80% Renewables By 2050 In US, Says NREL

April 13th, 2015 by **Guest Contributor**

By "He who shall not be named"

There are many ways to achieve high renewable penetration levels.

*According to **an NREL study** examining high renewable energy integration in the US, 80% of US electricity could be coming from renewables by 2050.*

Feel free to copy the above paragraph & link and use in response to incorrect claims that renewable energy can't provide most of our electricity needs.

*For responses to other anti-cleantech myths, see: **Anti-Cleantech Myths Debunked (Your #1 Resource)**.*

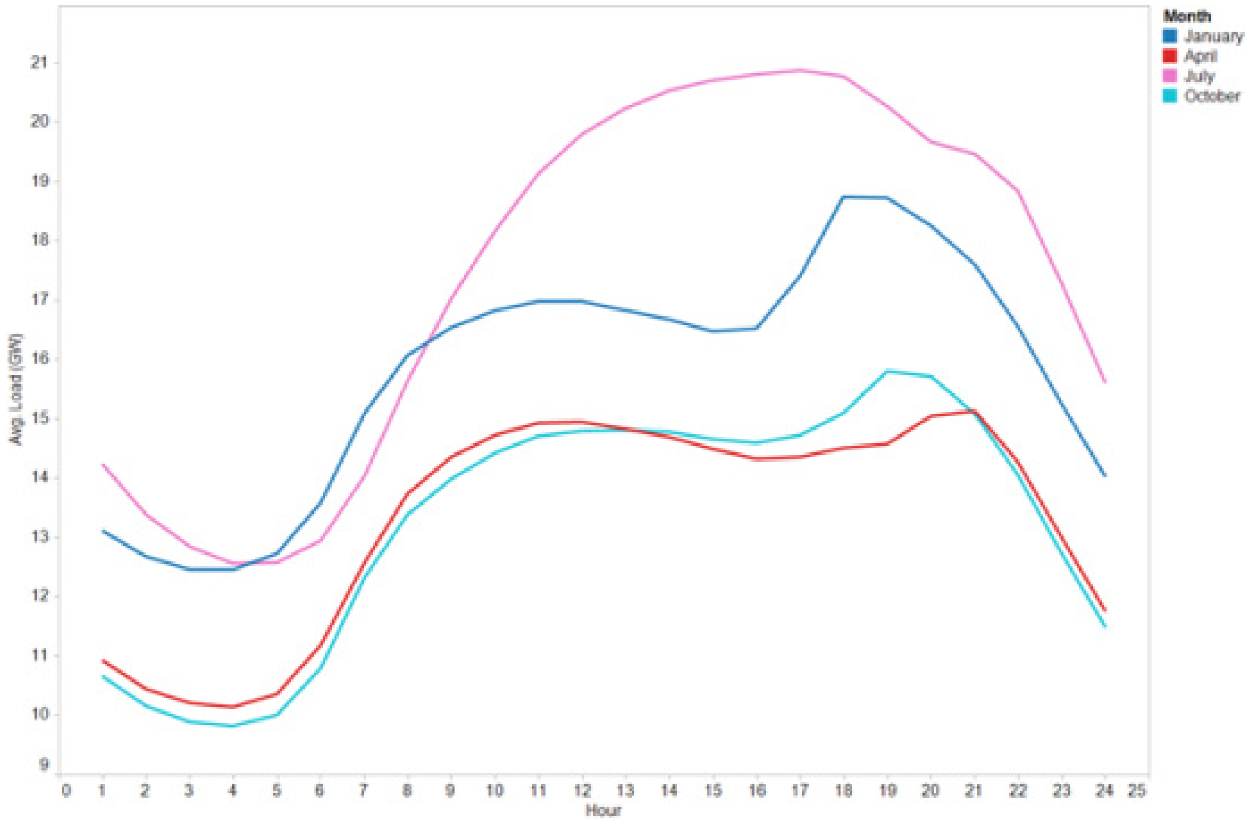
How can high levels of renewable energy be integrated when wind and solar resources are variable? First of all, it's important to remember that wind and solar are not the only renewables out there. High overall renewable energy integration can be achieved via a composite of regions with different integration levels and different means.

Some think of renewables as only wind or solar, and that they must supply all of the load in a small region. However, considering the large area of the US, a high level of renewables can be achieved without requiring every region to meet the same integration levels. Wind and solar are not the only sources of renewable energy, and storage need not be more than a small fraction of total capacity.

While it might at first be difficult imagining wind turbines supplying all of the electricity in one region, this is not how a renewables-centered future will operate. Variable renewables will be mixed with dispatchable ones like geothermal and hydro to produce the desired result. And different regions will have different mixes of renewables, sometimes relying on neighbors sending energy over transmission lines, like borrowing a cup of sugar. 80% renewables will not be 80% wind and solar in each city, region, or state — some places will have over 80% renewables, while others will have under 80% renewables.

The Power System: How Does It Work?

The power system is a complex system of generators, transmission lines, and distribution equipment overseen by system operators that keep generation matched with demand. Demand varies throughout the year, reaching a peak in the summer afternoon and changing shape year round.



System operators work like air traffic controllers, forecasting demand and generation daily. Large generators are often slow to respond and need time to be at full capacity. Operators forecast day-ahead demand and schedule generation accordingly. Since the load changes rapidly during the day, large and slow-moving baseload generators must be combined with faster-responding peaker units to meet load. Operators can also adjust demand. During times of excessive demand, the operator has agreements with major electric consumers, like aluminum smelters and water pumps, to decrease demand. Operators use transmission, flexibility, and resources to match demand.

Like a good cook must keep extra ingredients in the pantry, a system operator must also keep generation reserves available in case generators malfunction or load increases unexpectedly because of forecast error. Because generation and transmission capacity must be sized to exceed the maximum annual demand, sizable reserve generation must be available all year. The power system is already designed to respond to the changing whimsical demands of the Superbowl, New Year's Day, and big soccer games. This is one reason NREL found variable renewables can be integrated up to 35% with little effect on the existing system. (Similar findings have been made in Europe as well.)

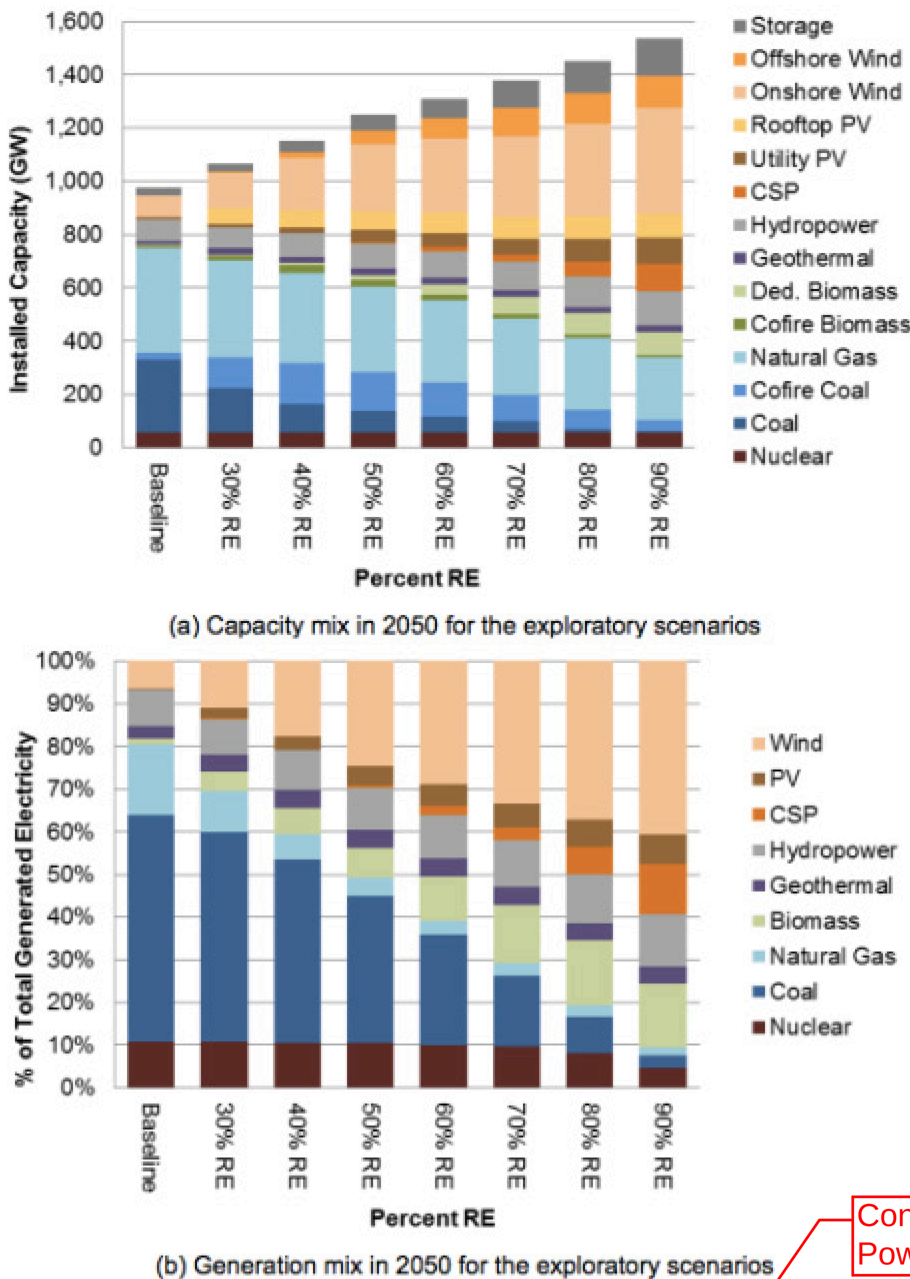
The operator must also consider transmission and distribution equipment limits. During hot days, transmission lines must carry lower currents. Sometimes loads are too high in a small area. High demand can cause local congestion. If too much demand is placed on a transmission line, power must be routed another way. Power professionals use tools to analyze the effects of demand variation on generation and transmission to plan power system needs.

Men and Women at Work: NREL Used Tools and Techniques Used for Conventional Systems

In the study noted above, NREL used software programs to consider renewables in the US over a range of future scenarios, including from 30% to 90% renewables, with variations in assumed technology improvement, future electricity demand, and fossil fuel cost. One tool was used to considered generation and load matching. A different tool was used to look at transmission lines to study requirements needed to meet demand. Thousands of simulations were run to determine generation, demand, and transmission balance. The study was based on 2010 renewable technology and included only improvements to technologies available then. Technologies such as enhanced geothermal, ocean technology, and floating offshore wind were excluded, as were cost declines in solar and wind power. It did include an expectation of increased demand due to electric vehicles.

How Did NREL Balance Sources To Demand? The Recipe

Many people, when they think of a "renewable energy grid," they think only of sunshine and wind producing the energy, but there is much more to a renewable grid than that. A cake is not just made of sugar.



Concentrating Solar Power

Figure ES-3. Installed capacity and generation in 2050 as renewable electricity levels increase (low-demand, RE-ITI technology improvement)

The capacity and generation mix for 80% renewables by 2050 can be examined in two charts on page xxx of the study (screenshots above).

The generation mix shows 38% wind, 6% PV, and 6% CSP in the generation mix, neatly dividing electricity generation at about 50% variable renewables. Hydropower and biomass each make up about

15%, comprising about 30% dispatchable renewables. The remaining 20% generation is conventional. Only a small percentage of storage is included.

Of course, at any given time, the amounts of each source may vary, and the total capacity exceeds demand all of the time, with some in reserve.

With 50% from variable renewables, 30% dispatchable renewables, about 10% storage, and considering that some capacity is always in reserve, it is much easier to see why variable renewables can be integrated successfully.

What those numbers don't show is how geographic dispersal, new system operations like Energy Imbalance Markets, transmission between regions, and demand response ease demand balancing. Those effects are baked into the simulations. The results show that variable renewables like wind and solar are not the only sources of renewable energy, and that storage is only a small fraction of total capacity.

Page xxxvi, Figure ES-6, shows an hourly dispatch curve, to give an example of the lowest coincident load and summer peak load responses, giving an idea of how they could be met. The study itself consists of many simulations of years of load data and generation mixes.

Particular attention was concentrated on the results of the 80% scenario. The US was divided into regions with results detailed for each. Some regions achieved higher integration and others less, while the balance of the US composite was 80% renewables.

Different Recipes for Different Folks

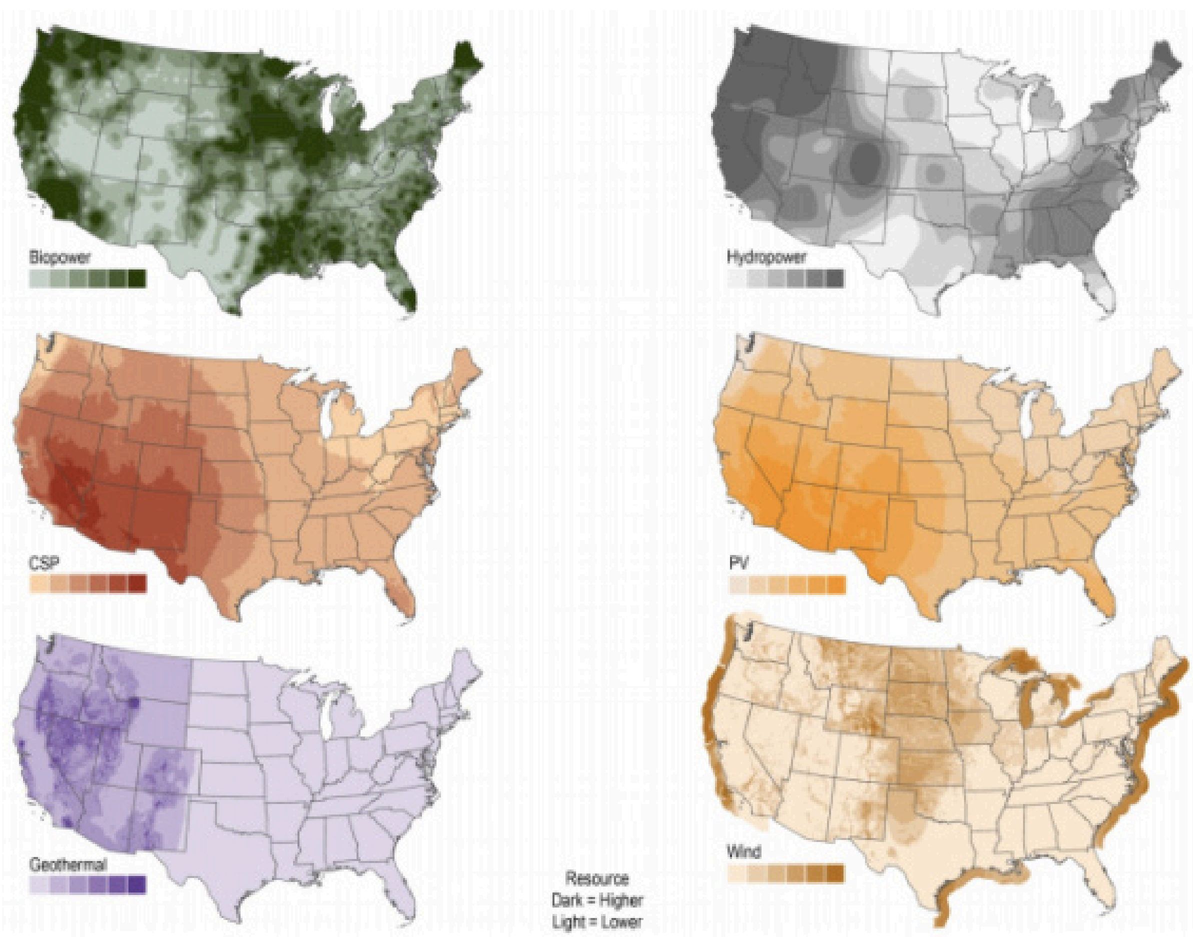


Figure ES-2. Geographic distribution of renewable resources in the contiguous United States

The United States has potential ocean energy and enhanced geothermal resources; however, these technologies were not modeled and therefore the resource potential is not included in this figure.

You can get a general sense of the regions' diverse renewable energy potential from the maps on page xxv (screenshot seen above). On page xxxii, you can examine the graphs of each region to understand the amounts of renewable energy for each region under an 80% renewable scenario.

As an example, the Pacific Northwest (PNW) achieved higher renewables integration than other regions. That area has abundant hydro and wind resources, and relatively low demand, so it's presumed Paul Bunyan can send a little excess energy to Pecos Bill. Currently, there are also plans to transmit large amounts of wind energy from the Midwest to the East Coast and other regions.

In the end, the study concluded that ***80% renewables by 2050 could be achieved and would be robust against constraints in transmission, flexibility, and resources***. "Multiple technology pathways exist to achieve a high renewable electricity future. Assumed constraints, which limit power system infrastructure, grid flexibility, or the use of particular types of resources can be compensated through the use of other resources, technologies, and approaches." Even under the high-demand scenario, demand was met by supply.

Here's more from NREL's Renewable Futures Study:

- Renewable electricity generation from technologies that are commercially available today, in combination with a more flexible electric system, is more than adequate to supply 80% of total U.S. electricity generation in 2050 while meeting electricity demand on an hourly basis in every region of the country.
- Increased electric system flexibility, needed to enable electricity supply and demand balance with high levels of renewable generation, can come from a portfolio of supply- and demand-side options, including flexible conventional generation, grid storage, new transmission, more responsive loads, and changes in power system operations.
- The abundance and diversity of U.S. renewable energy resources can support multiple combinations of renewable technologies that result in deep reductions in electric sector greenhouse gas emissions and water use.
- The direct incremental cost associated with high renewable generation is comparable to published cost estimates of other clean energy scenarios. Improvement in the cost and performance of renewable technologies is the most impactful lever for reducing this incremental cost.