Bidding Hydro Resources to Support High VRE Futures – Study methodology

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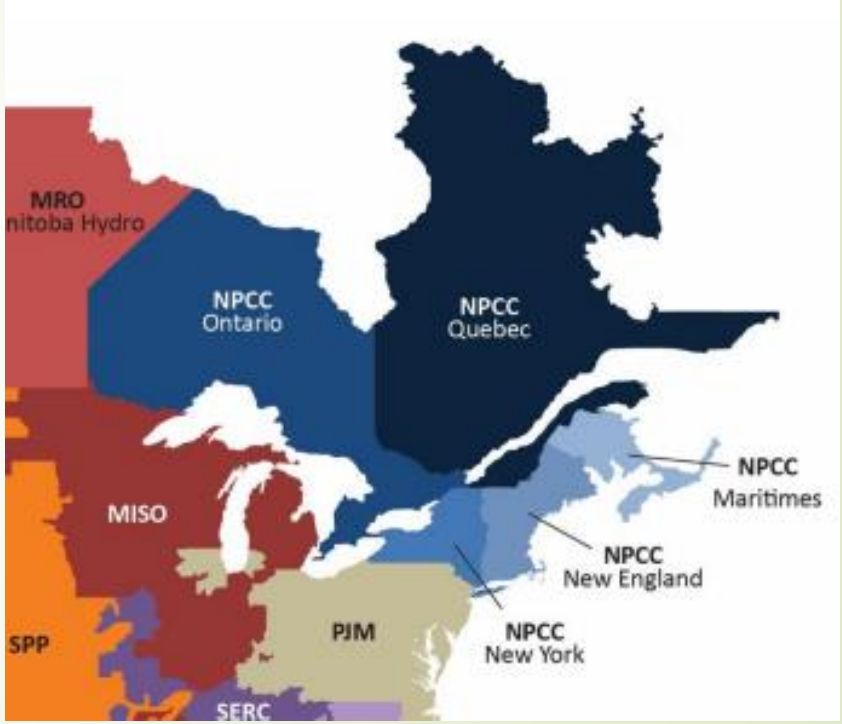
Bidding Hydro Resources to Support High VRE Futures – Context

- 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.

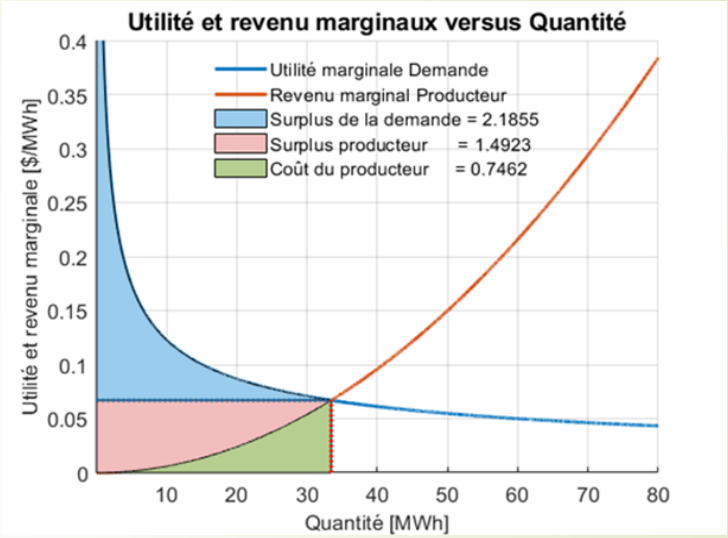


Why are we doing this study ?

- 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.



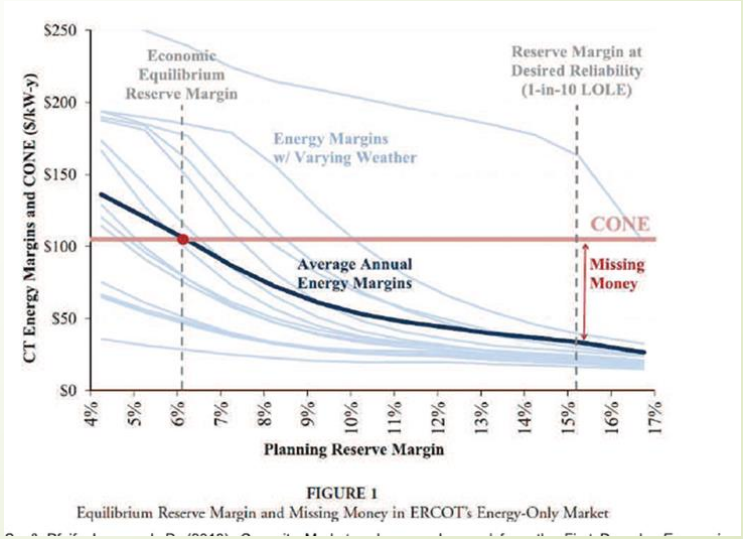


FIGURE 1
Equilibrium Reserve Margin and Missing Money in ERCOT's Energy-Only Market

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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?

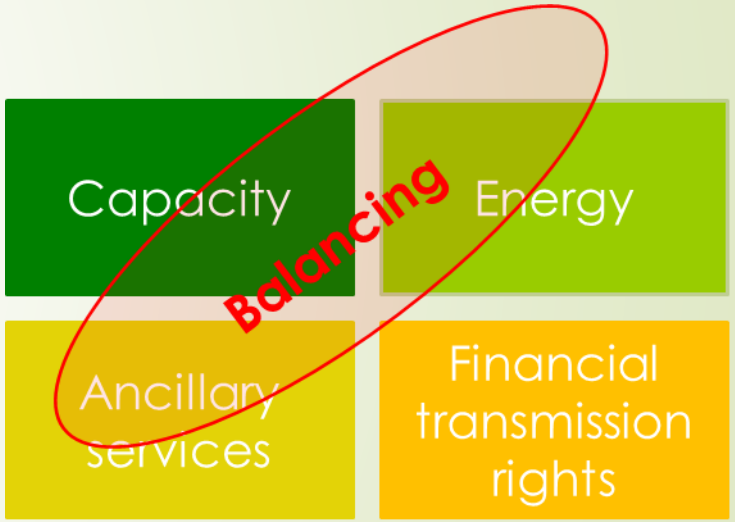
Situations in which hydro generation offers flexibility and capacity *for balancing*. Balancing is a concept rather than a product, traded as energy *in traditional markets*. Its value is that of the energy sold and varies according to the circumstances.

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.

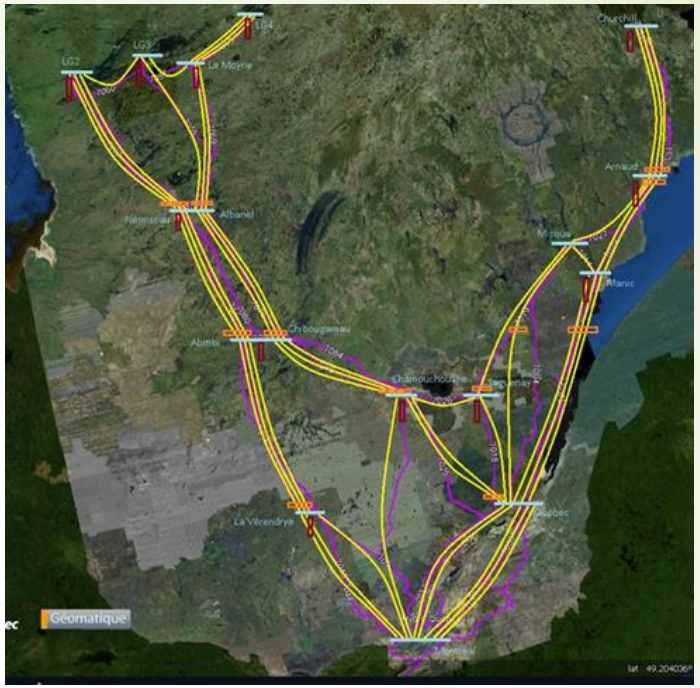


Traditional markets

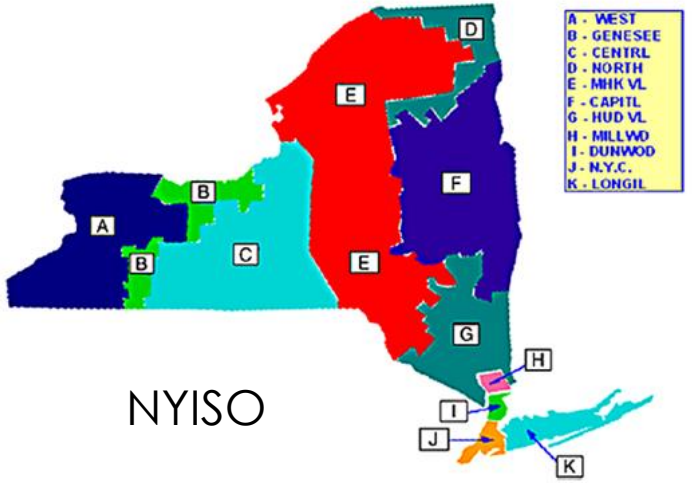
Description of power systems simulated in our study

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

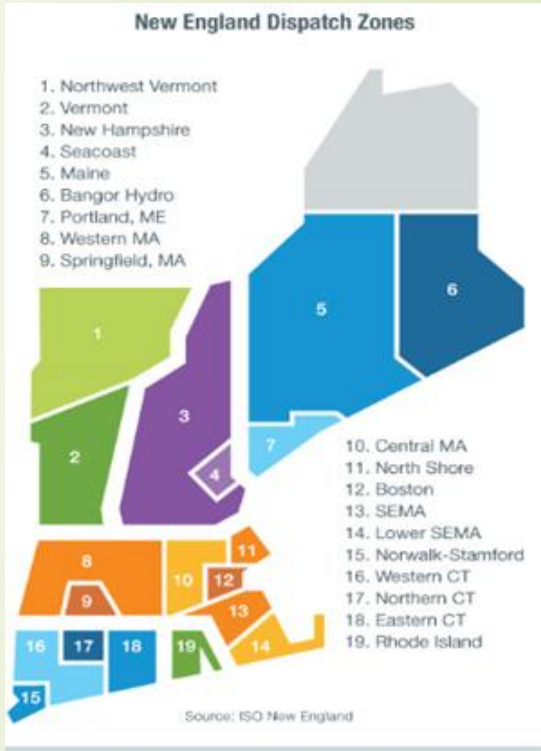


HQ



NYISO

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



ISONE

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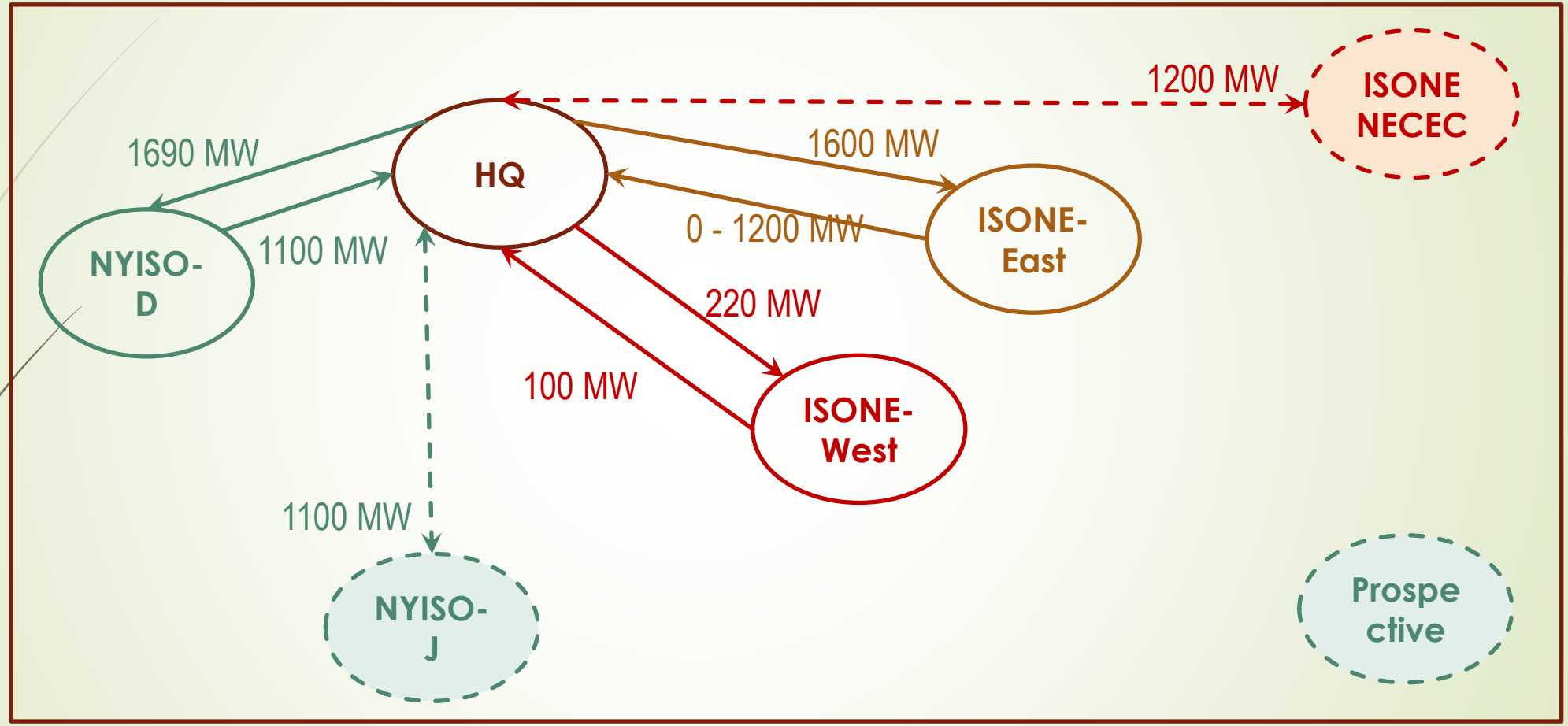
HQ interconnexions with neighbouring markets



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.

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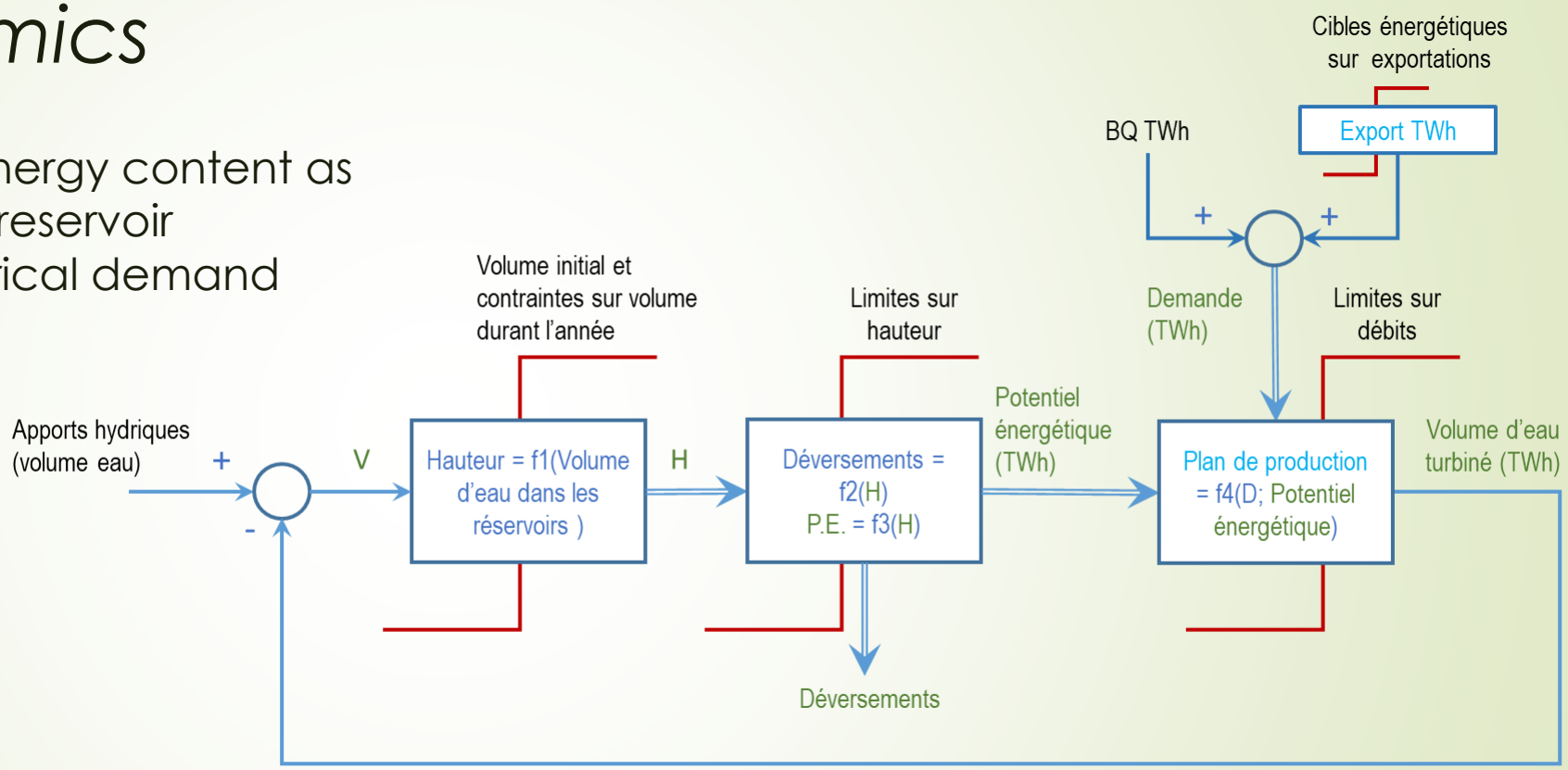
Representation of the hydraulic system dynamics

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.

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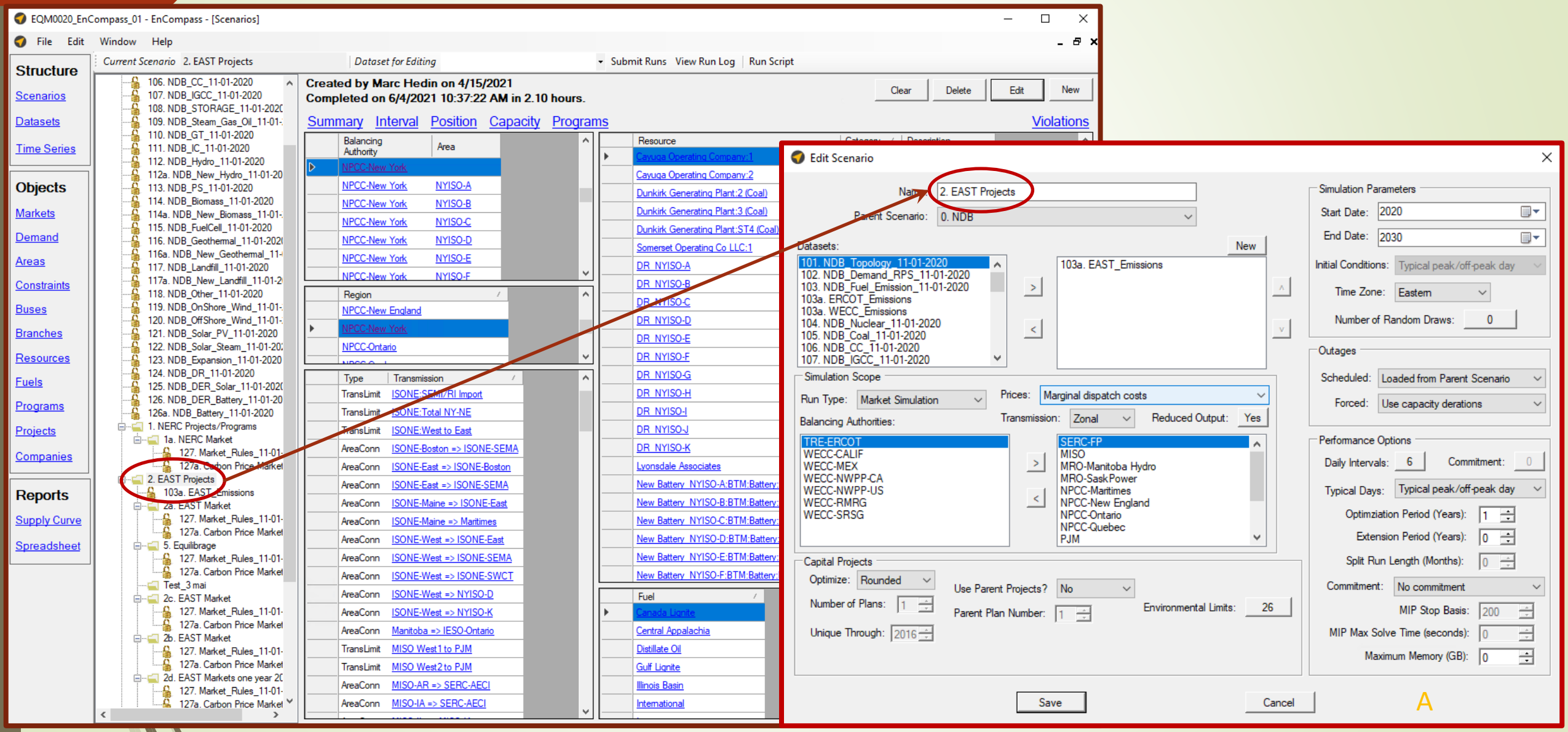
Where we are now with the simulation software

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"

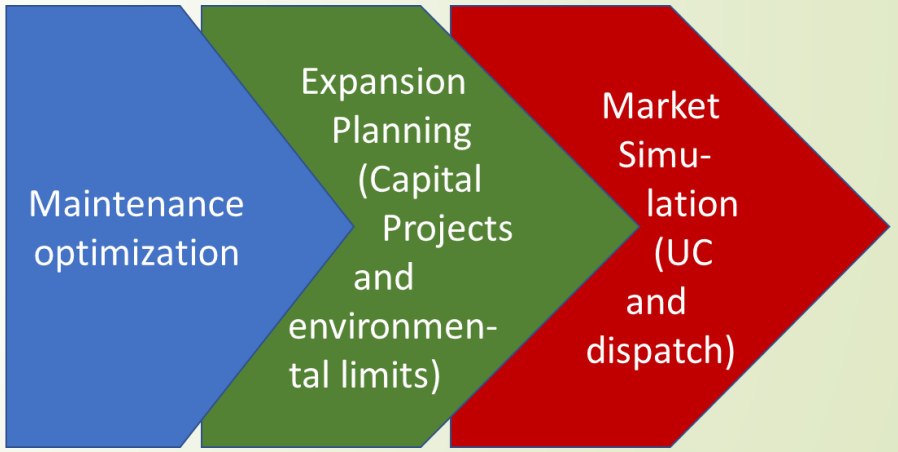


Example of a study, New York, New England and HQ

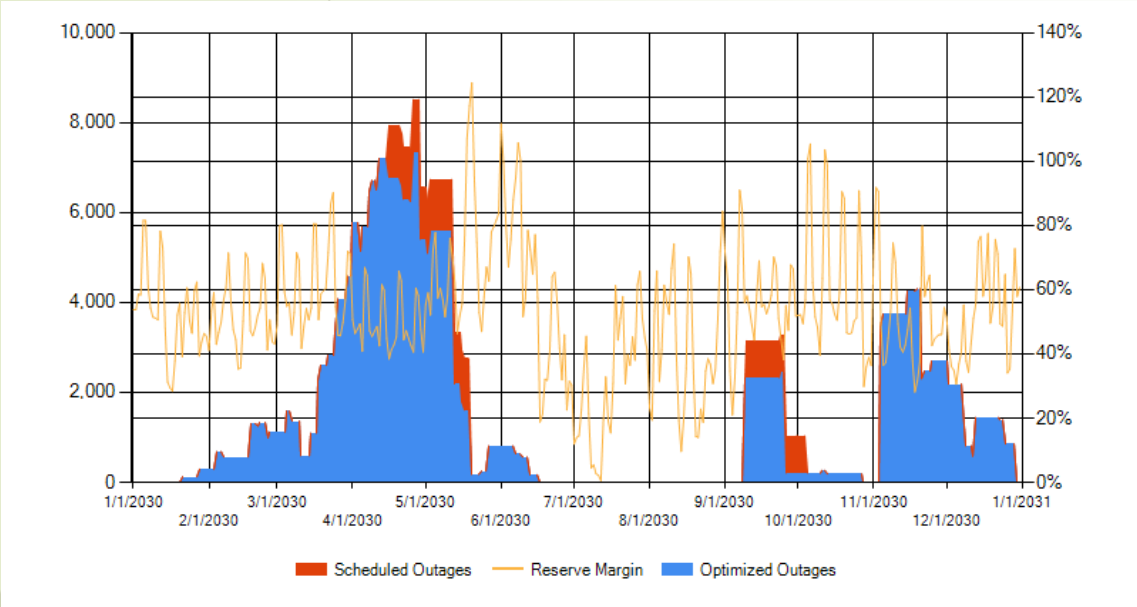
Techno-economic simulation including extensive data from the National Data Base provided by Horizons-Energy as part of the software.

Simulation steps :

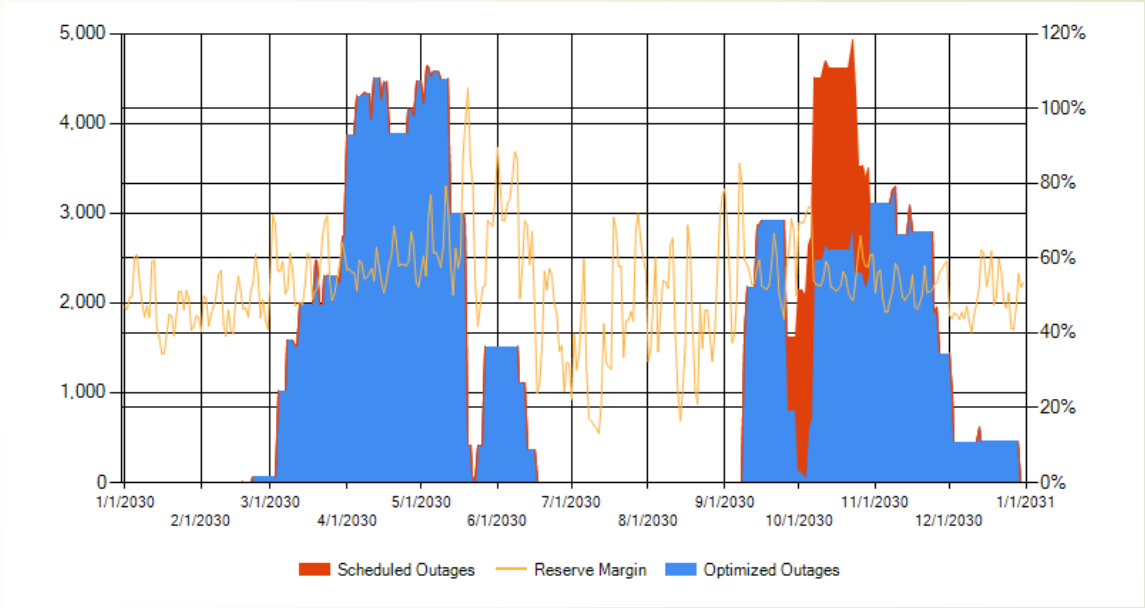
- Maintenance planning with initial resources only and a coarse time-step, 2020-2050.
- Capacity expansion (through capital projects and environmental constraints) with a finer time-step, 2020-2030
- Market simulation with fixed resources and network (one month to a year) with much finer time step (hourly)



Results : Maintenance optimization



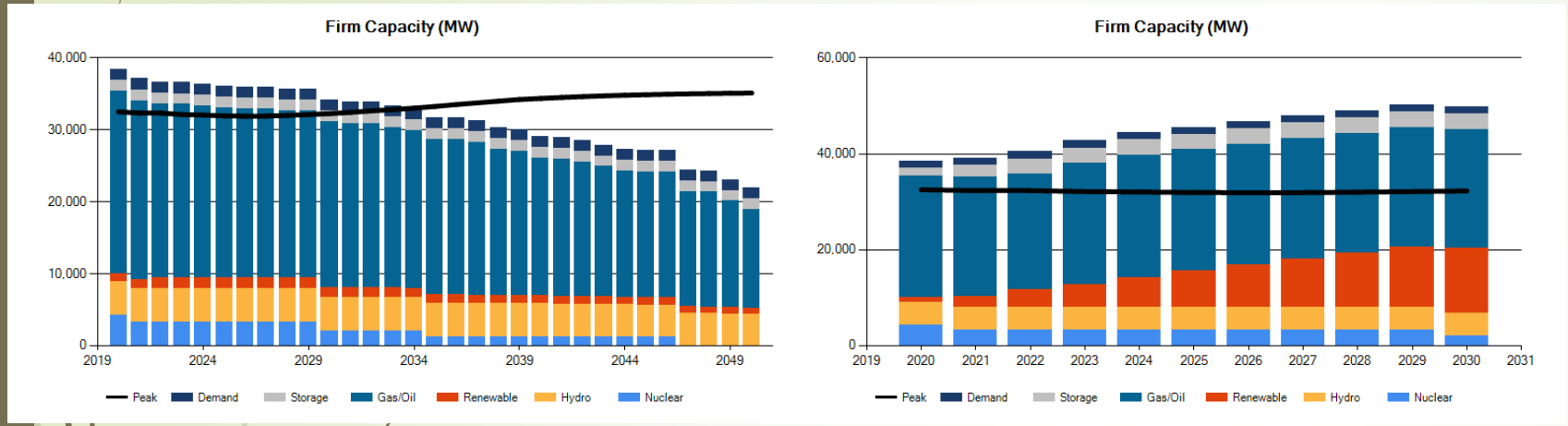
New York 2030



New England 2030

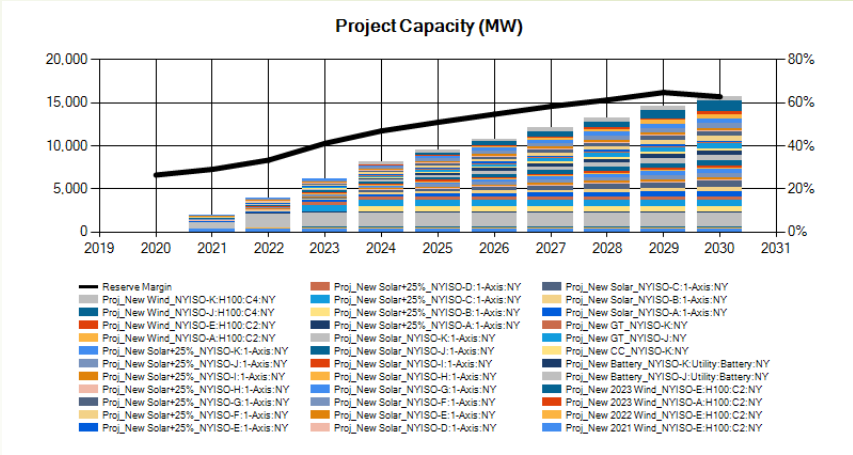
Examples of *maintenance* schedule optimization in 2030 with given prospective resources and an initial proposed maintenance plan.

Results : Expansion Planning for New York 2020-2030



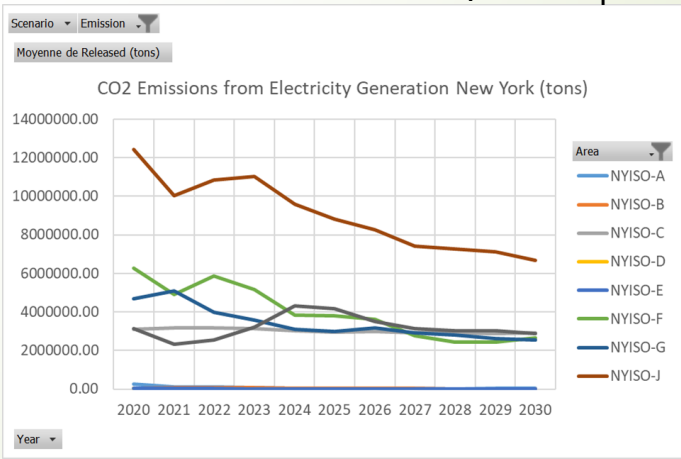
(a) Firm Capacity w/o expansion (2020-2050)

(b) Firm Capacity w expansion



(c) New Projects proposed /accepted by EnCompass

(d) Peak, off-peak and capacity prices



(e) CO_2 Emissions in different areas

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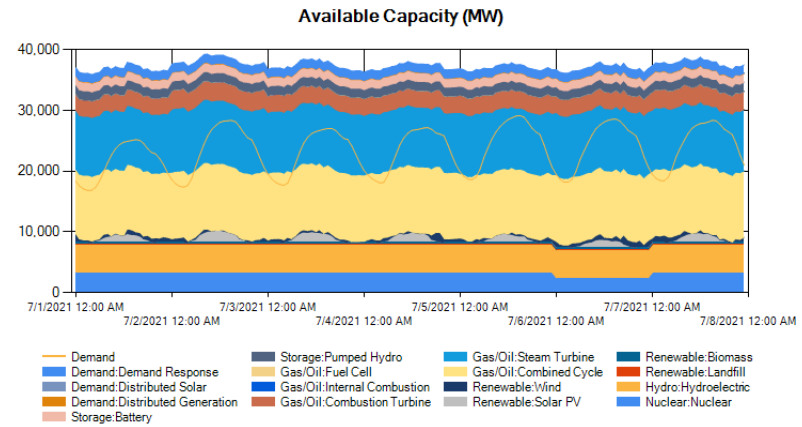
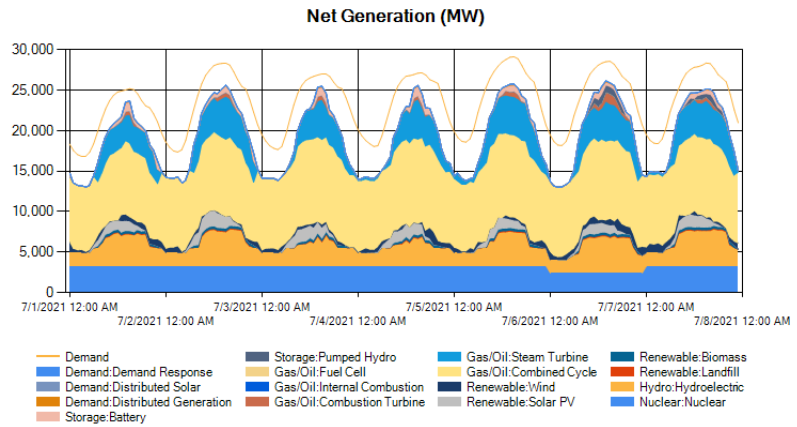
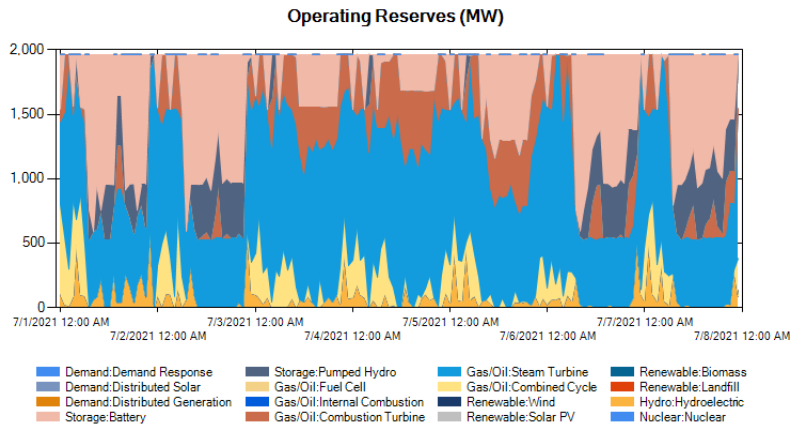
Results : Market Simulation New York July 2021



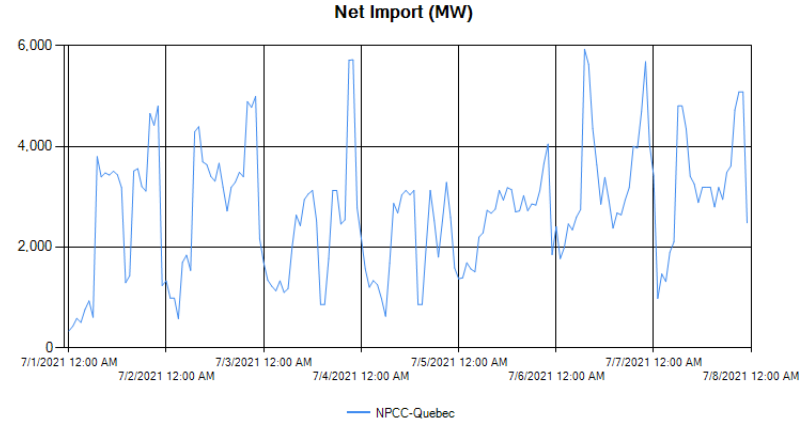
(a) Available Capacity (MW)



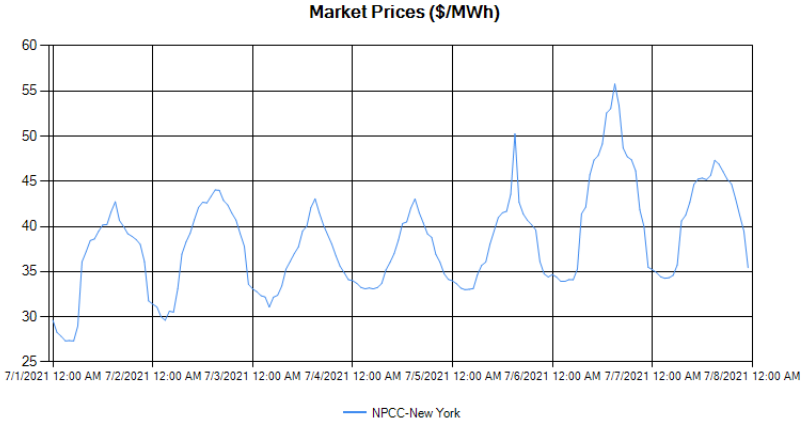
(b) Generation mix (MW)



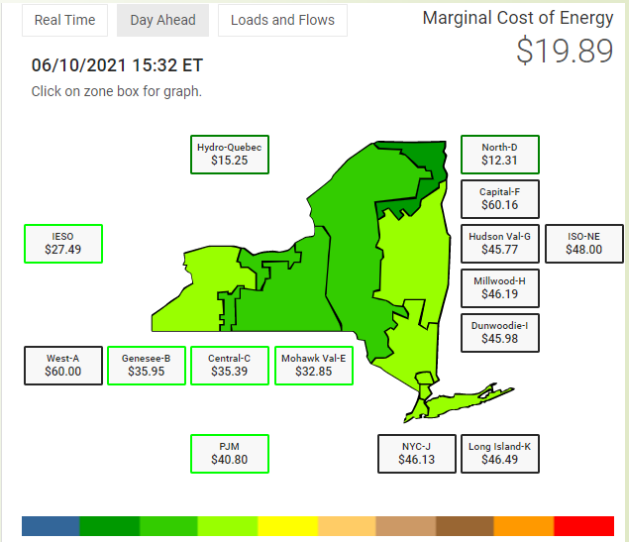
(c) Operating Reserves (MW)



(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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