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Renewable Generation Interconnection, Integration and System Balancing

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Maine Public Utilities Commission

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Agenda

- Overview of generator interconnection process
  - Local Utility (State)
  - New England Independent System Operator (ISO-NE) and Northern Maine System Administrator (NMISA) (Federal)
- Issues and opportunities for renewable energy integration
- System balancing issues

Why have a standardized interconnection process?

- Expedites new generator interconnections
- Helps to ensure grid reliability
- Avoids discrimination

What is the Interconnection Process?

- Process of getting an interconnection agreement with the local transmission and distribution company and/or ISO-NE
- The process is used to make sure interconnecting generators are integrated into the distribution and/or transmission system responsibly with respect to impacts on reliability, power quality and safety
  - For example, can not allow distributed generator to affect neighbors on feeder
- All costs of interconnection are generally the responsibility of interconnecting generator

Importance of the Interconnection Process

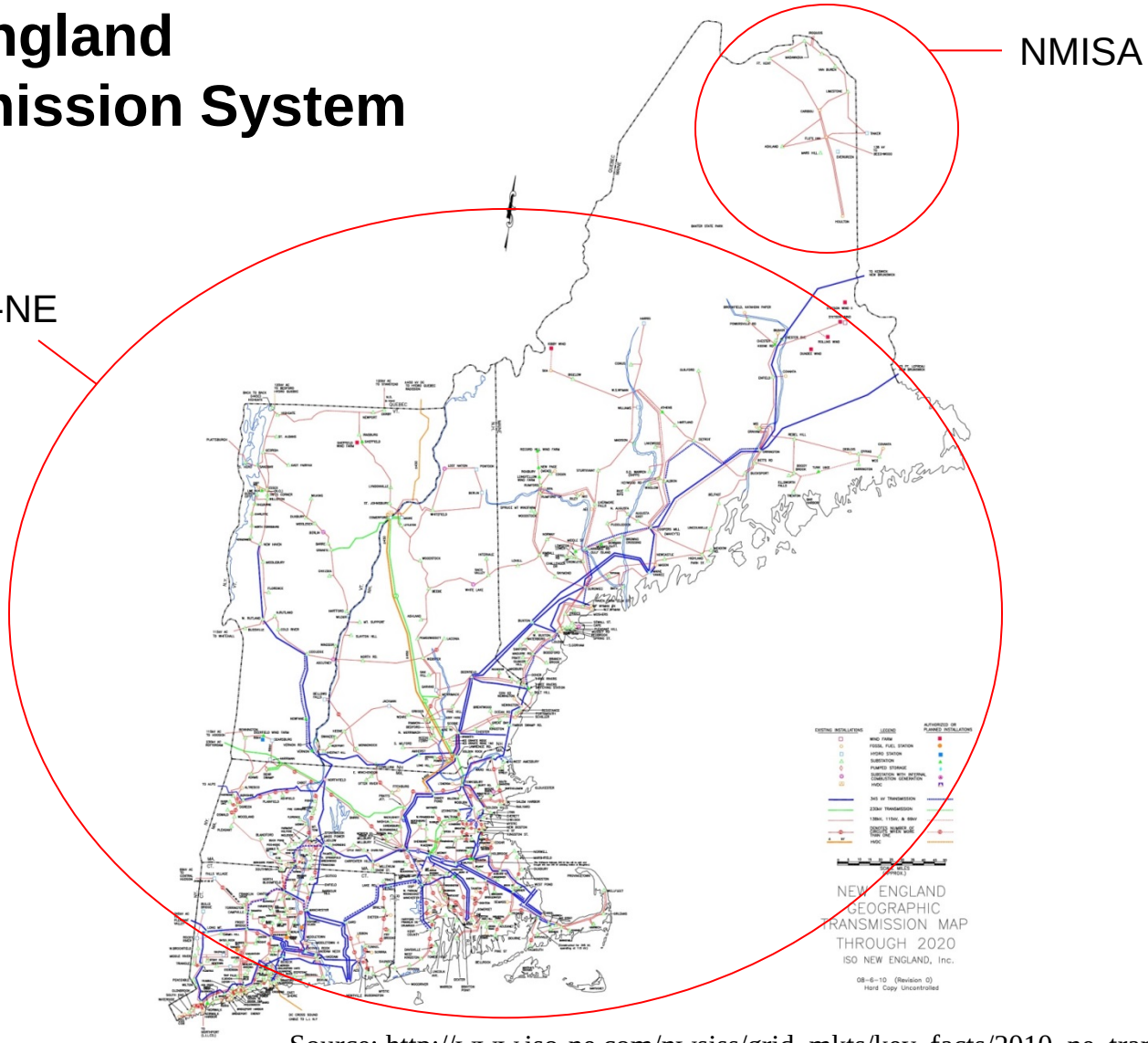
- Following the interconnection process is important because, for instance
  - a distributed generation system changes the one-way power flow from the utility to customer, which can present dangers to utility workers if proper equipment is not installed
  - a large generator changes power flows on the transmission system and may cause transmission circuit overloading under certain operating scenarios, affecting transmission system reliability. This is especially important for new variable renewable generation integration like wind.
- While robust and capable of handling minor disturbances, the quality of grid power is extremely important. The interconnection process ensures generation meets safety, reliability, & power quality requirements with regard to:
  - Islanding
  - Transient Voltage Conditions
  - Noise and Harmonics
  - Frequency
  - Voltage Level
  - Machine Reactive Capability

Generator Interconnection State vs. Federal Jurisdiction

- ***Federal (FERC Orders 2003, 2006, 661, others)***
  - All transmission interconnections
  - Distribution interconnections that already have a generator in the wholesale energy market, and the interconnecting generator will be in the wholesale energy market

- ***State***
  - Behind-the-meter generation (offsetting customer load)
  - Qualifying Facility (QF) generation (e.g., cogeneration)
  - Maine PUC standard interconnection procedures:
    - 2009 report to Legislature - “Statewide interconnection procedures for Maine’s utilities should be imposed.”
    - Effective in 2013, Chapter 324 Rule
      - http://www.maine.gov/tools/whatsnew/attach.php?id=93709&an=2

New England Transmission System



Source: http://www.iso-ne.com/nwsiss/grid_mkts/key_facts/2010_ne_trans_map_nonceii.pdf

Governing Regulations and Bodies

- State jurisdiction vs. FERC jurisdiction
  - Will your system impact the bulk power system (transmission)?
  - Will you sell to the market or will you sell to the host utility as a QF or under net metering?
  - Are you the “first on” the distribution feeder?
- ISO-NE Schedule 22 and Schedule 23 or NMISA Market Rule 8: If you will be connecting to the transmission system, or if you will sell to the market on an existing “FERC jurisdictional” feeder.
  - Independent System Operator New England or NMISA administers
  - Significant application fee and queueing

Governing Regulations and Bodies -Continued

- Distribution Level interconnection tariffs: Connection to a distribution feeder under “State Jurisdiction”
  - Local Distribution Company administers
  - Investor owned utilities in Maine now have a standardized process (Chapter 324)

State jurisdictional interconnection

- Small, distributed generation that connects to the distribution system primarily requires a State jurisdictional, local utility administered interconnection process.
  - <5 MW only necessitates ISO-NE notification of interconnection
- The Maine PUC specifies the local distribution system interconnection standards in Chapter 324 Rule. This process is used by the two investor owned utilities (IOU) in Maine (Central Maine Power (CMP) and Emera Maine)
- Municipally-owned utilities are not required to follow this process, and may follow a different criteria.

Maine Chapter 324 Small Generator Interconnection Rule

- **4 Levels of interconnection review based upon size**
  - **Level 1** - For certified, inverter-based facilities with a power rating of ten kilowatts (10kW) or less on radial or Spot Network systems under certain conditions.
  - **Level 2** - For certified generating facilities that pass certain specified screens and have a power rating of two megawatts (2MW) or less.
  - **Level 3** - For certified generating facilities that: (a) pass certain specified screens; (b) do not export power beyond the Point of Common Coupling; and (c) have a power rating of ten megawatts (10MW) or less.
  - **Level 4** - For all generating facilities that do not qualify for Level 1, Level 2 or Level 3 interconnection review processes, and are not subject to the jurisdiction of FERC.

Federal (ISO-NE) Jurisdiction of Interconnection

- If project is large enough (>6 -10 MWs), will need to interconnect to transmission system through Federal Energy Regulatory Commission (FERC) Small Generator Interconnection Procedures (SGIP)
  - Need to apply to the New England Independent System Operator (ISO-NE)
- If you will be selling your power to a third party, or bidding in capacity to the Forward Capacity Market (FCM) you may have to apply through ISO-NE
- If circuit is already “FERC Jurisdictional” and project is selling to a third party, it will need to apply to ISO-NE.
  - If another generator is selling to the wholesale market, then the circuit is FERC jurisdictional

http://www.iso-ne.com/genrtion_resrcs/nwgen_inter/index.html

Generator Interconnection Process

Large Generator (> 20 MW) or Small Generator (<= 20 MW)

- Large Generator Interconnection Process in ISO Tariff Schedule 22
  www.iso-ne.com/regulatory/tariff/sect_2/sch22/09-2-1%20fcmg-sched_22_.pdf
- Small Generator Interconnection Process in ISO Tariff Schedule 23
  www.iso-ne.com/regulatory/tariff/sect_2/sch23/09-2-1_fcmg_sched_23.pdf
- Generator Interconnection Technical & Market Requirements
  www.iso-ne.com/genrtion_resrcs/nwgen_inter/reg/index.html
- Application for Interconnection
  - Large (> 20 MW, with $50,000 deposit)
    www.iso-ne.com/genrtion_resrcs/nwgen_inter/lg_gen/index.html
  - Small (<= 20 MW, with $1,000 deposit)
    www.iso-ne.com/genrtion_resrcs/nwgen_inter/smgen_20/index.html
  - Less than 5 MW (notification only)
    www.iso-ne.com/genrtion_resrcs/nwgen_inter/reg/gen_not_form_less_5mw.doc
- Generator Interconnection Queue
  www.iso-ne.com/genrtion_resrcs/nwgen_inter/status/index.html

ISO-NE Interconnection Queue (snapshot)

- (updated monthly)

ISO New England Study Request Database - Public

Active Projects as of 4/2/2015

FERC Administered Transmission System

QP	Requested	Alternative Name	Unit	Fuel Type	Net MW	SumMW	WinMW	County	ST	OpDate	Interconnection Point	SIS	I39	Zone
89	6/6/2001	Cape Wind Turbine Generators	WT	WND	462	462	462	N/A	MA	12/31/2016	Near Barnstable 115 kV Substation	Yes	Yes	SEMA
178	11/2/2006	Brockton Combined Cycle	CC	NG DFO	332	332	371	Plymouth	MA	4/19/2017	115 kV F19 and E20 lines	Yes	Yes	SEMA
196	1/16/2007	Northfield Mt Upgrade #1	PS	WAT	25	295	295	Franklin	MA	6/1/2016	W. Mass Northfield 345 kV substation	Yes	Yes	WMA
272	8/1/2008	Oakfield II Wind - Keene Road	WT	WND	147.6	147.6	147.6	Aroostoock	ME	12/31/2015	BHE Keene Road Substation	Yes	Yes	BHE

- only oldest (highest queue position) units shown
  - actually over 100 facilities in queue, constituting over 25 GW of net capacity
  - not all projects are built

Generator Interconnection Process
Energy Market

- **Energy Market Only – Follow "traditional" interconnection process (ISO PP5-6 Minimum Interconnection Standard)**
  - Application for Service
  - Scoping Meeting
  - Optional Feasibility Study
  - System Impact Study
  - Optional Facilities Study
  - Interconnection Agreement

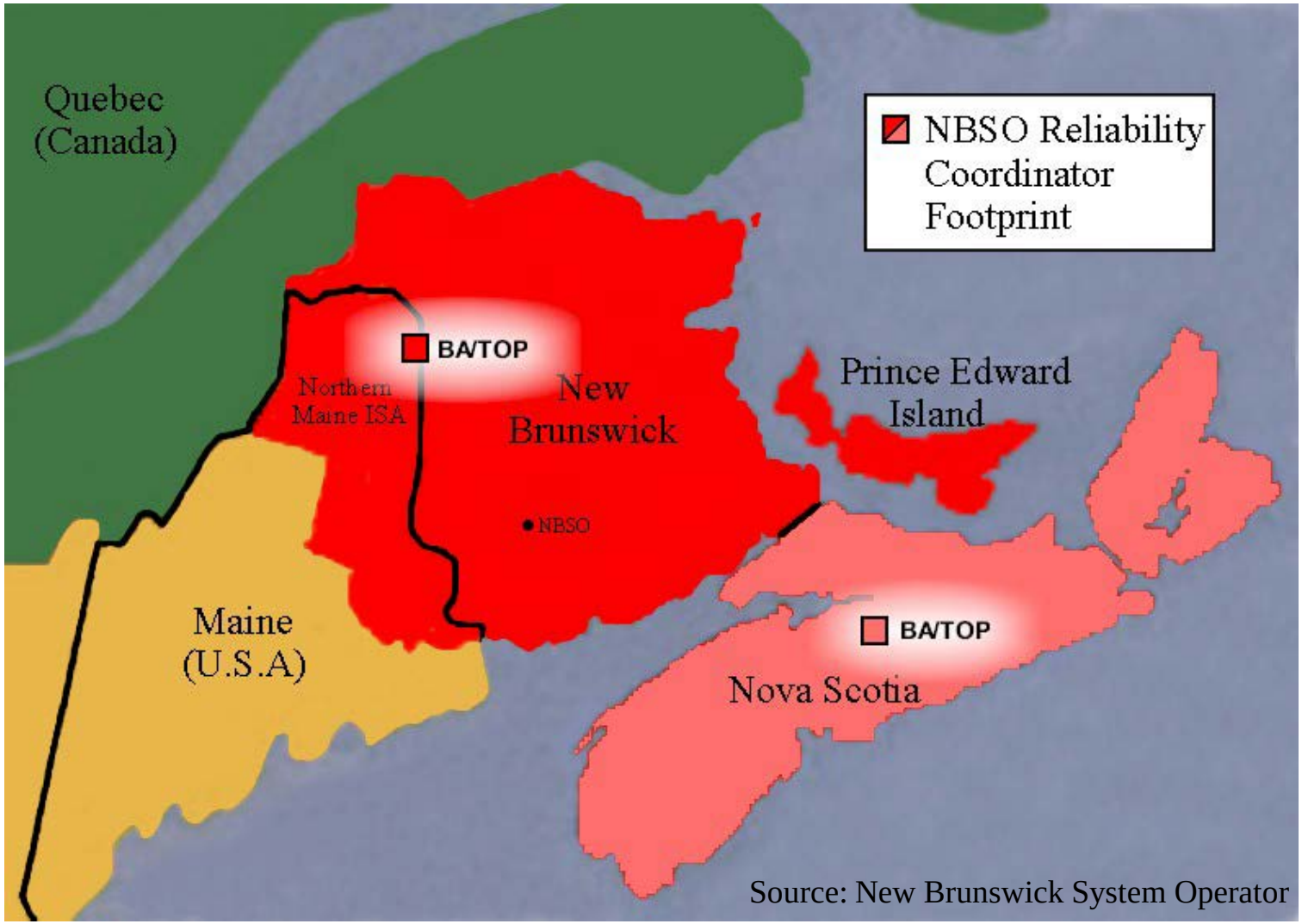
Generator Interconnection Process
Capacity Market

- **Capacity Market – Participate in Forward Capacity Market plus "traditional" interconnection process (ISO PP-10)**
  - Optional Non-Binding Group Analysis ("overlapping impact")
  - Optional Commitment to Upgrades to allow Capacity market participation
  - Participate in Forward Capacity Auction corresponding to in-service date
  - "Overlapping impact" study (if not already done), if capacity bid accepted from auction,
  - Commit to required upgrades for Capacity Market participation

The System Impact Study
Reliability with Generator Interconnection

- Accurate models are fundamental
- Transmission system must accommodate uncertainty and variability – assess reasonably stressed system conditions as appropriate (per ISO Planning Procedure 5)
- Generation must perform acceptably for a variety of disturbances (per NPCC Basic Criteria and ISO Reliability Standards - Planning Procedure 3)
- Acceptable performance requires:
  - "Low voltage ride-through" during system disturbances
  - Sufficient power factor for voltage control before and after disturbances
- Assess steady state, short-circuit, and dynamic stability performance

The Northern Maine System



Source: New Brunswick System Operator

Northern Maine System Administrator (NMISA)

- The Northern Maine Transmission System includes elements owned and operated by Eastern Maine Electric Cooperative, Houlton Water Company, Maine Public Service Company, and Van Buren Light & Power District, and which is not a part of ISO-NE.

- An entity that wishes to connect a new facility to the NMTS shall:
  - Submit a connection application, pursuant to the TO's Open Access Transmission Tariff (OATT)
  - provide the NMISA with copies of: all material submitted to the directly affected TO; the connection agreement and any other agreements with the directly affected TO; and any other information the ISA deems necessary and requests in writing.

NMISA Authority

- No entity shall connect any new facility to the Northern Maine Transmission System if such action is **disapproved by the NMISA**.
- The connection of a new facility consists of any of the following actions:
  - the connection of a new Generating Unit;
  - the connection and/or reactivation of an existing mothballed Generating Unit proposing to come back into service;
  - the addition or removal of any transmission facility located in Northern Maine and rated 69 kV or above, whether or not the transmission facility is or will be part of the Northern Maine Transmission System; or
  - the establishment of connections with a transmission system outside of the Northern Maine Transmission System.

Generator Interconnection Process
Role of the NMISA

- The NMISA shall evaluate each proposed connection of a new facility to determine whether:
  - it would adversely affect the Northern Maine Transmission System (NMTS)
  - it would provide reliability benefits thereto. The NMISA may, as prescribed in the Market Rules, conduct a cost-benefit analysis with respect to the reliability determination.

- The NMISA may disapprove a proposed connection of a new facility if the ISA determines:
  - that such connection would adversely affect the Northern Maine Transmission System; or
  - that the proponent of such connection has not provided the information required by the Market Rules on a timely basis.

Resource Integration and Balancing: Key Issues

- ***Wind Resources are in remote locations from most of the load centers and backbone transmission system***
  - "weak system" issues
  - Additional reinforcement may be needed
- ***"Wind Farms" are composed of tens to hundreds of individual generators***
  - A "farm" has its own collector network, typically to a "hub"
  - Hundreds of generators (typically 1.5 to 3 MW each) with their own control systems
  - Master control with slower response time
- ***Seasonal Variations***
  - While New England may benefit from an increase in electric energy provided by wind generation primarily during the winter period, the region will still need to have adequate capacity to serve summer peak demand.
  - Potential displacement of electric energy provided by existing resources raises some concern for maintaining adequate capacity (essential for resource adequacy) and a flexible generation fleet (essential to balance the variability of wind generation)
- ***Assessment of expected capacity value for Area resource adequacy***

Resource Integration and Balancing: Regulation

- ***A key power system control objective is to maintain a balance in the system between load and generation (accomplished by maintaining frequency and tie exchange)***
- ***Regulation is the MW required from generators or loads within a Balancing Area like New England that quickly (4 seconds) respond to changes in load and system frequency***
- ***Engineering models must accurately reflect the characteristics of renewable generators***
  - Voltage and frequency ride-through capability required
  - Real and reactive power response for voltage control
  - Manufacturers have unique designs with different control & performance features – all are induction generators
    IEEE standard model effort is underway
  - Low/no inertia for wind generators – possible larger frequency excursions
- ***The Regulation capacity requirement and will increase the frequency of utilization of these resources.***
  - The primary driver for increased regulation requirements due to wind power is the error in short-term wind power forecasting.

Resource Integration and Balancing: Reserves

- ***Reserves are the "insurance policy" that grid operators use to protect against credible contingencies (i.e. realistic power system faults and combinations of faults) that would negatively affect the operation of the power system.***

- ***ISO-NE uses several types of reserves***
  - Ten Minute Spinning Reserve (TMSR)
    - Synchronized with grid, can provide inertia and governor response
    - Units on Regulation can be counted towards TMSR
  - Ten Minute Non-spinning Reserve (TMNSR)
    - "Quick start" generation
    - New combined cycle plants in New England can ramp from cold start to 300 MW in 10 Minutes!
  - Thirty Minute Operating Reserves (TMOR)

- ***Operating Reserve Capacity Implications***
  - Capacity over and above what is required to provide energy in order to ensure reliability
  - Additional spinning and non-spinning reserves will be required as wind penetration grows

ISO-NE Wind Integration Study Observations

(*www.iso-ne.com/.../pac/mtrls/2010/nov162010/newis_iso_summary.pdf*)

- ***Capacity factors and capacity values for wind***
  - Diminish with increasing penetration or if transmission is not available
  - More expansive results will be presented to New England Stakeholders at the Planning Advisory Committee
- ***Wind could displace combined cycle, oil and gas-fired steam units (under higher penetration scenarios) in the energy market***

- ***High levels of flexibility will be needed to manage variability***
  - Important to maintain fleet flexibility even under decreased energy market revenues

- ***Centralized wind power forecasting will be required will require high quality data from wind projects***

- ***As wind penetration levels increase New England will require more regulation and reserves capability in order to maintain reliability***

- ***Significant transmission expansion is required for increased wind penetration levels over time***

Beyond Utility Scale Wind: The Challenge and Opportunity of Distributed Generation

- ***Opportunities***
  - Generation at load
  - Modularity
  - Cost predictability
  - Standard and low-cost interconnection process
- ***Challenges***
  - Non-dispatchability (e.g., photovoltaics)
  - System balancing costs (in an aggregate of many systems)
  - Storage costs (for individual systems)

Thank you. We would be happy to answer any additional questions you may have.

Questions?