An Analysis of U.S. Energy Portfolio Through 2050

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Abstract: We present a method for analyzing the nation's energy portfolio in the next 40 years based on (a) the rate of growth of demand for electricity, and (b) the rate of growth in the development of various renewable technologies including wind, photovoltaic, hydro, fuel cells, and solar thermal. The results are simulated for a scenario beginning in 2010 and ending in 2050.

Introduction: The electric energy presently produced in the United States amounts to about 4000 billion KWH. By 2020, United States is to produce 20 percent of its electricity from renewable energy sources. Given the present state of affairs, is this goal attainable and if so, will it result in sufficient reduction in CO2 emission? There has also been discussion of going to a 25-percent renewable portfolio by 2025 [1].

The demand for electricity is expected to grow by 22 percent by 2035 to over 5000 Billion KWh per year as shown in Figure 1, resulting in increase of about 8 percent CO2 emission by 2035 [2], [3]. Various electric energy portfolios (consisting of fossil fuels, nuclear, wind, solar, and biomass) have been proposed in which the CO2 emissions can be reduced to 41 percent (of 2005 levels) by 2035 and to 17 percent (83 percent below the 2005 levels) in 2050 [4]. In this work we examine these projections by analyzing the rate of growth of the fossil fuel sources in the next 40 years.

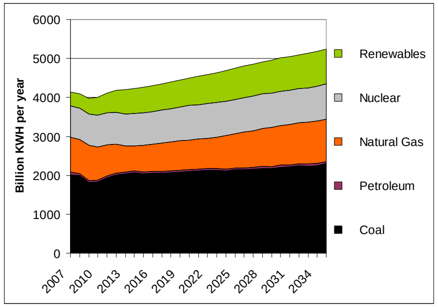

Figure 1: Total electricity generation by fuel type [2].

Electric Power Research Institute has proposed the energy portfolio depicted in Figure 2 in which a demand reduction of almost 2000 Billion KWH (almost 100% of the projected demand) in 2050 is assumed. In their scenario, the use of coal is gradually reduced to zero by 2030 while the use of natural gas is increased in this time interval as the renewables are building up to take larger shares. In the interim, the nuclear power production is also curbed while hydro maintains its constant share in the portfolio.

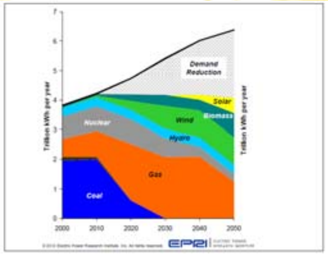

Figure 2: A possible scenario proposed by EPRI [4].

We previously presented a method for evaluating renewable and non-renewable energy technologies based on the weights given to the economic viability, the present level of the development, the environmental impacts, the after- production and clean-up cost, and the renewability and abundance of the source of the energy [5]. In this work we modify our previous model to incorporate (a) the rate of increase in the demand for electricity in the next 40 years, (b) the rate of growth in the development of various renewable technologies including wind, photovoltaic, hydro, and fuel cells, and solar thermal.

Method: Presently, the fuel cell and solar thermal provide a very small share of the renewable energy portfolio as shown in Figure 3. Both these two technologies are assumed to grow at a modest linear rate in the next several years resulting in about 5 Billion KWH per year in 2050s, which is a negligible percentage of the total electricity production in those years.

The three sources of hydro, wind, and photovoltaic are grouped together and are shown in Figure 4.

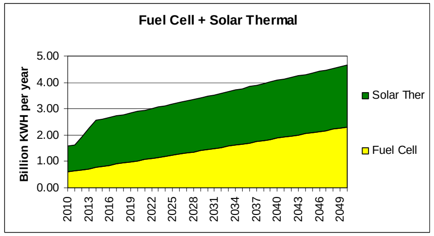

Figure 3: Linear growth of Fuel Cell and solar thermal.

The hydro energy is expected to stay near its present value of 277 Billion KWH per year, saturating to a level of about 300 billion KWH per year over the next several decades, mostly due to possible increase in run-of-river utilization. During these decades, the wind capacity is assumed to reach a level of 625 Billion KWH per year following a triangle function.

The photovoltaic capacity of the nation is assumed to grow parabolically. However, since the life expectancy of most solar panels is about 30 years, the capacity installed in 2010 is assumed to be removed from production in 2040, hence leveling off the growth curve to a value of about 180 Billion KWH per year.

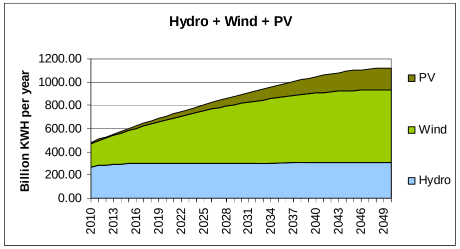

Figure 4: Predicted growth of Hydro, wind, and PV.

Results: Using the predictions of our model, we simulated the growth rates of the renewables as shown in Figure 5. To provide for a comparative basis, we also show the nuclear power production (which was assumed to stay near its present value of 900 Billion KWH per year). Based on this simulated scenario, the nuclear will provide a share almost equal to the all renewables combined. Although nuclear and renewables are grouped together, we should draw the distinction between the two since nuclear is not truly a "clean" source, nor is "renewable."

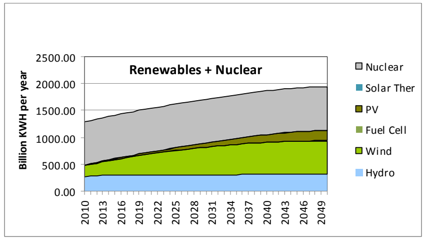

Figure 5: Forecast for all renewables and nuclear.

The hydro energy is expected to stay near its present value of 277 Billion KWH per year, saturating to a level of about 300 billion KWH per year over the next several decades. During these decades, the wind capacity is assumed to reach a level of 625 Billion KWH per year following a triangle function. The photovoltaic capacity of the nation is assumed to grow parabolically. However, since the life expectancy of most solar panels is about 30 years, the capacity installed in 2010 is assumed to be removed from production in 2040, hence leveling off the growth curve to a value of about 180 Billion KWH per year.

The resulting energy portfolio for the U.S. through 2050 is plotted in Figure 6. The portfolio accounts for the 25% growth in the consumption of electricity in the next 40 years. Although, the renewables, and particularly wind picks up a large share of the power production, the overall percentage of the renewables will be in 20 percentile range in the 2050s and not in 2020s as it is presently proposed.

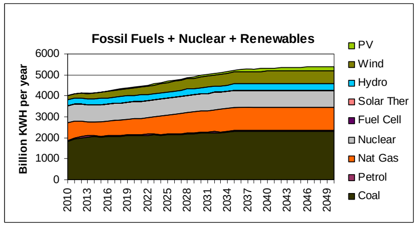

Figure 6: A possible energy portfolio for the U.S. through 2050.

Future Work:

(1) Calculation of the CO2 emissions of the simulated portfolio.
(2) Simulation of several other scenarios for reduced CO2 emissions.
(3) Various other what-if scenarios investigating different rates of growth of various renewable technologies.
(4) Simulation of distributed renewable power generation especially in connection to wind and photovoltaics.

References:

[1]: "Impacts of a 25-Percent Renewable Electricity Standard as Proposed in the American Clean Energy and Security Act Discussion Draft", *Energy Information Administration*, Office of Integrated Analysis and Forecasting U.S. Department of Energy Washington, DC, April 2009.
[2]: "Developing a Realistic and Balanced United States Electric Power Generation Portfolio, Assuring Energy, National, Economic and Environmental Security," *Atlantic Council*, May 2010.
[3]: "Table 8: Electricity Supply, Disposition, and Prices:" http://www.eia.doe.gov/oiaf/aeo/excel/aeotab_8.xls, December 2010.
[4]: "Creating a Low-Carbon Future," NARUC Joint Meeting of Committee on Electricity, and Committee on Energy Resources and the Environment, EPRI, February 2010.
[5]: Rahim Khoie, "A method for evaluating and selecting renewable and non-renewable energy technologies," *International Journal of Environmental Technology and Management*, Vol. 5, Number 2-3, pp. 203-229, 2005.