2015 Economic Studies
Common Assumptions
Scope of Work – Revised Draft

Planning Advisory Committee Meeting

Wayne Coste

PROJECT MANAGER, ECONOMIC PLANNING

Outline

- Summary
- Stakeholder Input for 2015 Economic Studies
- Economic Study Metrics
- Economic Study Assumptions Affecting Energy Cost Results
- Assumptions
  - Demand
  - Development of the base network model
  - Resource modeling
  - Interchange modeling
  - Operating reserve
  - Fuel prices

Three 2015 Economic Study Requests

- Keene Rd. Interface (SunEdison)

http://www.iso-ne.com/static-assets/documents/2015/04/a6_sun_edison_presentation_economic_study_keene_rd.pdf

- Impact of Offshore Wind Deployment on New England's Wholesale Electricity Markets and Operations [Massachusetts Clean Energy Center]

http://www.iso-ne.com/static-assets/documents/2015/04/a6_cec_presentation_economic_study_offshore_wind.pdf

- Impact of Maine Upgrades Identified in ISO-NE's Strategic Transmission Analysis for Wind Integration [RENEW Northeast (RENEW)]

http://www.iso-ne.com/static-assets/documents/2015/04/a6_presentation_renew_strategic_transmission_analysis_wind_integration_economic_study_req.pdf

Summary

- The ISO will perform all three Economic Studies
  - Draft results to be presented to PAC by late 2015 or early 2016
  - Final reports completed after consultation with the PAC
- The studies will compare the performance of the future system with additional representative future system improvements
  - The studies will not include detailed transmission planning analysis, such as new system impact studies
- The results ***may*** be used to
  - Identify the need for future Market-Efficiency Transmission Upgrades (METU)
  - Inform Public Policy requests for projects facilitating the integration of wind resources
    - Onshore wind resources in ME
    - Offshore wind resources in MA/RI
- These 2015 Economic Studies do not include comprehensive transmission planning analysis required for full development of transmission improvements, but build upon Strategic Transmission Analysis previously presented to the PAC

Stakeholder Input for 2015 Economic Studies

- The ISO is seeking input from the PAC today
  - Revised high level scope of work
  - General study assumptions
- Later PAC input will be sought on
  - Overall study results and conclusions
  - Review of draft report
- Special economic study working groups ***may*** be formed to provide the ISO input on very detailed technical modeling and simulation methods not of interest to the general PAC audience
  - This has been done to support past Economic Studies
  - Past study groups required a very limited number of conference calls
  - May have different study working groups for each of the Economic Studies
- ***Alternatively or in addition to the economic study working group***
  - PAC presentations will be structured to discuss the general PAC economic study issues upfront
  - More technical discussions will be discussed with PAC members as a last meeting agenda item

Economic Study Metrics

- Production Costs for the system
- Load Serving Entity Energy Expenses by RSP bubble
- Congestion for the system
- Flow Duration Curves by Interface
- Generation Energy Production by Fuel Type
- Environmental Air Emissions by Electric Generator Type
- ***New***: Approximate cost estimates of representative transmission upgrades that can relieve congestion
  - Comparison of Annual Carrying Charges (assumed at 14%-16% of capital cost estimates) of transmission improvements with the production cost savings resulting from transmission improvements

Economic Study Assumptions Affecting Energy Cost Results

- Demand forecasts
- Energy Efficiency growth rates
- Renewable development and integration
- Types and locations of new resource development
- Potential retirements
  - Coal
  - Oil
  - Nuclear
- Fuel price
- Environmental emission allowance prices

Key Simulation Data

- Demand (Reduced local load in Keene Road area will be reflected)
- Transmission
  - Transmission network – reflect RSP net forecast, transmission improvements, etc.
  - Internal interface limits
  - Phase shifters
  - Line monitoring
  - Contingencies
- Resources
  - Thermal units
  - Hydro units
  - Pumped storage
  - Wind units
  - Active Demand Resources, Energy Efficiency and Real-time Emergency Generators
  - Imports/Exports
  - Operating reserve requirements

Questions

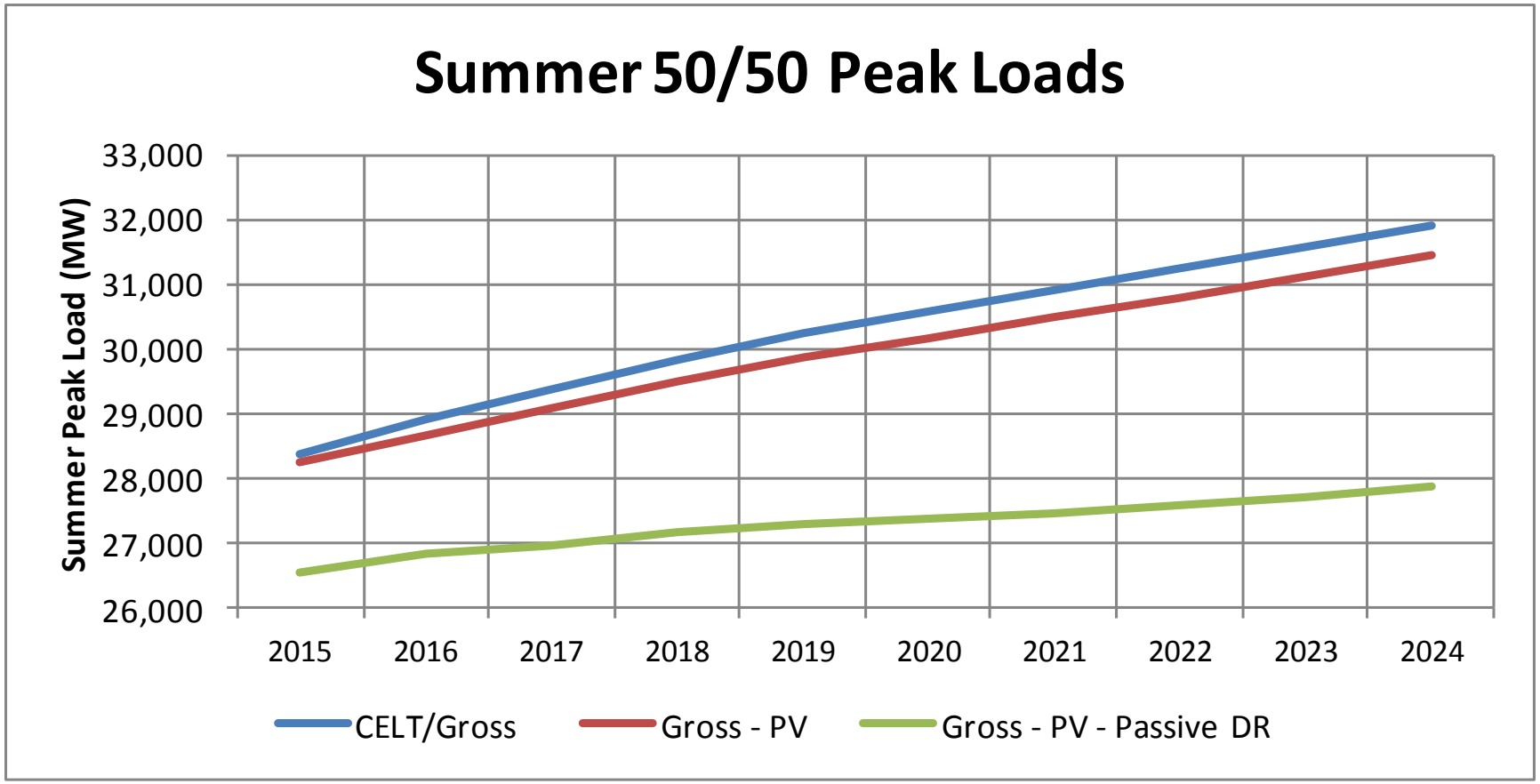
APPENDIX
SIMULATION METHODOLOGY

Development of Base Model

Overview of Assumptions – Consistent with 2015 CELT

- Demand
  - Net of Energy Efficiency (EE) and Photovoltaic (PV) – including forecasts
  - Active Demand Resources (DR) treated as supply
  - Hourly load profile based on 2006 weather (synchronized with wind / PV)
- Supply resources considered
  - Results from Forward Capacity Auction #9 for (2018/2019)
  - Energy Only Resources
  - Wind resources in the each study was specified by the economic study requestor

50/50 Summer Peak Load Forecast
Effect of Behind-the-Meter PV and Passive DR



Network Modeling

- Modeling of Transmission Network
  - Detailed modeling of ISO-NE region only
  - Representation for neighboring systems
    - Detailed network modeling not required for NY, NB, and HQ
    - Tie-line flows modeled by dummy resources at external nodes
    - Base flows based on historical line flows
- Transmission projects*
  - May 18, 2015 RSP Project List used to select transmission projects
    - All Proposed, Planned and Under Construction reliability upgrades
    - Excluded – RSP 1269, RSP 1280 and RSP 1517
    - Upgrades associated with the ISO Interconnection Queue projects that had PPA approval as of April 1, 2015
  - Generators
    - In the ISO Interconnection Queue with PPA approval as of April 1, 2015
    - Generators without PPA approval but have an obligation through FCA9

* Source: http://www.iso-ne.com/static-assets/documents/2015/06/draft_summary_of_steady_state_basecases_for_TPL_001_4.docx

Network Modeling (cont)

- Modeling of Internal Interface Limits
  - Internal interface limits in ME are mostly voltage or stability
  - Model major interfaces consistent with RSP15 transfer capability assumptions and the Strategic Transmission Analysis
- Modeling of transmission lines
  - All 230 kV and 345kV circuits ISO-NE region are monitored
    - Nearly 300 branches monitored
    - Includes transformers that step up to 230 kV and above
- Monitoring of transmission lines
  - 115 kV and above lines in areas of concern as appropriate
    - Maine for
      - Strategic Transmission Analysis – Wind Integration study
      - Keene Road study
    - SEMA / RI for off-shore wind study

Network Modeling (cont)

- Modeling of contingencies
  - Modeled same contingencies as defined in previous GridView cases
    - Based on 3 years of historical binding contingencies in Day-Ahead Market
    - 100 out of 160 frequently occurring identified and modeled
      - Full set of transmission planning contingences (OP-19) not modeled
  - Additional system contingencies identified by relevant Needs Assessments, Solution Studies and the Strategic Transmission Alternatives

Thermal Units

- Resources / assets / interconnected at specific buses
- For existing thermal units, use:
  - Production cost parameters such as: Heat rate curve, Start-up cost, No-load cost and etc.
  - Primary and secondary fuel definition are based on 2015 CELT
- Operational limits assumed same as previous economic study
  - Minimum up time, Minimum down time and Start up time
  - Ramp rate limits
- Energy limits: assume no energy limits
- Future thermal units
  - Generic
  - Production cost parameters based on: unit type, technology and rating

Thermal Units (Cont.)

- For combined cycle units
  - Individual machines for a combined cycle plant will be modeled separately
  - Typically interconnecting at different buses
- Outages
  - Thermal units derated to reflect the forced outages using Equivalent Forced Outage Rate (EFOR)
  - Planned maintenance schedule will be developed and held constant across cases

Hydro Units

- Hydro units modeled using
  - Hourly energy generation profiles
  - Used in previous economic studies
    - Generates more on-peak than off-peak
    - Reflects a minimum “must-run” value
- Hydro units in wind development areas
  - Hydro profiles will compliment wind profiles
  - Hydro prescheduled so that
    - With known wind profiles, low hydro generation during periods of low wind generation is discouraged
    - Facilitates maximize flows across export constrained interfaces

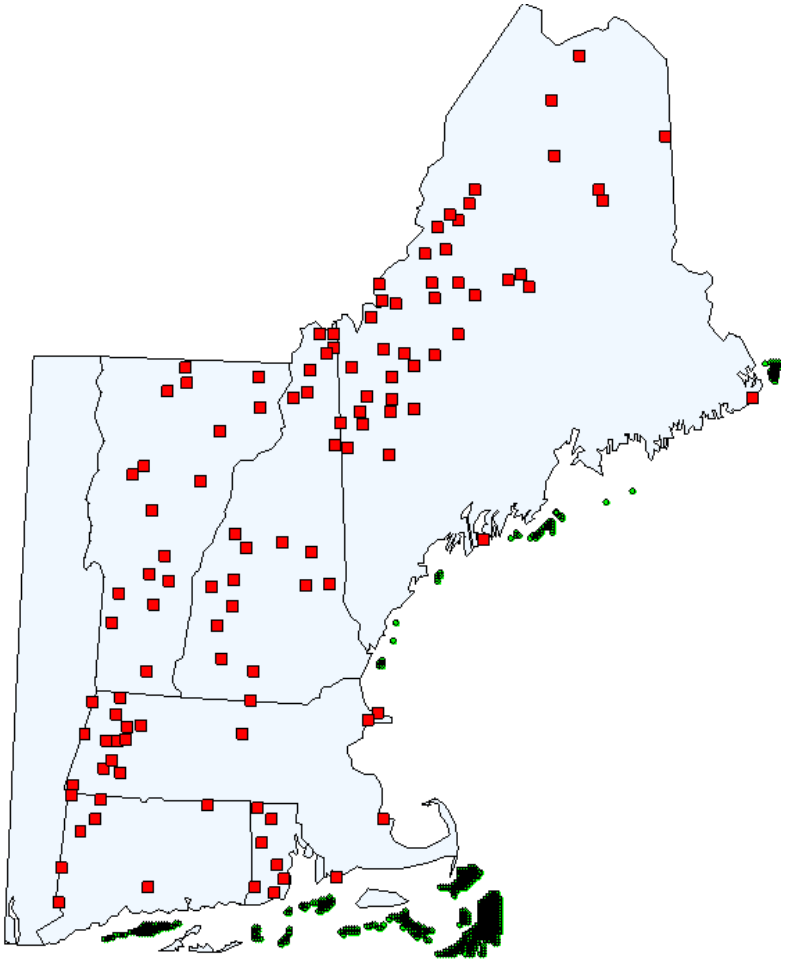
Pumped Storage Units

- Modeled in peak shaving mode
  - Pumping during off-peak hours
  - Generating during on-peak hours
- Pumped Storage physical parameters
  - Minimum pond size
  - Maximum pond size
  - Plant Capacity Factor
  - Based on assumptions used in previous studies

Wind Units

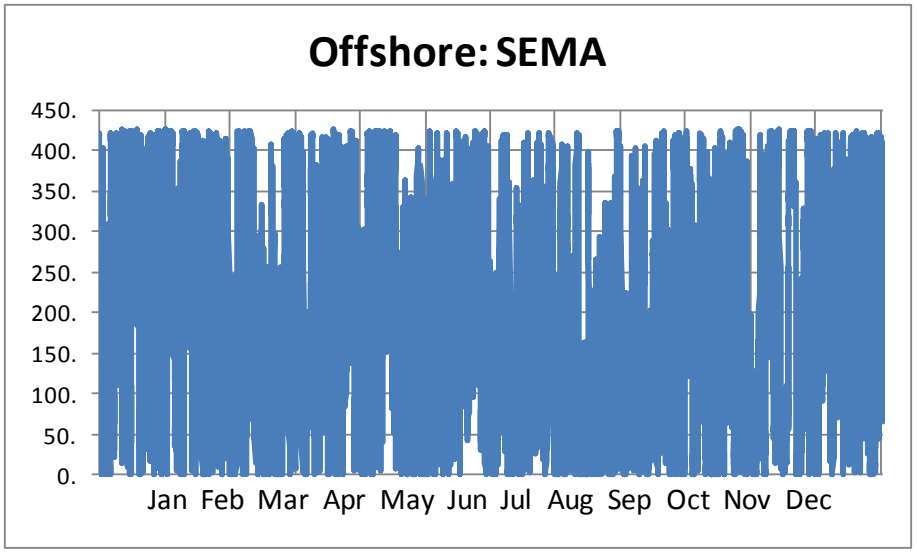
- Wind output modeled as hourly resources
  - Based on NREL Eastern Wind dataset
  - Simulated wind farm data points
    - For the eastern United States
    - For 2004, 2005, and 2006
    - Update in 2012 use newer composite power curves
      - Composite commercial megawatt-class power curves for onshore
      - Separate composite power curve for offshore
- Dispatch Hierarchy
  - Wind will be last resource curtailed (dispatch at $0/MWh)
  - Hydro will be next to last resource curtailed (dispatch at $5/MWh)
  - Imports will be curtailed before hydro (dispatch at $10/MWh)
  - Allows observation of transmission limitations by wind, hydro and imports

Location of Synthetic Updated EWITS Wind Data

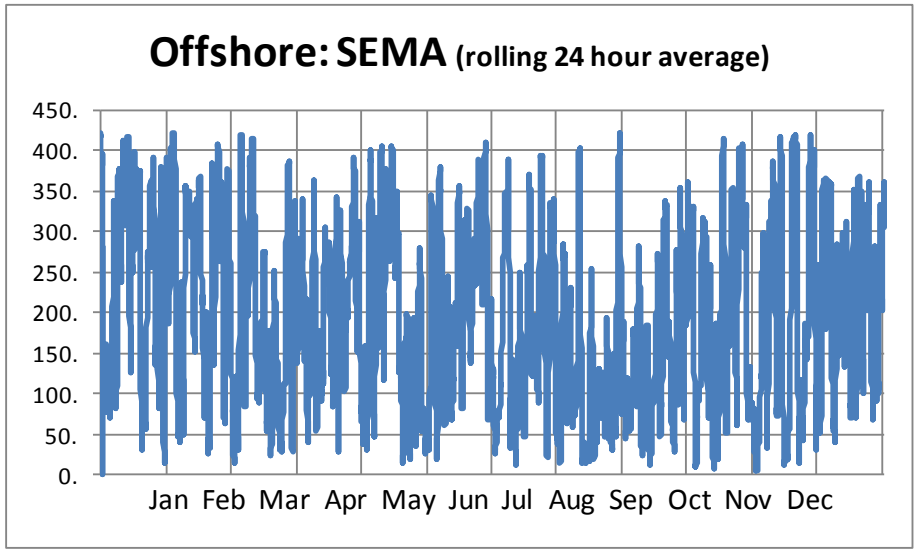


EWITS Wind Profiles Similar to NEWIS Profiles

Hourly Profile (to be used in the simulations)



Smoothed Hourly Profile (conceptual visualization)



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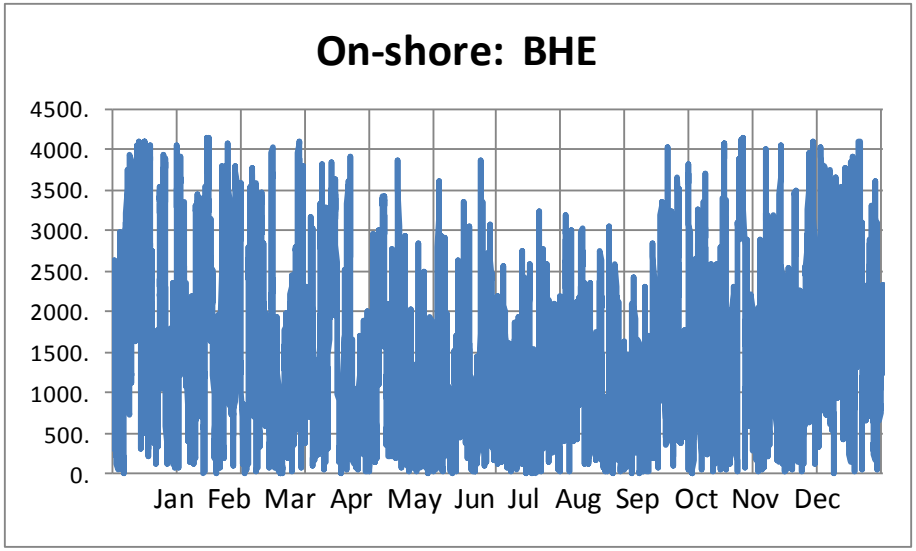

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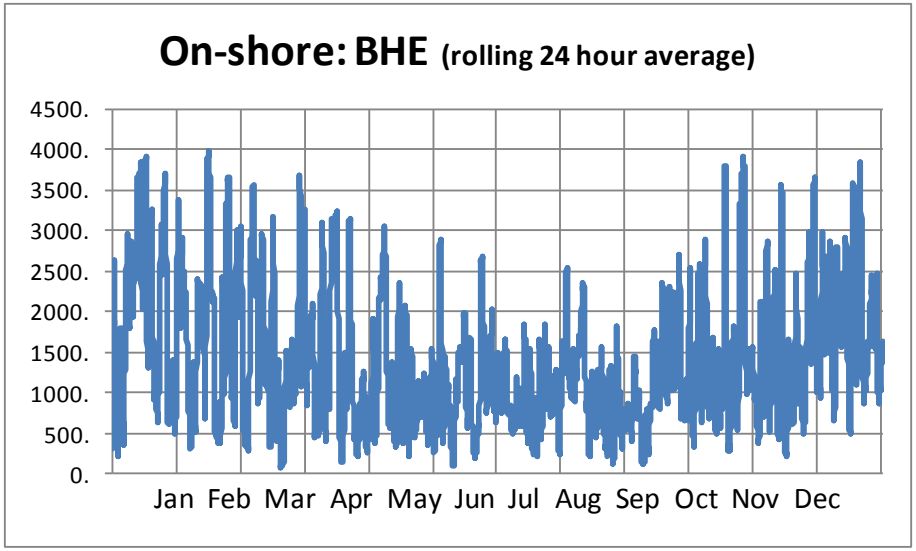


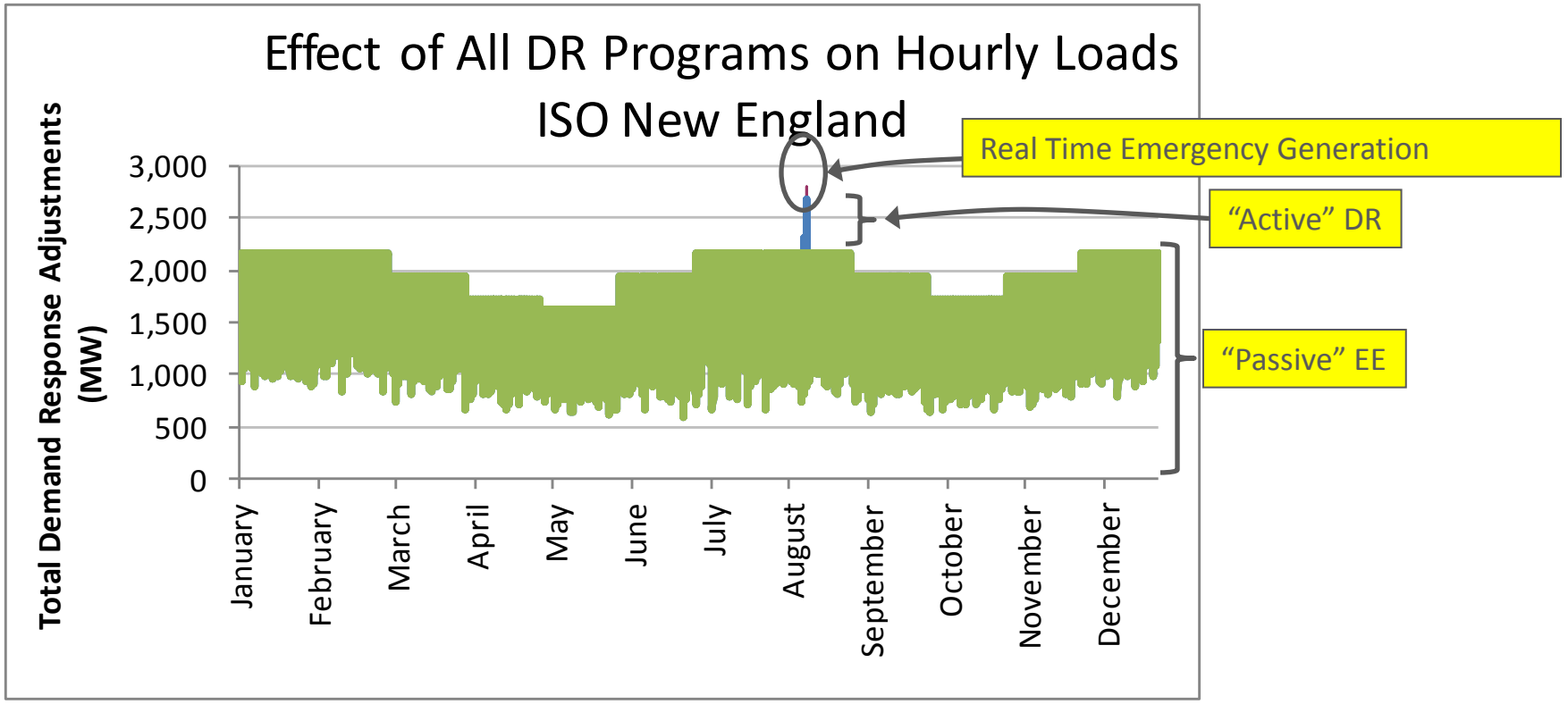
Photovoltaic

- Model forecasted PV resources and loads
- Incorporating a time stamped, chronological solar PV profile
- National Renewable Energy Laboratory (NREL) has developed a simulated solar PV dataset based on 2006 weather
  - New England specific
  - Profiles by RSP area available
- Consistent with methodology used for wind profile
- Profiles to be developed consistent with the PV forecast discussed with the DGFWG

Demand Side Resources

- Active DR, EE and RTEG are modeled explicitly
  - Hourly profile for each category of demand side resource
  - FCA amounts assumed after capacity commitment periods
  - Modeled the same as previous economic studies
    - Explicitly shows that Active DR and RTEG are expected to be used
    - Price based modeling of Active DR / RTEG is problematic
- EE Forecasts
  - The latest EE forecast through the year 2024 is reflected
  - Active DR and RTEG are held constant for years beyond capacity commitment period (same as other FCM resources)

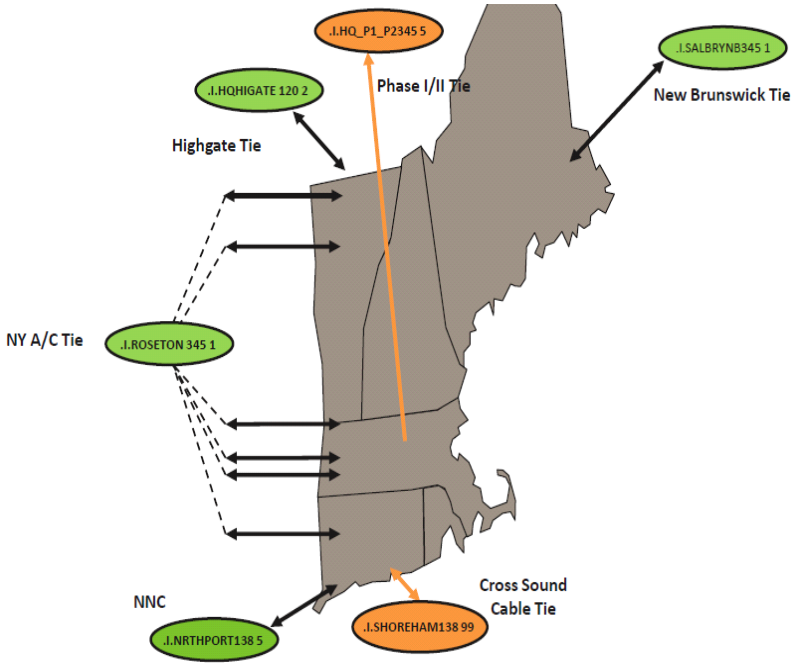
Load Modifiers (Base Case)
Energy Efficiency (EE), Active Demand Resources (DR) and Real-Time Emergency Generation (RTEG)



Imports and Exports

- Hourly imports and exports over the following external interconnections are modeled based on the **average** of 2012, 2013 and 2014 historical interchange values*
  - Highgate
  - HQ Phase II
  - New York AC (includes NNC)
  - New York DC-Cross Sound Cable
- Maritimes (New Brunswick)
  - Hourly imports and exports are modeled based on the highest diurnal values for the years 2013 and 2014
  - Sensitivity with 1000 MW import flow

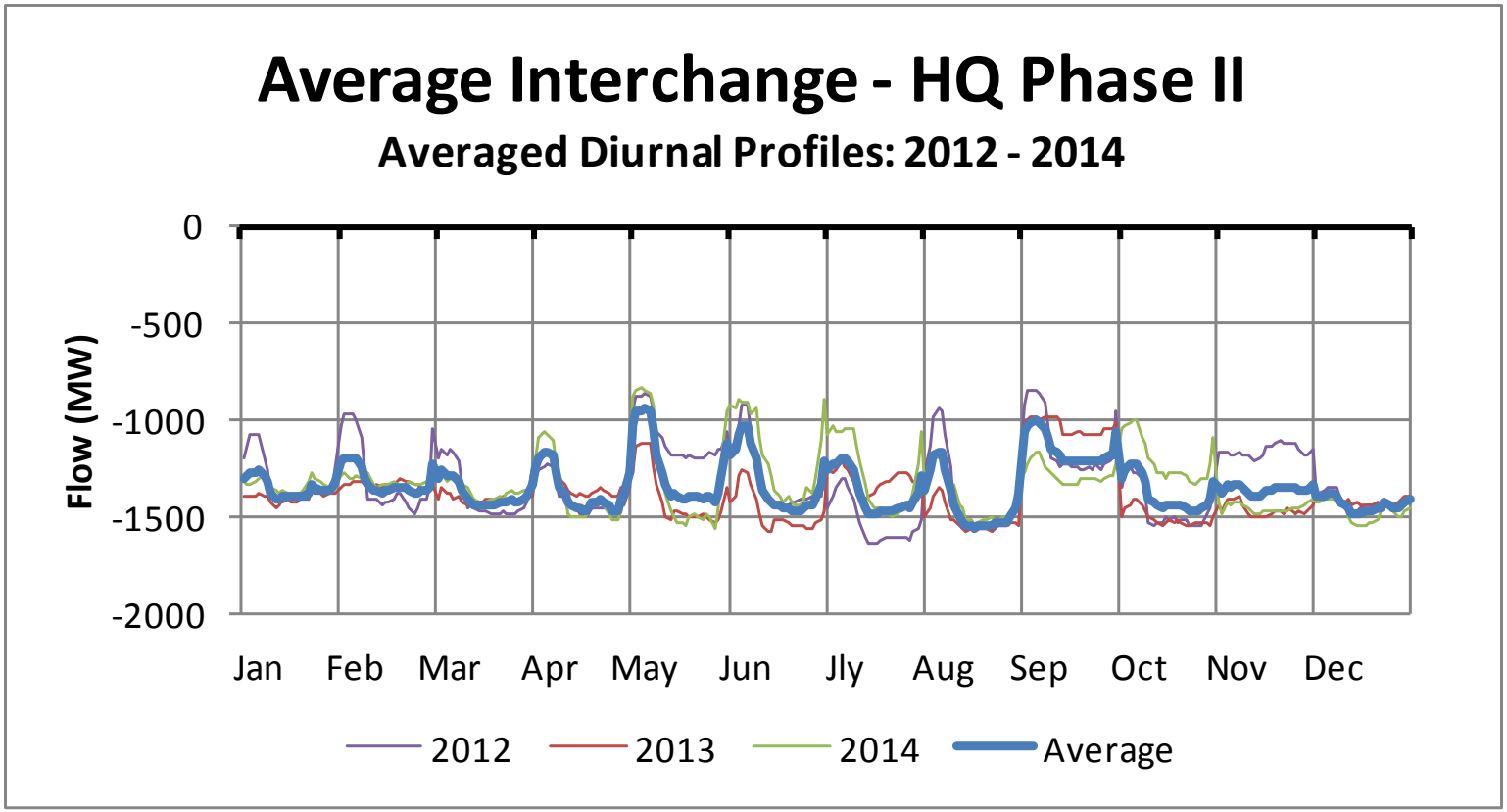
ISO -NE External Interface



Modeling of Imports/Exports

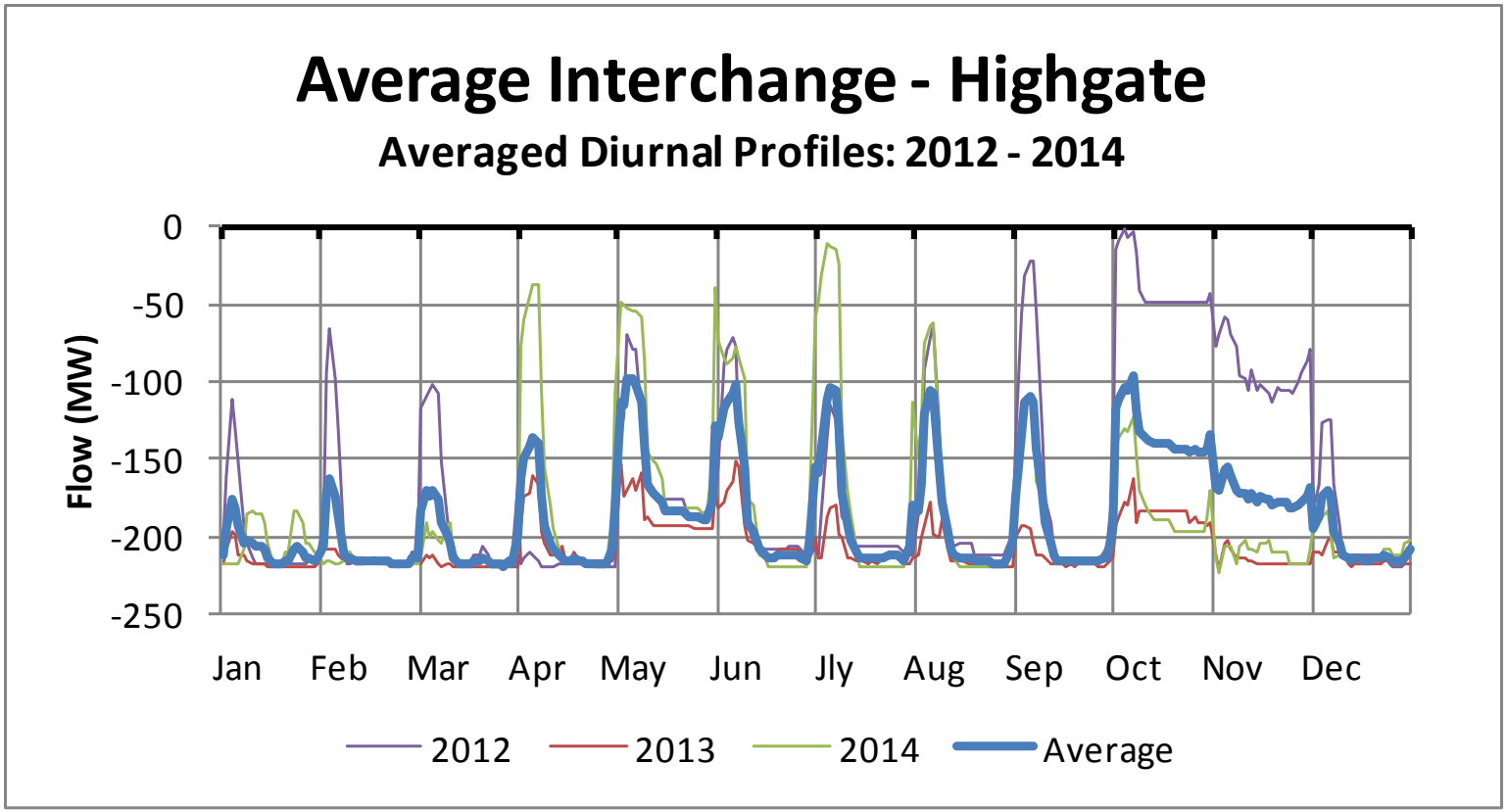
*The same approach used in previous economic studies for representing import/export assumptions

Quebec to New England: Phase II



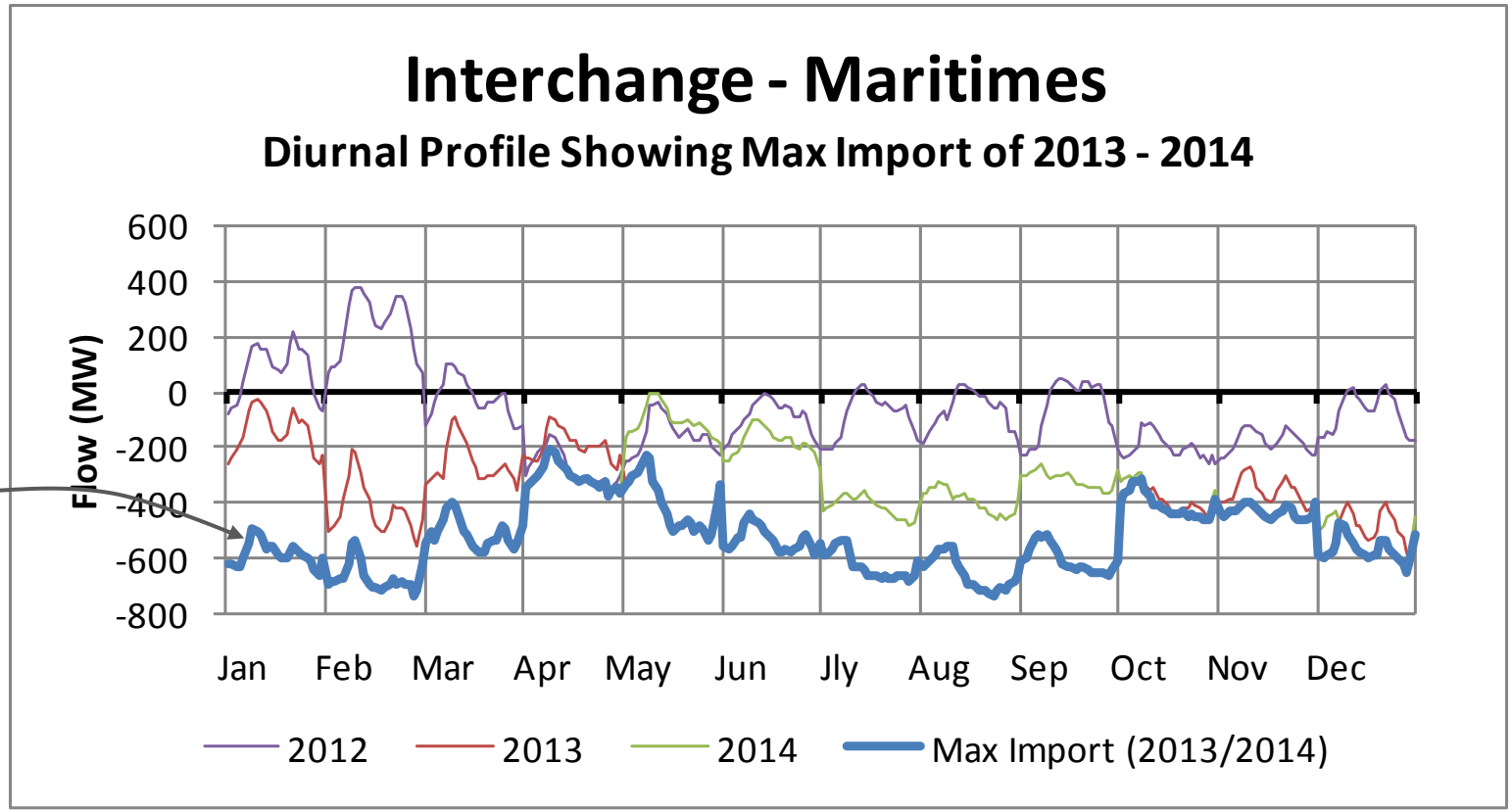
Note: negative values represent imports; positive values represent exports.

Quebec to New England: Highgate



Note: negative values represent imports; positive values represent exports.

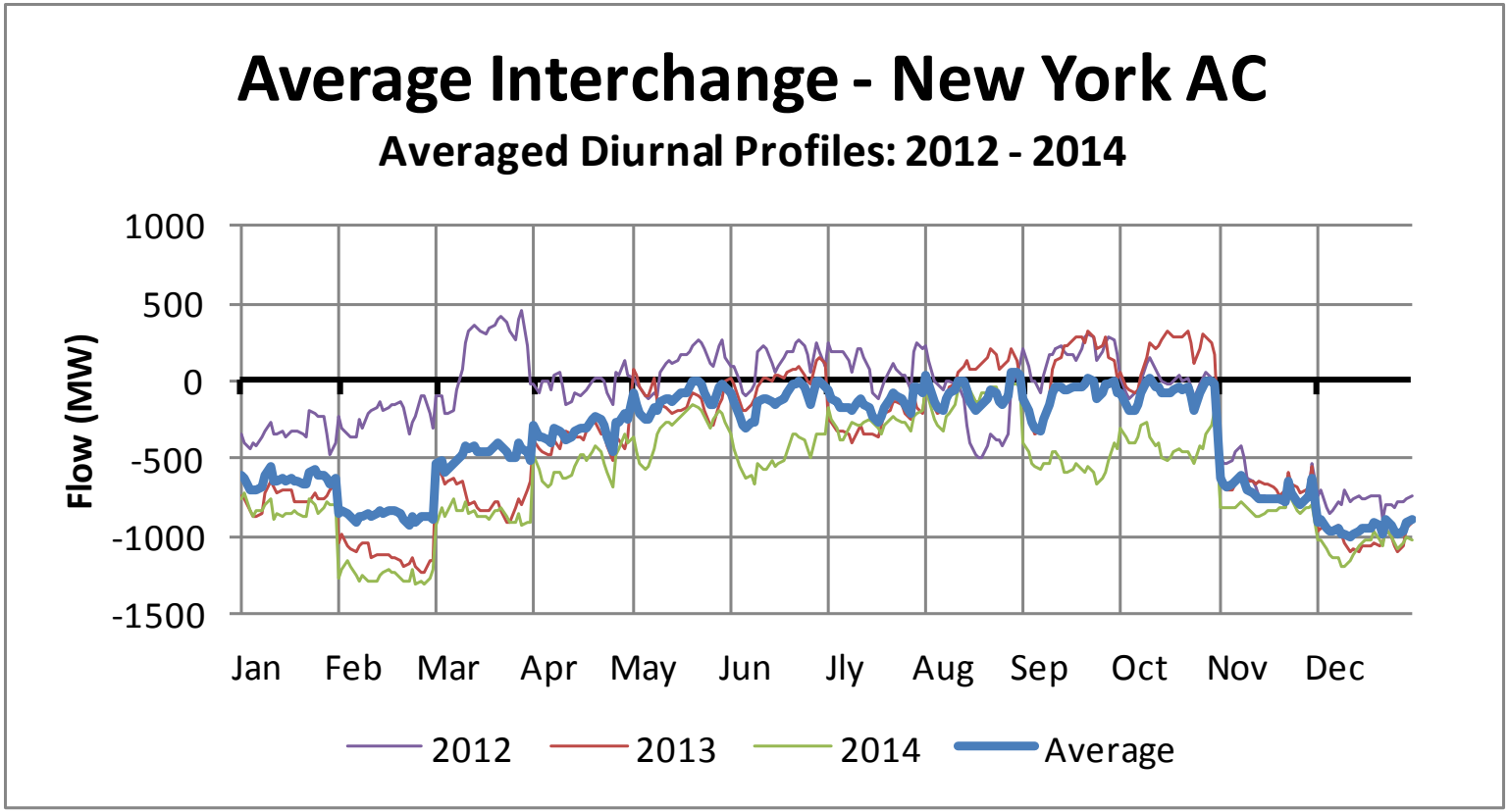
Maritimes to New England



Maximum Import

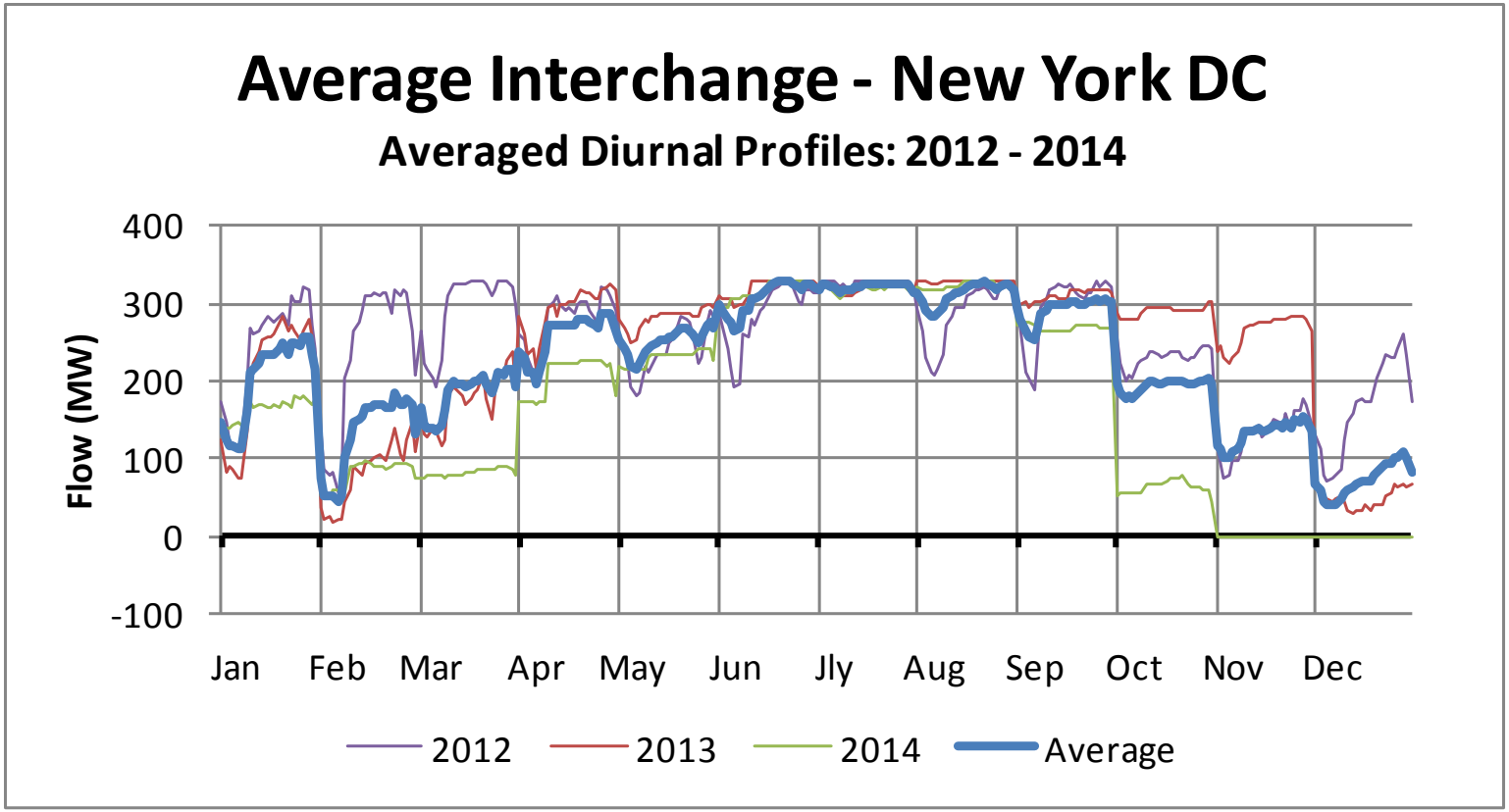
Note: negative values represent imports; positive values represent exports.

New England to New York - AC Interface



Note: negative values represent imports; positive values represent exports.

New England to New York - DC Interface



Note: negative values represent imports; positive values represent exports.

Modeling of Operating Reserves

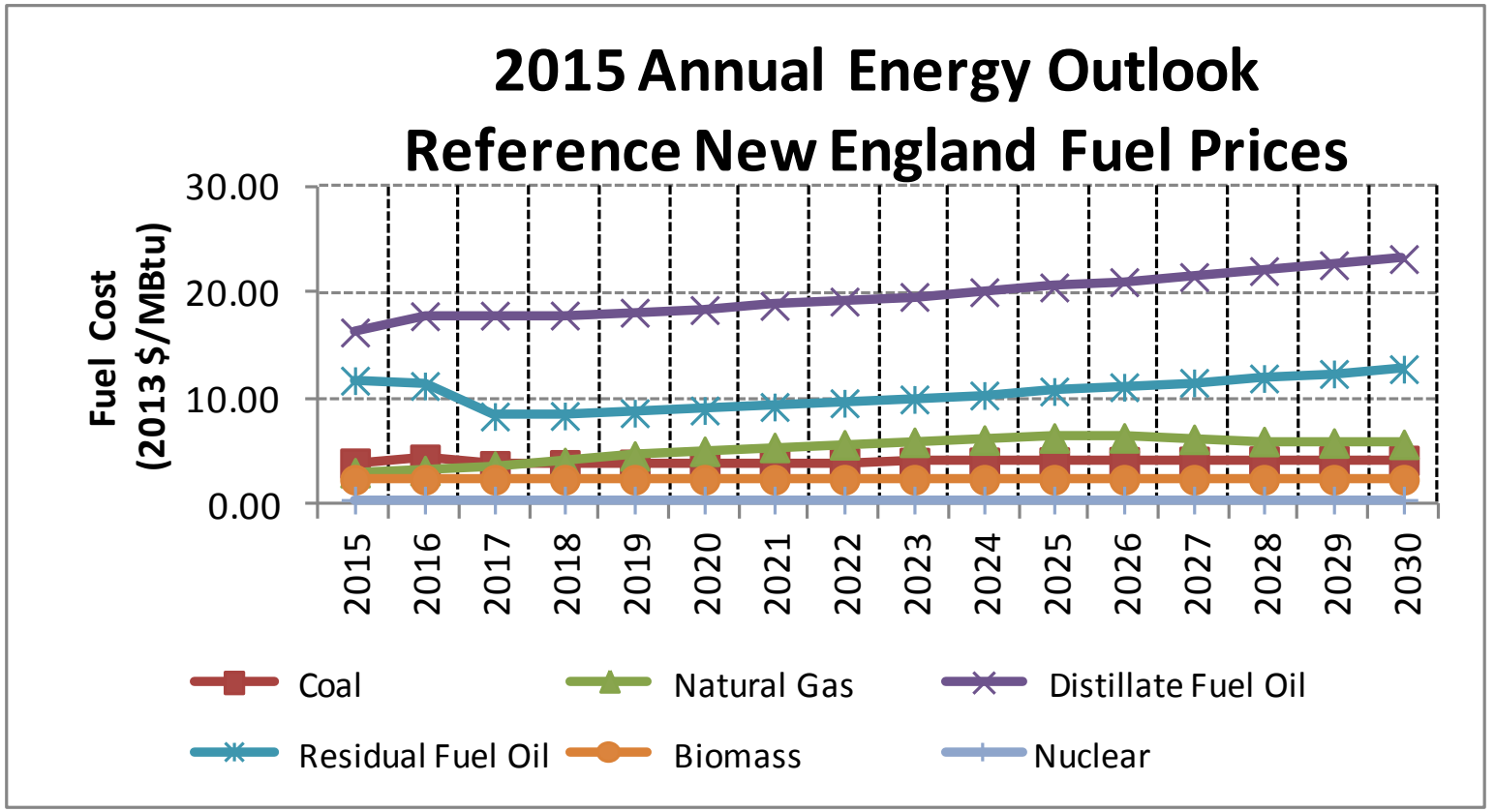
- Operating reserve requirement is determined in real time
  - Based on the first and second largest system contingencies
  - Resource profiles (hydro / wind / interchange etc) excluded
- Current operating reserve requirements
  - 125% of the first contingency in ten minutes split between
    - Ten-Minute spinning Reserve (TMSR) = 50%
    - Ten-Minute Non-Spinning Reserve (TMNSR) = 50%
  - Thirty-Minute Operation Reserve (TMOR) not modeled
    - Assumed to be adequate
    - Provided by hydro, pumped storage and quick-start resources
    - Reasonable assumption except, possibly, at times of peak loads

ISO-NE Reserve Requirement

Modeled	Not Modeled (assumed not a constraint)	
On-line: "Ten-Minute Spinning Reserve" (TMSR)	**Off-line: "Ten-Minute Non-Spinning Reserve" (TMSNR)**	**On-line or Off-line:"Thirty-Minute Operating Reserve" (TMOR)**
• Capability of on-line unit to provide increased energy within 10 minutes • Partially loaded on-line generator • Limited by ramp rate and Economic Maximum	• Capability of off-line resources to provide energy within 10 minutes • Off-line generation turbine, diesel or hydro generators • Load interruption – Dispatchable Asset Related Demand (DARD)	• Capability of resources to provide energy within 30 minutes • Can be either on-line or off-line resource • Generally the larger generation turbines • Load Interruption – DARD can also qualify

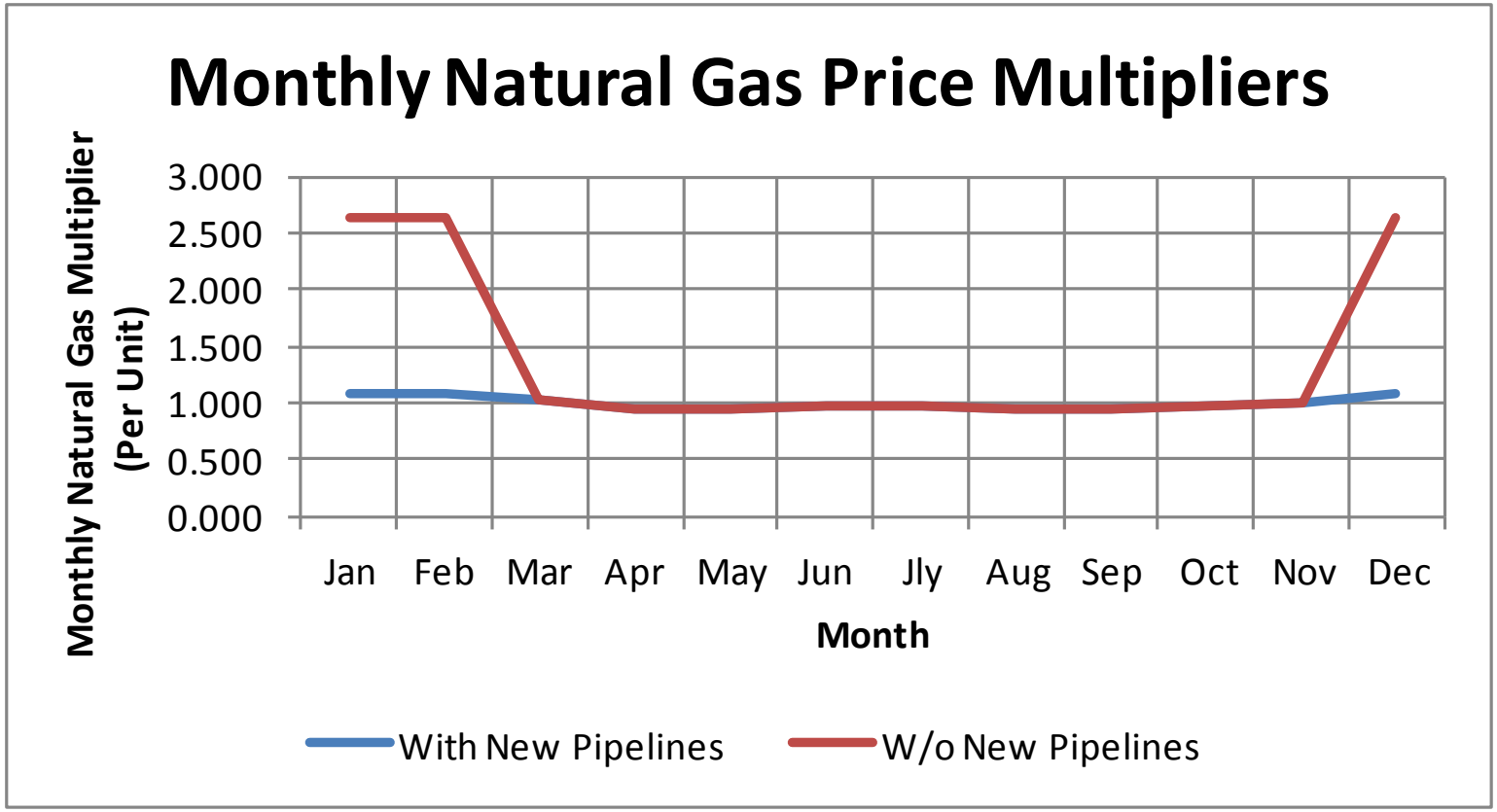
Reference: Introduction to Wholesale Electricity Markets (WEM 101) - Reserve Market Overview
http://www.iso-ne.com/support/training/courses/wem101/17_reserve_market_overview_likover.pdf

Fuel Price Forecast – EIA's 2015 AEO Base



Monthly Gas Price Profile

January, February and December gas prices equal residual oil in each year ($/MBtu)



Questions