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# The WIS:dom<sup>®</sup> Model

| Detailed Capacity Expansion & Production Cost Modeling

**FIRSTLY**

# Thank You

**FOR CONSIDERING US!**

Here at Vibrant Clean Energy, LLC we are dedicated to providing all our clients with the best quality experience possible. We listen to each of our client's needs and goals to produce an individual proposal specifically for them to achieve their deliverables. Our modeling system (WIS:dom®) is incredibly flexible and customizable so that it can be adapted for every client's particular needs.

We have secondary product lines that feed into WIS:dom®, such as weather and power data, climate estimates, input datasets for all generation and transmission, distributed generation siting and estimations, forecasting tools, and quarterly status reports of the US electricity system. These secondary products could help clients when they do not require a full optimized simulation of the electricity system.

Our team is highly qualified in the fields of energy modeling, weather, mathematics, economics, electricity markets and computer optimization. Further, they are accomplished at producing technical and summary reports as well as professional presentations to distill the results for the client's diverse audiences. We work synergistically combining our expertise to produce the very best outcomes for our clients.

**Dr Christopher Clack**

CEO

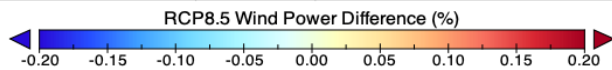
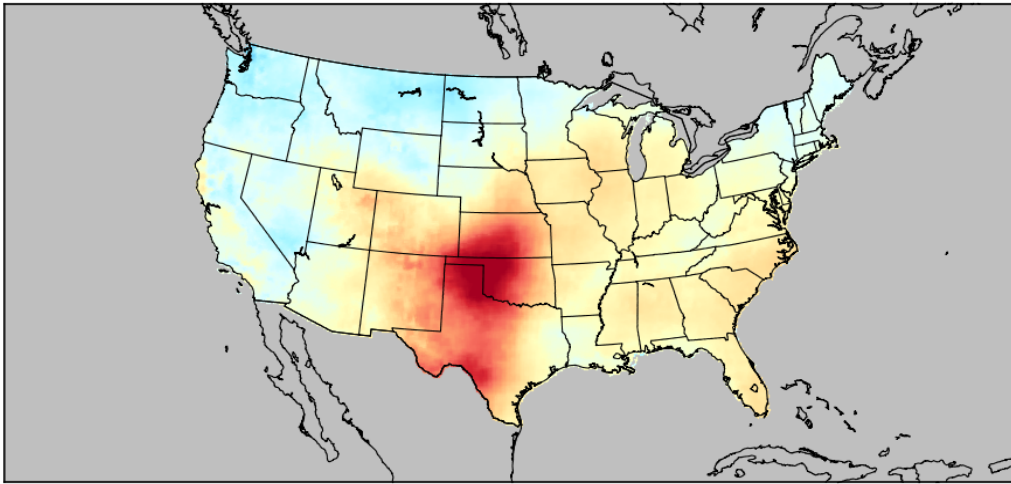
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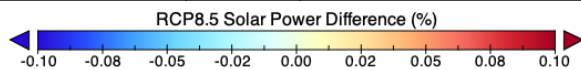
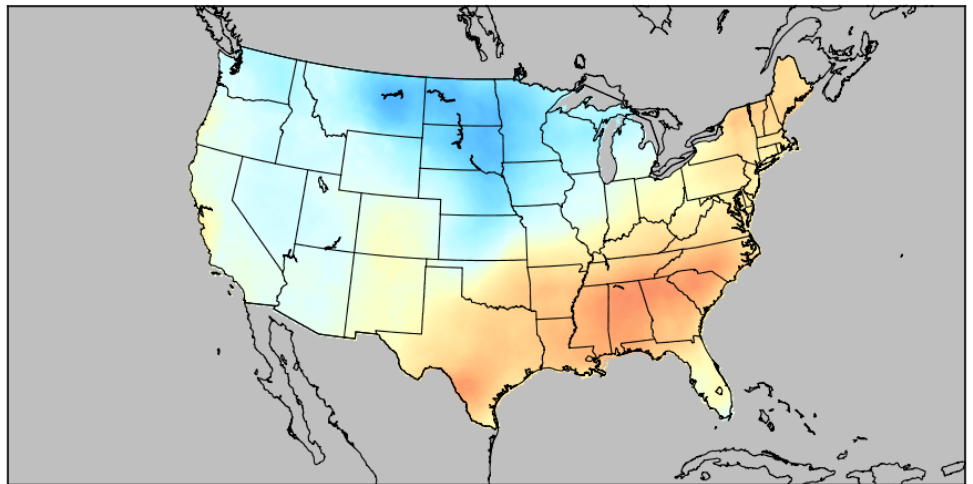
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Wind Power Change From 2014 Weather Year (RCP8.5)  
IPCC CMIP5



Solar Power Change From 2014 Weather Year (RCP8.5)  
IPCC CMIP5



# WE BUILD --- The Future

Our main mission at VCE® is to help create a clean energy future that is reliable, robust, resilient, and low-cost compared with alternatives.

# 1 | Our Story

## ... So Far

Vibrant Clean Energy, LLC (VCE®) is a Colorado company that has positioned itself as a world-class provider of renewable energy assessment and energy optimization studies. VCE®, since its beginnings, has focused on providing the analytical underpinning for the energy transition underway across the world. The team at VCE® have provided support to the private and public sectors enabling more intelligent implementation of energy resources onto the electricity grid.

The primary mission of VCE® is to provide clients with the least-cost pathways to fulfill their particular needs. The least-cost pathways can be benchmarked against sensitivities to assess the impacts of alternative options. VCE® has expertise on Renewable Energy (RE), Energy Efficiency (EE), electric/thermal energy storage, system integration, High-Voltage Transmission, Electric Vehicles (EVs), sector electrification, natural gas markets, economics, software development, policies and regulations, and big-data analytics.

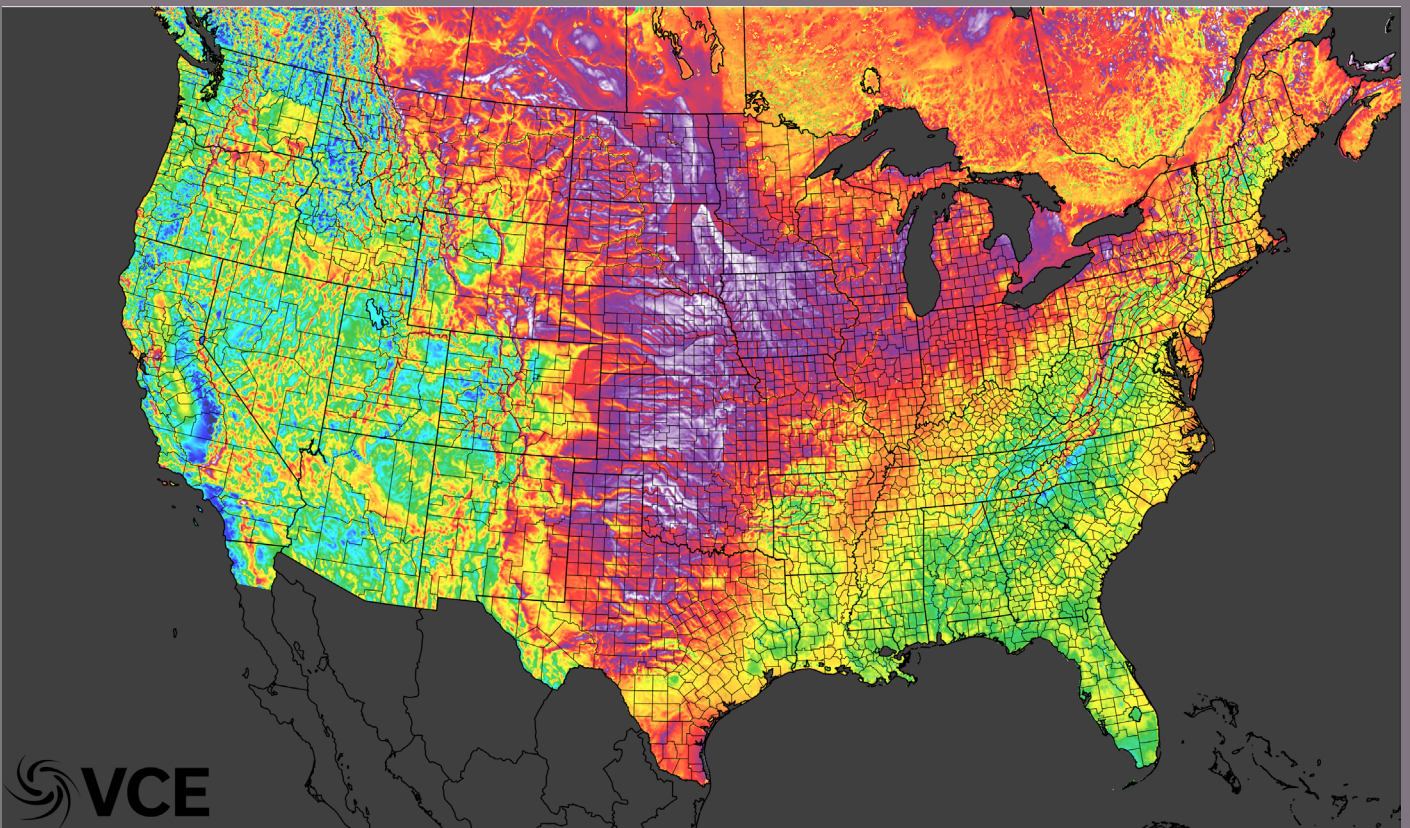
VCE® is led by founder and CEO Dr

Christopher T M Clack, who has a background in mathematics, statistics and renewable energy modeling. He has been building energy grid integration models for the past half-decade with a strong interest in agnostic cost co-optimization. All the models that Dr Clack has created are constructed from the ground up to incorporate high-resolution weather and load data. In a nutshell, the models are designed to deal with big data.

The flagship model is known as WIS:dom® [Weather-Informed energy Systems: for design, operation, and market optimization]. It is the successor to the C-OEM suite. It is the first, and only, commercially available combined capacity expansion and production cost model that can solve for the entire North American grid, while considering variable generation, at 5-minute 3-km resolution, transmission power flow, natural gas markets, generator physical limitations, retirements, and yearly investment periods. It, also, simultaneously solves for electricity storage cycling and planning, electric demand-side resources, sector electrification, and new fuel markets and supply.

# 2 | What is WIS:dom<sup>®</sup>?

WEATHER-INFORMED ENERGY SYSTEMS: FOR DESIGN, OPERATIONS AND MARKETS



## MODELING THE GRID IS OUR PLAYGROUND

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WIS:dom<sup>®</sup> is the core product of VCE<sup>®</sup> and it co-optimizes generation, transmission, distributed generation, storage, tempo-spatial scales to design low-cost energy systems of the future.

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# THE SOFTWARE

The WIS:dom<sup>®</sup> optimization model is a state-of-the-art energy model developed by Vibrant Clean Energy, LLC (VCE<sup>®</sup>). 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.



## High-resolution weather data

VCE<sup>®</sup> have created one of the highest spatial and temporal resolution weather and power data sets to describe variable generation within WIS:dom<sup>®</sup>.



## Co-Optimization of resources

Makes planning decisions based on production cost and future changes to demand while considering generation, storage, transmission, and distributed energy resources.



## US-wide modeling

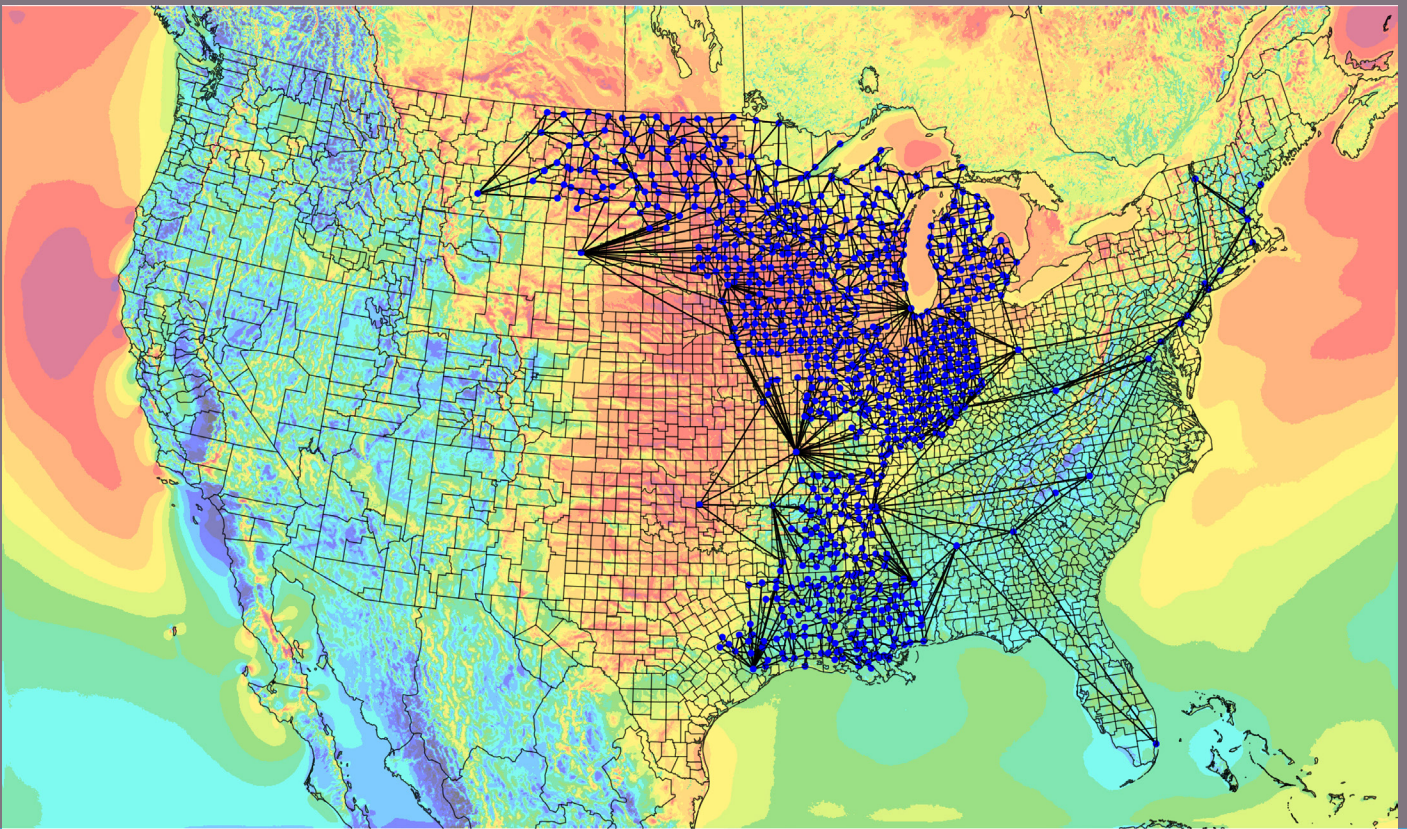
WIS:dom<sup>®</sup> is capable of scaling from any single balancing area up to a continent, while modeling all electric grid assets and transmission lines.



## Electrification of other sectors

WIS:dom<sup>®</sup> allows the user to model EVs, space heating, hydrogen production, industrial electrification and more to allow electrification of other sectors.

# 3 | Optionality in WIS:dom<sup>®</sup>



## EXPLORE YOUR MODELING OPTIONS

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WIS:dom<sup>®</sup> has been designed to be fully customizable and specified for each client's unique needs and requirements.





## RESOURCE SITING CONSTRAINTS

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- Wind and solar have a base GIS data layer for forbidden development sites;
- Conventional generation is limited to current or specified sites;
- Grid tied storage can be sited in utility or Behind the Meter;
- Distributed Energy Resources can only be sited in urban areas;
- Can model the entire US, but typically reduced to interconnect or ISO/RTO;
- Spatial constraints are applied within the gridded data to ensure no double use.



## TRANSMISSION EXPANSION CONSTRAINTS

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- Transmission upgrades can be limited by the user/client;
- Transmission and storage can be considered together as similar style assets;
- Explicit lines of interest can be included to determine the benefit/disadvantage of the lines;
- Multiple optional expansion can be offered to the model and it will determine the least-cost built out, while simultaneously considering the generation and load at dispatch intervals.



## INTER- AND INTRA-ANNUAL WEATHER DATASETS

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- A minimum of 3 years of hourly weather data is used over the domain purchased;
- The hourly data can be at 13-km or 3-km (or both, if desired);
- The hourly data can also include forecasts (2-hr, 6-hr), to assess the impact of forecast error [for real-time dispatch in WIS:dom®];
- 3-km 5-minute data is also available for the model;
- Capacity credit evaluation based upon various penetrations and weather variability;
- Available is 10 years of data, if needed for assessments. These are typically used for stochastic analysis.



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## INTERCONNECTION INFLUENCES OF EXTERNAL REGIONS

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- Model different geographic scales to determine the adjustment to client's plans based upon external influences;
- Geographic extent available: National; Eastern Interconnect, MISO, Michigan, Utility only (note other areas are available if utility is in other US regions);
- Rapid sensitivity analysis available with batch mode running optional.



## DISTRIBUTED RESOURCES AND OTHER CONSIDERATIONS

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- Electric vehicle adoption;
- Sector electrification and load shape changes;
- Residential/Commercial storage;
- Rooftop solar PV;
- Demand response/management;
- Role of charging/discharging vehicles on grid;
- Planning and following reserve requirements in a changing resource mix.



## NATURAL GAS MARKET AND INFRASTRUCTURE

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- Reduced form natural gas pipelines between the States;
- Inter-investment period elasticity for the natural gas market prices;
- Intra-annual cost curves for natural gas based on supply and demand over previous investment period and the elasticity;
- Natural gas storage and pipeline expansion co-optimized with the electricity sector.

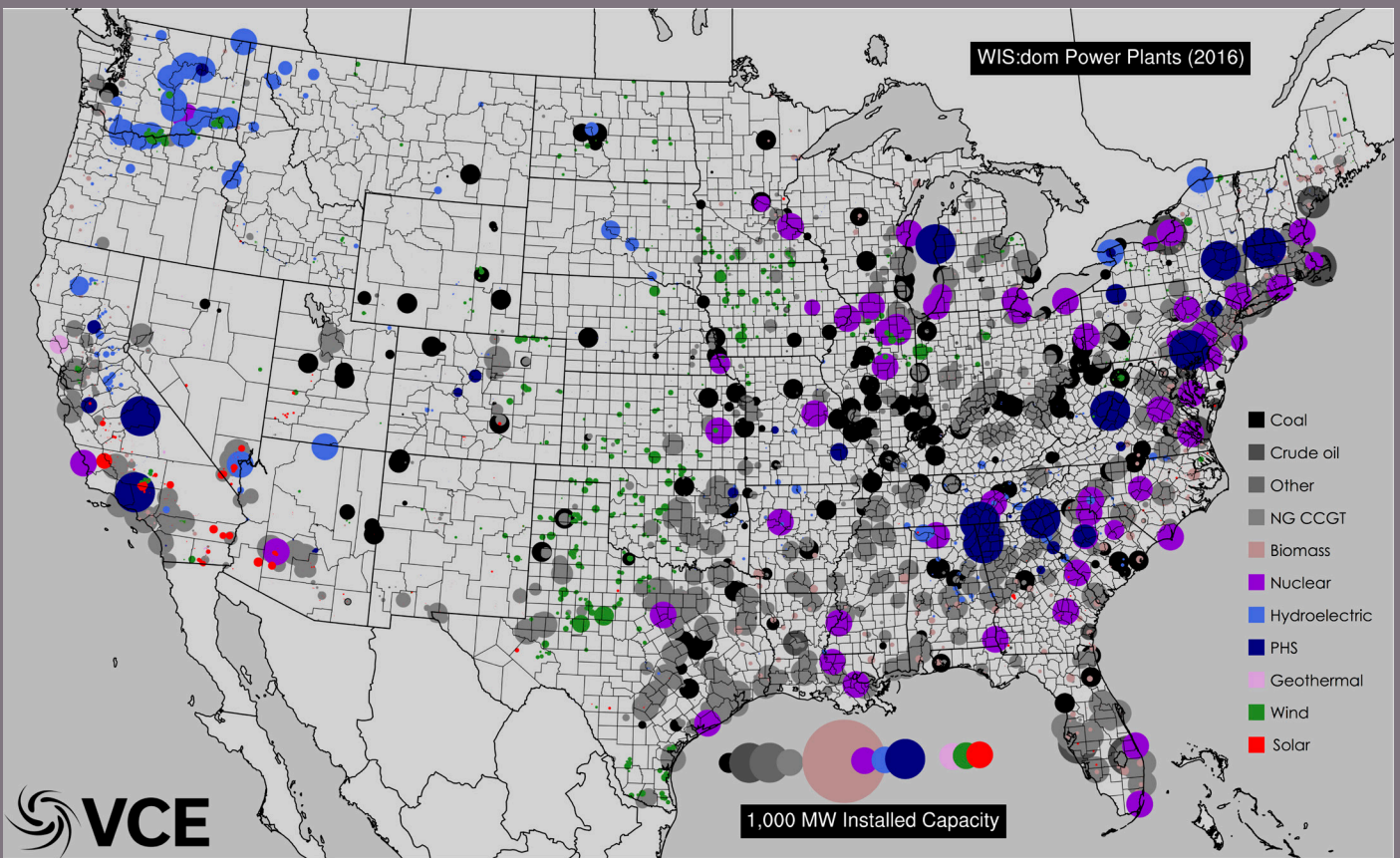


## MAIN TECHNOLOGIES AVAILABLE IN WIS:dom®

WIS:dom® includes the following possible technology options:

1. **Solar Photovoltaics**
  - a. Fixed axis,
  - b. 1-axis tracking,
  - c. 2-axis tracking,
  - d. Rooftop solar PV.
2. **Grid tied energy storage**
  - a. Li-Ion,
  - b. Flow batteries.
3. **Wind Turbines**
  - a. 80 m hub height,
  - b. 100 m hub height,
  - c. Other [120-160 m] hub heights,
  - d. Turbine designs,
  - e. Rotor diameter.
4. **Electric Vehicles**
  - a. Charging/discharging behavior,
  - b. Amount and location of EVs,
  - c. V2G, G2V, etc.
5. **Distributed Energy Resources**
  - a. Storage,
  - b. Heat pumps,
  - c. Other demand management.
6. **Large scale demand management**
7. **Novel Technologies**
  - a. Hydrogen production for seasonal storage;
  - b. Small modular reactors (SMR);
  - c. Modern salt reactors (MSR);
  - d. Carbon capture and sequestration (CCS);
  - e. Ammonia production for seasonal storage;
  - f. Synthetic fuels for circular energy economy.
8. **Climate change** is incorporated by nudging the historical weather years using CMIP5 climate data. The effected variables are wind, solar, temperature and precipitation.

# 4 | How WIS:dom<sup>®</sup> Works



## THE METHOD BEHIND OUR MODELING

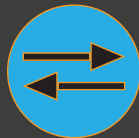
WIS:dom<sup>®</sup> is a highly detailed model that includes many aspects of the electricity grid and allows emergent behavior.

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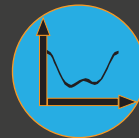
# THE METHOD



**WIS:dom<sup>®</sup>** relentlessly seeks the least-cost solution pathway for the electricity system



**Solves capacity expansion while co-simulating dispatch, transmission and storage expansion**



**WIS:dom<sup>®</sup>** produces estimated demand profiles for new technologies



**The model includes costs, energy and efficiency of hydrogen production**

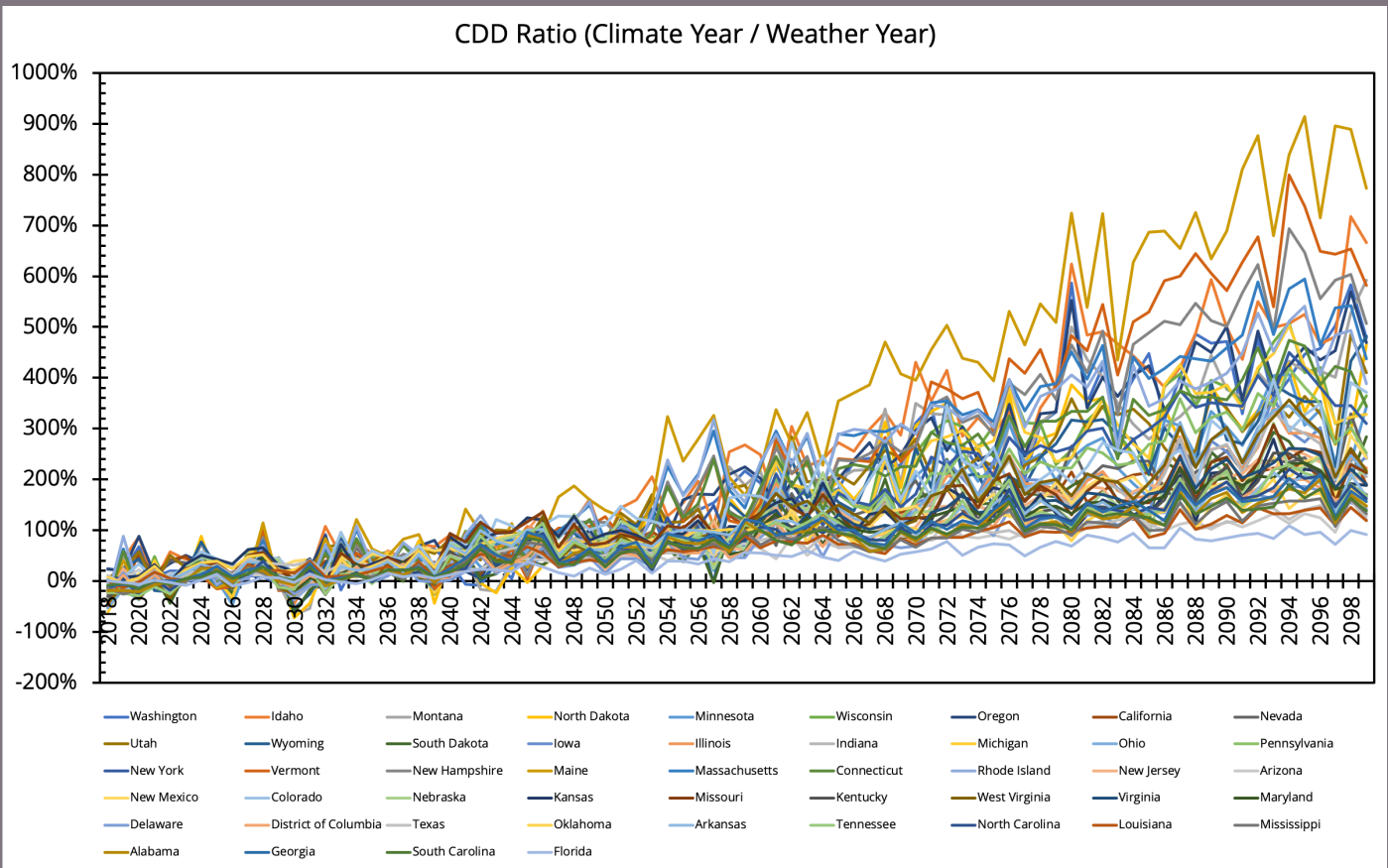


**Elasticity in fuel costs allows WIS:dom<sup>®</sup> to adapt to changing supply-demand levels**



**WIS:dom<sup>®</sup>** conforms to reserve requirements for every region in the US

# 5 | WIS:dom<sup>®</sup> and Climate Change



## KEEPING UP WITH THE CHANGING CLIMATE

WIS:dom<sup>®</sup> has been designed to incorporate weather nudging based upon the latest climate change modeling data.

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# CLIMATE FORCING

Climate change is impacting every aspect of the energy system and will continue to do so more and more in future years. WIS:dom® takes into account these changes over time.

**Wind and solar resources altered by the changing atmospheric conditions**

**Reduced efficiency of generation assets due to water and temperature changes**

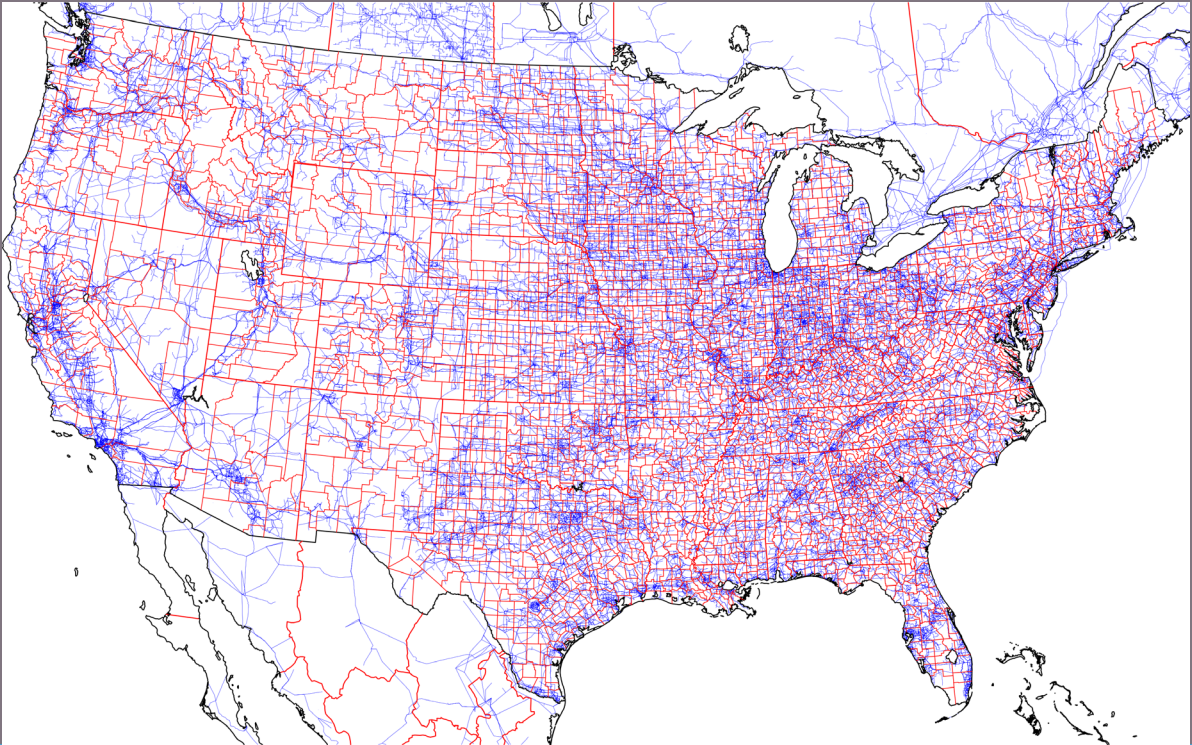
**Dynamic line rating altered by increased temperatures and lower wind speeds**

**Estimation of HDDs and CDDs for computation of distributed generation benefits**

**Estimated demand growth due to increased temperatures and more frequent cold snaps**

**Detailed modeling of hydroelectric and thermal water scarcity impacts**

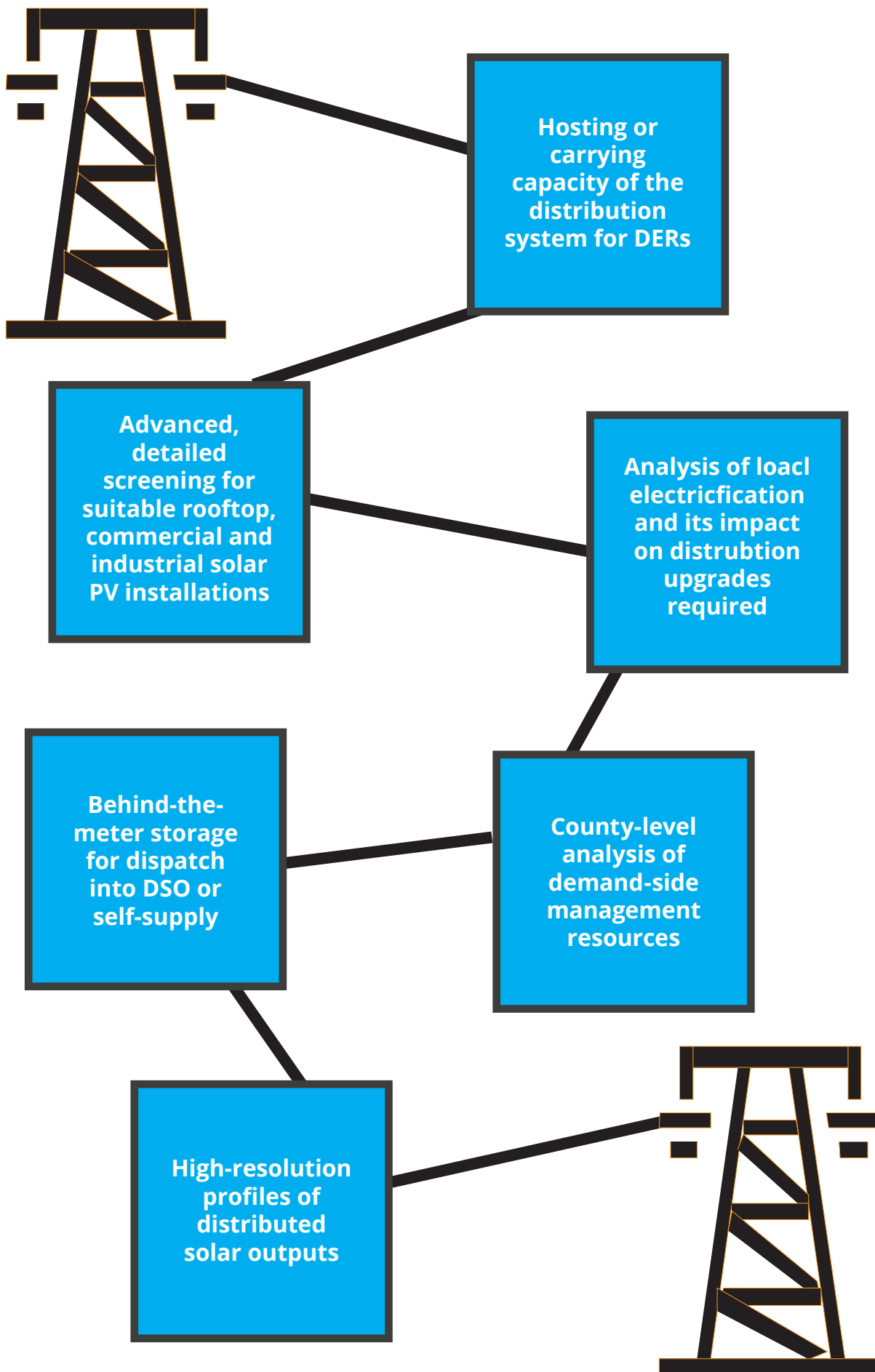
# 6 | Distribution Planning with WIS:dom<sup>®</sup>



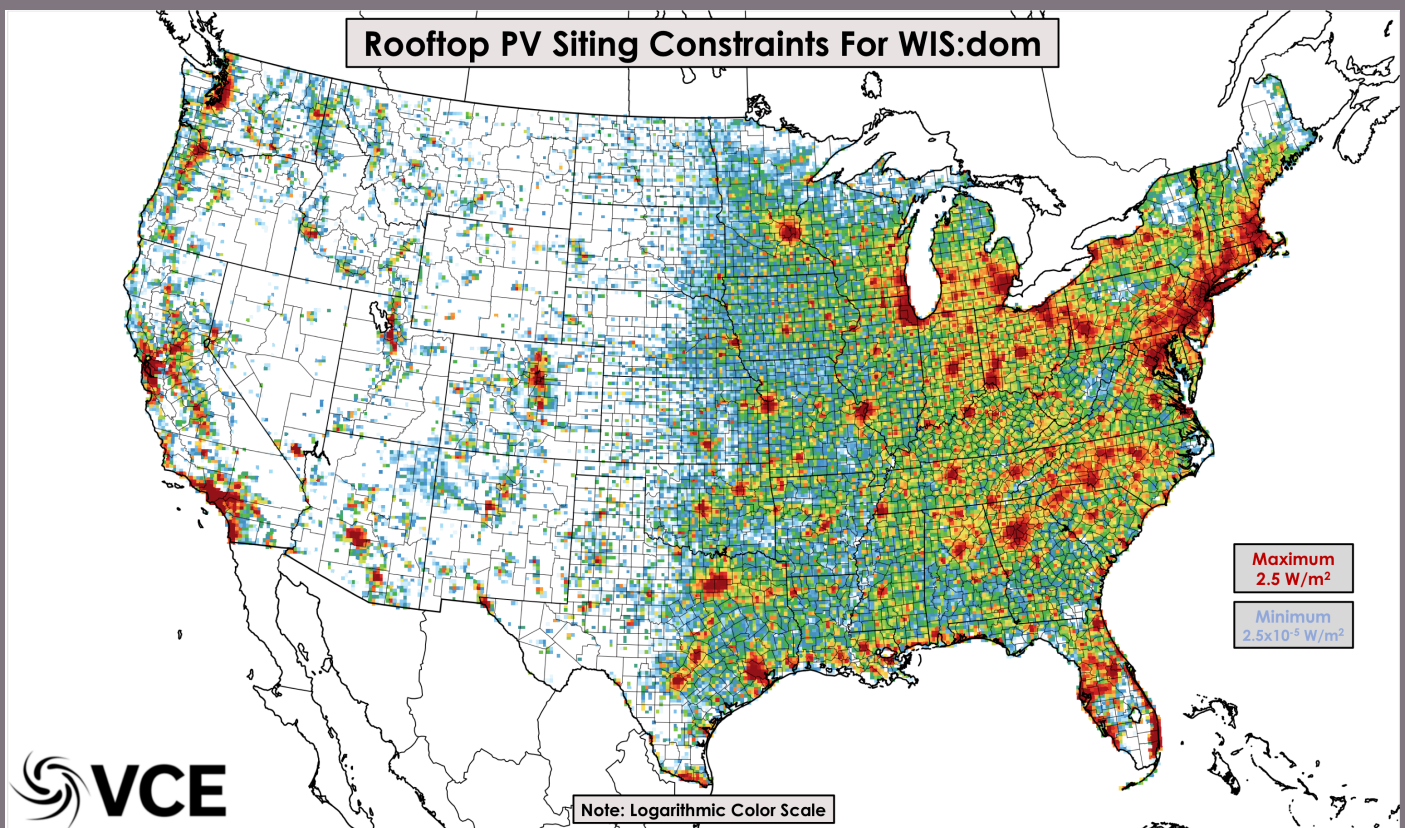
## HANDLING CUSTOMER ADOPTION OF DERs?

The WIS:dom<sup>®</sup> model incorporates behind-the-meter generation and storage to help plan the distribution system.





# 7 | Other VCE<sup>®</sup> Product Lines



## LOOKING FOR A DATASET? WE HAVE YOU COVERED!

For clients that do not require a full optimization model, we can provide accurate, up-to-date and detailed data sets that we use in our WIS:dom<sup>®</sup> model.





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