The North American Renewable Integration Study: An Introduction

NARIS Study Team

August 2018
State-of-the-art analysis of the U.S., Canada, and Mexico power systems, from planning through operations

WHAT WE’RE STUDYING

- Long-term pathways to a modern power system in North America
- Operational feasibility of very high-penetration scenarios
- Weather variability and uncertainty
- Value of enabling technologies: flexible hydro, thermal generation, demand response, storage, transmission
- Value of operating practices: interchange, enhanced scheduling, local generation, reserve provisions
North America Is Very Diverse in Energy Resources and Load

The availability of natural resources varies widely across regions.

So does how and when energy is used on the grid.

A modern power system can take advantage of this diversity to provide reliable, affordable, sustainable power.
How Big Is the North American Grid?

- Over 100,000 nodes on the transmission grid
- Over 10,000 generators
- Over 10,000 compute node-hours required to run an operational simulation

GROSS DOMESTIC PRODUCT

North America: $22 trillion (27%)
Rest of the World: 73%

Source: World Bank

GENERATING CAPACITY

North America: 1,300 GW (18%)
Rest of the World: 82%

Source: CIA

GENERATION

North America: 5,300 TWh (21%)
Rest of the World: 79%

Source: BP Statistical Review
Accelerating Grid Modernization in North America

**INFORMING**
grid planners, operators, market participants, and regulators of challenges and opportunities for the grid

- Is it **reliable** and **affordable**?
- What operating **practices** and **technologies** help the most?
- Are the “solutions” **robust**?
- What is the benefit of **inter-regional and cross-border** cooperation?

**ENABLING**
stakeholders to deepen and extend their understanding of renewables and modern power systems

- Creating and disseminating new **data**
- Pioneering and deploying new **methods** and computational **tools**

**CREATING**
a framework for future analysis

- **Stability** (i.e., frequency, transient, voltage)
- **Resilience** to extreme events (e.g., weather)
How it Works: Modeling Flow

**SCENARIO CREATION MODELS**

- **DATA**
  - wind
  - water
  - solar
  - thermal
  - power system

- **CAPACITY EXPANSION MODEL:**
  - NREL ReEDS
  - Transmission and generation buildout

- **DISTRIBUTED GENERATION MODEL:**
  - NREL dGen
  - Behind-the-meter buildout

**DETAILED SCENARIO ANALYSIS TOOLS**

- **OPERATIONAL (PRODUCTION) MODEL:**
  - Energy Exemplar PLEXOS
  - Operational analysis: Unit commitment and dispatch at 5-minute resolution

- **DEEPER ANALYSIS:**
  - Power flow
  - Reliability / resource adequacy
  - Electrification (hourly profiles)
  - Generation siting

What gets built and where?

How does it compare to other scenarios?
Data sets are developed almost entirely based on public data, processed using novel, replicable methods.
Putting It All Together:
The Scenarios
The **Scenarios**

Four overarching pathways for North American electric power system evolution **through 2050**

1. **Business As Usual**
   - System evolves as we plan and operate it today

2. **Low-Cost Variable Generation**
   - Same policies, but **lower costs** for emerging technologies

3. **Carbon Constrained**
   - New policies drive significant **carbon emissions reductions**

4. **Carbon Constrained + Electrification**
   - New policies drive significant carbon emissions reductions **plus electrification**
Scenario 1: Business As Usual

- **U.S.** has only state-level policies
- **Canada** reduces carbon emissions by 80%
- **Mexico** has 50% Clean Energy Standard

**SENSITIVITIES TO RUN:**

- With and without *coordinated transmission*
- With and without new *transmission between countries*
- Low, medium, and high *gas prices*
- Today’s level of *hydro flexibility*, less flexible, and more flexible
- *Macrogrid* or *independent* transmission buildout
- Early or typical *thermal retirements*
- With and without *limit on instantaneous VG*
Scenario 2: Low-Cost Variable Generation

- Same policies as Scenario 1
- Wind and solar achieve lower costs than today’s projections

SENSITIVITIES TO RUN:
- With and without coordinated transmission
- High or typical penetrations of distributed generation
- Low, medium, and high gas prices
Scenario 3: Carbon Constrained

- 92% reduction in carbon emissions in Canada; 80% in U.S. and Mexico
- Generally consistent with the Mid-Century Strategies in all countries

SENSITIVITIES TO RUN:
- With and without coordinated transmission
- With and without new transmission between countries
- Low, medium, and high gas prices
- Today’s level of hydro flexibility, less flexible, and more flexible
- Wet or dry hydro conditions
- Macrogrid or independent transmission buildout
- Early or typical thermal retirements
- With and without limit on instantaneous VG
- High or typical penetrations of distributed generation
- Lower or typical projected wind, solar, and storage costs
Scenario 4: Carbon Constrained + Electrification

Same as Scenario 3, but with added electrification

SENSITIVITIES TO RUN: ?

WHY THIS SCENARIO?
Electrification could double load and shift peaks between seasons. This could have a substantial impact on the results of the study.
Example (not actual) types of visualizations
NARIS
Scenario Viewer Tool

2017 NARIS Results Viewer - DRAFT

Scenario 1: BAU
Scenario 2: None
Select Display Region: All (default) - Custom

Generation (2030): Land-based Wind (TWh)

Compare Technologies System Metrics

View and compare the contributions of each technology category to the total estimated generation or capacity.

BAU: Generation
PRAS LOLE early draft results (representative)

Node color = LOLP%

Edge color = CF%