

# Scientific, Economic, and Political Feasibility and Implementation of Increasing Wind Power 20-Fold and Solar Power 350-Fold

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## Scientific Feasibility

In order to decrease CO<sub>2</sub> emissions by 25 billion tons over the next 50 years yet still meet the same energy production as coal power plants, it is necessary to either increase wind power 80-fold or increase solar power 700-fold. Since wind power and solar power have offsetting peak production hours, it is proposed that the two readily available technologies be used together in order to replace the current coal system. By cutting each goal in half, the same amount of power is displaced by both wind and solar.

This ambitious program requires that 1,050 GW of 90-percent-time coal is replaced by 1,050 GW peak wind power globally. The US is now responsible for producing 20% of the world's CO<sub>2</sub> each year. This percentage equates to 210 GW worth of coal-produced CO<sub>2</sub>. Spread evenly over 50 years, 210 GW of wind power would average to 4.2 GW of wind farms completed each year. For reference, this installation would be equivalent to seven of the proposed 600 MW Delaware wind farms opening each year, for a total cost of \$11.2 billion. However, since the lifetime of wind turbines is assumed to be 25 years, after the first 25 years, the oldest turbines will need to be replaced. Thus the cost for the first 50 years increases by a factor of 1.5, for an effective 50 year project plan of \$840 billion.

The wind farms can be built either on or off-shore. Applications of off-shore wind turbines are particularly attractive because of relatively high and sustained wind velocities.<sup>1</sup> Such installations take place approximately 10 miles offshore and avoid the issue of disturbing public views. Also, the areas where bird migration occurs can be easily avoided due to their predictable behavior, therefore minimizing bird casualties. The 350 new locations should be chosen strategically to increase power supply in areas where coal plants will be decommissioned. The first 25 years will include only new farms while the next 25 years will include replacing old turbines as they expire. The real plan, however, will focus on building more turbines in the first few years of the program while waiting for photovoltaic systems to become economically competitive with coal and wind.

Solar power would be needed to displace 210 GW of coal power plants in the US by the year 2050. This corresponds to approximately 747.3 square miles (0.02% of US land) of 15% PV efficiency. A 40 MW solar farm is in the process of being installed in Germany for the US equivalent of \$171 million (\$4.27/W). By extrapolating the cost of this plant, \$898 billion would be needed. In reality this cost would be much lower due to the economy of scale.

The technology for solar power has existed since the 1970s, but it has not been economically feasible to implement. Global factors coupled with recent technological improvements have spurred rapid growth in the industry. Increased efficiencies of traditional solar cells and thin film PV cells (CdTe and CIGS) have decreased material cost and production to make PVs a viable alternative to coal. Currently, 22% efficient silicon PVs are commercially available.<sup>2</sup> Thin film cells with 11% efficiency are currently being produced at a fraction of the single crystal PV.<sup>3</sup> Research and development will address these efficiency barriers. Because of the toxicity of CdTe thin films, it is proposed that films of this nature only be used for large scale power generation where the human contact is minimal. Also R&D should be continued for organic PVs and intermediate band gap solar cells because of the potential (cheap production and improved efficiencies respectively) of both areas.

## Economic Feasibility

Growth of one electricity source relative to another is highly dependent on the relative cost of electricity produced by each.<sup>4</sup> In the electricity generation sector, it is especially important for electricity generated from alternative energies such as wind and PV to reach "grid parity", the point in time when the price of electricity from a developing source drops to that currently provided by the grid. Electricity from wind has already reached grid parity throughout much of the U.S., but grid parity for PV generated electricity is not expected to be reached for until 2015.<sup>5</sup> For this reason, steering the U.S. electricity sector towards a target of 18% wind & solar (9% each) will be more expensive compared to coal in the short term, but more cost effective in the long term. This is seen in the table below, which shows the cost of installing the target generation capacities by 2020 and 2050:

Electricity Source	2020		2050	
	Capacity (GWeq)*	Installed Cost (billion \$)	Capacity (GWeq)*	Installed Cost (billion \$)
PV+ Wind	95	52	420	141
Coal	95	28	420	224

\*GWeq stands for equivalent GW of generating capacity and accounts for differences in the load factors of coal plants and renewable.

Although the U.S. will need to pay about 85% more in the next 11 years, the projected drops in prices of wind and PV technology in the next 40 years (driven by the investment during the first 11) are expected to lead to a 58% cost savings in the long term. These economic benefits arise solely from an electricity generation standpoint and do not include the gains from producing the wind and PV technology in the U.S.

### Political Feasibility

The incentives required to achieve the needed developments have a high level of political feasibility, as demonstrated by the many incentives already provided by the current administration, the house and the senate. Leaders in the many energy and environment related committees and subcommittees have already supported the provisions in the economic stimulus package, specifically the 30% investment tax credit, totaling nearly \$2 billion. In addition, this bill created a bonus Research and Development tax credit equal to 20% of R&D expenditures. The Senate committees on Environment and Public Works and Energy and Natural Resources are both chaired by Democrats whose states have and will greatly benefit by increasing solar and wind energy development. In congress, the chairs of the committees on Energy and Commerce, Natural Resources, Science and Technology, and Joint Economic committee are all Democrats that have supported the incentives for renewable energy generation and development. In addition, a house select committee on energy independence and global warming, established by Speaker Pelosi, was formed to “add urgency and resources...to address the challenges of America’s oil dependence and the threat of global warming.”<sup>6</sup> The political presence and will are both present and have demonstrated their ability to implement the beginnings of a national renewable energy program. These national commitments on the long-term, such as the elimination of the solar electric credit cap until January 1, 2017, will provide for the regulatory certainty needed for the development of a domestic renewable energy market, and thus for the electric production industry.

Federal regulatory certainty could be furthered by the establishment, through the Federal Energy Regulatory Commission, of a national net metering or feed-in tariff standard and requirement for utilities. Although net metering is available in 43 states, and the District of Columbia, the establishment of a national standard coupled with a federal obligation to allow for the provision of electricity from independent and individual electricity producers would allow for a more modular, better adapted renewable energy strategy. The increased ease of access to utility distribution and transmission systems would decrease the barriers to entry for individual suppliers, and increase the investment in modular renewable energy alternatives better adapted to the specific local conditions, and thus increase both the diversity and number of solutions possible.

### Implementation

When the program initiates, there will be priorities as to which areas of the country will receive the funds to build the first wind farms. Offshore areas in the densely populated northeast and southeast continental United States will receive the highest priority followed by offshore wind farms in southwest United States and Northern California/Southern Oregon because of high population density and “superb” winds, respectively.<sup>7</sup> Hawaii and Alaska would receive off-shore priority. Areas in Wyoming and Illinois would receive funding to build onshore wind farms to help power the Rocky Mountain states and the Midwestern states, respectively.

As the wind farms are constructed, funding will be going to research and development for photovoltaic cells. After 6 years, PV systems are likely to be economically feasible to be implemented on a grand scale. Southwestern desert states will also be given priority for solar farm development.

The Federal Government will place incentives and subsidize parts of the projects to individual energy companies to ensure timely building. After approximately 15 years, most of the country will have some form of renewable energy in the near vicinity to produce power. The following 10 years will have more growth throughout the U.S. The subsequent 25 years will be maintenance and replacement of aging wind and solar farms.

## References

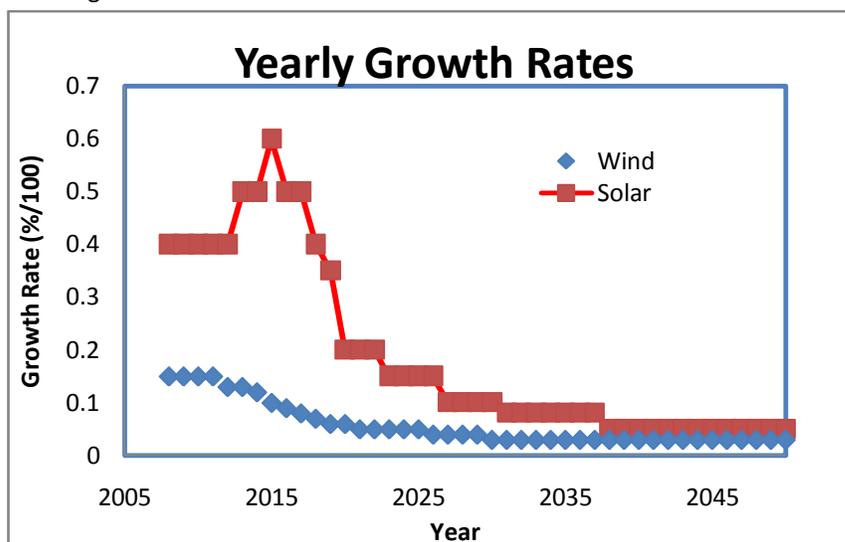
- 1 – *Offshore Wind Energy Factsheet*. American Wind Energy Association.  
<[http://www.awea.org/pubs/factsheets/080821\\_offshore\\_fact\\_sheet.pdf](http://www.awea.org/pubs/factsheets/080821_offshore_fact_sheet.pdf)> Retrieved January 26, 2009.
- 2 – *SunPower – Smarter Solar >> Products + Services >> Commercial Solar Panels*. SunPower.  
<<http://www.sunpowercorp.com/Products-and-Services/Commercial-Solar-Panels.aspx>> Retrieved January 26, 2009.
- 3 – von Roedern, B., Ullal, H.S. *Solid State Technology*. 51.2 (2008)
- 4 – *The Solar Coaster: January 2008*. <[http://solarcoaster.blogspot.com/2008\\_01\\_01\\_archive.html](http://solarcoaster.blogspot.com/2008_01_01_archive.html)> Retrieved January 26, 2009.
- 5 – *Abengoa Solar :: About us :: General :: News :: News Archive ::2008*.  
<[http://www.abengoasolar.com/sites/solar/en/about\\_us/general/news/archive/2008/20080930\\_noticias.html](http://www.abengoasolar.com/sites/solar/en/about_us/general/news/archive/2008/20080930_noticias.html)>  
Retrieved January 26, 2009.
- 6 – *The Select Committee for Energy Independence and Global Warming*. House of Representatives.  
<<http://globalwarming.house.gov/>> Retrieved January 26, 2009.
- 7 – *United States – Wind Resource Map*. Wind Powering America.  
<[http://www.windpoweringamerica.gov/pdfs/wind\\_maps/us\\_windmap.pdf](http://www.windpoweringamerica.gov/pdfs/wind_maps/us_windmap.pdf)> Retrieved January 26, 2009.

## Appendix

### A.1 Calculations for Projected Costs of PV, Wind, and Coal-generated electricity

#### Assumptions

- Projections of costs of wind and PV installations from 2009 to 2050 were based off of linear experience curves (Cost vs. Installed Capacity). Data for these curves were obtained from:
  - For wind: Janginger, M. “A global experience curve for Wind energy”. *Energy Policy*, 133-150 (2005).
  - For PV: [http://www.iea.org/textbase/work/2007/learning/Nemet\\_PV.pdf](http://www.iea.org/textbase/work/2007/learning/Nemet_PV.pdf)
- The cost of more coal-generated electricity was calculated according to \$ 0.8 billion for a new 500 MW Integrated Gasification Combined Cycle coal fired plant. Neither an increase in the price of building coal plants nor increases in the price of mining and purchasing coal were considered in this calculation.
  - Source: <http://www.appvoices.org/index.php?/air/coalplants/>
- Annual growth rates for wind and solar were set as follows:



Where the growth rate trend for wind was kept consistent with the projections for the world wind energy association and those for solar show a 5 year lag before growth rate sky rockets due to a combination of reaching grid parity and the fruition of investments from the previous five years.

- Coal was assumed to grow at a constant rate until the new target capacity was met in 2050