The WIS:dom Optimization Model

The flagship energy grid model of Vibrant Clean Energy, LLC

The WIS:dom (Weather-Informed energy Systems: for design, operations and markets) optimization model is the state-of-the-art energy model developed by Vibrant Clean Energy, LLC (VCE). It is the first commercial co-optimization model of energy grids that was built from the ground up to incorporate vast volumes of data; starting with high-resolution weather and demand data.

WIS:dom simultaneously co-optimizes the capacity expansion requirements (generation, transmission, and storage) and the dispatch requirements (production cost, power flow, reserves, ramping, and reliability) for the entire electric (energy) grid of interest. Not only does WIS:dom co-optimize these critically linked properties, it was developed from the ground up to work with "big data". The model can determine the cost/benefit ratios for new HVDC transmission lines, compared with other technologies. It can also determine the risk and rewards from retiring existing generators for the topology of the transmission infrastructure; simultaneously to determining how more variable generation is deployed to replace them.

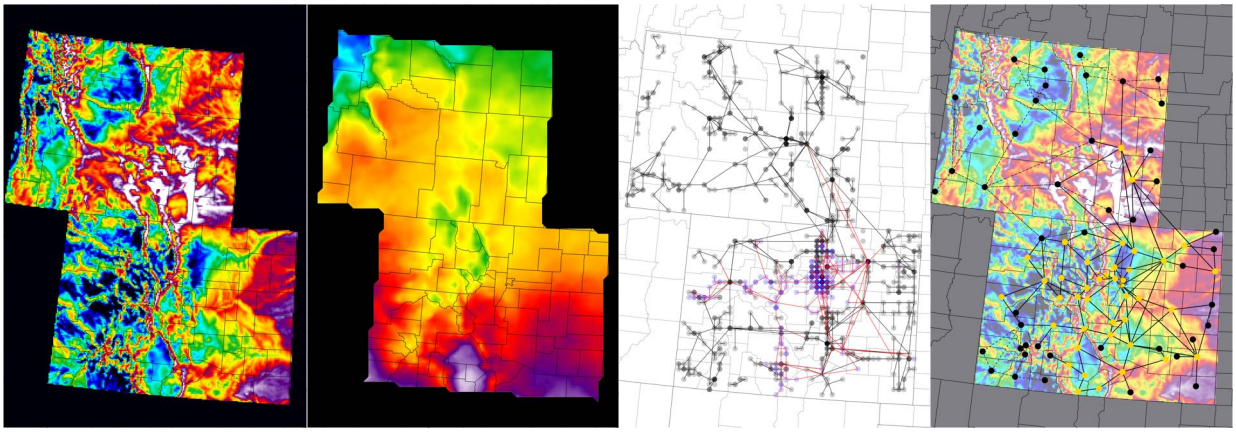
WIS:dom utilizes high-resolution (spatially and temporally) weather data to determine resource properties over vast spatial-temporal horizons. Thus, WIS:dom can be used on scales as small as campuses, cities, counties or states/provinces; but uniquely can also be used for sovereign entities and continents. Moreover, these scales can be nested, allowing high-fidelity local modeling accompanied with lower-fidelity larger areas to create feedbacks within the model that simulate outside influences on local markets.

The model relies on publically available data where possible, and contains default values for generators, transmission, storage, production cost and resource siting. However, WIS:dom was designed from the beginning to allow "plug-and-play" capability, whereby it can take advantage of customized datasets required for detailed modeling of specific questions, markets or balancing areas. For example, higher-resolution weather data over a utility or ISO; or proprietary heat rates for generators within a utility.

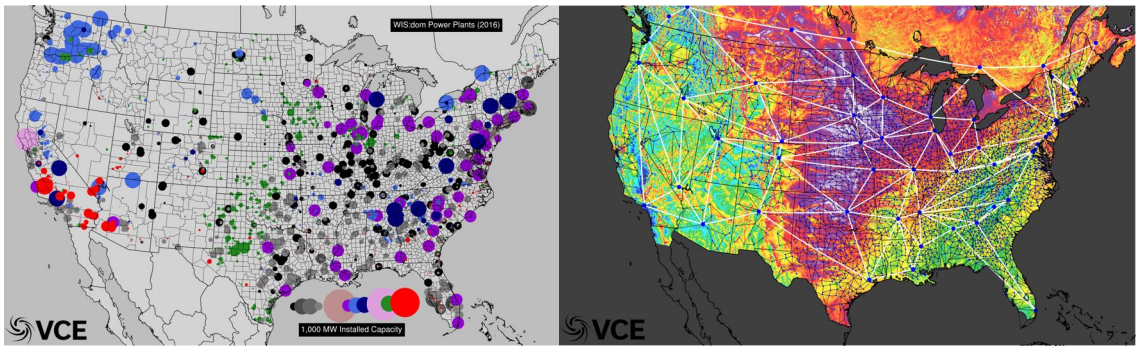
The modeling framework is unique and consistent across various scales facilitating more transparent analysis between results derived. With WIS:dom new opportunities are identified due to the co-optimization detecting patterns ignored by other modeling endeavors.

The WIS:dom optimization model allows datasets to be added for specific local interests. For example, WIS:dom can be deployed for any country or continent around the globe. The model requires the local datasets (or uses the default global one) and then can study various questions of interest – such as greenhouse gas emission, HVDC transmission links, variable generation and reliability, water consumption, air pollution, electric vehicle penetrations, electric heating, jobs and tax revenues, and more.

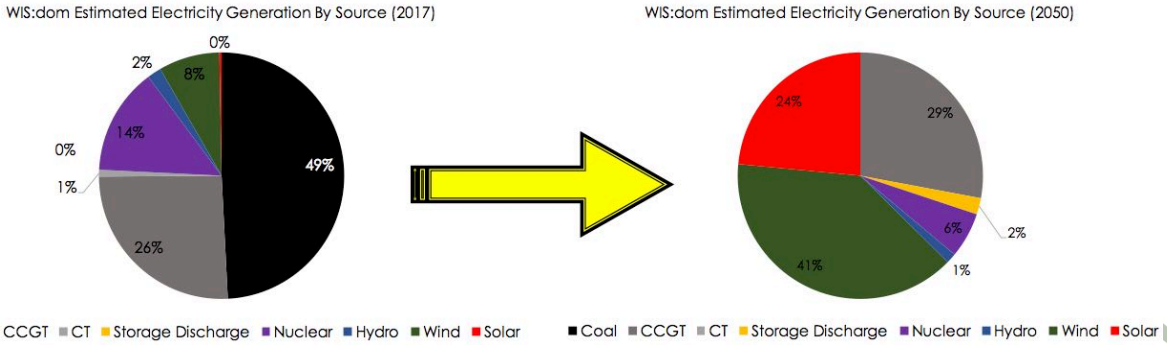
Example Data / Graphics from WIS:dom



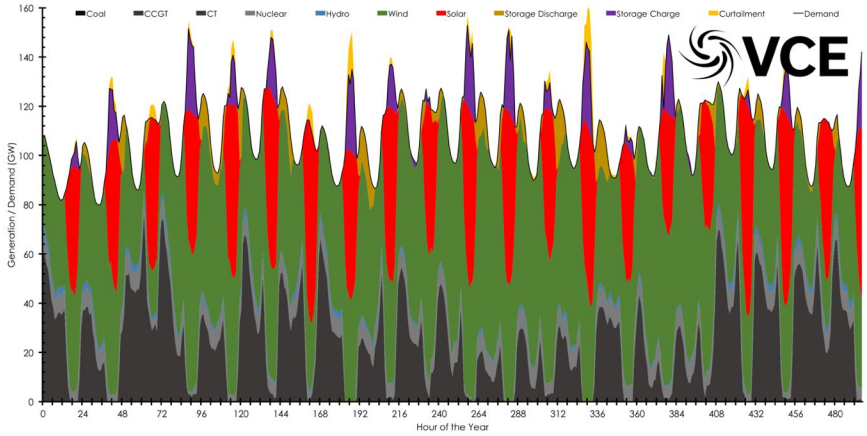
Example WIS:dom representation of Wind Resource (Far Left), Solar Resource (Left Center), AC Transmission Representation (Right Center) for Colorado and Wyoming and reduced form transmission for CO/WY with wind capacity factor (Far Right).



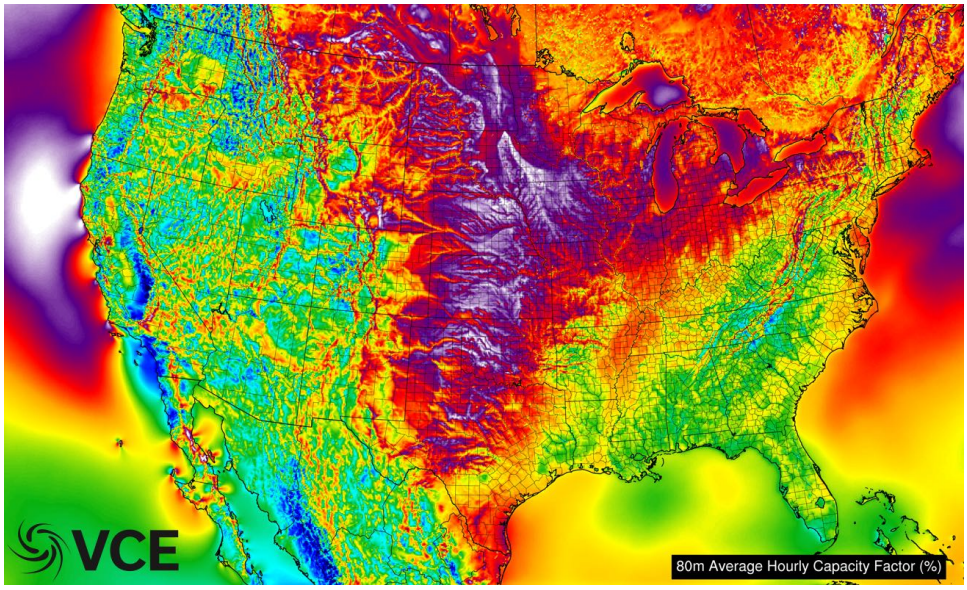
Example of a WIS:dom solution for a national US electric system. The system is the least-cost system without a price on carbon. Generator siting is determined (left) as well as the HVDC transmission corridors (right) simultaneously with the dispatch of generation, transmission, storage, and demand.



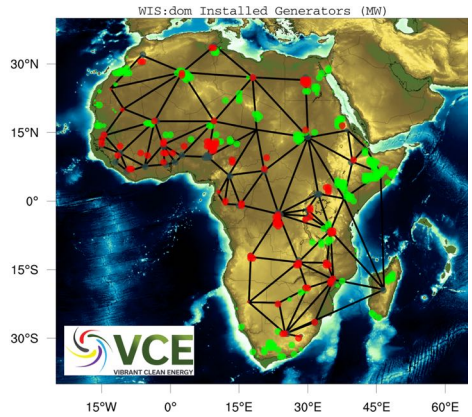
WIS:dom can provide various pathways and portraits for deep decarbonization of energy systems. The above example, shows how WIS:dom modeled the decarbonization of the MISO electric grid from 2016 (left) to 2050 (right). The resulting mix of generation reduced GHG emissions by 80%. The model managed the retirement of the entire coal fleet simultaneously with a change to 65% of generation coming from variable generation, while load was growing at 0.7% per annum.

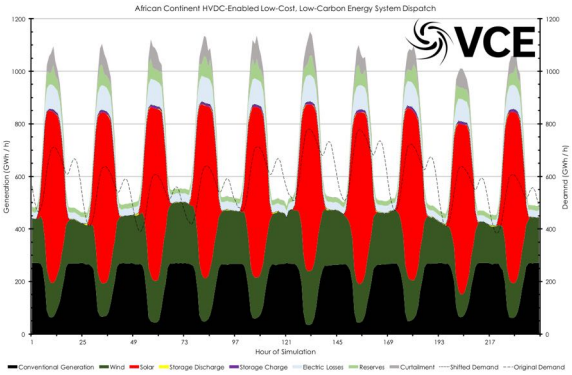


The dispatch of an 80% decarbonized MISO electric grid using the WIS:dom optimization model scenario. It shows the flexibility of the system when integrating renewables and storage, when transmission assets are considered alongside.



Long-term high-resolution (both spatially and temporally) allow for accurate modeling of the variable generation possible for electricity. They are the backbone of the resource for wind and solar generation. At VCE, LLC, we have 5 years of 3-km USA, 10 years of 13-km North America, and [up to] 25 years of 0.5° global weather data. Here we show the 3-km wind power average capacity factor. We also have similar images for solar PV and CSP.





The WIS:dom optimization model was not just developed for deployment in the United States. It was designed from the ground up to be able to optimize for any domain, given the correct datasets. In the example here, we show the African HVDC-enabled solution for low-cost, low-carbon energy for 2050. WIS:dom describes the dispatch of the system each hour for an entire year, while co-optimizing generation, transmission, storage and demand management expansion for the whole continent.