Factsheet: Renewable Electricity Futures

In the summer of 2012 the National Renewable Energy Laboratory (NREL) published Renewable Electricity Futures Study,[i] an investigation of the extent to which renewable energy supply can meet the electricity demand of the United States, excluding Alaska and Hawaii, by 2050. The authors compared various renewable integration scenarios from 30% to 90%, with a focus on 80%, and specifically analyzed the technical implications to the U.S. electricity system with increasing levels of renewable energy.

The final report was published in four volumes:

- **Volume 1:** Executive Summary, and Exploration of High-Penetration Renewable Electricity Futures
- **Volume 2:** Renewable Electricity Generation and Storage Technologies
- **Volume 3**: End-Use Electricity Demand
- **Volume 4:** Bulk Electric Power Systems: Operations and Transmission Planning

*"While this analysis suggests such a high renewable generation future is possible, **a transformation of the electricity system would need to occur** to make this future a reality. This transformation, involving every element of the grid, from system planning through operation, would need to ensure adequate planning and operating reserves, increased flexibility of the electric system, and expanded multi-state transmission infrastructure, and would likely rely on the development and adoption of technology advances, new operating procedures, evolved business models, and new market rules." (pg xvii, http://www.nrel.gov/docs/fy12osti/52409-1.pdf, emphasis added)*

METHODOLOGY

In order to study the impacts of greater renewable energy generation across the United States, the study authors developed more than two dozen scenarios, which can be grouped into the following categories: a low-demand, baseline scenario; exploratory scenarios, which look at varying levels of renewable energy integration from 30% to 90%; the core 80% renewable energy scenarios; and analyzed the impact of various fossil fuel cost assumptions and higher levels of electricity demand. Figure 1 is a diagram from the report showing these various scenarios.

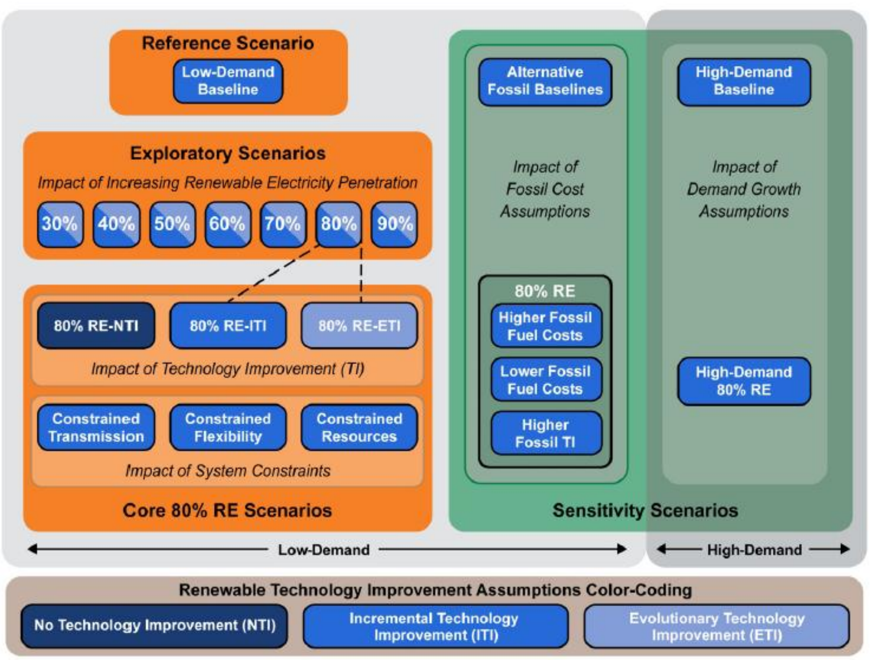

Figure 1: Modeling scenario framework for RE Futures. (Figure ES-1, (pg xxii))

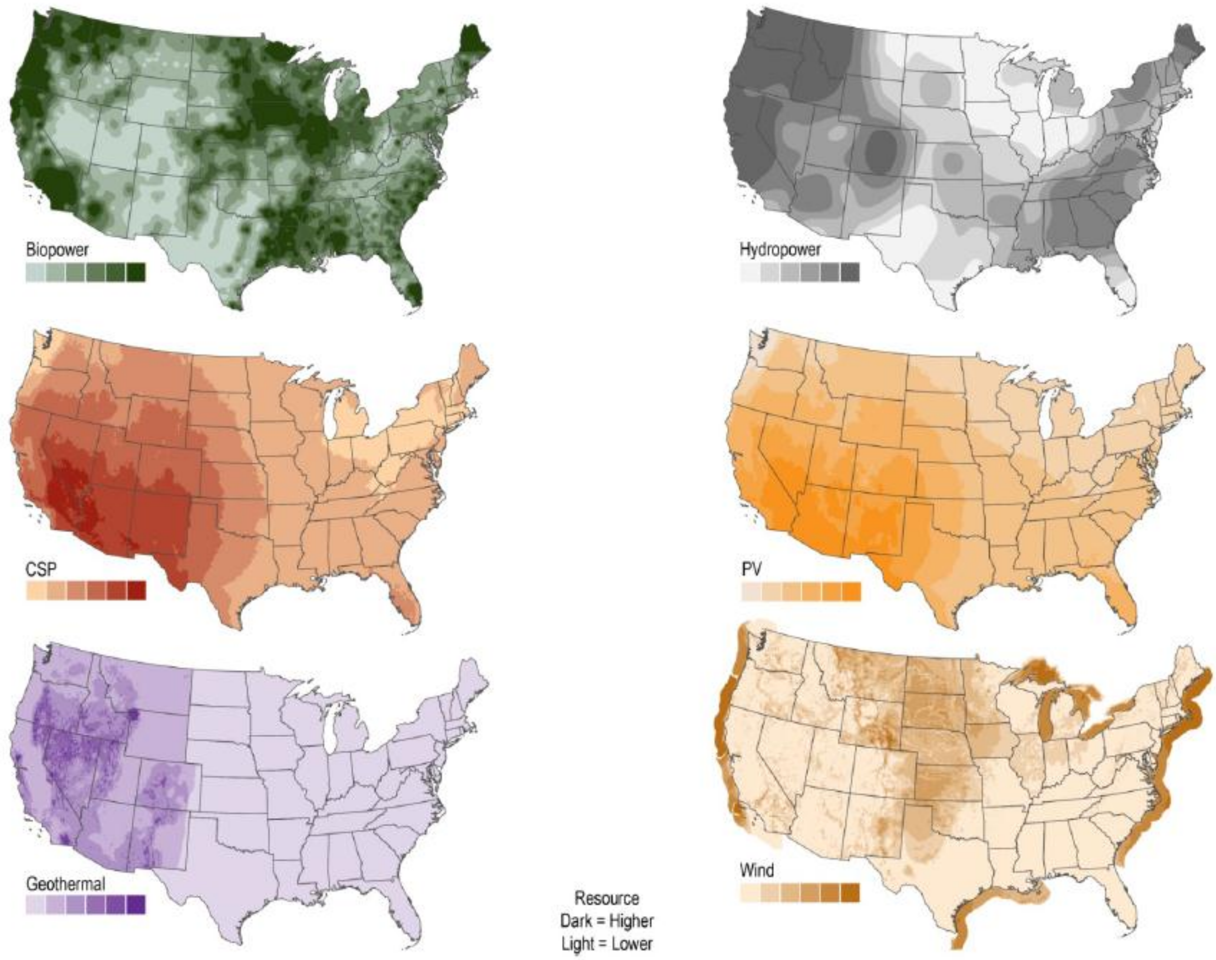

Figure 2: Geographic distribution of renewable resources in the contiguous United States. (Figure ES-2 (pg xxv))

For each scenario, the report authors included a consideration of a variety of factors, all of which can have an impact on the overall electricity grid operations in the U.S., and can have particular impacts with high levels of renewable energy generation:

Energy Efficiency: Energy efficiency was assumed to be present at levels sufficient to keep demand flat in most scenarios over the 40-year study period.

Transportation: The study assumes some shift from petroleum towards electricity as a transportation fuel.

Grid Flexibility: The study assumes improvements are made in this area so that the integration of high levels of renewable energy is more efficient. The study concludes that grid flexibility is a central requirement for a system with high levels of renewable energy generation. Energy storage and load shifting also play key roles in system flexibility, especially at higher levels of renewables.

Transmission: The study assumes that expansion of the existing high-voltage transmission lines would be necessary to connect renewable energy generation sources to load centers. Distribution-level upgrades were not considered in this study; however given the typical installation of distributed solar PV on homes and buildings in many locations, these distribution-level upgrades can be expected to be necessary as well.

Siting and Permitting: This study was not intended to take on the difficult and often charged debates surrounding the permitting and siting of renewable energy technology, in particular wind energy. Since this report focuses on the technical requirements for high renewable energy generation, it is assumed that unless otherwise excluded by land use requirements, renewables are allowed.

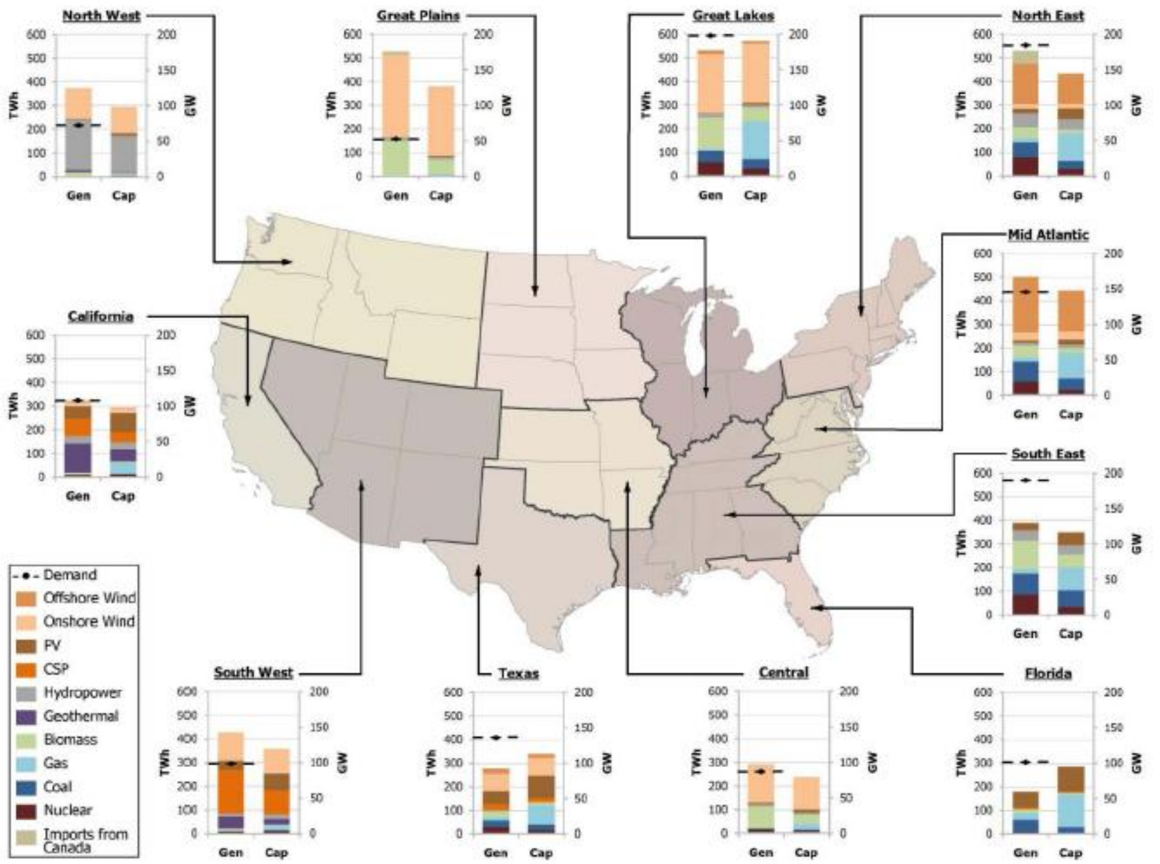

Figure 2: Renewable generation and capacity in 2050 by region under 80% RE-ITI scenario (low demand, Incremental technology improvement). (Figure ES-4 (pg xxxii))

In order to accurately model the integration of up to 90% renewable energy generation, the report authors had to characterize the various available renewable resources across the country. The study considers commercially available biogas, geothermal, hydropower, solar PV, concentrating solar power (CSP), and wind energy technologies in this characterization. The report authors did not perform a new analysis of the resource potentials, rather they gathered existing information from recent reports. The potentials for each technology shown in Figure 2 are based on historical climate patterns. Report authors found “the aggregate renewable generation resource is many times greater than current electricity demand”.[ii]

Once the quality and availability of renewable resources were defined, the authors utilized two models to characterize the U.S. grid operations under the various scenarios described above. The primary model, which served as the backbone to the study was the NREL Regional Energy Deployment System (ReEDS) model. This model allowed the authors to determine whether the available renewable resources, spread out across the contiguous 48 states, would be adequate to meet future electricity demand. The authors also used the ABB model, GridView, which looks more closely at the electricity grid, and allowed the authors to determine what, if any, impacts to the operation of the grid would result from greater levels of wind and solar PV, which are variable generation sources by nature.

MAIN FINDINGS

- **There is adequate renewable energy resource potential available** and every region of the U.S. would play a role in this transition. Figure 3 shows the regional breakdown by renewable technology under the 80% "low-demand" scenario.
- **Using technology that is already commercially available,** it is possible to achieve as much as 80% renewable energy generation.
- **There are multiple ways to use avaialble technology** in order to achieve a high-renewable electricity future. For instance, energy storage, demand dispatch, and load shifting can all be used in varying amounts to better utilize wind and solar power when it is available and to potentially reduce the generation capacity needed. The energy storage technologies included in this study are pumped hydro energy storage, compressed air energy storage, and batteries. (pg 1-30)
- **The amount of renewable energy added each year to achieve 80% renewables by 2050 can be met by today's existing global production capacity**, but the amount added each year would be much higher than recent additions in the U.S. For instance, in the core 80% scenarios, the study authors estimate it would take two to six times the the annual renewable energy capacity added in 2010 and 2011.
- **There were no insurmountable obstacles in "manufacturing capacity, materials supply, or labor availability."** In other words, we already have the factories, the stuff, and the people to make all the renewable technology we need for 80% renewable energy by 2050.
- **There was a corresponding decrease in direct greenhouse gas emissions** with increasing levels of renewable energy development.

"Reductions in fossil energy consumption will have environmental implications beyond air emissions, including implications related to water quality, terrestrial and marine contamination, and waste disposal, not only associated with electricity generation facilities but also for activities related to fuel extraction and transportation. Further, air emissions reductions will have implications for human health and climate change." (pg xliv)

MAJOR CONCLUSIONS

- **In order to accommodate higher levels of renewable energy, more flexibility is needed in the electricity system.** This includes use of energy storage and demand-side management to better combine variable generation sources with demand.

- **Additional transmission will be required to move renewable energy generation to the load centers.** Figure 4 shows that a large portion of this additional transmission is in the central portion of the country, though a significant amount of capacity additions are also shown in the mid-Atlantic region.

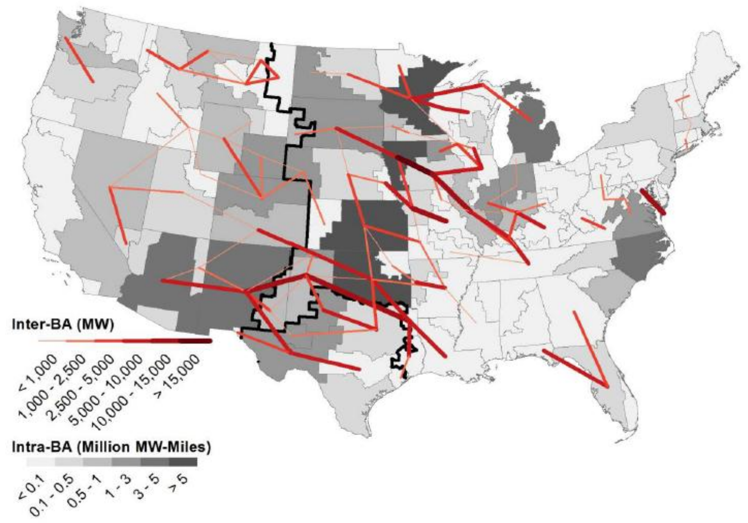

Figure 3: New transmission capacity additions and conceptual location in the 80% RE-ITI scenario (Figure ES-9 (pg xlii))

- **The costs of electricity with 80% renewable energy generation are within the ranges provided by other clean energy scenarios.** Figure 5 compares the cost estimates from similar studies by the Environmental Protection Agency and the Energy Information Administration.

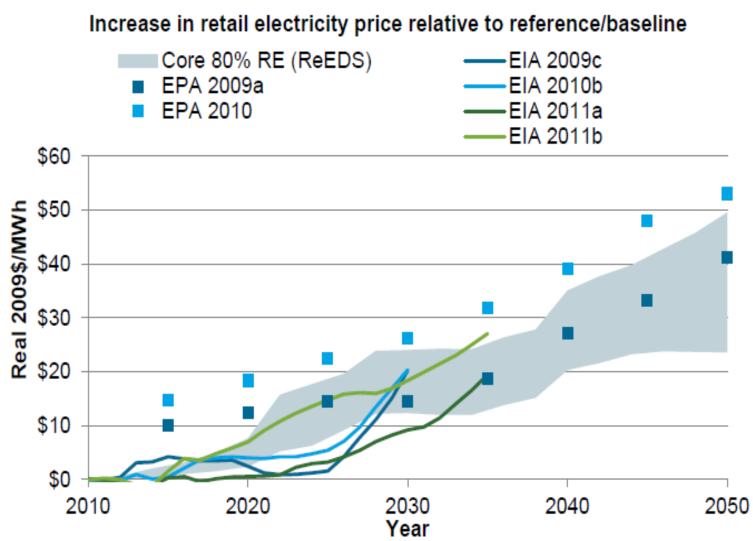

Figure 4: Average increase in retail electricity rates relative to study-specific reference/baseline scenarios (Figure ES-10 (pg xliii))

- **There remain areas where further research is needed.** Issues surrounding the power system's reliability and a greater understanding of the obstacles associated with integrating higher levels of renewables need further investigation. Similarly, a comprehensive cost-benefit analysis on the larger economic and environmental implications of high levels of renewable energy generation would expand the discussion to include the many broad benefits of reducing fossil fuel consumption.

WHAT DOES THIS MEAN FOR A RENEWABLE MARYLAND?

Maryland can and will play a role in a U.S. electricity future with significant renewable energy integration. The findings and conclusions in this study also support existing Maryland policies for reducing greenhouse gases and increasing renewable energy and energy efficiency across the state, and provide evidence that there is room to strengthen these policies.[iii]

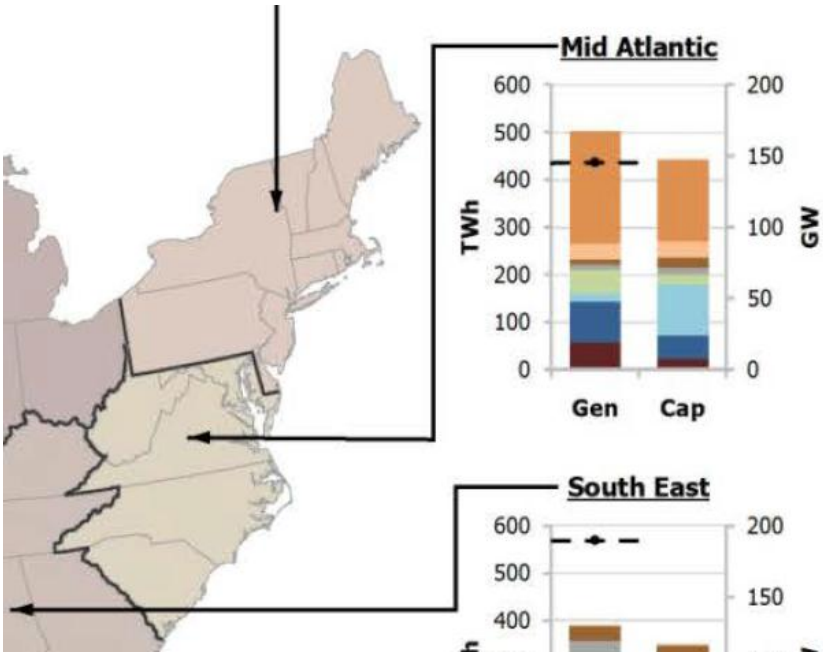

Figure 5: Close up of mid-Atlantic region from map in Figure 3 above. Data shows both the projected generation mix and capacity mix of various technologies by 2050. The large dark orange bar indicates offshore wind, the leading contributor of renewable energy technology for this region.

Comprehensive analyses like the NREL *Renewable Electricity Futures Study* highlight the importance and potential for greater results by working with a broad range of sectors and incorporating a variety of concerns. In order for Maryland to successfully transform its electricity system to a fully renewable one, it will take cooperation and agreement among those currently working for a cleaner and more sustainable future.

While this national-level study and a state-specific Renewable Maryland study can help illustrate the potential for renewables and the areas where greater improvements are needed, there are elements of any complex system that cannot be fully understood or accurately analyzed until implemented. Someone has to take the first step to start uncovering these only-in-the-real-world issues. Maryland has made great strides in supporting greater renewable energy generation, and is poised to take on this leadership role.

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Notes:

[i] *Renewable Electricity Futures Study (Entire Report)*:
National Renewable Energy Laboratory. (2012). *Renewable Electricity Futures Study*. M.M. Hand, S. Baldwin, E. DeMeo, J.M. Reilly, T. Mai, D. Arent, G. Porro, M. Meshek, D. Sandor, eds. 4 vols. (NREL/TP-6A20-52409). Golden, CO: National Renewable Energy Laboratory. http://www.nrel.gov/analysis/re_futures. All page citations refer to Volume 1 of this study, unless otherwise noted.

[ii] Executive summary page xxv footnote 20

[iii] Maryland has a Renewable Portfolio Standard of 20% electricity generation by 2022 and is required to reduce greenhouse gas emissions 25% by 2020, relative to a 2006 baseline emissions level. For more information about these and other state-wide energy policies, see: http://energy.maryland.gov/mdGoals.html.