



#### WEATHER-DRIVEN RENEWABLE ENERGY ANALYSIS:

Implications for an Optimized Electric Power System Utilizing a National High-Voltage Direct-Current Transmission Network

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#### Wind & Solar Integration Challenges

The integration of high volumes of wind and solar power to reduce emissions will require significant changes to the electric power system in coming decades

- Wind and solar are weather-driven and variable sources of energy generation
- Without storage, uncontrollable fluctuations can cause reliability challenges in meeting demand
- Need for back-up operating reserves, which increase costs and often cannot adjust power output fast enough
- Risk of over-generation



#### The National Energy with Weather System (NEWS) Simulator





\*\* A cost-optimizing model for the U.S. Power Grid for 2030
\*\* Determines optimal blend of

power generation sources and locations throughout the U.S.



\*\* Emission reductions up to 80% without increased costs and with current technology, using the national transmission system

## **Research Objectives**

- 1) Incorporate and evaluate impact of existing U.S. electric sector policies in the NEWS Simulator
  - No Policies
  - State Renewable Portfolio Standards (RPS)
  - Federal Production Tax Credit (PTC) and Investment Tax Credit (ITC)
- 2) Assess the National HVDC System compared current electricity markets and a regional expansion scenario
  - Current Electricity Markets
  - Regional Expansion
  - A Revised National HVDC Transmission Network

## Boundary Modeling Methodology

State Boundaries & Electricity Market Regions

### State Boundaries: Grid Points to States

Original 32 Regions



State Wind and Solar Sites



State Boundaries



State Existing Generation 2012



#### State Hourly Electric Load; Nuclear & Hydro Generation

State Average Load (MWh)





State Average Nuclear Generation



State Average Hydroelectric Generation



#### New State HVDC Load Centers: Locations, Distances, and HVAC Losses



### **Power System Modeling Scenarios**

#### **Current HVAC Networks (sub-NERC)**

**Regional HVAC Expansion (NERC)** 



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## Policy & Grid

# Assessment

#### **Power Grid & Policy Assessment**

#### **Electric Sector Carbon-Free Generation (%)**

#### Carbon Dioxide Emissions (MMTCO<sub>2</sub>)



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### **Power Generation Siting**

#### **Current Markets**



#### **Regional Expansion**



National System

\* PTC & ITC Policy Scenarios



Proliferation of Wind Sites in Great Plains and Northeast U.S.

## Summary

- NEWS Simulator utilizes NOAA's weather expertise to optimize a cleaner power sector, reduce emissions, and mitigate climate change
- The present research expands the NEWS modeling capabilities to assess electric sector policies and new power system scenarios
- The implementation of a national network enables significantly more renewable energy deployment; lower electricity costs and emissions compared to current and regionally expanded networks
- The PTC and ITC provide large market incentives for renewable generation as well as enhance impact of the national network; Current RPSs will be largely ineffective by 2030

## Future Work

- Submit paper for journal publication
- Senior thesis assessing physical and institutional challenges, including analysis of wholesale electricity market reform and transmission expansion
- Further simulations and NEWS model expansions:
  - Combined policy scenario of existing policies (RPS, PTC & ITC, cap-and-trade)
  - SO<sub>2</sub>, NO<sub>x</sub>, and Hg regulations (must track these first)
  - National policies: carbon tax, RPS, etc.
  - Apply model outside of U.S.

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### **Questions?**

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More information on NEWS Study: http://www.esrl.noaa.gov/gsd/ renewable/news-simulator.html

Photo by Will von Dauster, 2015

## Policy Modeling Methodology



