Staff Subcommittees
on Electricity
&
Electric Reliability
Vermont Weather Analytics Center

Helping to make Renewable Energy Reliable

Kerrick Johnson
July 24, 2016
# Extreme weather a top global risk

<table>
<thead>
<tr>
<th>Economic</th>
<th>Environmental</th>
<th>Geopolitical</th>
<th>Societal</th>
<th>Technological</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storms and cyclones</td>
<td>Severe income disparity</td>
<td>Severe income disparity</td>
<td>Income disparity</td>
<td>Interstate conflict with regional consequences</td>
</tr>
<tr>
<td>Flooding</td>
<td>Chronic fiscal imbalances</td>
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<td>Extreme weather events</td>
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</tr>
<tr>
<td>Corruption</td>
<td>Rising greenhouse gas emissions</td>
<td>Rising greenhouse gas emissions</td>
<td>Unemployment and underemployment</td>
<td>Failure of national governance</td>
</tr>
<tr>
<td>Biodiversity loss</td>
<td>Cyber attacks</td>
<td>Water supply crises</td>
<td>Climate change</td>
<td>State collapse or crisis</td>
</tr>
<tr>
<td>Climate change</td>
<td>Water supply crises</td>
<td>Mismanagement of population ageing</td>
<td>Cyber attacks</td>
<td>High structural unemployment or underemployment</td>
</tr>
</tbody>
</table>

Source: World Economic Forum
State Policy Requirements Drive Proposals for Renewable Energy

State Renewable Portfolio Standard (RPS)* for Class I or New Renewable Energy by 2020

<table>
<thead>
<tr>
<th>State</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME</td>
<td>10%</td>
</tr>
<tr>
<td>NH</td>
<td>11%</td>
</tr>
<tr>
<td>RI</td>
<td>12.5%</td>
</tr>
<tr>
<td>MA</td>
<td>15%</td>
</tr>
<tr>
<td>CT</td>
<td>20%</td>
</tr>
<tr>
<td>VT</td>
<td>59%*</td>
</tr>
</tbody>
</table>

* State Renewable Portfolio Standards (RPS) promote the development of renewable energy resources by requiring electricity providers (electric distribution companies and competitive suppliers) to serve a minimum percentage of their retail load using renewable energy. Vermont’s new Renewable Energy Standard has a ‘total renewable energy’ requirement (reflected above), which recognizes large-scale hydro and all other classes of renewable energy.

Source: ISO-NE
By the end of 2016, installed solar is likely to equal 20% of Vermont’s electric demand.
Climate Change and Health in Vermont

Climate-related effects already threaten Vermonters’ health*

– Extreme weather events
– Heat-related illness and deaths
– Cyanobacteria (blue-green algae) blooms
– Rising tick-borne disease incidence
– Runoff from heavy rains polluting water bodies
– Increase in allergenic pollen

*Source: Vermont Department of Health
Rising sun — solar capacity growth accelerates

No AMI data available

*Assuming the same growth as March-December 2015
Vermont Weather Analytics Center

A powerful weather, energy data and analytics platform built with IBM that utilizes four coupled models and leading-edge analytics to deliver the most precise and accurate wind and solar generation forecasts in the world. VWAC enables us to:

- Increase grid reliability, community resiliency
- Lower weather event-related operational costs
- Garner full value from renewable generation
Vermont Weather Analytics Center
Four integrated models

Load Forecast Model

Generation Forecast Model

Renewable Energy Stochastic Engine
RISE Model

Deep Thunder Weather Model
Vermont Weather Analytics Center

Data Sources
- Generation
- Transmission
- Distribution
- Maintenance
- Smart Meters
- GIS
- Weather
- Spacecraft
- EMS
- Regulations
- Customers
- Distributed Energy

VTWAC Models
- Deep Thunder Weather Forecast
  - Electric Demand + Net Metering Forecast
  - Renewable Power Forecast
    - Solar & Wind
  - RISE Renewable Integration Stochastic Engine

Outcomes
- SMARTER DECISIONS
- Maximize Supply
- Manage Demand
- Better Balance Grid
- Maximize Asset Value
- Enhance Grid Reliability

Daily Data Volumes
<table>
<thead>
<tr>
<th>Model</th>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weather</td>
<td>5 GB</td>
<td>670 GB*</td>
</tr>
<tr>
<td>Solar</td>
<td>2 MB</td>
<td>15 MB</td>
</tr>
<tr>
<td>Wind</td>
<td>5 MB</td>
<td>3 MB</td>
</tr>
<tr>
<td>Demand</td>
<td>5 MB**</td>
<td>30 MB</td>
</tr>
<tr>
<td>RISE</td>
<td>20 MB</td>
<td>1.1 GB</td>
</tr>
</tbody>
</table>

*50 GB drive downstream models
**plus 5 GB smart meter data
Solar power forecast accuracy = ~95% (20 farm aggregate)  
(as of 3/2016)
Accuracy
Wind generation forecasts

Wind power forecast accuracy = ~90%
(as of 3/2016)
Accuracy
Demand forecasts

Vermont

Demand forecast accuracy - % Error (as of 3/2016)

State: 2.3%
DUs: 2.6%
Substations: 3-8%
Demonstrated Benefits

Safety & reliability
• More informed emergency response
• Road condition updates
• Geographically targeted customer updates

Operations
• Improved outage scheduling
• Ability to determine grid capacity for additional solar on the transmission system down to substation level
• Demand analysis capability to substation level

Planning
• Increased reliability of planning assessments due to AMI data integration
• Improved Non-transmission alternative development

Demand management
• Greater visibility to potential demand response events
• Increased peak management capability
• Efficiency measures validation
Value Continues to Grow

- Link VWAC data to VELCO’s Energy Management System
- Deliver customized data streams to meet individual distribution utility needs
- Finalize operational performance metrics
- Continue work with ISO New England for better renewables integration, forecasting and cost efficiency

In the future…

- Link to VT emergency management, environmental and ag agencies for safety, water quality impacts, disaster cost recovery records, and more
- Deliver weather intelligence for weather dependent businesses such as ski areas, agriculture, and tourism
- Monetize VWAC investment to further benefit customers
Next steps – operationalize/quantify value

Improving core service delivery
Develop core competence independent of IBM

VERMONT
- Enable & complement grid transformation
- Enhance renewables integration & operations
- Secure collaborative value

NEW ENGLAND
- Uplift to ISO New England
- Enhance grid effectiveness
- Planning
- Markets
“Our great new adventure.”

Kerrick Johnson, Vice President
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