

Bidding Hydro Resources to Support High VRE Futures – Study methodology

June 15 2021

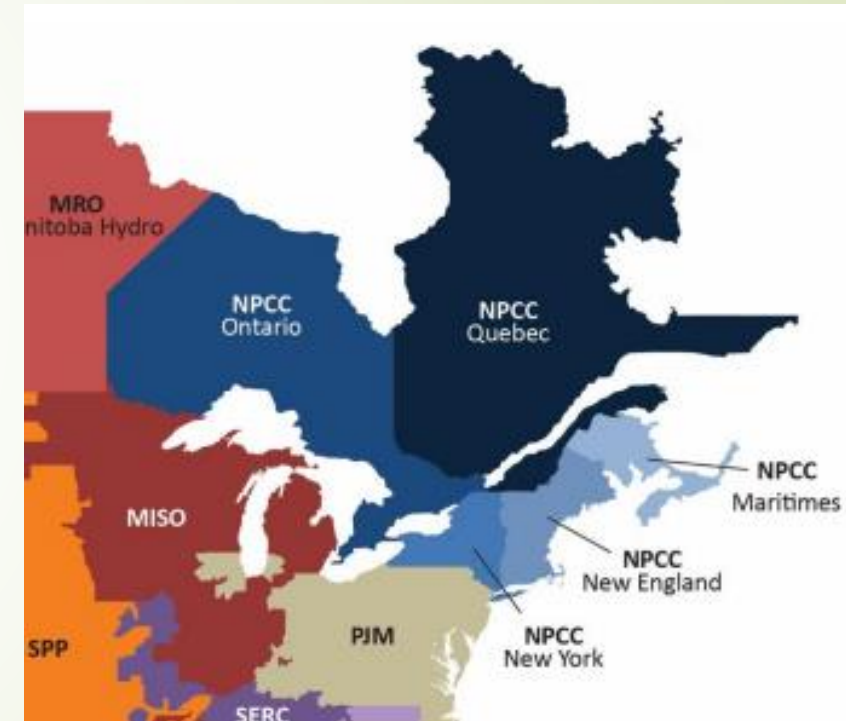
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Bidding Hydro Resources to Support High VRE Futures – Context

- Clearly a high penetration of Variable Renewable Energy (VRE) will require the support of a large fleet of flexible resources.
- Hydro generation, and in particular that backed by large reservoirs, is surely one of the most advantageous flexible resources for both ramping capability and energy capacity.
- With its large-reservoir hydro generation capacity, Hydro-Quebec (HQ) finds itself in an advantageous position to support the high penetration of VRE, and in particular that of its neighbouring electricity markets, New York and New England.
- We are at the beginning of a study of which the ultimate goal would be to develop « *Bidding strategies for Hydro Resources to Support Future High Penetration Scenarios of VRE* »
....but for now, we are getting ahead of ourselves.

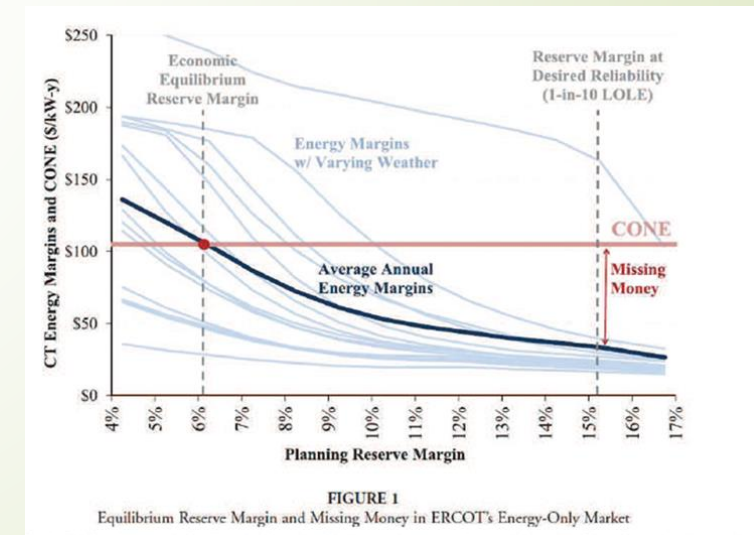
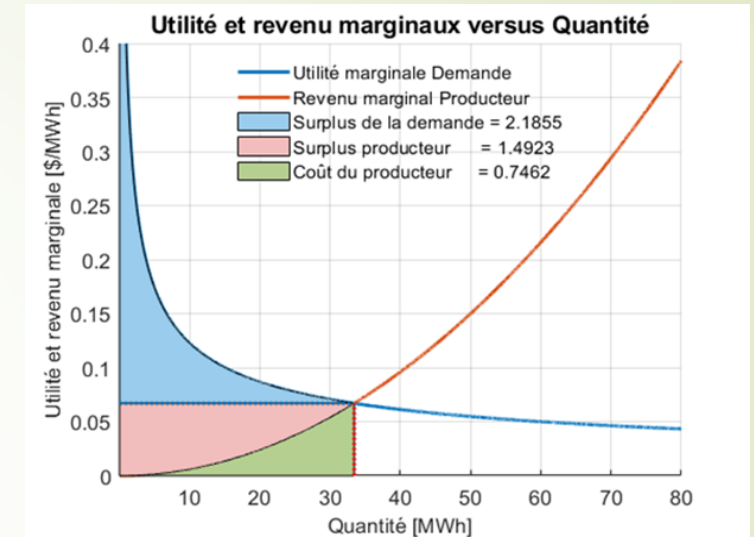


Why are we doing this study ?

- ▶ Studying what? Study of how HQ can participate in the balancing of renewable energy resources in the various products of its neighbouring markets.
- ▶ Published studies have shown a good synergy between the hydro generation of HQ and its neighbouring markets to attain their decarbonization goals. However the results are global for the North American North-East and do not reveal the exact position of Hydro-Quebec and other participants and their contributions in the various markets.
- ▶ This study will try to identify the actual contributions and rewards for individual players each operating for its own benefit in a system that strives for social optimality.

Initial Thoughts

- What we know : Principles from economic theory applied to market clearing of supply and demand with marginal pricing (Top figure).
- What we actually have : The real electricity markets which deviate from the pure economic theory, relying on out-of-market payments (i.e. capacity markets, uplifts) to recover the “missing money”. (Bottom figure)
Results of these markets are readily available on market websites (i.e. NYISO, ISONE, etc).
- Market participants anticipate how the markets might evolve in the new environment, relying on both economic principles and market rules.
- Powerful simulation tools are available but they cannot capture exactly the real behaviour of the power systems and markets.



Basic methodology of the study

- Perform a techno-economic simulation of the present and future electricity systems of HQ and its neighbours. Future developments include
 - High penetration of renewable generation
 - Network expansion, generation additions and plant retirements
 - Constraints imposed by environmental programs on emissions or penetration levels (ex. CLCPA in NY) to achieve decarbonization goals.
- Analyze the simulation results :
 - Identify situations in our simulations where the use of large-reservoir hydro generation to *balance* variability and uncertainty of augmented VRE brings advantages to all players.
 - Study the profitability of all participants through market instruments and identify their cost recovery.
- Eventually construct bidding guidelines for participants in the new environment, based on market operations supported by theory and as anticipated by simulations.

What situations do we wish to identify?

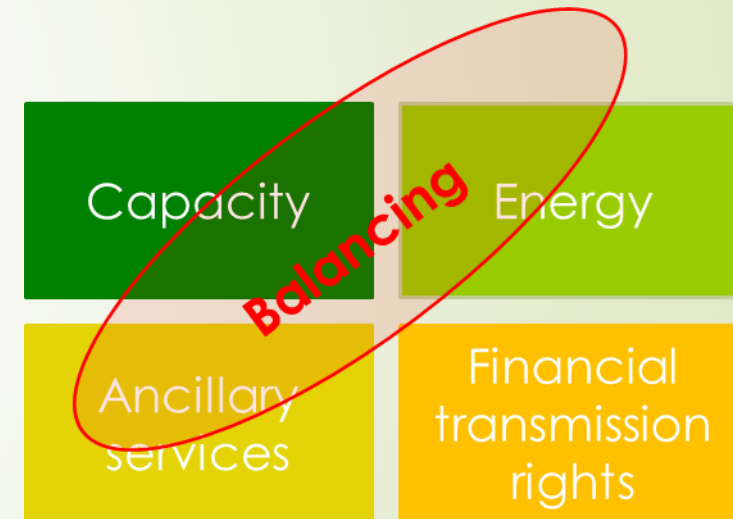
Situations in which hydro generation offers flexibility and capacity for balancing. Balancing is a concept rather than a product, traded as energy in traditional markets. Its value is that of the energy sold and varies according to the circumstances.

Very short term: Power supplied over minutes for regulation as part of the ancillary services. Low amounts of energy provided continuously.

Short term: Daily power to meet ramping requirements of VRE. Niche for batteries/flexible generation. Requires large amounts of intermittent energy.

Medium term: Energy to compensate for long periods (days) of low / high VRE generation for which battery storage would be insufficient. Large amounts of power and energy called infrequently.

Long term: Readily available large capacity able to absorb the more or less predictable seasonal surpluses / deficits of VREs. Energy systems with large storage capacity.



Traditional markets

*Description of power systems simulated
in our study*

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Power System Topology

- Zonal representation of the NYISO and ISONE
- Inter-zonal transmission is represented by a pipe-flow model using only capacity
- HQ will also be represented in similar manner to be coherent with the rest

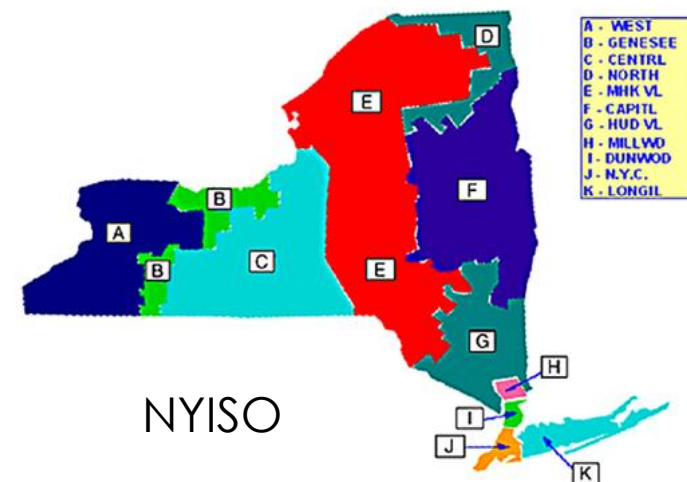
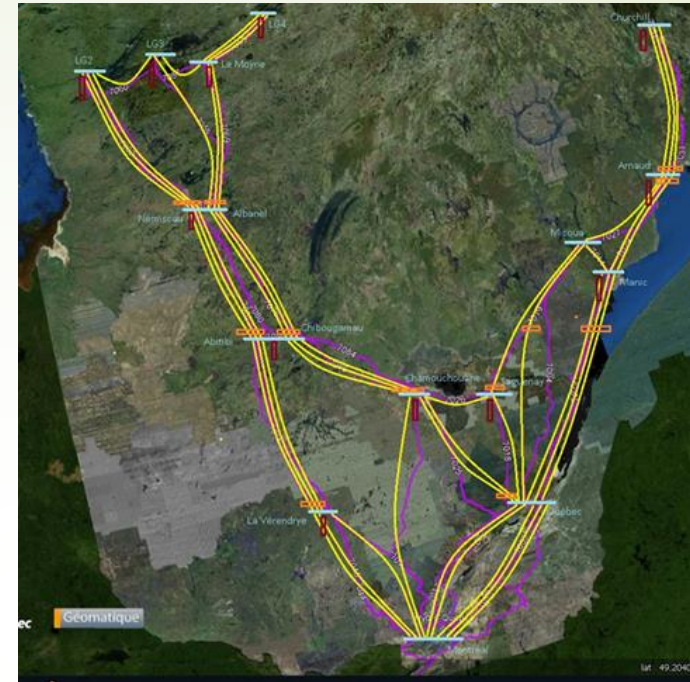
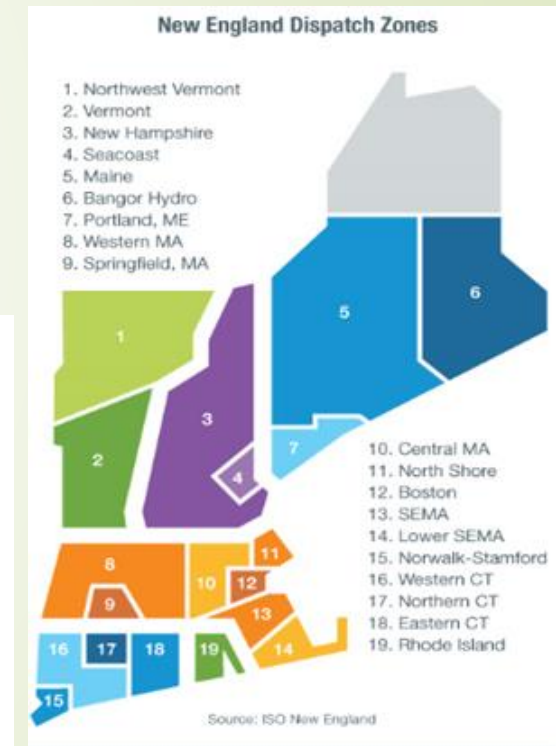


FIG. 1. New York Control Area internal zones. Source: NYISO.

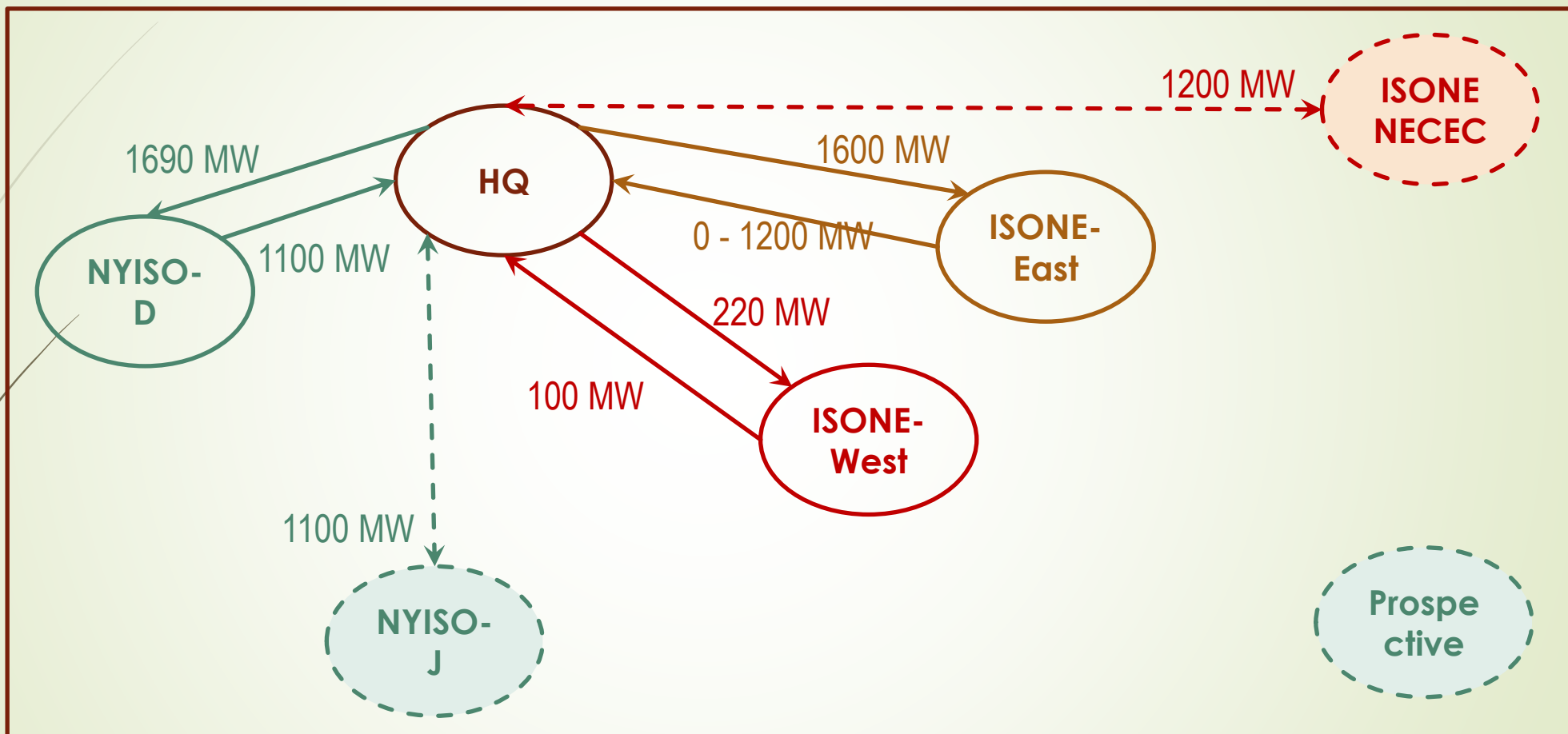
HQ



ISONE

A

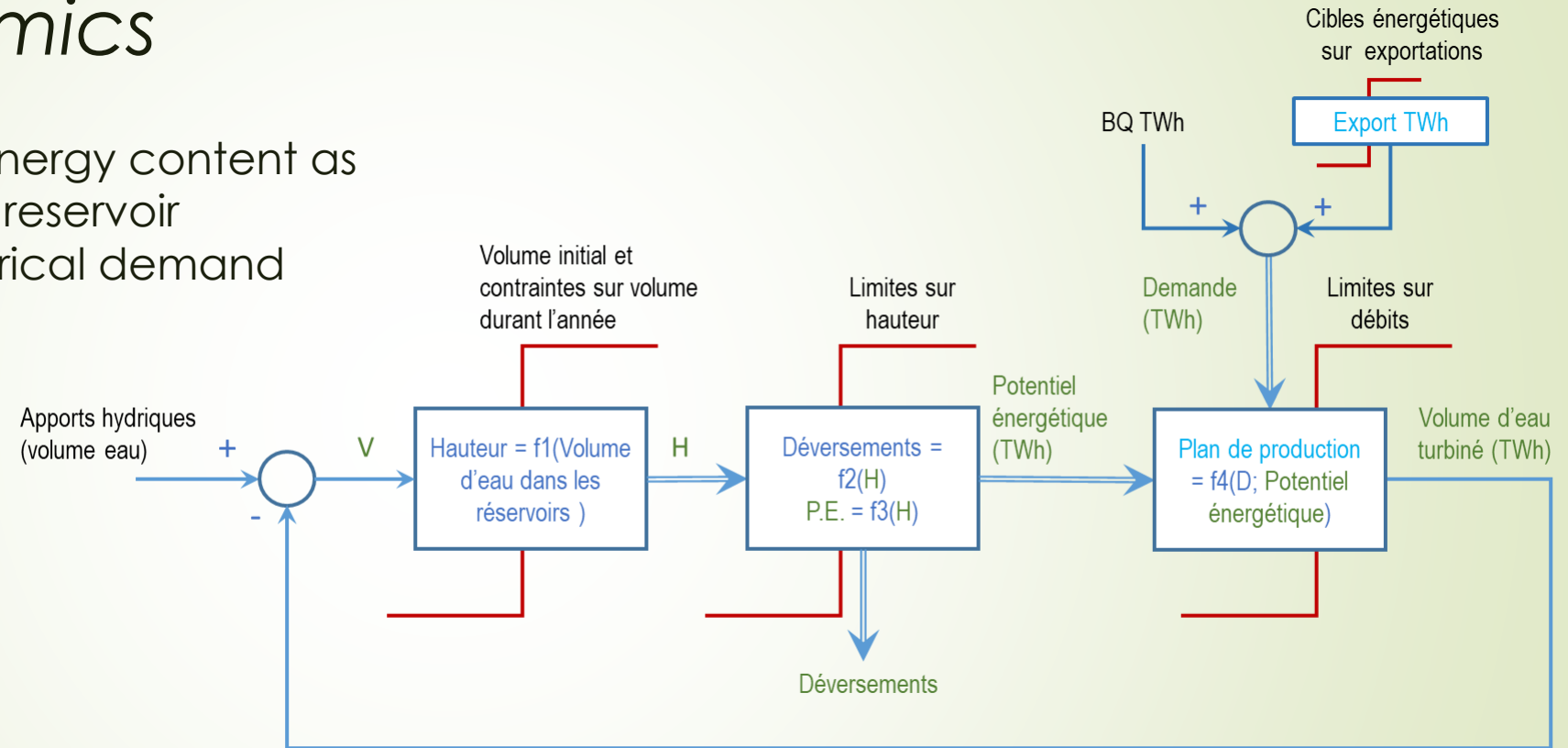
HQ interconnexions with neighbouring markets



Note that the forward and backward interconnexion capacities are different. In general the HQ to neighbouring markets capacity is greater than that of the reverse capacity.

Representation of the hydraulic system dynamics

Dynamics of the reservoir energy content as a function of hydro inflows, reservoir parameters and total electrical demand (Quebec + exports)



Generation plan optimizes the economic value of the reservoir energy as a function of total demand (Quebec + exports to the neighbouring markets) and energy availability.

Where we are now with the simulation software

Learning period of the power planning model software *EnCompass* to put in place a study methodology

Description of a typical simulation

Preliminary results

Two main menus of the software “EnCompass”

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The screenshot displays the EnCompass software interface. The main window is titled "EQM0020_EnCompass_01 - EnCompass - [Scenarios]". The left sidebar contains a "Structure" panel with a tree view of scenarios and datasets. The "2. EAST Projects" scenario is selected and highlighted with a red circle. The main area shows a "Dataset for Editing" table with columns for Balancing Authority, Area, Resource, and Capacity. The "2. EAST Projects" scenario is also highlighted in the table. The "Edit Scenario" dialog is open, showing the "Name" field set to "2. EAST Projects" (circled in red), "Parent Scenario" set to "0. NDB", and a list of datasets. The "Simulation Parameters" section shows "Start Date" as 2020, "End Date" as 2030, and "Initial Conditions" as "Typical peak/off-peak day". The "Performance Options" section shows "Daily Intervals" as 6, "Commitment" as 0, and "Typical Days" as "Typical peak/off-peak day".

Structure Panel:

- Scenarios
- Datasets
- Time Series
- Objects
- Markets
- Demand
- Areas
- Constraints
- Buses
- Branches
- Resources
- Fuels
- Programs
- Projects
- Companies
- Reports
- Supply Curve
- Spreadsheet

Dataset for Editing Table:

Balancing Authority	Area	Resource	Capacity
NPCC-New York	NYISO-A	Cavaya Operating Company 1	
NPCC-New York	NYISO-B	Cavaya Operating Company 2	
NPCC-New York	NYISO-C	Dunkirk Generating Plant:2 (Coal)	
NPCC-New York	NYISO-D	Dunkirk Generating Plant:3 (Coal)	
NPCC-New York	NYISO-E	Dunkirk Generating Plant:ST4 (Coal)	
NPCC-New York	NYISO-F	Somerset Operating Co LLC:1	
NPCC-New York	NYISO-G	DR NYISO-A	
NPCC-New York	NYISO-H	DR NYISO-B	
NPCC-New York	NYISO-I	DR NYISO-C	
NPCC-New York	NYISO-J	DR NYISO-D	
NPCC-New York	NYISO-K	DR NYISO-E	
NPCC-New York	NYISO-L	DR NYISO-F	
NPCC-New York	NYISO-M	DR NYISO-G	
NPCC-New York	NYISO-N	DR NYISO-H	
NPCC-New York	NYISO-O	DR NYISO-I	
NPCC-New York	NYISO-P	DR NYISO-J	
NPCC-New York	NYISO-Q	DR NYISO-K	
NPCC-New York	NYISO-R	Lyonsdale Associates	
NPCC-New York	NYISO-S	New Battery NYISO-A:BTM:Battery	
NPCC-New York	NYISO-T	New Battery NYISO-B:BTM:Battery	
NPCC-New York	NYISO-U	New Battery NYISO-C:BTM:Battery	
NPCC-New York	NYISO-V	New Battery NYISO-D:BTM:Battery	
NPCC-New York	NYISO-W	New Battery NYISO-E:BTM:Battery	
NPCC-New York	NYISO-X	New Battery NYISO-F:BTM:Battery	
NPCC-New York	NYISO-Y	Fuel	
NPCC-New York	NYISO-Z	Canada Lignite	
NPCC-New York	NYISO-AA	Central Appalachia	
NPCC-New York	NYISO-AB	Distillate Oil	
NPCC-New York	NYISO-AC	Gulf Lignite	
NPCC-New York	NYISO-AD	Illinois Basin	
NPCC-New York	NYISO-AE	International	

Edit Scenario Dialog:

Name: 2. EAST Projects

Parent Scenario: 0. NDB

Datasets:

- 101. NDB_Topology_11-01-2020
- 102. NDB_Demand_RPS_11-01-2020
- 103. NDB_Fuel_Emission_11-01-2020
- 103a. ERCOT_Emissions
- 103a. WECC_Emissions
- 104. NDB_Nuclear_11-01-2020
- 105. NDB_Coal_11-01-2020
- 106. NDB_CC_11-01-2020
- 107. NDB_IGCC_11-01-2020
- 103a. EAST_Emissions

Simulation Scope:

Run Type: Market Simulation

Prices: Marginal dispatch costs

Balancing Authorities:

- TRE-ERCOT
- WECC-CALIF
- WECC-MEX
- WECC-NWPP-CA
- WECC-NWPP-US
- WECC-RMRG
- WECC-SRSG
- SERC-FP
- MISO
- MRO-Manitoba Hydro
- MRO-Sask Power
- NPCC-Maritimes
- NPCC-New England
- NPCC-Ontario
- NPCC-Quebec
- PJM

Capital Projects:

Optimize: Rounded

Use Parent Projects? No

Number of Plans: 1

Parent Plan Number: 1

Unique Through: 2016

Environmental Limits: 26

Simulation Parameters:

Start Date: 2020

End Date: 2030

Initial Conditions: Typical peak/off-peak day

Time Zone: Eastern

Number of Random Draws: 0

Outages:

Scheduled: Loaded from Parent Scenario

Forced: Use capacity derations

Performance Options:

Daily Intervals: 6

Commitment: 0

Typical Days: Typical peak/off-peak day

Optimization Period (Years): 1

Extension Period (Years): 0

Split Run Length (Months): 0

Commitment: No commitment

MIP Stop Basis: 200

MIP Max Solve Time (seconds): 0

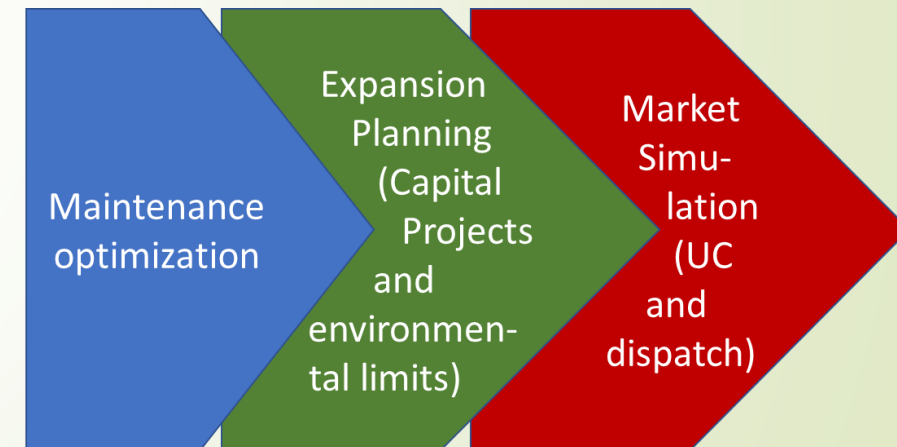
Maximum Memory (GB): 0

Example of a study, New York, New England and HQ

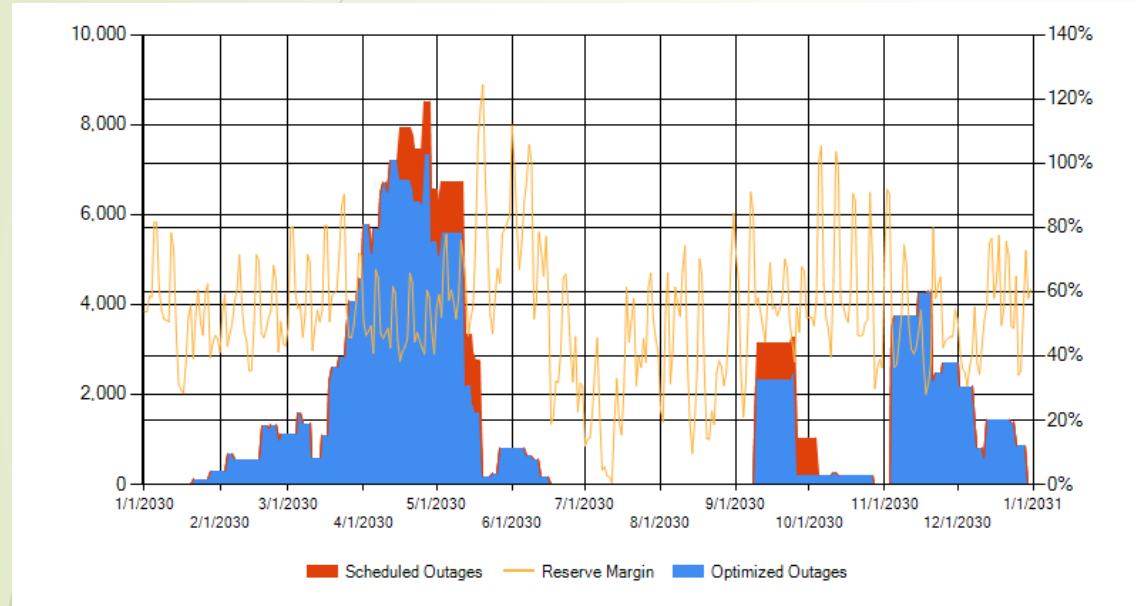
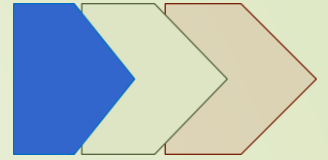
Techno-economic simulation including extensive data from the National Data Base provided by Horizons-Energy as part of the software.

Simulation steps :

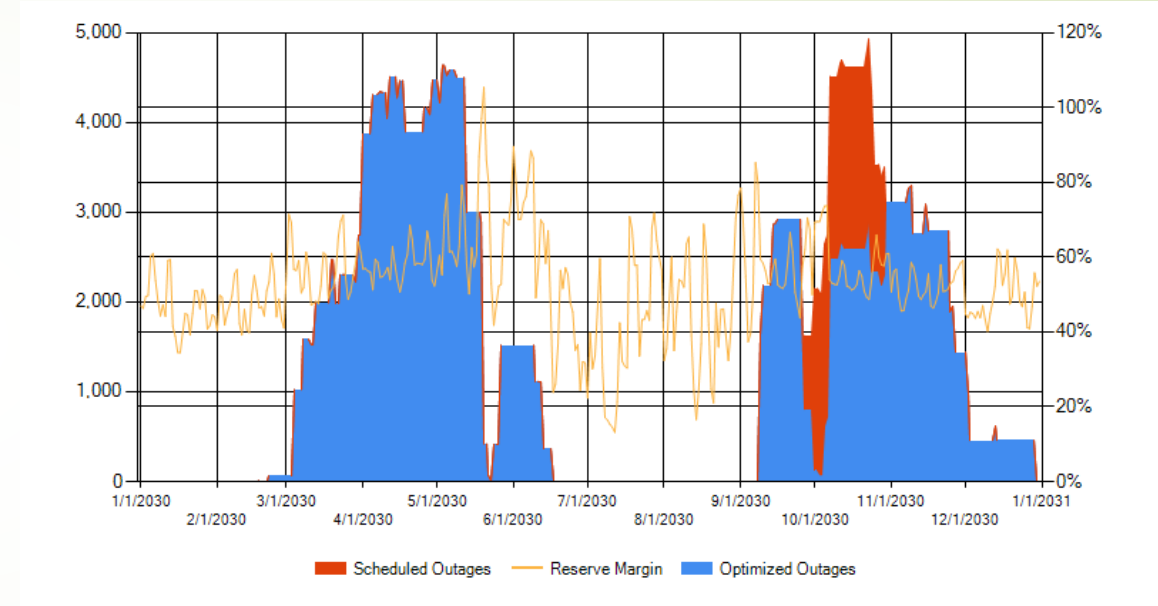
- Maintenance planning with initial resources only and a coarse time-step, 2020-2050.
- Capacity expansion (through capital projects and environmental constraints) with a finer time-step, 2020-2030
- Market simulation with fixed resources and network (one month to a year) with much finer time step (hourly)



Results : Maintenance optimization



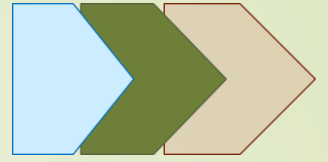
New York 2030



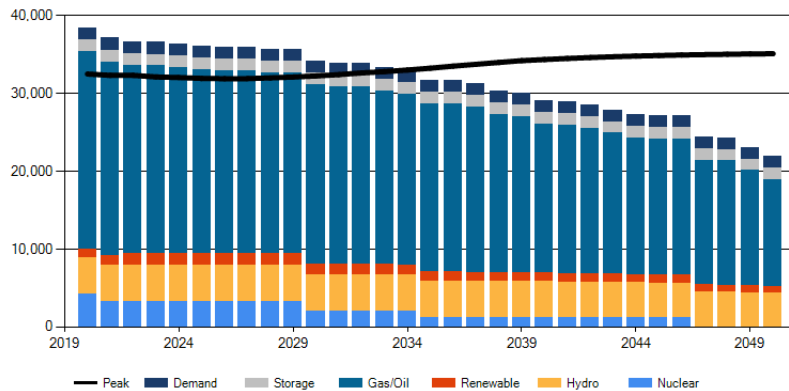
New England 2030

Examples of maintenance schedule optimization in 2030 with given prospective resources and an initial proposed maintenance plan.

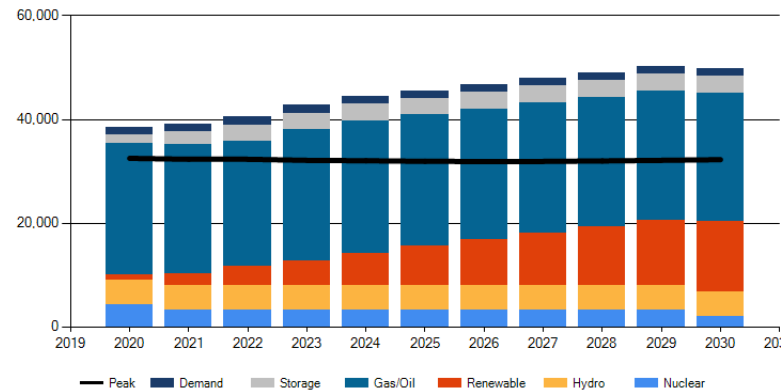
Results : Expansion Planning for New York 2020-2030



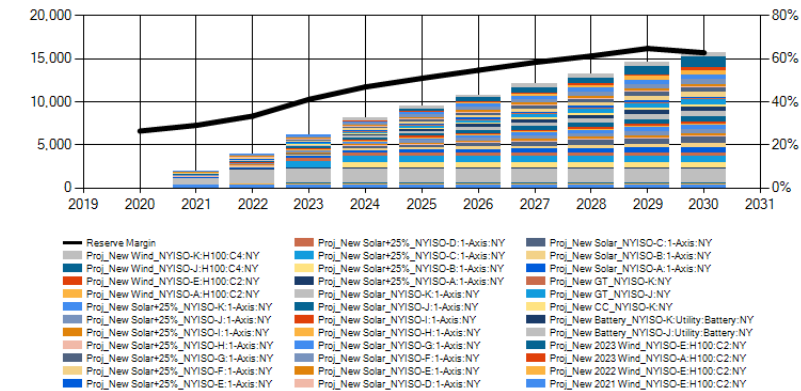
Firm Capacity (MW)



Firm Capacity (MW)



Project Capacity (MW)

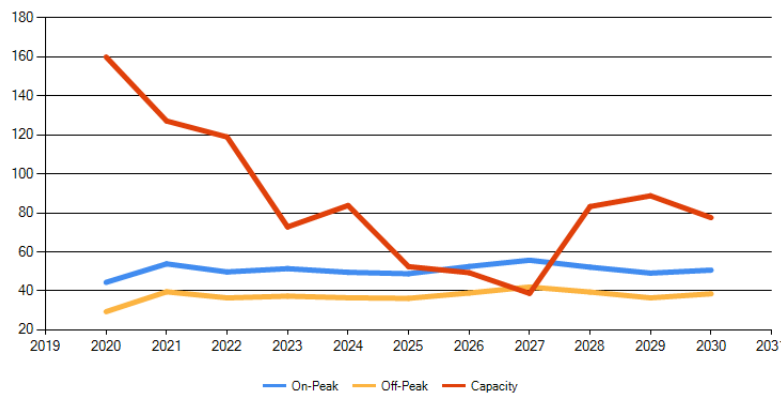


(a) Firm Capacity w/o expansion (2020-2050)

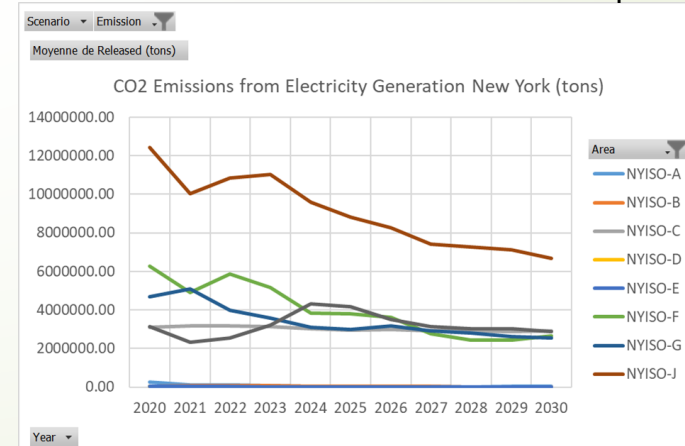
(b) Firm Capacity w expansion

(c) New Projects proposed /accepted by EnCompass

Area Prices



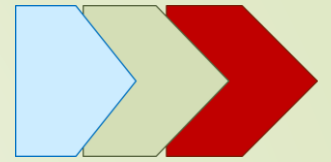
(d) Peak, off-peak and capacity prices



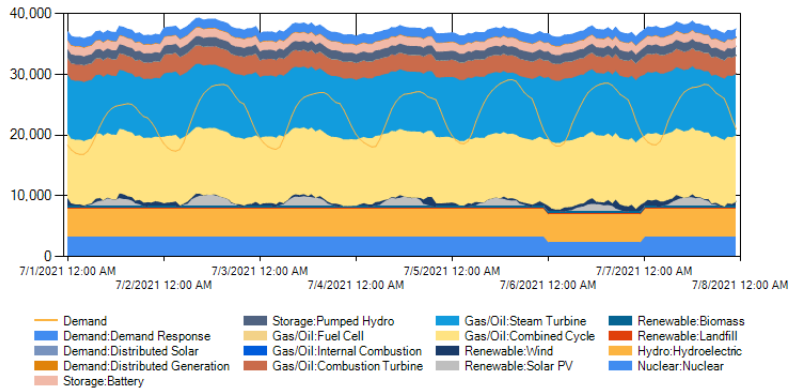
(e) CO₂ Emissions in different areas

Results : Market Simulation New York

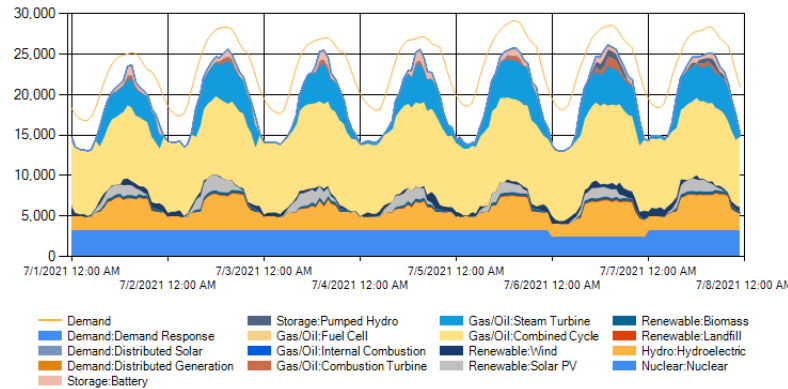
July 2021



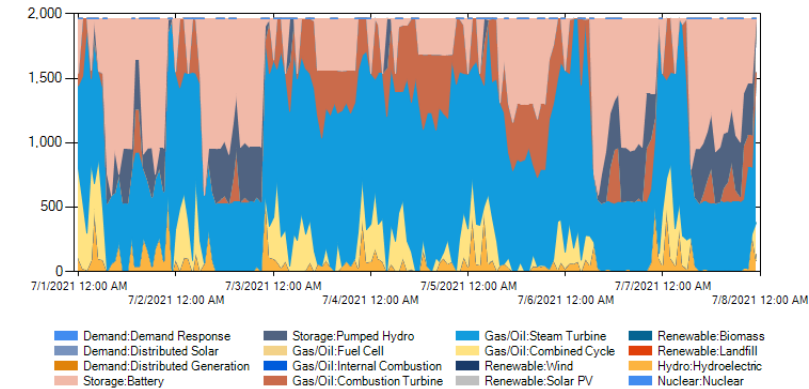
Available Capacity (MW)



Net Generation (MW)



Operating Reserves (MW)

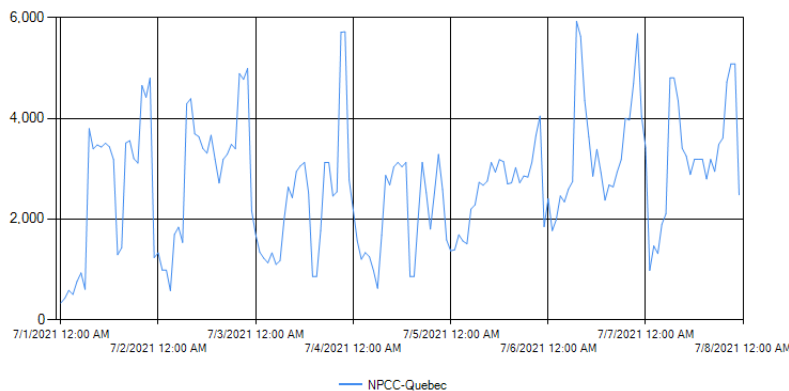


(a) Available Capacity (MW)

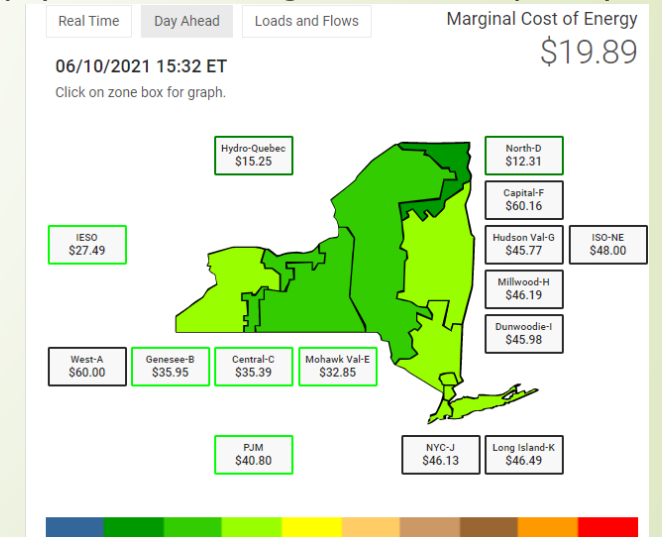
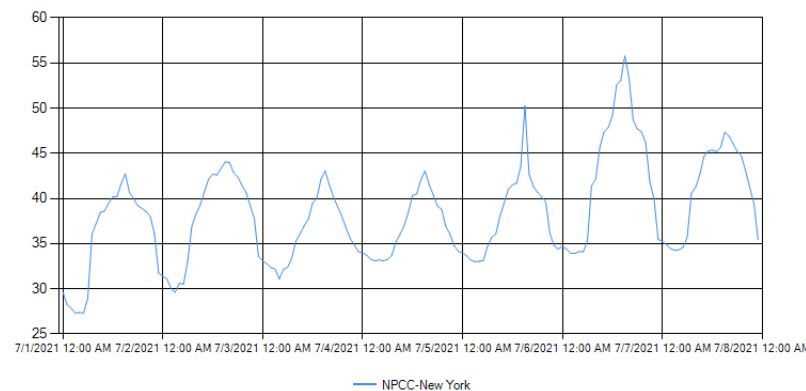
(b) Generation mix (MW)

(c) Operating Reserves (MW)

Net Import (MW)



Market Prices (\$/MWh)



(d) Net Imports

(e) Prices

(f) Energy prices from NYISO June 10th 2021

Where we are now with the project

1. We have software which simulates the electricity market with detailed data for our neighbouring markets and access to HQ system data
2. We will now start simulating scenarios of
 - Conditions on the table right now for the neighbouring regions up to 2030
 - Tightened environmental limits, higher VRE penetration for the neighbouring regions
 - HQ network expansion with the recently proposed interconnections (HQ-NY City and HQ-Maine)
 - HQ's participation in markets where it is presently active but also in those where presently it cannot participate, possibly including different commercial arrangements (ex. bilateral agreements for different existing and new energy products).

Where we are now with the project : Analysis

3. Analysis :

Identify situations in which the hydro generation of HQ will offer flexibility and capacity for the balancing over different time horizons and over the various markets.

- *Short term balancing*
- *Medium term balancing*
- *Long term balancing*

In the new environment, the participants will adapt their energy management strategies. This will affect the energy mix and prices.

Companies who can offer similar advantages with similar / different technologies will face competition from each other for their balancing capability.

Thank you!



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