**Wholesale Electricity Prices in a High Renewable Energy and Natural Gas Future**

Wesley Cole, National Renewable Energy Laboratory, 720-391-4897, Wesley.Cole@nrel.gov

Bethany Frew, National Renewable Energy Laboratory, 303-275-3819, Bethany.Frew@nrel.gov

Nina Vincent, National Renewable Energy Laboratory, 303-275-4329, Nina.Vincent@nrel.gov

Trieu Mai, National Renewable Energy Laboratory, 720-440-4456, Trieu.Mai@nrel.gov

## Overview

The U.S. electricity system is expected to continue to experience rapid change, with most business-as-usual projections showing a future grid mix that is dominated by natural gas and renewable energy (Cole et al. 2017; EIA 2018). This growth in natural gas and renewable energy (primarly wind and photovoltaics (PV)) is driven by the sustained low cost of natural gas (EIA 2018) and the declining cost of wind and PV (NREL 2017). In a future with relatively low natural gas prices and a large share of resources with no marginal cost of generation, the wholesale electricity prices are likely to be significantly different than today’s prices on an annual, seasonal, and diurnal basis. Additionally, capacity prices also have the potential to evolve given that net peak demand for electricity (i.e., demand minus variable renewable energy production) could shift from afternoons to evenings or from summer to winter, and that battery storage has the pontential to outcompete other resources for meeting capacity needs. In this work we explore these future pricing trends among a range of forward-looking scenarios in order to understand what factors might affect the electricity prices of the future grid.

## Methods

This work relies on two power sector models: the Regional Energy Deployment System (ReEDS) model and the PLEXOS model. ReEDS is a least-cost optimization model that assesses the deployment and operation (including transmission) of the electricity sector of the contiguous United States through 2050. It has the ability to model the integration of renewable energy technologies into the grid. ReEDS captures renewable energy resources through the use of 356 individual resource regions and 134 balancing areas across the U.S. and is able to handle renewable energy issues such as variability in wind and solar output, transmission costs and constraints, and ancillary services requirements.(Eurek et al. 2016). PLEXOS is a commercial production cost model developed by Energy Exemplar capable of doing high-resolution unit commitment and economic dispatch (Energy Exemplar 2017). In this work we use the ReEDS model to develop a suite of scenarios that show how the grid might evolve under various sensitivities including natural gas prices, renewable energy costs, demand growth, retirements, and policy considerations. Given the capacity expansion nature of the ReEDS model, we use it to provide the capacity prices from the various scenarios for the different regions across the country. We then translate the 2050 ReEDS grid mix (both generation and transmission) into the PLEXOS production cost model, where we use PLEXOS to do hourly unit commitment and economic dispatch. We rely on the PLEXOS outputs to produce hourly timeseries of representative energy and ancillary service prices.

## Results

The ReEDS model shows that capacity prices are lower in the near-term due to the current general over-capacity situation that exists in the U.S. Once reserve margins stabilize near the NERC-recommended reserve margin levels (NERC 2017), the long-term capacity values are fairly steady and largely set by the cost of building new natural gas combustion turbines or battery storage. Energy and ancillary service prices vary more considerably, especially across scenarios. Energy and ancillary service prices depend on natural gas prices, wind and solar penetration levels, retirements, and regional load profiles. In this work we will specifically quantify these trends and show how they change on a annual, seasonal, and diurnal basis across scenarios.

## Conclusions

Energy and capacity prices are metrics for a given power system; however, little work has been done to examine how these metrics might change in future grid mixes. By coupling a production cost model with a capacity expansion model, this work finds that energy prices, and to a lesser extent capacity prices can be highly dependent on the evolution of the power system. Understanding the trends and implications of these electricity prices can help system planners, policymakers, and other power sector stakeholders make better decisions in shaping the future electricity system.

## References

Cole, Wesley, Trieu Mai, Paul Donohoo-Vallett, James Richards, and Paritosh Das. 2017. “2017 Standard Scenarios Report: A U.S. Electricity Sector Outlook.” Technical Report NREL/TP-6A20-68548. Golden, CO: National Renewable Energy Laboratory. https://www.nrel.gov/docs/fy18osti/68548.pdf.

EIA. 2018. “Annual Energy Outlook 2018.” DOE/EIA-0383(2017). Washington, D.C.: U.S. DOE Energy Information Administration. https://www.eia.gov/outlooks/aeo/pdf/AEO2018.pdf.

Energy Exemplar. 2017. “PLEXOS Integrated Energy Model.” 2017. https://energyexemplar.com/.

Eurek, Kelly, Wesley Cole, David Bielen, Stuart Cohen, Bethany Frew, Jonathan Ho, Venkat Krishnan, Trieu Mai, and Daniel Steinberg. 2016. “Regional Energy Deployment System (ReEDS) Model Documentation: Version 2016.” NREL/TP-6A20-67067. Golden, CO: National Renewable Energy Laboratory. http://www.nrel.gov/docs/fy17osti/67067.pdf.

NERC. 2017. “2017 Summer Reliability Assessment.” http://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/2017%20Summer%20Assessment.pdf.

NREL. 2017. “2017 Annual Technology Baseline.” Golden, CO: National Renewable Energy Laboratory. http://www.nrel.gov/analysis/data\_tech\_baseline.html.