NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Eastern Renewable Generation Integration Study

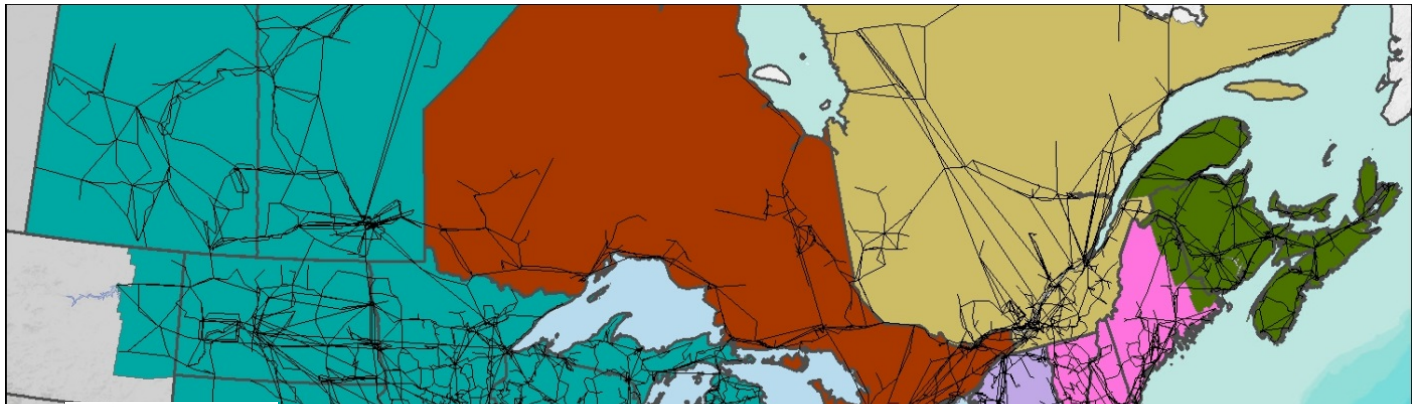
Aaron Townsend, Ph.D.

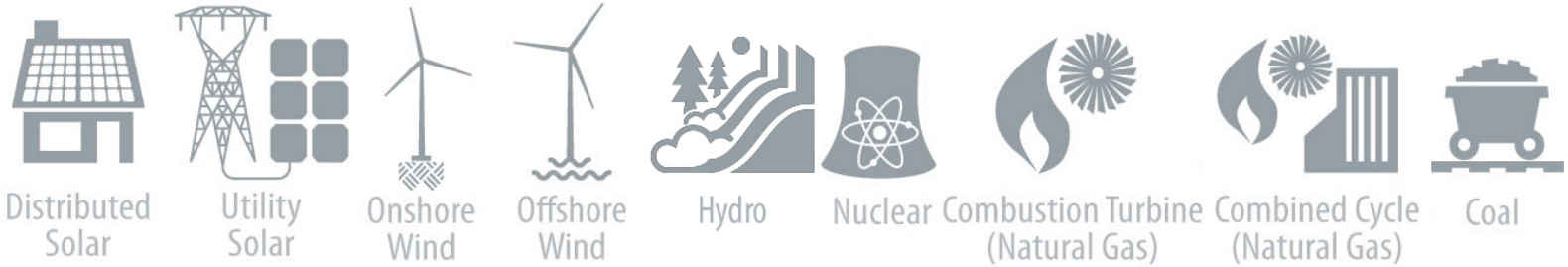
Solar Power International

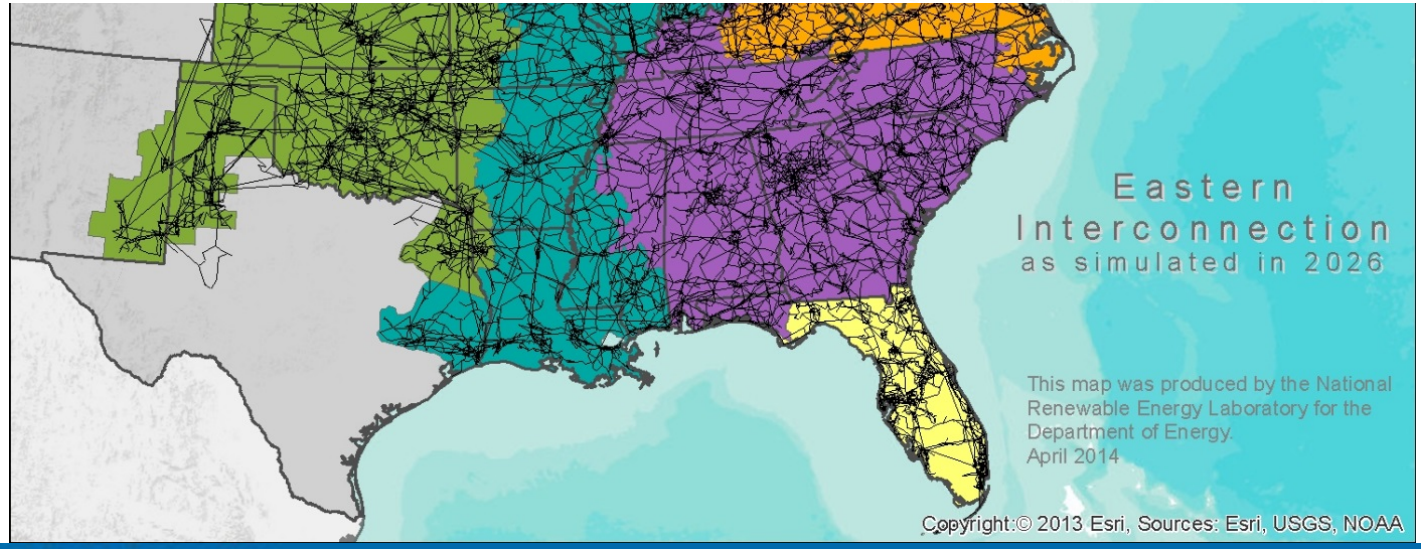
Las Vegas, Nevada
October 21, 2014

NREL/PR-6A20-63053

Eastern Renewable Generation Integration Study







Answering Critical Questions

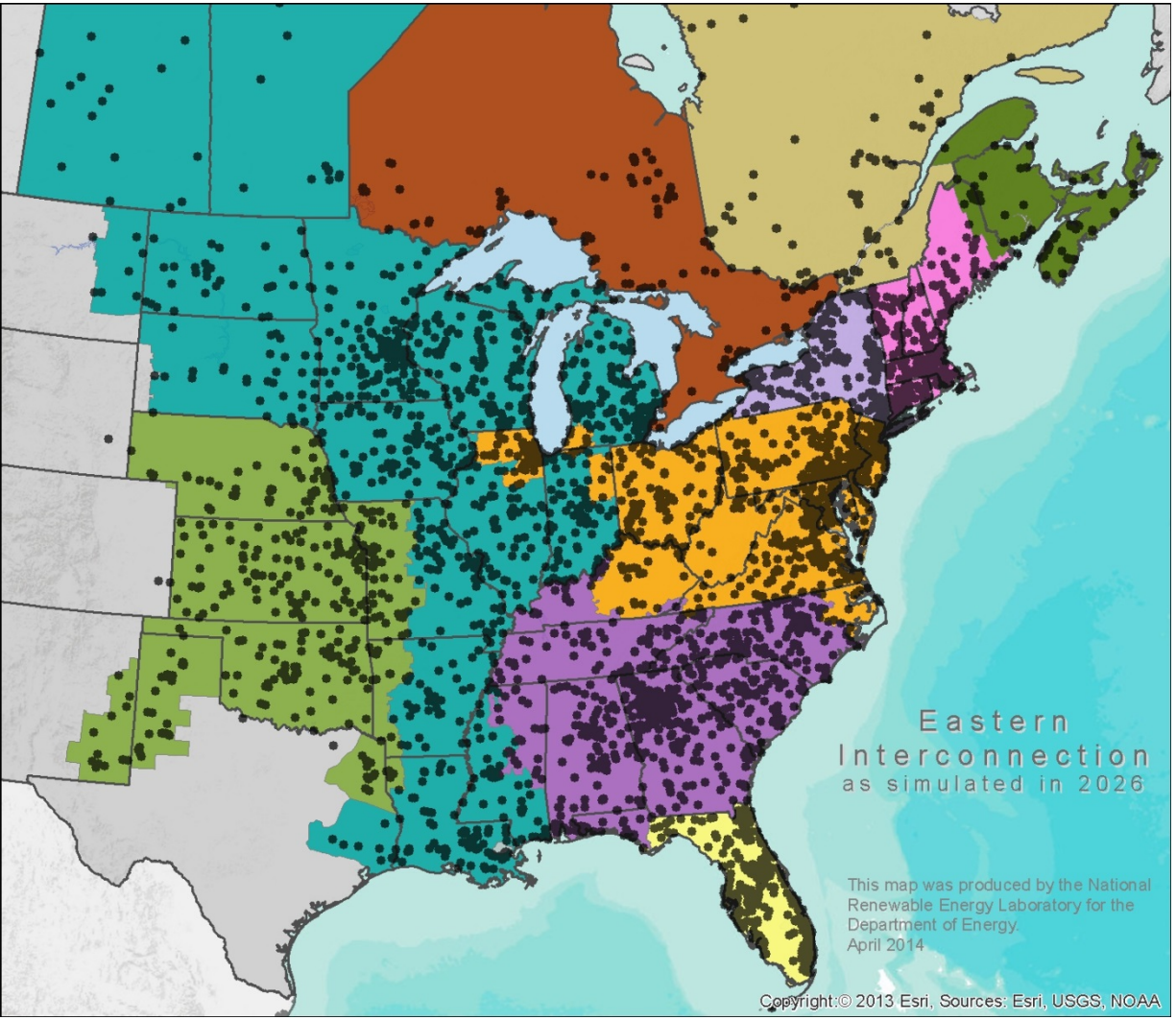
Critical questions:

- **How might power system operations be impacted by wind and solar power generation?**
- **Could the operational impacts differ based on policy decisions about regional versus national deployment strategies?**
- **How can different operational practices mitigate the effects of variability and uncertainty?**

Study Limitations

- **We lack:**
  - Bilateral power purchase and other contractual agreement data
  - Detailed operational constraints and/or complete unit-specific data in the generation models
  - Capability to simultaneously model different dispatch intervals in different balancing authority areas
- **Uncertainties:**
  - Future cooperation and/or sub-hourly dispatch across the interconnection
  - The amount and location of variable generation
  - Transmission system additions
  - Generation additions and retirements
  - Gas and coal prices

The Eastern Interconnection

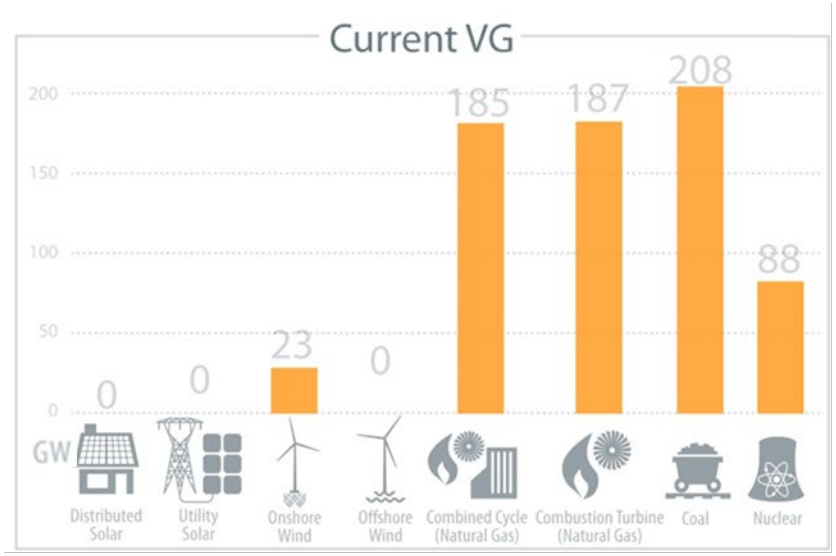


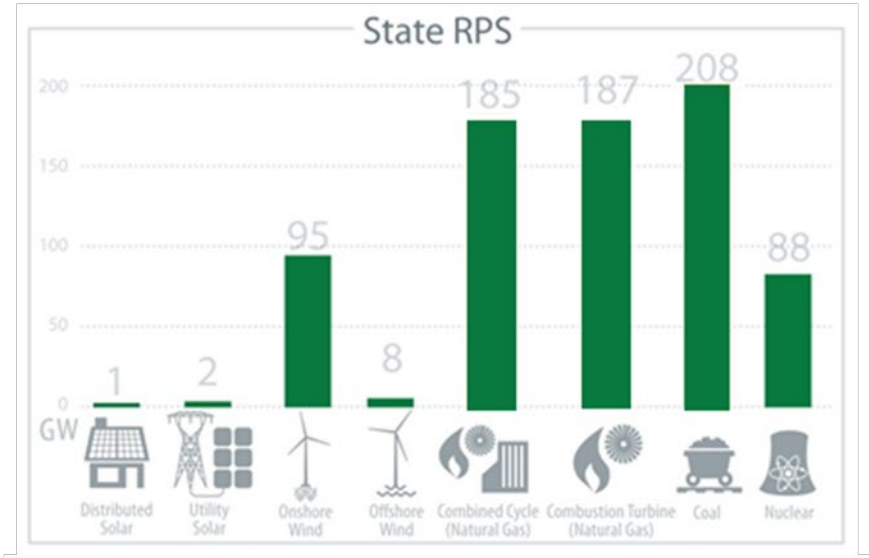
- Generating capacity:
  700 GW
- Generating units:
  7,500
- Load:
  3,000 TWh
- Population:
  240 million people
- 70% of US Load
- Transmission length:
  459,000 miles
- Nodes:
  60,000
- Transmission lines:
  50,000

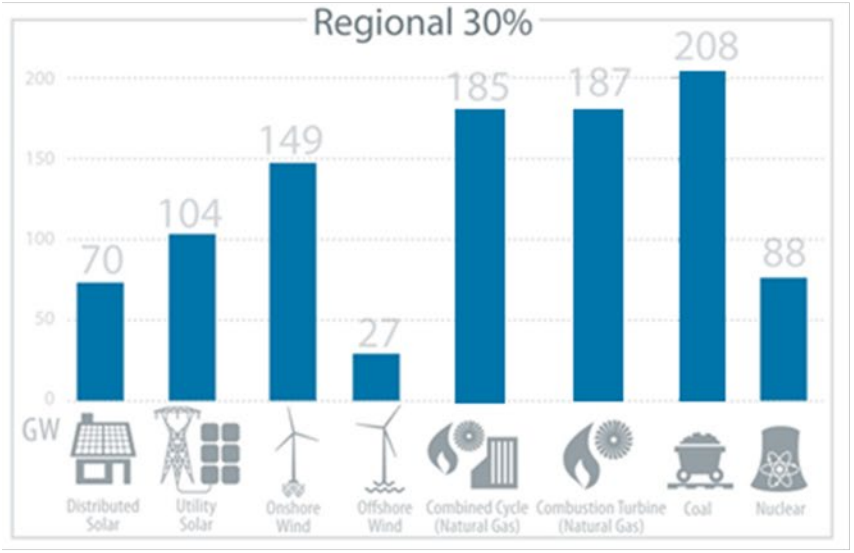
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

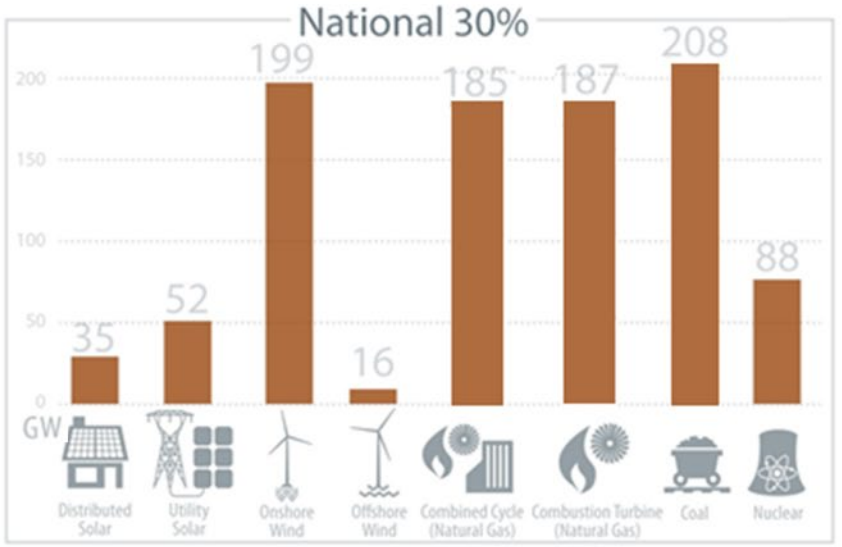
Approach

2026 Study Scenarios



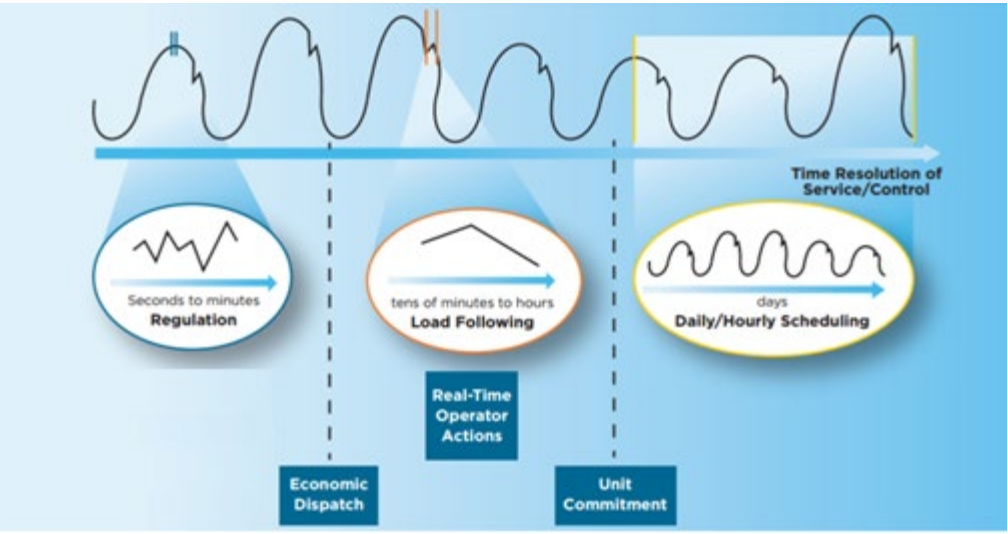




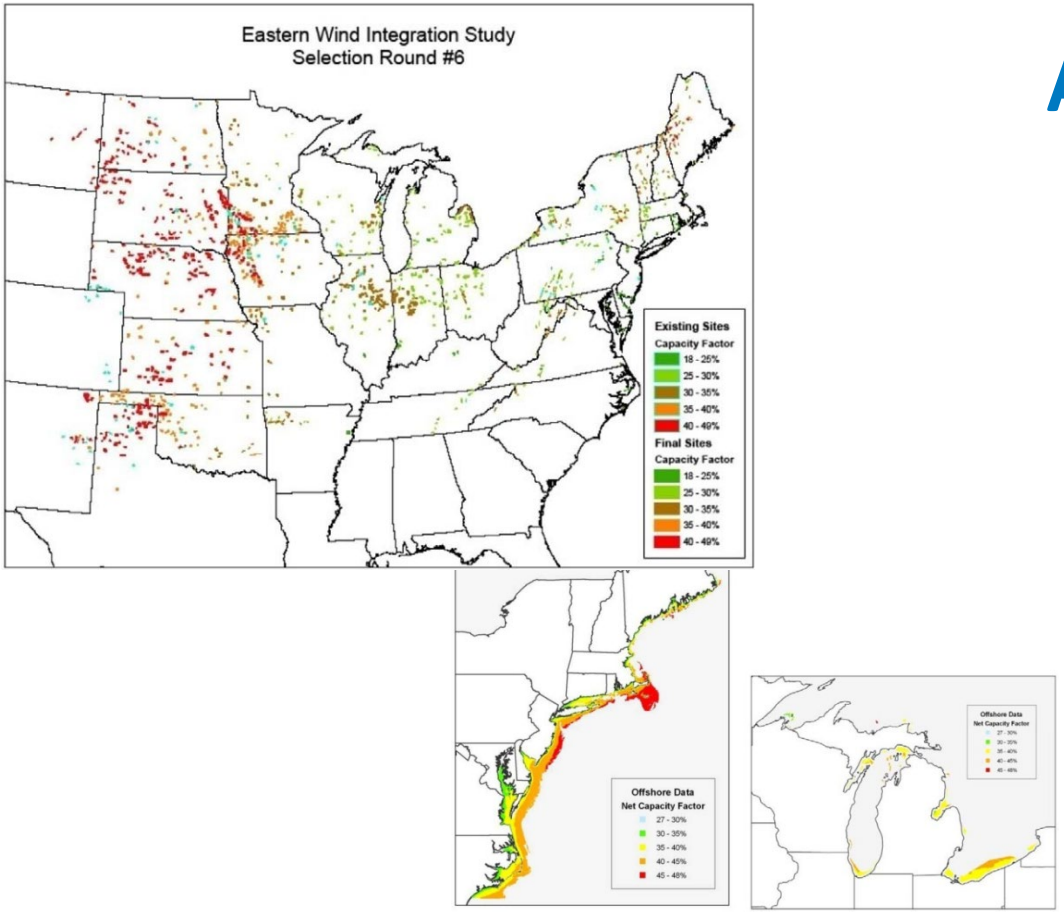


Modeling Software

- **PLEXOS**
  - Unit commitment and economic dispatch
  - Nodal DC power flow
  - Day-ahead (hourly)
  - Real-time (5-minute)
  - Mixed-integer



Eastern Wind Data Set



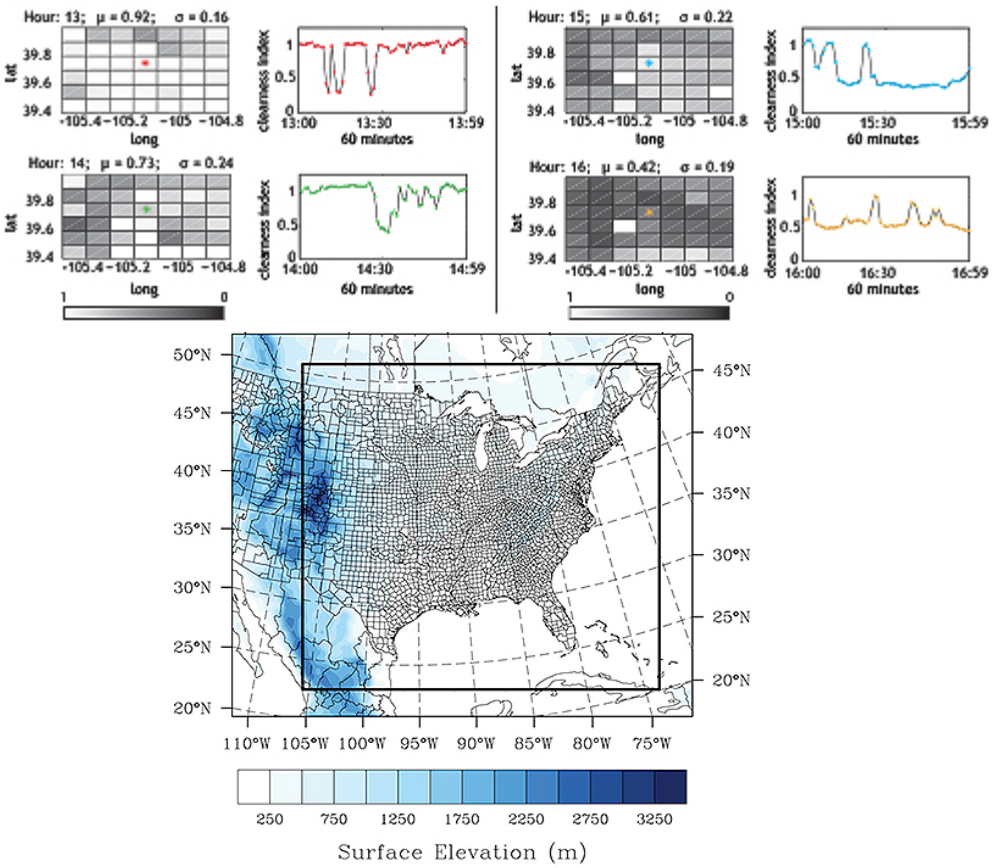
About the data

- Simulated power data
- Sites: 1,326
- Years: 2004–2006
- Time: 10-minute resolution
- Capacity: 580 GW
- Mesoscale model
- 2-km resolution

Where to get it: http://www.nrel.gov/electricity/transmission/eastern_wind_methodology.html

Where it has been used: PJM Renewable Generation Integration Study, SPP Wind Integration Study

Solar Integration Data Set



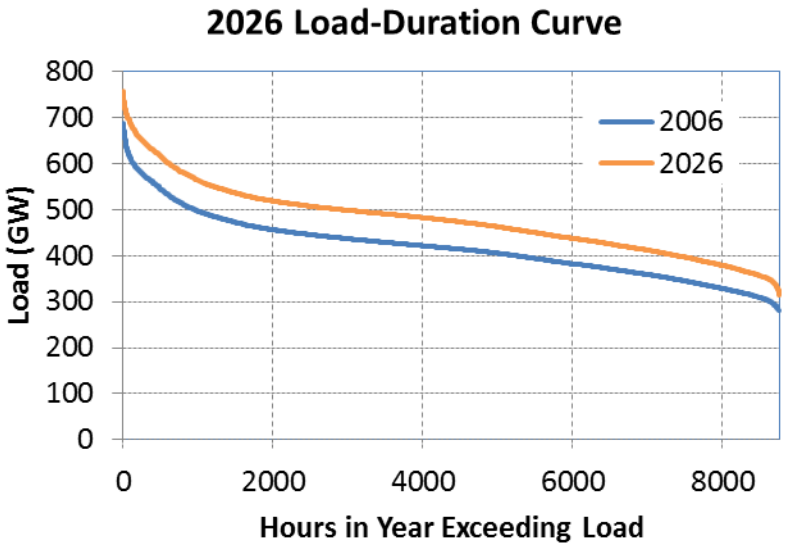
About the data

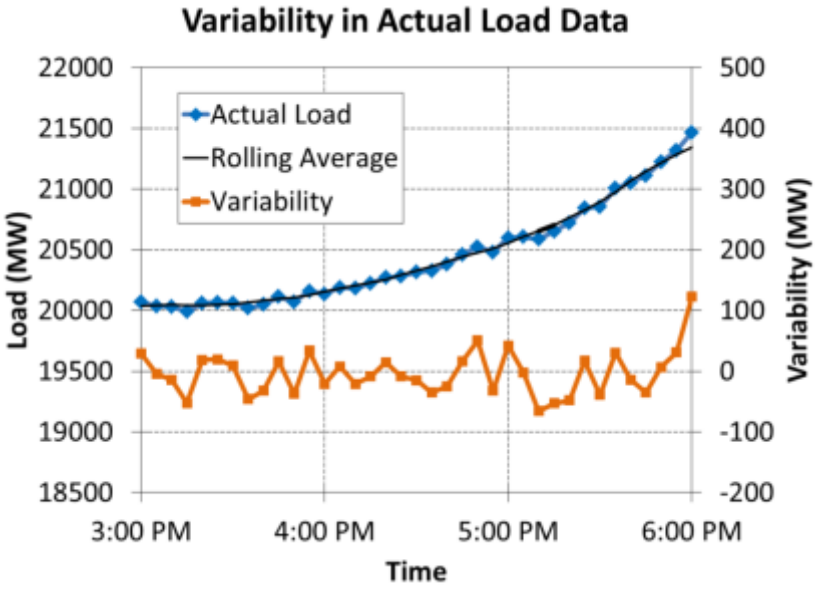
- Simulated power data
- Sites: 4,089
- Years: 2006
- Time: 5-minute resolution
- Capacity: 174 GW
- Multiple forecasts

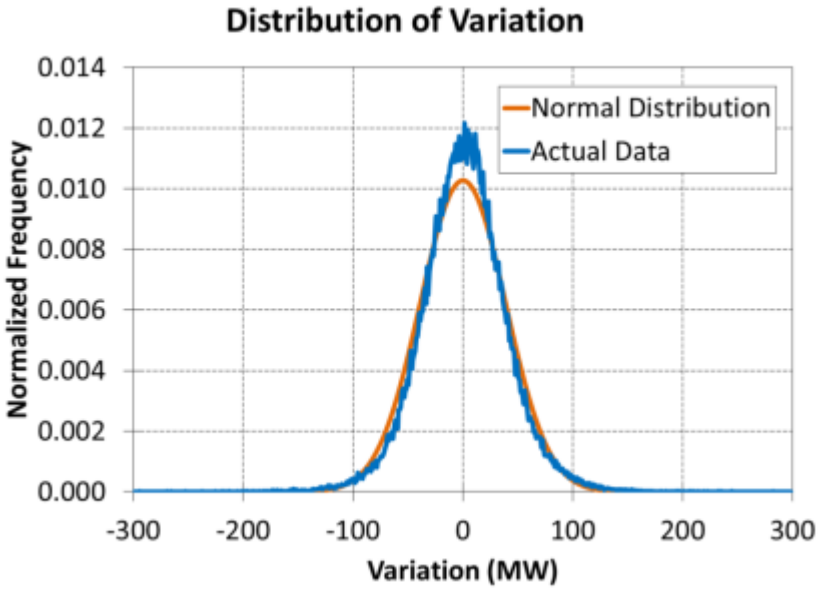
Where to get it: http://www.nrel.gov/electricity/transmission/solar_integration_methodology.html

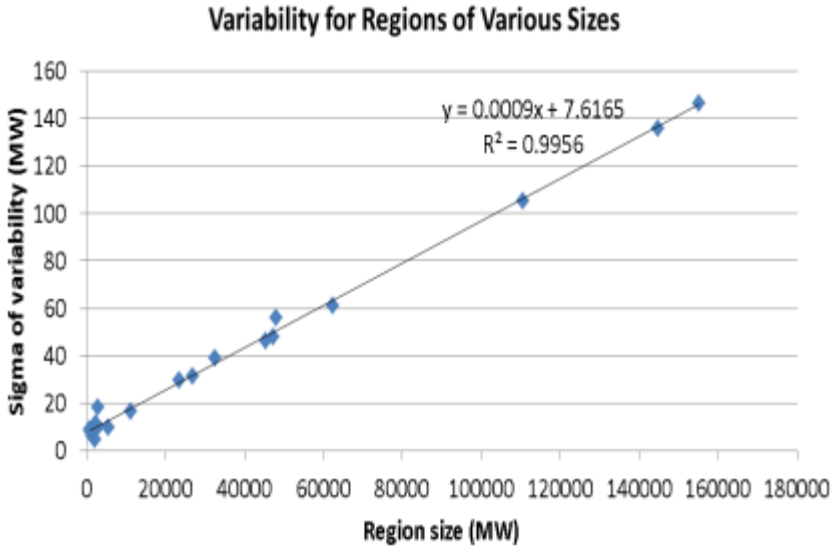
Where its been used: Minnesota Renewable Integration and Transmission Study, FPL Solar Integration Study

Sub-Hourly Load Data for 2026





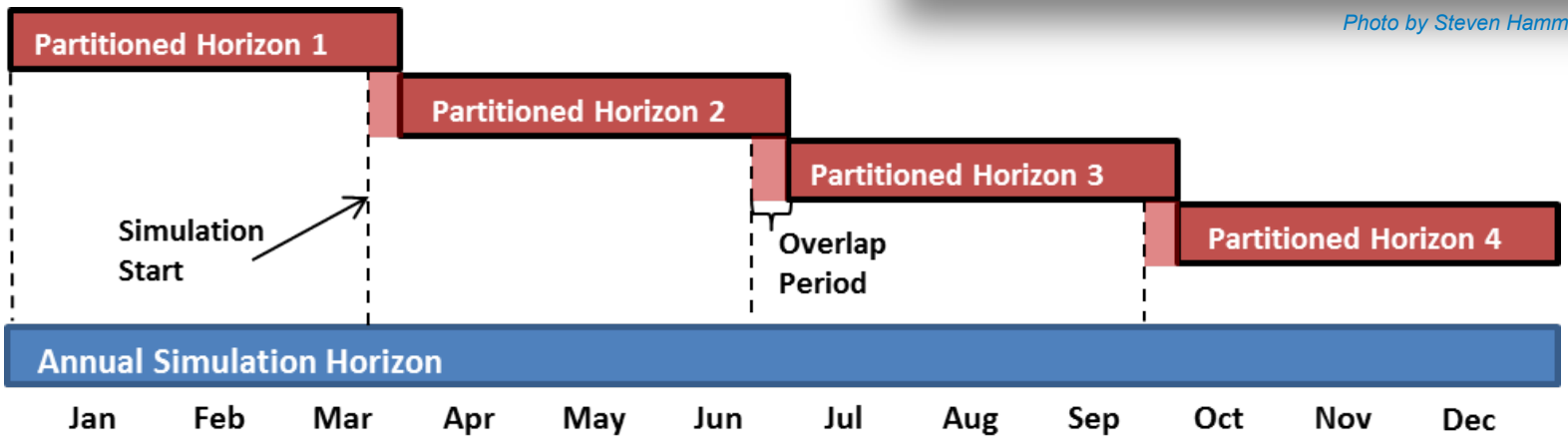




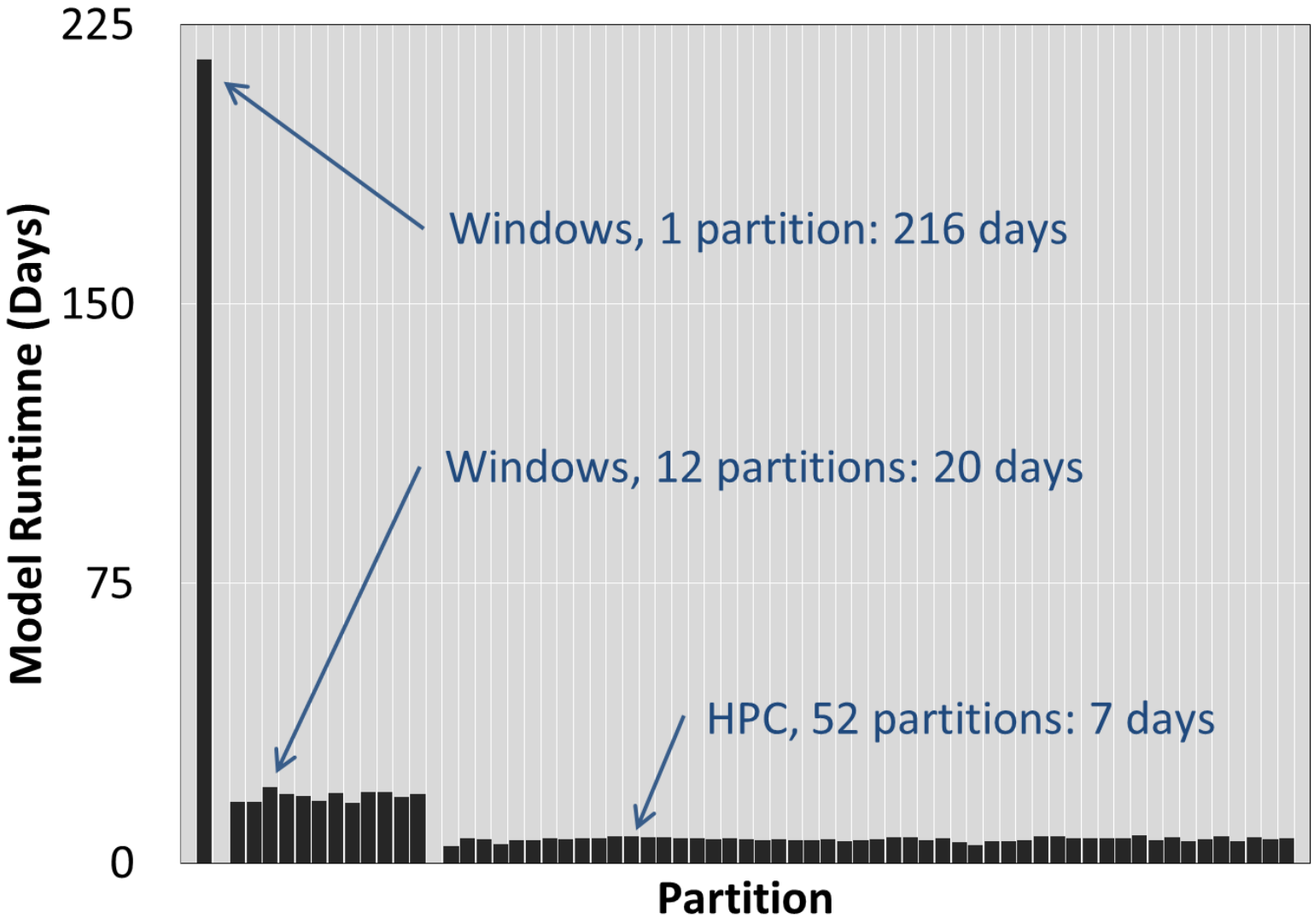
High Performance Computing

- A decision at time *t* is not dependent on the state of the system at previous time intervals, given a delay of *n* time periods.

Photo by Steven Hammond, NREL



Simulation Time Comparison



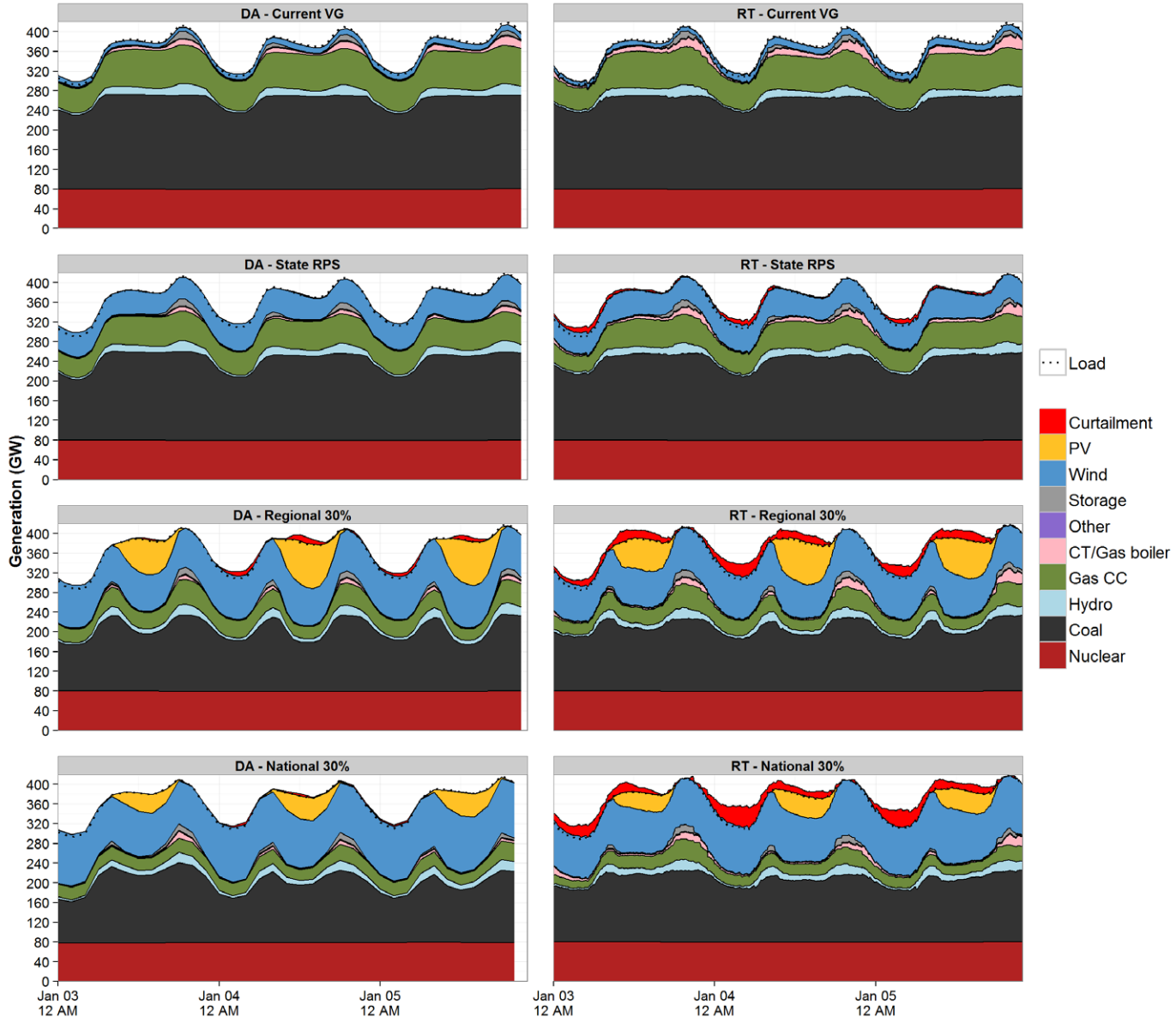
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Simulations

2026 Study Year Setup

- Day-ahead plus real-time (DA+RT) operational sequence
- Hourly commitment schedules for non-quick-start generators fixed in DA
- 5-minute dispatch in RT
- Regulation and contingency reserves in both DA and RT

Preliminary Results: DA and RT Dispatch



Mitigation Goals

- Minimize production costs
- Minimize emissions
- Minimize reserves violations
- Minimize RT unplanned startups

Mitigation Option: Intra-Day Unit Commitment

- **Why?**
  - Take advantage of better short-term forecasts to recommit medium-startup time units such as NGCCs
  - Actively discussed in industry
  - Other studies either did not include it, or assumed it as part of the base case.
  - Isolates impacts
- **Approach**
  - Add a third operational step between DA and RT that commits combined cycle units.
  - 4 hour is the appropriate time period because the typical startup times needed for CCs is ~4 hours.

Mitigation Option: Flex Reserves

- **Why?**
  - Ensure ramping capacity is available to address variability and uncertainty
  - Actively discussed in industry
  - Other studies either did not include it, or assumed it as part of the base case
  - Isolates impacts
- **Approach**
  - Add a third spinning reserve product in the DA but not the RT
  - Consistent with WWSIS-2 base case

Mitigation Option: Combined

- **Why?**
  - Evaluate aggregate impact of mitigation options
  - Do the strategies reduce the effectiveness of each other?
- **Approach**
  - Use both intra-day unit commitment and flex reserve options

Timeline

- Running simulations now
- Technical Review Committee meetings in December and March
- Final report available summer 2015

Get Involved

- **Learn more:**
  http://www.nrel.gov/electricity/transmission/eastern_renewable.html
- **Get data:**
  http://www.nrel.gov/electricity/transmission/data_resources.html
- **Final report: summer 2015**
- **Contact:**
  aaron.townsend@nrel.gov

This work was supported by the U.S. Department of Energy under Contract No. DE-AC36-08-GO28308 with the National Renewable Energy Laboratory.