STOCHASTIC NODAL ADEQUACY PLATFORM (SNAP™) AS A MARKET MECHANISM FOR COMPENSATING TRANSMISSION FOR SYSTEM ADEQUACY

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T C R

What are the Problems?

- System Adequacy in the Emerging Power System
- Transmission Planning and Remuneration for System Adequacy
- Demarginalization of Energy Markets

What are the Problems?

- System Adequacy in the Emerging Power System
  - *Under a high level of renewable integration, adequacy events are no longer driven by independent outages of multiple large generators that are overlapping in time.*
  - *Instead, future adequacy events will be driven by the highly correlated, primarily weather dependent, nature of intermittent (variable) resources*
  - *Adequacy events will not be the proverbial 1 day in 10 years loss of load but much more evenly spread over time with potential supply shortages of significant duration (consider the impact of a week of non-ending rain or a major snowstorm over a large territory on PV generation)*
  - *Planning for a larger reserve margin will not be the solution*
  - *Providing for System Adequacy requires new metrics and new solution methods*
- Transmission Planning and Remuneration for System Adequacy
- Demarginalization of Energy Markets

What are the Problems?

- System Adequacy in the Emerging Power System
- Transmission Planning and Remuneration for System Adequacy
  - *Resource adequacy challenges will likely require stronger and quite different transmission interconnections*
  - *Transmission constraints emerging under system adequacy events will have random patterns that are not presently understood or anticipated*
  - *Transmission planning will need to adapt to these challenges while remaining focused on the economic impact*
  - *Cost recovery mechanisms will be even more difficult to develop and justify*
- Demarginalization of Energy Markets

What are the Problems?

- System Adequacy in the Emerging Power System
- Transmission Planning and Remuneration for System Adequacy
- Demarginalization of Energy Markets
  - *The potential for multiple zero marginal cost and/or negative bid units to set the market clearing prices happens today (e.g., curtailments) but clearly increases in likelihood as we move forward State Incentives such as those that focus on drastically reduced emissions from the power sector*

The Role of Transmission in Providing System Adequacy

- Imagine a power system without a transmission grid
  - *You need a generator attached to each load*
  - *If a generator has an outage rate of 4%, the load would not be served for 350 hours per year*
  - *A second generator (100% reserve margin) will provide LOLE of ~40 days in 10 years*
  - *To achieve a 1 day in 10 years standard you will need about 300% reserve margin*
- For comparison, by using a transmission grid to pool resources we have been operating the system under the "1 day in 10 years" standard at a reserve margin of ~15%
- Grid's contribution to system adequacy appears *too big to measure*
- Indeed:
  - *We have developed no metrics to measure this contribution*
  - *We are lacking in adequacy assessment methods and tools in deciding where to build generation vs. transmission*
  - *All capacity market debates have been centered on generation incentives and not on transmission incentives*

Compensation for the Least Cost Dispatch needs to be REDEFINED to incorporate:

- The use of Non-Zero Marginal Costs where they remain (LMPs) AND
- Quantifiable measures of the value of system adequacy
  - *Reflecting the value of EVERY energy resource*
  - *Positive or negative*
  - *Fossil or non fossil, schedulable or intermittent*
  - *Recognizing both the SPATIAL and TEMPORAL nature of the problem in a new framework*
- Requires an economically based approach to system adequacy rather than the engineering-based approach as currently applied

Our Proposal: Stochastic Nodal Adequacy Platform (*SNAP*™)

Develop the Platform and the mathematics to identify the expected (probabilistically determined) value of system adequacy at every node in the system such that this value can be incorporated into the price of delivered energy as seen by consumers.

The good news…We now have cloud computing

- With Cloud Computing we can run TENS OR HUNDREDS OF THOUSANDS of scenarios
- Incorporate the stochastic uncertainties of:
  - *Traditional generation outages*
  - *Transmission outages*
  - *Behind-the-meter generation*
  - *Price based demand response*
  - *Weather driven demand*
- Most importantly … Incorporate the stochastic intermittency of renewable resources as correlated with demand

Calculation of SNAP: The Steps …

1. Develop / Quantify or simply define the ***VALUE OF LOST LOAD*** (**VOLL**) that reflects:
   - *The cost to society of not supplying an incremental MWh*
   - *The monetary value of shed load*
   - *[Initially a single value; overtime more complex by customer class, location and time block, ultimately -- a market-driven value]*
2. Energy Suppliers would offer into the Day Ahead Market
   - *Only those suppliers that are committed in the DAM to provide energy or ancillary services would be eligible to receive SNAP payments*
3. Reserves would offer into the Day Ahead Market
4. The ISO would then solve the Day Ahead Market on an hourly basis for the next day (including Reserves) as is done now.
5. Given knowledge of the offers and the sources and locations of those offers, The operator of the ***PLATFORM*** would perform the Day Ahead *SNAP* assessment and determine day-ahead adequacy payment to all suppliers *accepted* in DAM to provide energy or ancillary services

Reliability Dispatch (RD): The operator of the Platform would, as a matter of routine:

- Define and perform a ***very large number*** of RD Monte Carlo scenario simulations each testing the adequacy of the system for the Day Ahead horizon at each node and for each hour
- Each RD scenario is a Security Constrained Optimal Power Flow (SCOPF) calculation in which *all* available resources are ***entered into the analysis at zero cost***
- When there is load shedding, then it sets the dispatch order and prices
- RD assess the feasibility of the grid to serve demand under transmission and generation contingencies subject to system topology and availability of resources whether traditional or renewable
- The solutions are driven by weather and by load that is modeled stochastically to account for behind the meter generation, new electrification loads such as electric vehicles and any time or condition or price-based demand response.

SNAP #1

- In each hour *h* for each node *n* and each scenario *k*, compute the ***Stochastic Nodal Adequacy Price*** (SNAP(*h*,*n*,*k*))
- If the system is feasible for a given scenario and hour, SNAP= 0 at all nodes for that scenario and hour
- If the system is infeasible and load must be shed somewhere, the RD yields non-zero SNAP values varying by location
- In each scenario, a resource is paid SNAP at its node for each MW available for energy in that scenario times the probability weight of that scenario. No SNAP payments are made for reserves
- Actual payment is computed as a sum of payments over all scenarios

SNAP #2

- Load payments under each scenario are determined by the *SNAP* value at the load node or zone times the load served after load shedding; multiplied by the scenario weight
- In each scenario, a transmission facility earns the *adequacy rent* – the difference in *SNAP* values under that scenario times the flow determined in the RD solution and multiplied by the probability weight of the scenario
- The total DAM payment to and by all parties is the sum of payments based on LMPs and on *SNAP*s

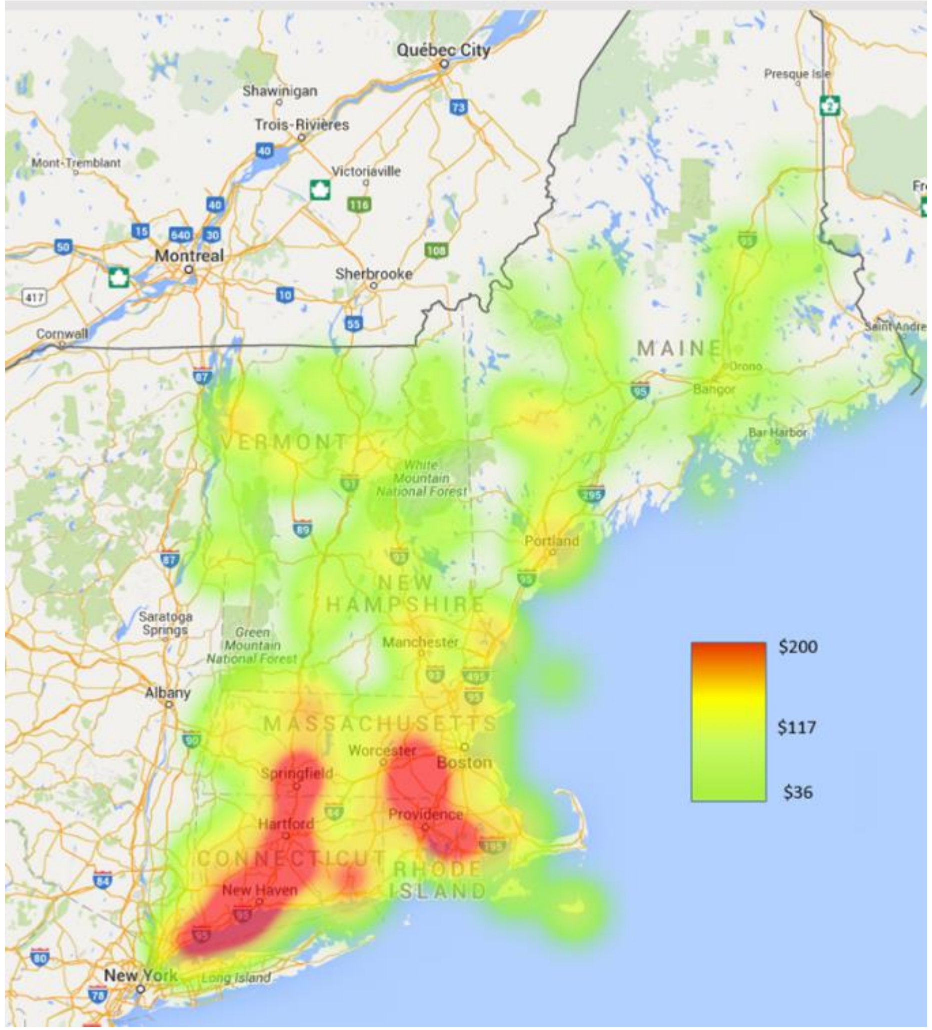
Market-based Payments for Transmission Services

- Transmission collects:
  - *Congestion rent in the energy market PLUS*
  - *Adequacy rent from SNAP*
- Loads pay LMPs and SNAP
- Generators receive LMPs and SNAP
- <u>Cost allocation problem is solved</u>

The Beauty of *SNAP*

- SIMPLICITY in concept, even if computationally intense
- SNAP pays variable generators for unambiguous contribution to system adequacy compensating them for each MWh delivered at the time of need
- SNAP may assess negative charges on self-scheduled generators if they cause adequacy problems
- SNAP provides locational values to ancillary services: forward-made payment to reserves can be benchmarked to the nodal opportunity costs they forego in the energy and adequacy markets
- SNAP provides unambiguous market-based payment to transmission for its contribution to system adequacy
- SNAP provides market signals needed to co-optimize development of generation, demand measures and transmission

Illustrative SNAP Map of ISO New England



Source: J. Golids et. al. (2016)

Simulations were performed by Newton Energy Group in early 2016 using the ENELYTIX modeling system, dataset and modeling assumptions for a one-year period September 2016 through August 2017

SNAP values shown in this Figure are measured in $/kW-year and range between $36/kW-year and approximately $200/kW-year.

References

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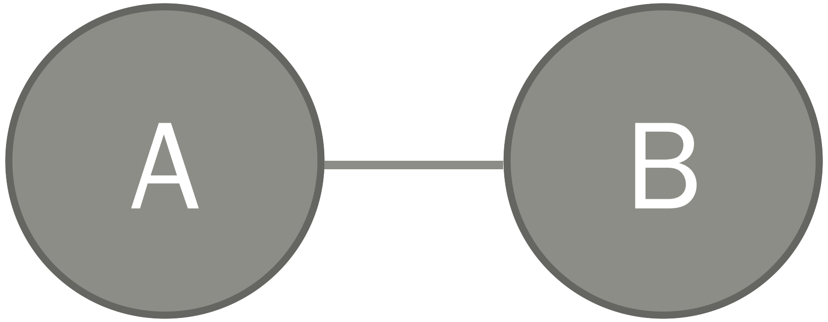
On the Structure of SNAP Payment for Transmission



- If SNAP(A) = SNAP(B), this does not mean that transmission between A and B has no adequacy value
- Imagine that we run 100,000 Day-ahead scenario and analyze 24 x 100,000 = 2,400,000 cases
- In 99.99% of these cases we observe no adequacy events
- In 0.01% of cases (240 cases) we observe load shedding such that
  - *In 120 of cases Zone A is helping zone B and 120 cases zone B is helping zone A*
  - *In each of these 240 cases, transmission between A and B collects adequacy rent*
  - *Yet the SNAP value in A and B may be the same*

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