrating Solar Thermal Power? John Farrell, September 2011

Economic Impact Assessment of ONAMI, Oregon Economic and Community Development Department, October 2008

Economic Impact of North Dakota Centers of Exellence Program, 2007 – 2009, Leistritz, Bangsund, and Hodur

EGS Could Play Major Role in Low-carbon Economy, Robert Crowe, Renewable Energy Network

Electric Power Monthly, U.S. Energy Information Administration, December 2011

Electric Vehicle Batteries, Pike Research, 2011

Electricity Generation From Renewables 2004-2008, U.S. Energy Information Agency, 2011

Employment Dynamics and State Competitiveness, Wells Fargo Secutities, Economics Group, 2011

Ending the Energy Stalemate: A Bipartisan Strategy to Meet America's Energy Challenges, 2007, National Commission on Energy Policy

Energy Cost Chart, 1970-2010, DOE, (coal, distillate petroleum, natural gas, and wood products … national data)

Energy Costs by State, 1970-2010, DOE, (spreadsheet for coal, distillate petroleum, natural gas, and wood products)

Energy Cost Comparisons, Galen Barbose, RH Wiser, Naim Darghouth

Energy Data for Decision Makers, National Renewable Energy Lab, 2011

Energy Efficiency Resource Standards: A Progress Report on State Experience, American Council for an Energy Efficient Economy, June 2011

Energy Efficiency Services Sector: Workforce Education and Training Needs, Research Into Action, March 2010

Energy Self-Reliant States, Farrell & Morris, 2010

Energy Source Cost Comparisons, Jack Pare, September 3, 2007

Energy Storage Industry Grows To Integrate Wind, Solar, Robert Crowe, August 2011

Entrepreneurship, University of Nebraska, August 2011

Estimating the Costs and Benefits of the Smart Grid, EPRI, 2011

Ethanol Industry: The Next Inflection Point, Brian Curtis, U.S. May, 2008

Factors Affecting Adoption of Renewable and Other Sources of Electricity Freeing The Grid, Network for New Energy Choices, 2010

First U.S. Grid-Tied Solar Energy Storage Goes On-Line, Pete Singer, September 2011

From Innovation to Infrastructure; Financing First Commercial Clean Energy Projects, CalCEF Innovations, June 2010

Fuel Cells Technologies Market Report 2008, U.S. Department of Energy

Gainesville, Florida, Becomes a World Leader in Solar, John Farrell, January 2012

How to Compete and Grow: A Sector Guide to Policy, McKinsey Global Institute, March 2011

Generation Technologies, Center for Climate and Energy Solutions, November 2011

Geothermal Assesses Its Potential, Renewable Energy News, May 2011

Geothermal: The Safe Way to Use The Energy Beneath Our Feet, Jordann Kaye, June 2011

Geothermal Technologies Market Report,U.S. Department of Energy, 2012

Global Consumer Wind Study 2011, Vestas

Global Trends in Sustainable Energy Investment, Bloomberg, 2010

Group Purchase Gets Residential Solar to Grid Parity in Los Angeles, John Farrell, December 2011

Illinois Green Energy Finance Initiative, Marnin Lebovitz, March 2010

In depth: Molten salt-based central receiver technology, Andrew Williams, June 2011

Inexpensive Grid Stability Solutions, Tom Konrad, 2011

Integrated Generation Technology Options, Electric Power Research Institute, 2011

Investing in Innovation, Pew Charitable Trust, 2007

Investing in Our Competitive Future: Approaches to Increasing Early Stage Capital in Washington State, Technology Alliance, 2007

Is natural gas a climate change solution for Canada? David Suzuki Foundation, 2011

Isothermal CAES: Better Than Molten Salt Thermal Storage? Campbell & Stancich, July 2011

Job Creation Possibilities in Hydropower, Navigant Consulting, September 2009

Jumpstarting a Clean Energy Revolution, Breakthrough Institute, September 2009

Kentucky's Bucks for Brains Initiative, Kentucky Council on Postsecondary Education, 2009

Levelized Cost of New Generation Resources in the Annual Energy Outlook 2011, National Energy Modeling System, 2010

Life After the 1603 Grant: The Road Ahead, Sara Rafalson, November 2011

Linear Motion Solutions for Vacuum Deposition Chambers in PV Manufacturing, Thomas Christmann, July 2011

Major Potential for Wave and Tidal Energy Production Near U.S. Coasts, DOE, January 2012

Making an Impact, Assessing the Benefits of Ohio's Investements in Technology- Based Economic Development Programs, Stanford Research Institute, September 2009

Making Sense of Clusters, Joe Cortright, 2006

Making the Case for Spinning Reserve on the Grid, Chris Campbell, 2011

Maximizing Returns, California Budget Office, 2002

Microgrids: Smart or Dumb? Pike Research, Peter Asmus, October 2010

Module Level Management Emerges from the Shadows, Richard Pitkin, June 9, 2011

Multiple Engineering Cooperative Program, OSU, PSU, OIT, 2009

National Solar Jobs Census 2011, The Solar Foundation, October 2011

New Dawn for Solar Millennium, CSP, June 2011

New Lab to Help Utilities "See" Grid of the Future, Heather Lammers, NREL, December 7, 2011

100 Percent Renewables: The Resources are There, Says UN Report, Carl Levesque, American Wind Energy Association, May 2011

North America's High-Tech Economy, Milken Institute, 2011

Oil's Uncertain Future, McKinsey Research, November 2011

Onshore wind energy to reach parity with fossil-fuel electricity by 2016, Bloomberg, November 2011

Oregon's Clean Energy Economy, Clean Edge, 2011

OSHU Economic Impact on Oregon, ECONorthwest, 2009

Population and Energy, Graham Zable, London School of Economics, 2002

Predictions for Solar Infrastructure in 2012: No Longer the Ugly Stepchild, Marcelo Gomez, January 201

PV Installed Cost, M.I.T, 2011

Regrid: Re-wiring the thinking on grid-tied renewables, Albrecht Tiedemann, June 10, 2011

Reassessing Renewable Energy Subsidies, Bipartisan Policy Center, March 2011

Renewable Energy in America, American Council of Renewable Energy, August 2010

Renewable Energy Technology Cost Review, Melbourne Institute, 2011

Renewable Energy Country Attractiveness Indices, Ernst & Young, May 2011

Renewables Industry Faces Skills Shortage, Kate Garratt, May 2011

Report to Legislative Assembly on Public Purpose Expenditures, 2009-2010, ECONorthwest

Research, Science and Technology Parks Creating High-Wage Jobs, Association of University Research Parks, 2011

Resource Revolution, McKinsey Global Institute, November 2011

Restoring U.S. Competitiveness, Center For Public Policy Innovation, February 2012

Science and Engineering Graduate Students by State, 2001-2007, National Science Foundation

Securing America's Energy Future, A Role for Science and Technology, Shephard, Texas Sustainable Energy Research Institute, September 2010

Senate Bill 5921, 2009, Washington State Legislature

Shale Fracking, DOE, Shale Gas Production Subcommittee, November 2011

Sixth Northwest Conservation and Electric Power Plan, Northwest Power Planning Council

Sizing the Clean Economy, A Green Jobs Assessment, Brookings Institute, 2011

Solar 2011: Lower Shipments Lower Prices, Morgan Stanley, February 2011

Solar and Nuclear Costs: The Historic Crossover, Blackburn & Cunningham, July 2010

Solar Energy and Cost-Competitiveness, Solarbuzz, 2011

Solar Grid Parity 101, John Farrell, January 2012

Solar Power Generation in the US: Too expensive, or a bargain? Perez, Zweibel & Hoff, 2011

Solar PV Balance of System, Rocky Mountain Institute, 2011

Solar Retail Pricing, Solarbuzz Quarterly, October, 2010

Solar Systems Retail Pricing, Solarbuzz, May 2011

Solar Technologies Market Report, NREL 2008

Solar Thermal Plants Scrap Steam for Photovoltaic, Reuters, July 2011

Some Skepticism on Solar Thermal Power's Storage Potential, John Farrell, January 2012

Starting Smaller; Staying Smaller: America's Slow Leak in Job Creation, Kauffman Foundation, 2011

State Clean Energy Toolkit, CleanEnergy States Alliance

State Science and Technology-Based Economic Development, Battelle Memorial Institute, May 2004

State Technology and Science Index 2010, Milken Institute

Taking Root in the Silicon Forest, Heike Mayer, 2005

Taking Solar to the Next Level, Rocky Mountain Institute, August 2010

Tax Credits for 'Angels' Get Clipped, Wall Street Journal, 2012

Tech-Based Economic Development and the States: Legislative Action in 2011, SSTI

Texas Emerging Technology Fund, a Statute, State of Texas, 2005

The 2010 State New Economy Index, Ewing Marion Kaufman Foundation, 2010

The BC Energy Plan, Province of British Columbia, 2010

The Competitive Imperative, Joe Cortright, 2005

The Consequences of Miniaturization on Grid Conductors, Tom Falcon, July 2011

The Economic Benefits of Investing in Clean Energy, University of Massachusetts, June 2009

The Future of Geothermal Energy; Impact of Enhanced Geothermal Systems (EGS) on the United States in the 21st Century, MIT, 2006

The Power to Reduce CO2 Emissions, Electric Power Research Institute, 2009

The Power to Transform: U.S. Power and Utilities Sector's Role in Cleantech Deployment, *Delloite*, 2011

The Problem of Innovation, Aaron Wrenn, 2011

The "Rebound Effect": A Perennial Controversy Rises Again, Cameron Burns and Michael Potts

The Rise of Concentrating Solar Thermal Power, Ucilia Wang, 2011

The Sector Information Technology Forgot, Tom Konrad, 2011

The State of Technology, Electric Power Research Institute, 2009

Tiny Solar Cell Could Make a Big Difference, Bill Scanlon, NREL, December 2011

Top 5 Coolest Ways Companies are Integrating Renewable Energy into the Grid, Stephen Lacey, 2011

Tracking the Sun III; The Installed Cost of Photovoltaics in the U.S. from 1998-2009, Berkeley Labs, Galen Barbose Naïm Darghouth Ryan Wiser

Translating Innovations into U.S. Growth, McKinsey Research, May 2011

U.S. Billion Ton Update: Biomass Supply for a Bioenergy and Bioproducts Industry, DOE, August 2011

U.S. Clean Energy Leadership Index, Pernick & Yonker, Clean Edge

U.S. Ethanol Industry, BCurtis Energies Group, 2008

U.S. Inland Technical Potential Nameplate Hydropower by State, Navigant Consulting

U.S. Solar Market Trend 2010, Larry Sherwood, June 2011

U.S. Venture Capital Dollars Invested by State, 2006-2011, SSTI & PricewaterhouseCoopers

Utilities and Cleantech, Delloite,

Vermont Enacts First-In-Nation Solar Registration, Renewable Energy News, 2011

Wave Energy Converter, Pacific Gas & Electric, 2010

West Virginia Energy Outlook: Identifying Synergies Between Renewables and Fossil Fuels, Eric Mathis, 2012

What Cleantech Should Know About Chasm Crossing, Dallas Kachan, July 2011

What Happens When the Incentives Expire? Navigant Consulting, May 2011

When Will Renewable Energy Companies Overtake Traditional Energy Companies? Jennifer Kho, Renewable Energy Network, January 2010

Where Smart People Live, Rob Pitingolo, May 2010

Why "Market-Based" is a Poor Criteria for Solar Policy, John Farrell, October 2011

Wind Technologies Market Report 2008, U.S. Dept. of Energy

Winds of Change, American Wind Energy Association (AWEA), BlueGreen Alliance (BGA), United Steelworkers (USW), 2010

World Renewable Electricity Generation by Energy Source, 2007 – 2035, excluding wind and hydropower, DOE, May 2010

Youth Magnet Cities, Wall Street Journal, May, 2009