The Future Role of Hydropower in the Northeastern US and Beyond

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Background

• A look at the future role of hydropower in the Northeastern US and beyond and how it can best support the reliable and economic evolution of decarbonization efforts

• Challenges driven by the integration of 10s of GWs of variable energy resources

• Work supported by DOE and NREL as part of the extensive activities of the DOE Water Power Technology Office
Outline

• Summarize the current New England System
• New England Duck Curve
• What the Potential Future Holds
  • Renewables, load, ties to neighbors
• Challenges
• Hydro’s Potential Contributions
• Moving the Ball Forward
New England Region

- Population 14.8 million
- More than 350 generators and 9,000 miles of high-voltage transmission lines including electrical interconnections to New York and Canada
- 31,500 megawatts (MW Capacity Obligation) of total supply and 767 MW of demand resources
- All-time peak demand of 28,130 MW set on 02/09/2006
- $3.0 billion energy market and $2.7 billion capacity market with more than 500 active participants
New England Region

• ISO-NE is the Independent System Operator for the Region
  • Under FERC jurisdiction

• Major Responsibilities
  • Operating the Regional Power System (NERC registered RC, BA, TOP)
  • Administering Wholesale Electricity Markets
  • Managing Regional Power System Planning (NERC registered PA, TP, RP, TSP)
  • Independent of companies doing business in the market
  • No financial interest in companies participating in the market
  • Neutral as to resource fuel type
New England’s Duck

An example:

• High Solar Day May 2, 2020

• Significant BTM PV impact

• Midday price depression

• Evening price spike

*ISONE Day-Ahead LMP 5-22-20
New England: Ambitious Plans & Limited Ties

- HVDC to Quebec ≈ 2250 MW
- AC to Maritimes ≈ 1000 MW
- Ties to NYISO ≈ 1400 MW
# New England Generation Mix and Flat Load

<table>
<thead>
<tr>
<th>Resource</th>
<th>2020</th>
<th>2029</th>
<th>Daytime Spring Available ‘29</th>
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</thead>
<tbody>
<tr>
<td>Fossil/Thermal/Nuke</td>
<td>31475</td>
<td>30808</td>
<td>15374</td>
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<tr>
<td>Hydro*</td>
<td>1994</td>
<td>2093</td>
<td>2093</td>
</tr>
<tr>
<td>Storage</td>
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<td>Solar PV**</td>
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<td>5348</td>
<td>4712</td>
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<tr>
<td>Offshore Wind</td>
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<td>2377</td>
<td>428</td>
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<tr>
<td>Offshore Wind</td>
<td>30</td>
<td>11381</td>
<td>3423</td>
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<tr>
<td>Totals***</td>
<td>38148</td>
<td>55952</td>
<td>21819</td>
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</tbody>
</table>

* 37% of hydro is run-of-river; balance has pondage
** includes some PV+BESS
*** Assumed typical spring outages and wind capacity factors

Net load growth ≈ zero

**Sources:**
- ISO-NE CELT 2020 CELT Report (tab 1.1 Summer Peak)
- ISO-NE Interconnection Request Tracking Tool (06/18/2020)
- ISO-NE Non-Price Retirement Requests and Retirement De-list Bid spreadsheet (06/18/2020)
New England in the Years to Come

- Combined BTM Solar and Offshore Wind impact on Net Load
- Possible “what if” future duck curve challenge
  - Illustrative, not exhaustive
    - Expected wind & solar on light load day
  - What challenges does it present from operational perspective?
    - Over generation
    - Renewable curtailments & out of merit must run (sub-optimal dispatch)
    - Congestion

May 2, 2020: Future BTM PV with High Offshore Wind and Utility-scale Solar

- Load
- Net Load (with 200% of 2020 BTM PV)
- Net Load minus Offshore Wind on a windy day minus Utility-scale solar on a sunny day

11000 MW “excess”
It’s not just MWs and MWhs

• System needs critical Essential Reliability Services (ERS) to maintain reliability:
  • Keeping frequency healthy: inertia & frequency response
  • Keeping voltage healthy: voltage regulation and reactive power supply
  • Keeping protection working and inverters (wind, solar, BESS) stable: maintaining short circuit strength
  • Putting the system back together: black start & system restoration
  • Following the variations: Reserves and Ramping

• ERS can become scarce with increasing renewables/changing resource mix and retirements.

• Hydro can provide all ERS

• Some of these services are presently under-valued or lack market signals for investment
Hydro’s critically important services

**Frequency control:**
Primary & fast frequency response (PFR and FFR)
- Hydro primary frequency response *can* be excellent
- Advanced Pumped Storage has *best in industry* performance; FFR possible
- No market signals to invest in upgrades and undervalued (no FFR market yet)

**Voltage control:**
Excitation systems
- Hydro (older) may benefit from upgrades to increase the speed of excitation and increase lead/lag reactive capability
- Locational aspects (especially remote areas) v. important
- Condenser mode increasingly valuable
- No market signals to invest in upgrades and limited market revenue stream

**Inertia:**
Contributes to grid stability; supports reduced (RoCoF)
- Increasing recognition of value/need and many systems starting to monitor
- Condenser mode increasingly valuable
- No market signals to explore higher inertia hydro designs and undervalued no market yet

09/27/2021
Hydro’s critically important services, con’t

System restoration & blackstart:
• Hydro already important to system restoration
• With retirements and increasing focus on grid resilience, expect higher attention
• Market mechanisms usually cost recovery only; sometimes completely absent
• Mechanisms to encourage investment mostly absent

Ramping and Regulation services:
• Operational agility, ability to support ramping valuable
• Some emerging efforts to determine ramping needs
• Market constructs emerging to pay (e.g. “Flexiramp service”)
• Already an important role for hydro; expect increased value with changing resources mix

Short circuit contribution:
• Required for protection systems and to support inverter stability
• Highly locational; remote areas high value (esp. in proximity to wind)
• Increasing recognition of value/need
• Condenser mode increasingly valuable
• Not paid service today
Moving the Ball Forward: Hydro’s future role

• Getting the most out of Hydro Flexibility
• Address the overgeneration challenge
• Constraints on Hydro Operation
• A new look at planning
• Paying for it all
Moving the Ball Forward: Hydro’s future role

• Getting the most out of Hydro Flexibility
  • Actively look for ways that existing hydro can offer more; e.g. condenser mode, physical plant upgrades, etc.
  • Look for positive impacts on stability limits; inertia; short circuit/protection
  • Investigate value of Variable Speed PSH

• Address the overgeneration challenge
• Constraints on Hydro Operation
• A new look at planning
• Paying for it all
Moving the Ball Forward: Hydro’s future role

• Getting the most out of Hydro Flexibility

• Address the overgeneration challenge
  • Pumped storage offers large scale storage options
  • Pumped storage is proven technology with long in-service expectation
  • Works well with other options that will also be required

• Constraints on Hydro Operation

• A new look at planning

• Paying for it all
Moving the Ball Forward: Hydro’s future role

• Getting the most out of Hydro Flexibility
• Address the overgeneration challenge

• Constraints on Hydro Operation
  • Be mindful of emerging increases in operational constraints on mechanical components, environmental and other externalities (non-traditional power outputs)
  • Help set priorities on when flexibility most valuable and constraints are most costly; help resolve conflicts

• A new look at planning
• Paying for it all
Moving the Ball Forward: Hydro’s future role

- Getting the most out of Hydro Flexibility
- Address the overgeneration challenge
- Constraints on Hydro Operation

- A new look at planning
  - Factor in the contribution and value of hydro provided ERS
  - Making PSH a regional asset by considering its value on a more global footprint by including potential benefit to neighboring RC/BA/markets
  - Factor in increased value of moving toward Variable Speed PSH as opposed to traditional PSH
  - Create market structures to incent needed development and share costs

- Paying for it all
Moving the Ball Forward: Hydro’s future role

• Getting the most out of Hydro Flexibility
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• Constraints on Hydro Operation
• Making PSH a regional asset

• Paying for it all
  • Create incentives for investment (in hydro) that creates additional systemic benefits
  • Revisit capacity market structures to better value functionality of high-performance resources, especially advanced PSH
  • Consider market structures that allow hydro resources (and other resources) to realize revenues from both energy/capacity/ERS markets and regulated return for systemic benefits
Moving the Ball Forward: Hydro’s future role

- Getting the most out of Hydro Flexibility
- Address the overgeneration challenge
- Constraints on Hydro Operation
- Making PSH a regional asset
- Paying for it all

➢ Hydro will be even more important in the near future and eventually a deeply decarbonized future
Questions