

U.S. DEPARTMENT OF
ENERGY

Office of
ENERGY EFFICIENCY &
RENEWABLE ENERGY

North American Renewable Integration Study (NARIS) Project ID #M5

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NREL



FY17–FY18 Wind Office Project Organization

“Enabling Wind Energy Options Nationwide”

Technology Development

Atmosphere to Electrons

Offshore Wind

Distributed Wind

Testing Infrastructure

Standards Support and International
Engagement

Advanced Components, Reliability, and
Manufacturing

Market Acceleration & Deployment

Stakeholder Engagement, Workforce
Development, and Human Use Considerations

Environmental Research

Grid Integration

Regulatory and Siting

Analysis and Modeling (cross-cutting)

Project Overview

M5: North American Renewable Integration Study

Project Summary

The North American Renewable Integration Study (NARIS) will analyze the challenges and opportunities of transitioning to a modern electric power system in North America through the year 2050. It is a partnership between the U.S. Department of Energy, the Ministry of Energy in Mexico, and Natural Resources Canada. NARIS studies timescales from multiple decades down to minutes and will produce novel data sets, methods, and tools for stakeholders and future use.

Project Objective & Impact

The key questions that the study has been designed to address include:

- How reliable and affordable will the grid be in a variety of scenarios?
- What operating practices (e.g., regional cooperation) and technologies (e.g., storage, demand response) are most important to reliable and affordable operation?
- Are these solutions robust to a wide variety of scenarios and meteorological conditions?
- What is the benefit of interregional and international cooperation in planning and operations?

Project Attributes

Project Principal Investigator(s)

Greg Brinkman

DOE Lead

Charlton Clark

Project Partners/Subs

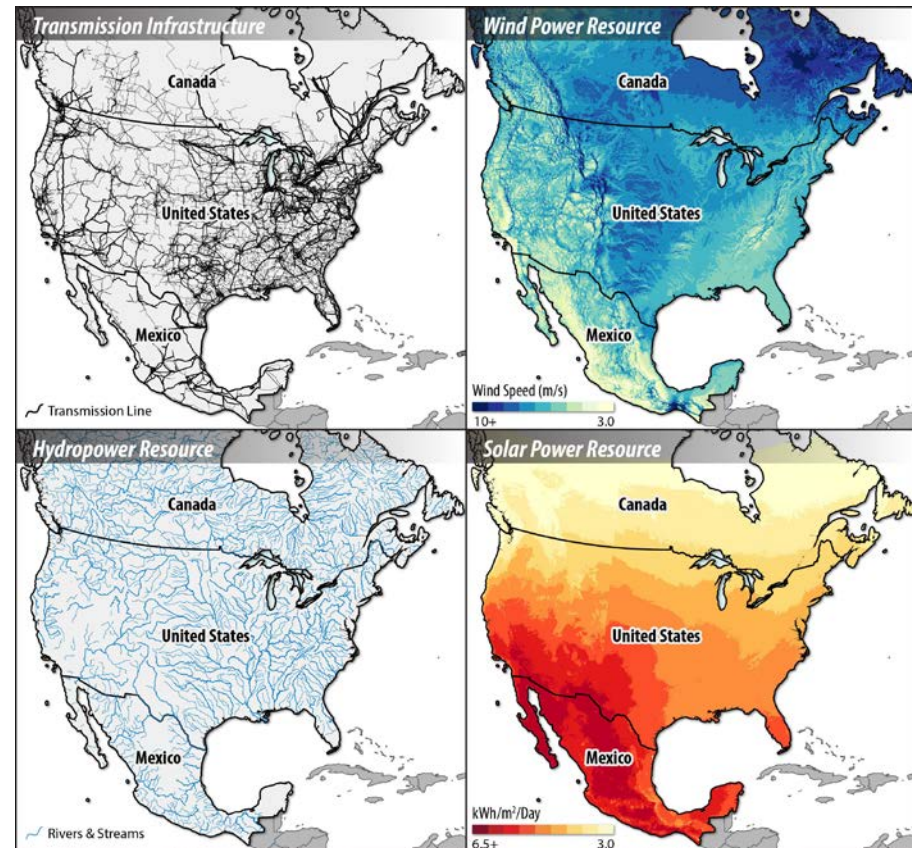
Ministry of Energy in Mexico
Natural Resources Canada
Technical Review Committee of 40 organizations, primarily utilities and grid operators

Project Duration

Completed 2 of planned 3 years

Technical Merit and Relevance

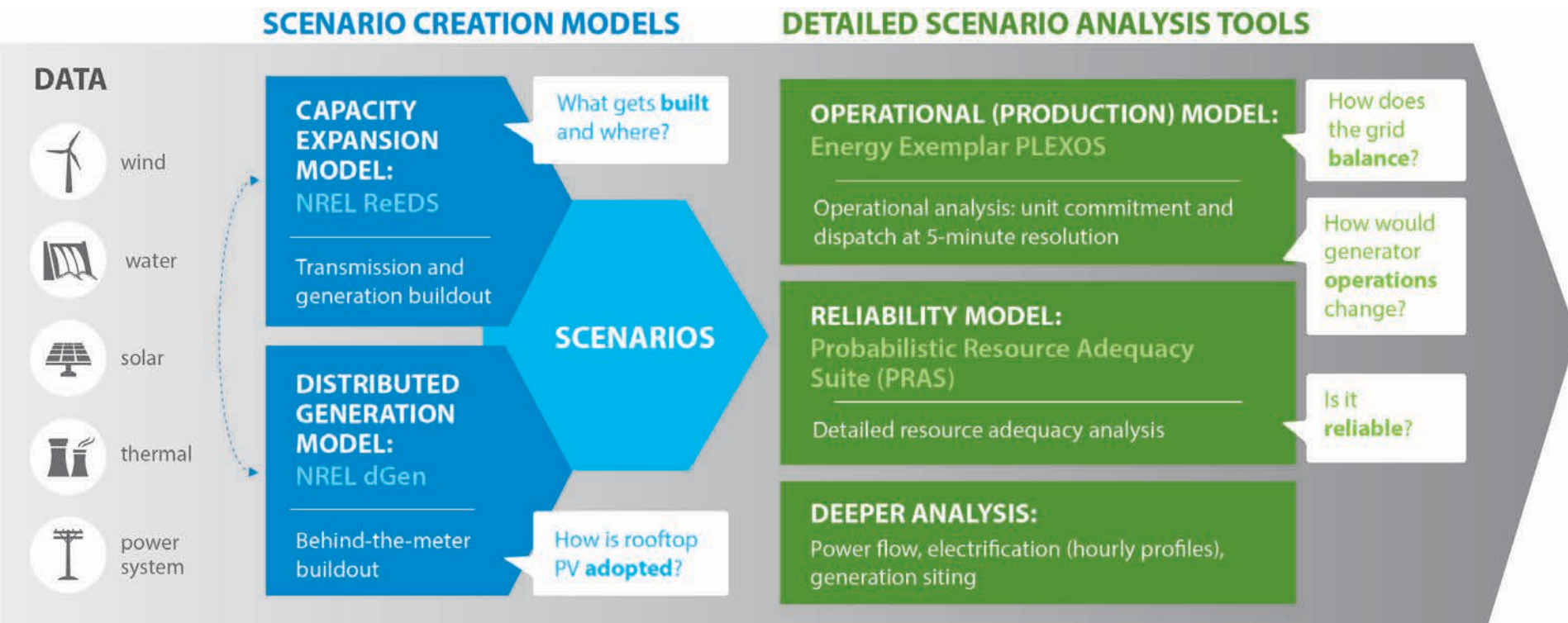
The grid is evolving and a modern power system can take advantage of the diversity of resources. North America has some of the best wind and solar potential in the world.



- Industry needs methods, tools, and data to study detailed, continental-scale questions about system integration, transmission, operational practices, and enabling technologies.
- We are creating open models and data where possible to inform questions about system integration and also enable stakeholders to further the work.

Approach and Methodology

- Partnership between the U.S. Department of Energy (DOE), the Ministry of Energy in Mexico, and Natural Resources Canada
- Co-funded and managed by DOE's Wind Energy (WETO), Solar (SETO), and Water (WPTO) Technologies Offices

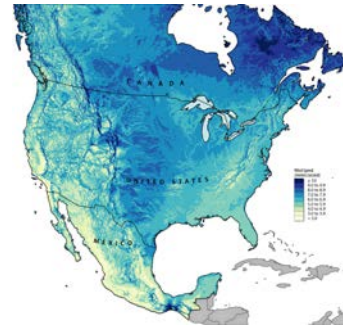
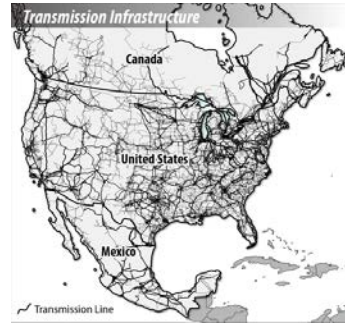


- New, continental-scale methods and data are being developed for each of these models and analysis

Novel need for **detail** in continental modeling

POWERFLOW CASE IMPORTS (GridDB)

100+ cases representing all US/Canada interconnections, 12-year span, load flow periods, automated import

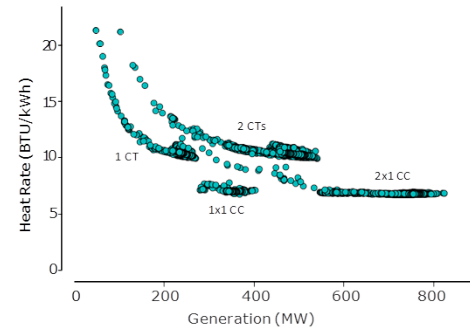


METEOROLOGY

7 years of 5-min time resolution data for wind and solar generators consistent with load

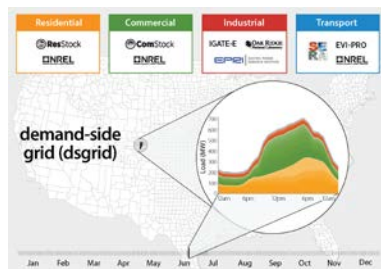
GENERATOR PARAMETERS

Detailed analysis of historical operating parameters, such as heat rate, minimum generation levels, etc.



LOAD

Detailed meteorologically-consistent load data (adjustable to future conditions)



PARTNERSHIP AND TECHNICAL REVIEW

Ongoing review of all data, assumptions, and methods by system operators and others

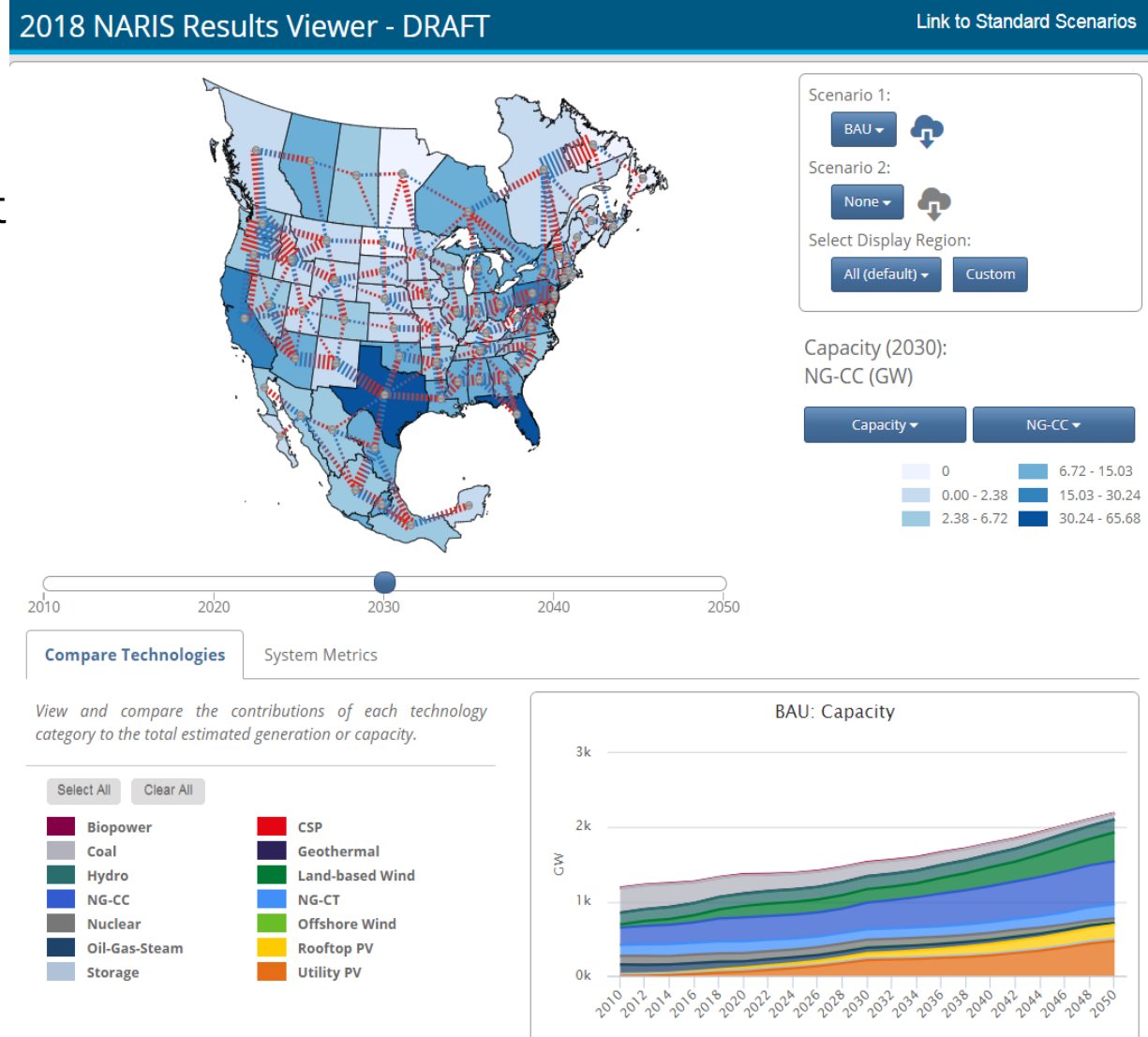


Accomplishments and Progress

- **2 years into a 3-year study**
 - Intentionally-limited publication and presentations
 - Five in-person Technical Review Committee meetings so far (4 in FY 2017 and FY 2018)
 - All milestones complete
 - One delay due to scheduling of a Technical Review Committee meeting
 - Some analysis and/or models have changed after milestones due to overall study decisions to shift scenarios, etc.

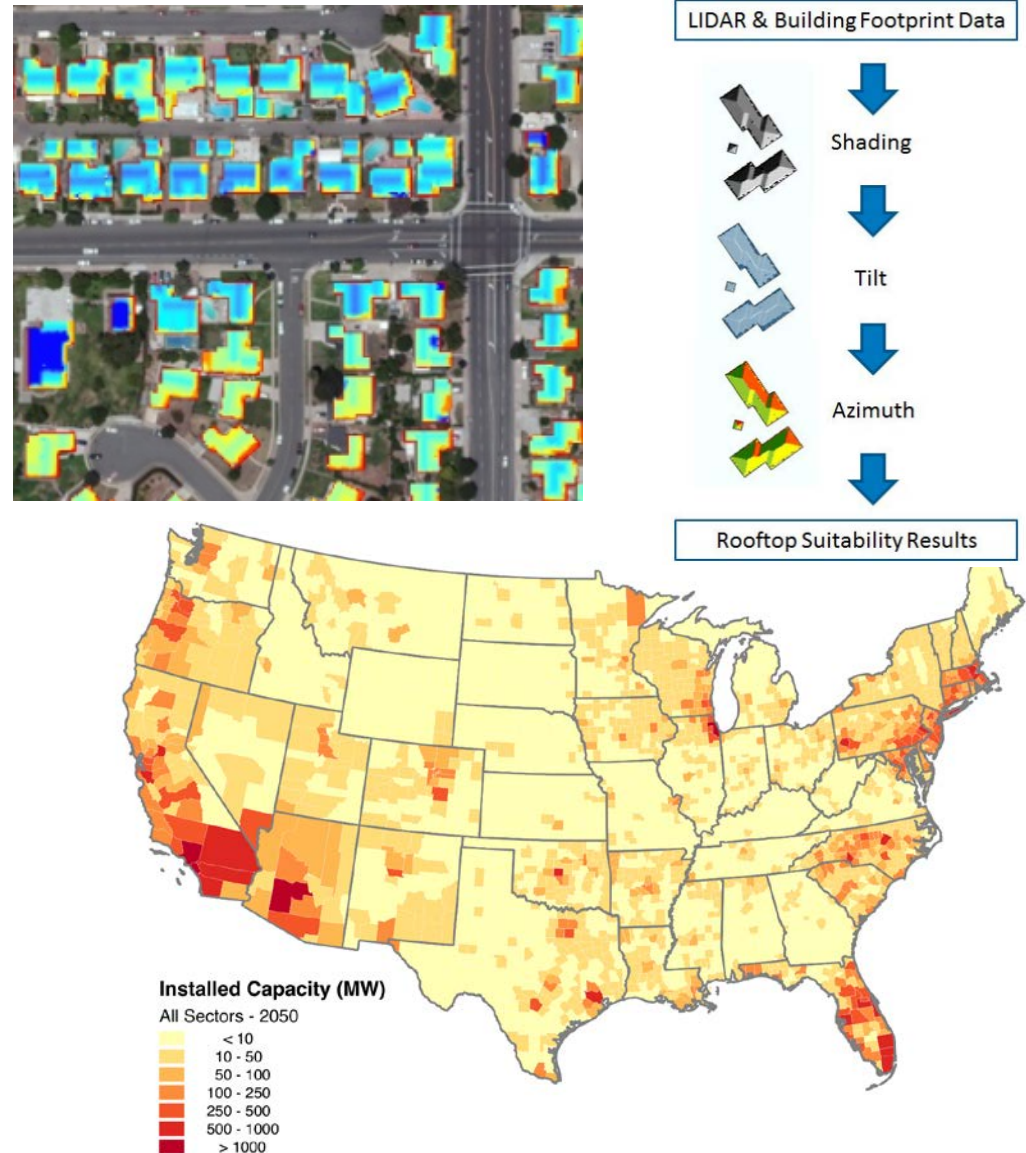
Capacity expansion scenario analysis (ReEDS)

- Continental model developed
- Model run for 40 different combinations of assumptions, including:
 - Wind and solar costs
 - Gas price
 - Transmission cooperation (inter-regional and international)
 - Electrification
- Interactive tool for technical review and (eventually) communication/outreach



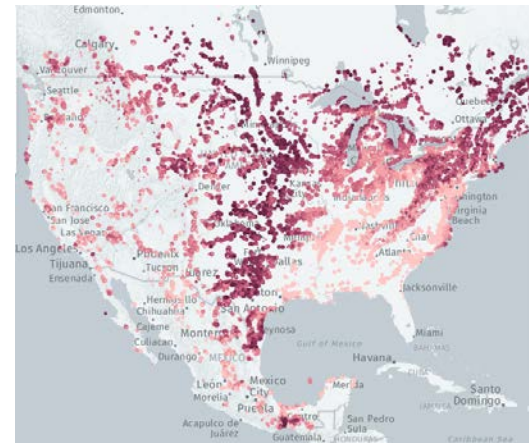
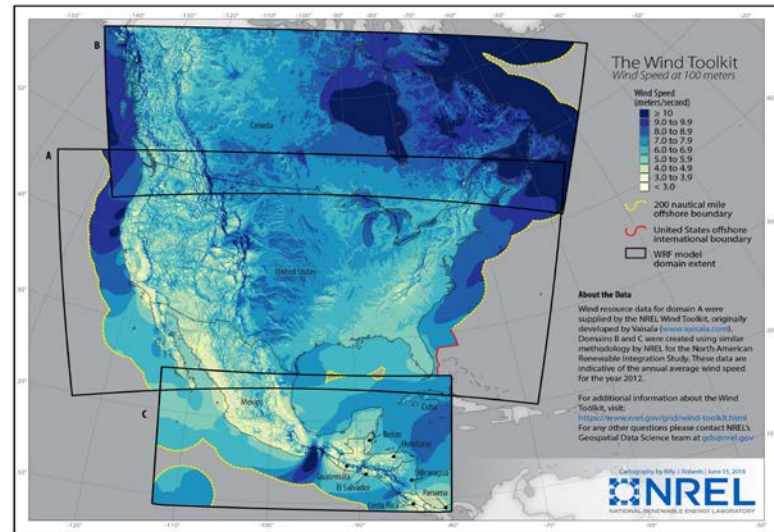
Distributed generation modeling (dGen)

- Continental model developed (extended from US tool)
- Agent-based model using Lidar and extensive socio-economic data to understand adoption
- County-level resolution in the United States
- Price feedback with capacity expansion tools (ReEDS)



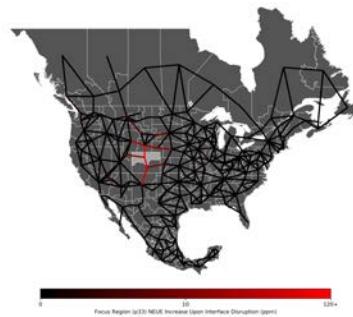
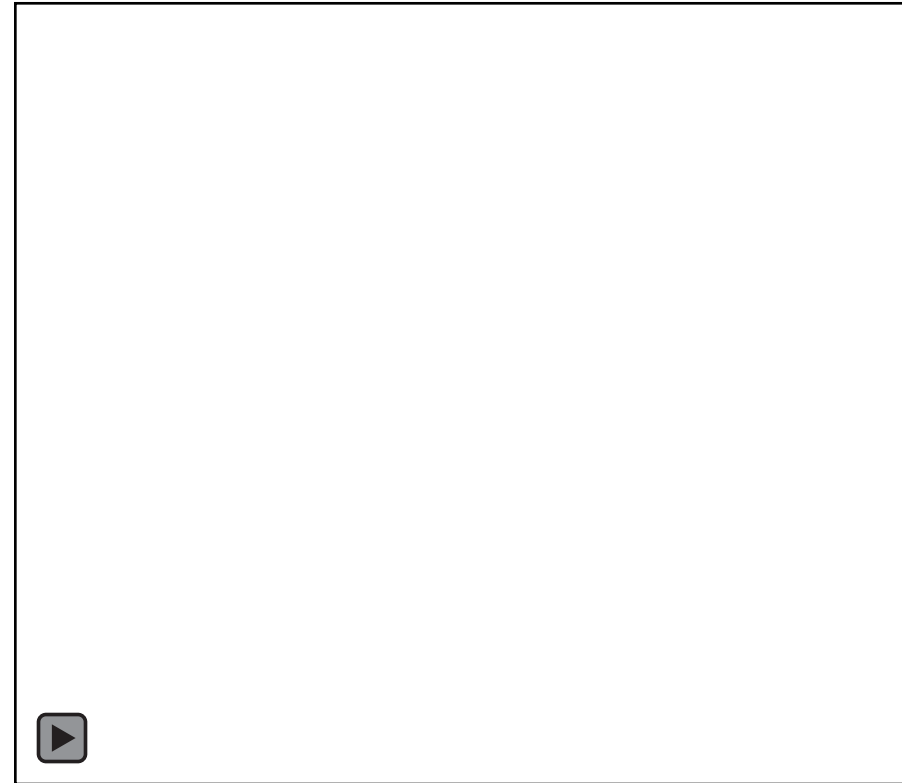
Renewable energy potential (reV) geospatial tool

- Enables consistency between tools involving petabytes of data
- New 5-minute WRF modeling for wind analysis in the US (2014), Canada (2007–2014), Mexico (2007–2014)
- Detailed geospatial analysis of scenarios possible (e.g., interactive siting analysis for a variety of assumptions)
- Downscaling solar data to 5-minute resolution for entire continent, creating time- and meteorologically- consistent forecasts



Probabilistic Resource Adequacy Suite (PRAS)

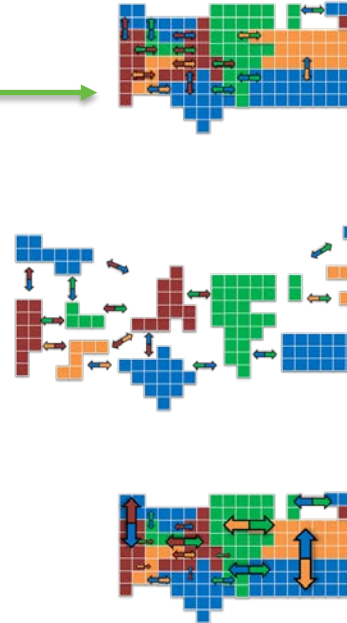
- Tool developed for NARIS, continental data populated by capacity expansion tool
- Simulates billions of different grid conditions
 - Consistent meteorology for wind/solar/load
 - Randomized outages
- Identifies contribution of renewables to reliability
- Identifies key infrastructure for reliability



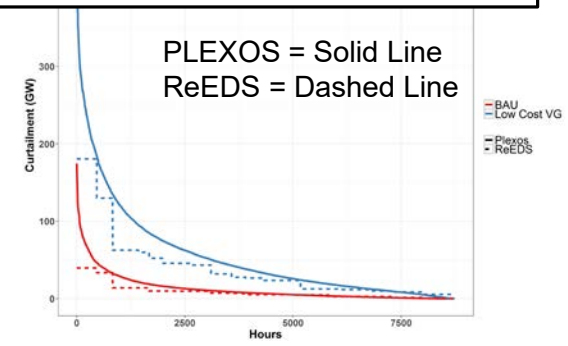
- First draft visualization
- Red shows periods of highest risk of unserved energy
- Note change of regions during different seasons and times of day

Operational simulation/prod cost (PLEXOS)

- Continental-scale model with detailed representation and realistic interregional interactions via geographic decomposition
- 5-minute time resolution, will model 7 years of meteorology (not done yet)
- Understand how grid operates, forecast error impacts, benefits from transmission, etc., in detail
- Comparisons with capacity expansion simplified dispatch, with feedback from learning



Hydropower flexibility sensitivities designed to understand the role of hydro in the future grid and the value of hydro flexibility



Communication, Coordination, and Commercialization

- Ongoing communication and coordination involves engagement the Technical Review Committee of 40 organizations (mostly grid operators and utilities)
- Due to the review needs of three countries, we are not engaging audiences outside the Technical Review Committee until the end of the project. This will focus on:
 - Presentations (by study team and enabling Technical Review Committee members to present on the study)
 - Interactive (web) content and visualizations
 - Data and open-source tools
 - Reports and journal articles



Upcoming Project Activities

- **Finalize the detailed modeling**
 - Operational modeling with PLEXOS
 - Reliability modeling with PRAS
- **Summarize study findings to the public**
- **Public report**
 - Focus on visualizations
 - Capacity expansion (interactive)
 - Operational
 - Reliability/resource adequacy (partially interactive) for understanding how the grid operates during tail events (follow-on work for “extreme events”)