Capacity Value Study Summary

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ICAPWG

December 6th, 2018

Agenda

- Summary of Stakeholder Comments on GE Study
- GE MARS
- IRM Study
- Background
- Capacity Value Study: Approach and Methodology
- Cases
- Other Studies and Methodologies
- Appendix

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Background

- In 2012, the NYISO with the NYSRC performed an analysis on SCR's contribution to Resource Adequacy.
  - http://www.nysrc.org/pdf/MeetingMaterial/ICSMeetingMaterial/ICS_Agenda135/2012%20SCR%20Study%20Report%20for%20ICS%20-final-05-01-12.pdf
- IN 2014, NYISO initiated an effort to increase the duration requirement from 4 to 6 hours for the SCR program
  - http://www.nyiso.com/public/webdocs/markets_operations/committees/bic_icapwg/meeting_materials/2014-07-21/SCR%20Performance%20Obligations%20_ICAPWG072114.pdf

Background (continued)

- **Previous discussions on the Capacity Value from this year:**
  - February 2nd ICAPWG
    - http://www.nyiso.com/public/webdocs/markets_operations/committees/bic_icapwg/meeting_materials/2018-02-02/Capacity%20Value%20of%20Resources%20with%20Energy%20Limitations.pdf
  - April 26th ICAPWG
    - http://www.nyiso.com/public/webdocs/markets_operations/committees/bic_icapwg/meeting_materials/2018-04-26/04232018%20Capacity%20Value%20of%20Resources%20with%20Energy%20Limitations.pdf
  - July 24th ICAPWG
    - http://www.nyiso.com/public/webdocs/markets_operations/committees/bic_icapwg/meeting_materials/2018-07-24/Capacity%20Value%20of%20Resources%20with%20Energy%20Limitations.pdf
  - October 9th ICAPWG
    - http://www.nyiso.com/public/webdocs/markets_operations/committees/bic_miwg/meeting_materials/2018-10-09/Expanding%20Capacity%20Eligibility%20clean.pdf
  - November 29th 2018 ICAPWG
    - http://www.nyiso.com/public/webdocs/markets_operations/committees/bic_icapwg/meeting_materials/2018-11-29/DER%20Capacity%20Market%20Updates%20and%20Schedule.pdf

Capacity Market Design Schedule

- December 6th ICAPWG – discuss GE MARS tool, IRM Study and assumptions, Capacity Value Study and assumptions, and Other Studies
- December 18th ICAPWG – continue today's discussion
- Next steps - continue discussions on analysis

Definitions

- **Capacity Value**
  - How much perfect capacity of a particular resource is necessary to provide an equivalent reliability benefit in a given location
  - Capacity Value is independent of transmission constraints
  - Capacity Value for a traditional generator can be approximated by UCAP
- **NYCA-wide Reliability Value**
  - The amount of perfect capacity spread throughout NYCA proportional to existing capacity which would provide an equivalent reliability benefit
  - NYCA-wide Reliability Value incorporates the impact of transmission congestion
- **Capacity Margin**
  - The difference between the total amount of resources on the system and the system load [MW]
    - Capacity Margin [MW] = total amount of resources [MW] – system load [MW]

Summary of Stakeholder Comments on GE Study

Summary of Stakeholder Comments on GE Study

- Concerns with the load shapes that were used in the study (i.e. out of date, conservative)
- Concerns that the system was modeled At Criterion rather than at Level of Excess
- Concerns surrounding limitations of the GE MARS tool (i.e. perfect foresight) as well as the limitations in the post processing methodology (e.g. can only dispatch resources in full capacity blocks or in 50 MW blocks, does not evaluate start-up times)
- Questions on methodology and whether NYISO would consider an ELCC study approach
- Will NYISO consider additional analysis (either through GE or external consultant)?
  - Will the NYISO consider location of resources in analysis?

GE MARS

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GE MARS

- **GE MARS software is used for the purpose of the IRM study**
  - GE Multi-Area Reliability Simulation Software Program (GE MARS)
    - A system simulation program that models the generation system, the interconnections between areas, and chronological hourly load demand
    - The software conducts probabilistic analysis using a Monte Carlo simulation
    - Potential uses of GE MARS software:
      - Generation system adequacy
      - Installed capacity requirements
      - Benefits of reserve sharing
      - Need for implementing emergency operating procedures
      - Reliability impact and capacity value of variable resources

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GE MARS cont.

- **In its simulation, GE MARS "produces probability distributions that show the actual yearly variations in reliability that the NYCA could be expected to experience"**
  - The model takes random events such as forced outages of generating units and transmission capacity into account when determining NYCA reliability
  - "Deviations from the forecasted loads are captured using a load forecast uncertainty model"

Reference [1]

GE MARS cont.

- GE MARS calculates the following three reliability indices:
  - Daily LOLE – Daily Loss of Load Expectation (days/year)
    - The expected number of days per year for loss of load events in the NYCA
  - Hourly LOLE – Hourly Loss of Load Expectation (hours/year)
    - The expected number of hours per year for loss of load events in the NYCA
  - LOEE – Loss of Energy Events Expectation (MWh/year)
    - The expected number of MW-hours per year for loss of energy events in the NYCA
- The NYSRC uses the Daily LOLE to set the NYCA IRM requirements

IRM Study

Purpose of IRM Study

- **The IRM Study is conducted annually by the NYSRC to set the NYCA Installed Capacity requirements for the upcoming Capability Year while maintaining the criterion of a Loss of Load Expectation (LOLE) = 0.1 days/year**
  - The IRM Study is used to "derive the amount of capacity that must be available to the NYCA to ensure resource adequacy and reliability criterion are met"
  - The IRM is represented as a percentage
    - e.g. 18.2% for 2018
- **Main drivers of change in IRM are the load forecast and uncertainty, resource availability, and the topology of the NY system**

Reference [4]

IRM Methodology

- **Using the As Found Supply load forecasts and uncertainties, and system topology evaluate how much capacity is needed to maintain the reliability target**
  - This is done by removing and shifting supply between locations until the reliability target is met

IRM Study

- **The GE MARS model uses multiple load shapes for the IRM Study**
  - This modeling feature allows different load shapes to be used for each of the seven Load Forecast Uncertainty (LFU) bins
  - The NYISO uses a combination of the 2002, 2006, and 2007 load shapes for the Load Forecast Uncertainty bins
    - 2007 Load Shape represents the average load shape
    - 2002 Load Shape represents a flatter shape
      - i.e. higher number of days of risk exposure with the average load shape
    - 2006 Load Shape represents a peaked shape
      - i.e. most likely to be experienced at the extremes

Load Forecast Uncertainty

- **The NYSRC IRM Database models 7 Load Levels (Load Level 1, 2006 Historic Load Shape; Load Level 2, 2002 Historic Load Shape; Load Levels 3-7, 2007 Historic Load Shape) to represent Load Forecast Uncertainty**
  - For each Load Level, a Historic Load Shape is used as a basis, and is scaled up such that the peak load of the Historic Load Shape matches the peak load forecast of the of the year being studied
    - i.e. the 2002 Load Shape is scaled up proportionately such that the peak load of 2002 is equal to the forecasted peak load for 2018. The entire load shape is multiplied by the peak load multiplier (the value used to scale up the 2002 peak load) to forecast the Load Shape for 2018 Load Level 2, including the Load Forecast Uncertainty Multiplier
  - See following slide for details on the Load Forecast Uncertainty bins

Load Forecast Uncertainty cont.

Table A.5 2018 Load Forecast Uncertainty Models

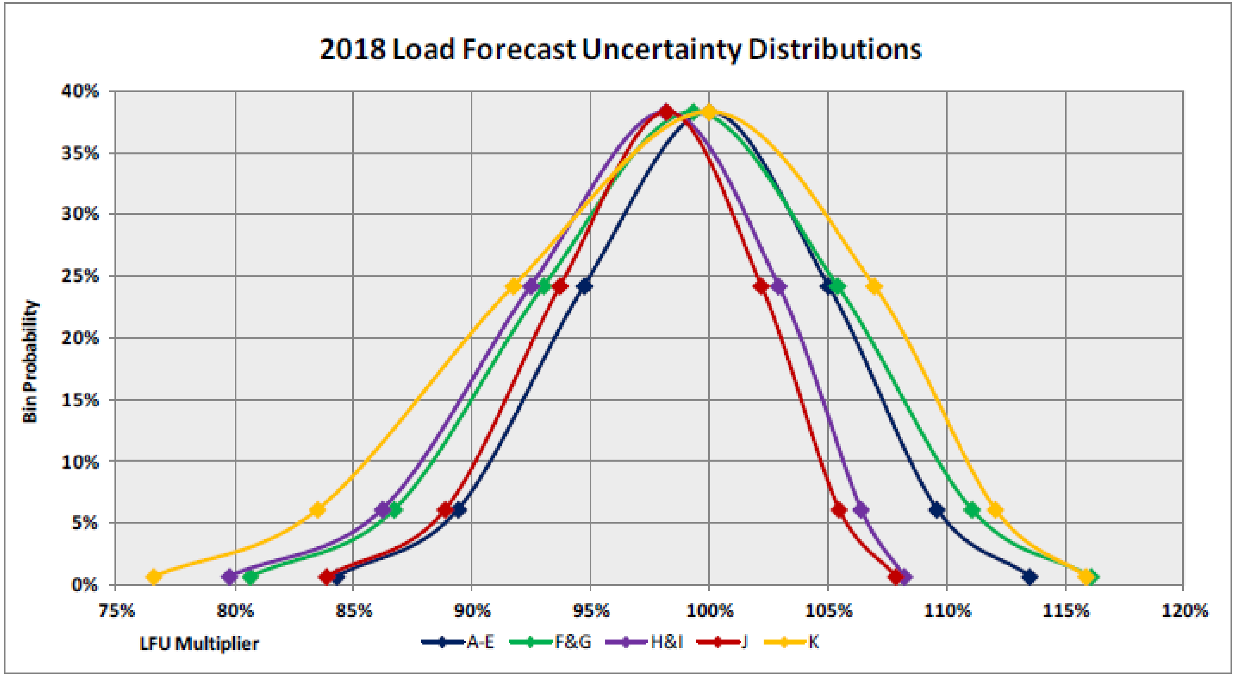
2018 Load Forecast Uncertainty Models

Bin	Probability	A-E	F&G	H&I	J	K
B7	0.62%	84.31%	80.67%	79.78%	83.88%	76.59%
B6	6.06%	89.44%	86.74%	86.24%	88.87%	83.51%
B5	24.17%	94.74%	93.03%	92.49%	93.71%	91.75%
B4	38.30%	100.00%	99.33%	98.17%	98.21%	100.00%
B3	24.17%	105.02%	105.41%	102.93%	102.19%	106.95%
B2	6.06%	109.59%	111.07%	106.39%	105.47%	112.06%
B1	0.62%	113.51%	116.08%	108.22%	107.86%	115.86%

Delta	A-E	F&G	H&I	J	K
Bin 4 - Bin 7	15.69%	18.66%	18.39%	14.34%	23.41%
Bin 1 - Bin 4	13.51%	16.76%	10.04%	9.65%	15.86%
Total Range	29.19%	35.42%	28.43%	23.99%	39.27%

Load Forecast Uncertainty cont.

Figure A.2 LFU Distributions



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Load Shapes

- The NYISO compared the load shape using actual load from 2018 to two of the actual load shapes used in the IRM Study (2002 and 2006)
  - 2018 load shape does not include add back of Demand Response activations
  - 2002 and 2006 load shape do include add back of Demand Response activations
- The following slides show the comparison between the actual 2018 load and the load shapes from the previous years
  - Load from July Peak Day
  - Average load in July

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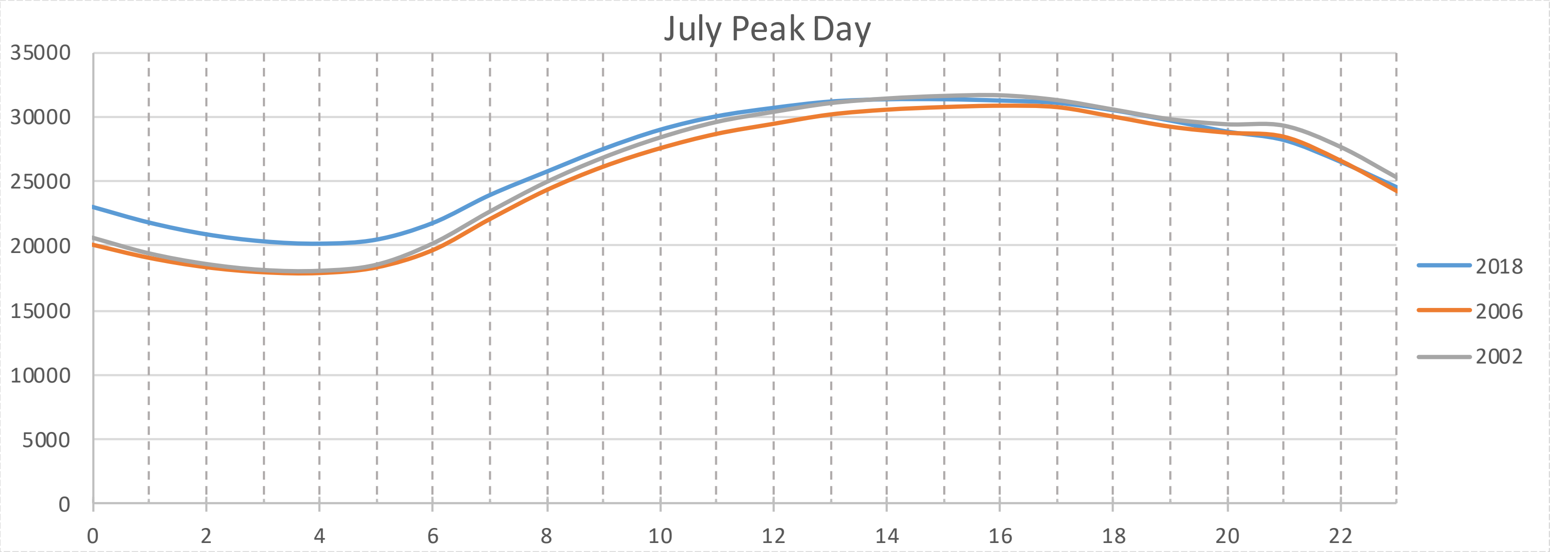
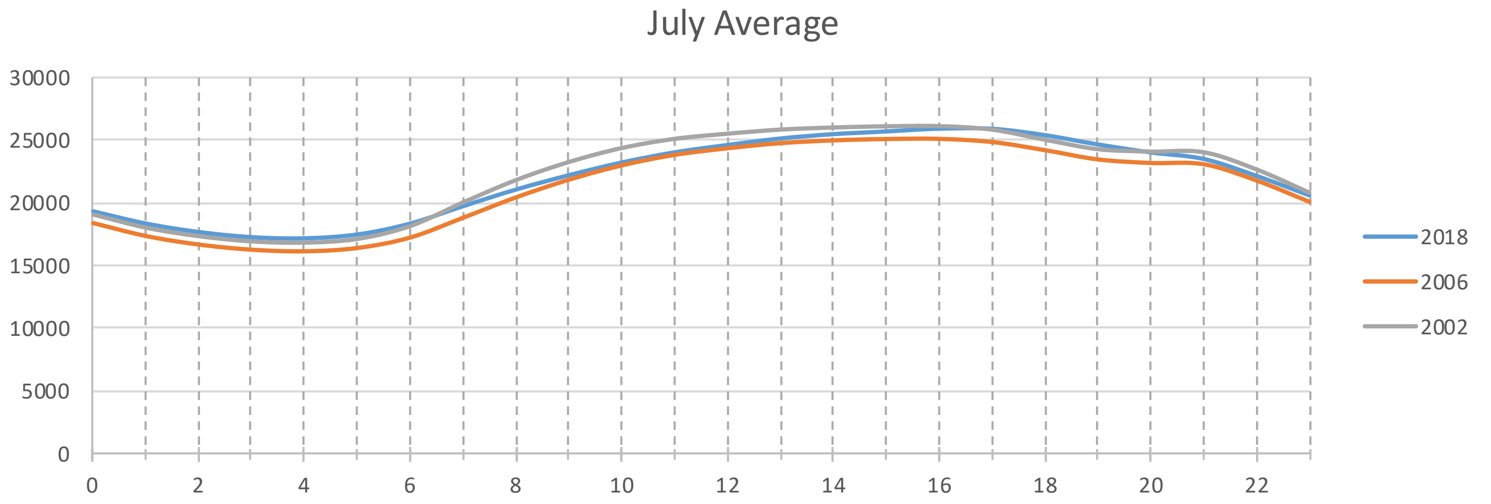
Load Shapes cont.



This analysis shows that the July 2018 Peak Day load shape is comparable to the 2002 and 2006 load shapes. As previously mentioned, the IRM Study scales up the load shapes (2002, 2006, 2007) proportionately to the year being modeled (e.g. 2018)

Load Shapes cont.



This analysis shows that the July 2018 Average load shape is comparable to the 2002 and 2006 load shapes. As previously mentioned, the IRM Study scales up the load shapes (2002, 2006, 2007) proportionately to the year being modeled (e.g. 2018)

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Background

Background

- **NYISO engaged GE to perform a study to compare the value of resources with different maximum duration capabilities**
  - The study uses the Resource Adequacy model used by NYSRC to establish the NYCA installed capacity requirements
  - This study used the outputs of the GE MARS tool as inputs into a post-process routine to perform this study

Capacity Value Study

- **Capacity Value Study**
  - Compares the value of new resources to the value of perfect capacity resources
    - Adds the resource to the modeled system
    - Remove other resources from the modeled system until we return to reliability index
    - Capacity Value = size of resources removed / size of resource added
  - Capacity Value Studies are comparing the resources added against the fleet of modeled resources

Effective Load Carrying Capability Study

- **Effective Load Carrying Capability Study**
  - Determines the value of new resources that would be added to the system relative to the incremental load it can support
    - Add the resource to the modeled system
    - Add load to each hour using the load shape model to the modeled system until we return to reliability index
    - ELCC = size of load added / size of resource added
  - Effective Load Carrying Capability Studies are comparing the resources added against the load shapes

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Why a Capacity Value Study?

- The NYISO chose to conduct a Capacity Value Study to compare the value of resources with duration limitations to existing system resources as the NYISO anticipates increased penetration of duration limited resources to replace existing resources in the NYCA in the near future
  - The NYISO expects to use these values to establish the value of these duration limited resources in the Installed Capacity market
  - The NYISO believes the reliability requirement setting process will incorporate the value of these resources in meeting load
    - The NYISO believes that as the resources are added to the system and are modeled with their limitations, the IRM/LCR process will incorporate them in establishing requirements
- The NYISO chose to conduct the Capacity Value Study because it will reflect the value of all resources rather than reflecting the value of new resources only under the ELCC Study
  - ELCC measure by itself cannot be used to compare the relative value of resources with different duration limitations
- The NYISO chose to conduct the Capacity Value Study using the ratios of added capacity vs removed capacity instead of looking at the individual reliability improvement from incremental capacity because adding significant amounts of incremental capacity (1000s of MW) drives the reliability value well beyond what can be meaningfully measured

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Capacity Value Study: Approach and Methodology

Capacity Value Study

- **The study uses the outputs of GE MARS and utilizes a post processing method to schedule the resources against the hourly NYCA capacity margin for each iteration**
- **GE MARS post processing method**
  - The post processing method uses the outputs of the IRM model (from GE MARS) as the basis for the analysis to incorporate resources with duration limitations
    - Outputs of IRM model: 8760 hours for each run (total of 2500 runs), capacity margin, and emergency assistance available
    - The method looks at variables such as: duration of use, penetration, resource diversity, persistence of use, performance, and seasonal or daily limitations
    - More detail on following slides

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Methodology

- **How Capacity Value is calculated**
  1. The Capacity Value Study is modeled at the reliability index
     - i.e. at criterion system – 2018 IRM requirements and LOLE = 0.1 days/year
  2. Adds resources with duration limitations in equal increments for all hours
     - Reliability improves
     - More details on following slides
  3. Remove perfect capacity that does not have any duration limitations
     - This method equates to adding perfect load (to the forecast) in equal increments for all hours
     - Reliability decreases
     - This step is repeated until the reliability index is reached
     - More details on following slides

Capacity Addition

- **Resources with duration limitations are added in equal increments for all hours**
  - For each case, the post processing method schedules the resources to meet the system need at the most optimal time for the resource
    - The most optimal time of the day has the smallest *capacity margin* + *emergency assistance* available
    - e.g. a 4-hour resource would be scheduled in the most optimal 4 hours of the day
  - The method takes resource diversity into account when scheduling the resources, such that each block is scheduled independently
    - e.g. with resource diversity of 50 MW blocks, each duration limited resource would be scheduled 50 MW at the most optimal time

Variables

- **Duration of use**
  - The duration value corresponds to the number of hours that the resource is capable of running
- **Penetration**
  - The penetration value corresponds to the number of MW provided by resources that are added to the system in each case

Variables cont.

- Resource diversity
  - Total resource penetration is scheduled simultaneously
    - e.g. for a total resource penetration of 1000 MW, all 1000 MW of resources are scheduled simultaneously
  - Resource penetration is scheduled in smaller increments
    - e.g. for a total resource penetration of 1000 MW, resources are scheduled in 50 MW increments

Variables cont.

- **Persistence of use**
  - The amount of times that a resource can be dispatched in the time frame
    - e.g. dispatched once each day (time frame of 1 year)
- **Performance**
  - Considers the availability of the resources
    - e.g. 0% forced outage rate
- **Seasonal or daily limitations**
  - Factors that may influence whether or not the resource is available
    - e.g. only available May – October annually
    - e.g. only available HB 12 – 20 on a daily basis

Capacity Removal

- **Remove perfect capacity that does not have any duration limitations, testing various levels of perfect capacity until the reliability target is reached**

  1. If the resource with duration limitations is scheduled in a given hour, remove perfect capacity from NY Areas proportional to the capacity added in those locations
     - e.g. if 100 MW resource with duration limitations is scheduled in HB 15, remove 60 MW of perfect capacity from the locations proportional to the added resources
  2. If the resource with duration limitations is not scheduled and all NY Areas have capacity margins greater than or equal to zero, remove perfect capacity from NY Areas proportional to the surplus
     - e.g. if the 100 MW resource with duration limitations is not scheduled in a given hour and the capacity margin for this hour is 300 MW, remove 60 MW of perfect capacity from the locations proportional to the surplus capacity margin
  3. If the resource with duration limitations is not scheduled and any NY Area has a capacity margin less than zero, remove perfect capacity proportional to base case UCAP
     - e.g. if the 100 MW resource with duration limitations is not scheduled in a given hour and the capacity margin for this hour is -200 MW, remove 60 MW of perfect capacity from the locations proportional to the original supply

Cases

Cases

- **Two cases were analyzed in the study, for multiple scenarios of resource penetration and hour durations**
  1. Base Case – 2018 IRM Base Case with Optimized LCRs
  2. High Wind High Solar – 2018 IRM with additional 2000 MW Wind and additional 2000 MW Solar
     - These Wind and Solar MW are in addition to the existing Wind and Solar MW that is already considered in the 2018 IRM Base Case

Cases cont.

- **Base Case**
  - The study uses 2018 Base Case data to determine the Capacity Value of resources on the current system using this year's IRM and Optimized LCR requirements
    - The IRM is established with the LOLE criterion of 0.100 days/year

Cases cont.

- **High Wind - High Solar Case**
  - The study assumes a case where 2000 MW of Wind and 2000 MW of Solar resources in addition to the Wind and Solar that already exists in the 2018 IRM Base Case
    - This assumption captures the effects of additional wind and solar penetration on our current system
    - This case has been rebalanced to maintain the LOLE criterion of 0.100 days/year

Rationale for cases

- **Why does the base case use the 2018 IRM?**
  - One of the primary objectives of the Capacity Market is to establish a market mechanism to procure the capacity requirements established by the NYSRC/IRM studies
  - It is appropriate to align the Capacity Value of resources with duration limitations to the reliability value provided and, therefore, conduct the Capacity Value Study using the most recent NYSRC approved IRM (2018)
  - It is important that the Capacity Value be based on the current and/or very near term expected system conditions with periodic updates to the Capacity Value to minimize the uncertainty and errors in forecasting system conditions too far into the future

Rationale for cases cont.

- **Why look at High Wind - High Solar case?**
  - It is appropriate to model a High Wind - High Solar case because it represents a possible future of the NYCA system
  - The High Wind - High Solar case assumptions were based on the most recent NYSRC approved IRM (2018)

Duration and Penetration

- **For both the Base Case and High Wind - High Solar Cases, the following scenarios were analyzed:**
  - Durations – 1, 2, 4, 6, 8, 10, 12, 16, and 24 hours
  - Penetrations – 100, 250, 500, 1000, 2000, and 4000 MW of resources with duration limitations

Duration and Penetration cont.

- **Duration and Penetration**
  - The analysis assumed 9 different durations of resources and 6 different levels of resource penetration
  - The 9 durations represent the various capabilities of different resources that may be to be added to the system in the near future
  - The 6 different levels of resource penetration represent the resource mix that may be to be added to the system in the near future

Resource Diversity

- **The study also analyzed two different methods for dispatching the resources for both the Base Case and High Wind - High Solar Case**
  - No diversity assumed for resource dispatch
    - This method represents resources such as SCRs that are not on real-time dispatch by RTD
      - For example, all SCRs in a zone are activated together (consistent with actual activation)
    - e.g. for a total penetration of 1000 MW, all 1000 MW are called at once
  - Diversity assumed for resource dispatch
    - This method represents resources such as ESR and dispatchable DER that are on real-time dispatch by RTD
    - e.g. for a total penetration of 1000 MW, resources are dispatched in 50 MW increments

Other studies referenced by Stakeholders

Other studies referenced by stakeholders

- **IEEE – Estimating the Capacity Value of Concentrating Solar Power Plants with Thermal Energy Storage: A Case Study of the Southwestern United States (2012)**
  - Case study estimates the capacity value of CSP plants at three sites in the southwestern U.S. (California, Nevada, and New Mexico)
    - Analysis uses historical data from 1998-2005
    - Study does not analyze capacity value as a function of resource penetration
  - Capacity value is measured through ELCC Study – determine the value of resources added to the system
    - Looks at the capacity value of concentrating solar power (CSP) development, specifically: CSP with thermal energy storage
- **The results of this study are not comparable to GE's Capacity Value Study because the study looks at resources:**
  - Specific to one type of resource (concentrating solar with thermal energy storage)
  - Located in the southwestern U.S.
    - The system conditions in the southwestern U.S. may not be comparable to those in NYS

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Other studies referenced by stakeholders

- **IEEE – A Dynamic Programming Approach to Estimate the Capacity Value of Energy Storage (2014)**
  - Case study estimates the capacity value of storage in five utility systems: Pacific Gas and Electric (PG&E), Southern California Edison (SCE), NV Energy (NE), Public Service Company of New Mexico (PNM), and FirstEnergy (FE)
    - Analysis uses historical data from 1998-2005
    - Study does not analyze capacity value as a function of resource penetration
  - Capacity value is measured through ELCC Study – determine the value of resources (in this case energy storage) added to the system
    - Capacity value is highly sensitive to storage dispatch decisions, which are determined by energy prices
- **Even though the approach of the study varies from the GE Capacity Value Study, the value results are comparable (1-10 hour durations equal to ~40-90% Capacity Values)**
  - This study is not clear on the assumptions used to derive their conclusions
- **The results of this study are not comparable to GE's Capacity Value Study because the study looks at resources:**
  - Specific to one type of resource (energy storage)
  - Based on energy prices
  - Located in the southwestern U.S.
    - The system conditions in the southwestern U.S. may not be comparable to those in NYS

Other studies referenced by stakeholders

- **ICF – Unlocking the Hidden (Capacity) Value in Energy Storage (2016)**
  - Case study models ERCOT's grid using ICF's Stochastic Resource Assessment Model
    - Modeled a future year (2018) using projected generation/load data
    - Study does not analyze capacity value as a function of resource penetration
  - Recommends measuring the capacity value of resource (in this case energy storage) through ELCC or ideal-generator method (IGM)
    - Calculate the capacity value of resource by evaluating the improvement in LOLE assuming that it is available for hour(s) (corresponding to resource's duration)
  - Concluded that a 1 hour 100 MW energy storage system can provide 46 MW of firm capacity, and a 4 hour 100 MW energy storage system can provide 99 MW of firm capacity
- **The results of this study are not comparable to GE's Capacity Value Study because the study looks at resources:**
  - Specific to one type of resource (energy storage)
  - Located in the southern U.S.
    - The system conditions in the southern U.S. may not be comparable to those in NYS

Other methodologies NYISO has reviewed

Other methodologies NYISO has reviewed

- NREL
  - Methods to Model and Calculate Capacity Contributions of Variable Generation for Resource Adequacy Planning (IVGTF1-2): Additional Discussion (2011)
    - Recommends ELCC approach for Resource Adequacy Planning
    - Suggests alternative reliability metrics that ELCC can be based on:
      - LOLP/LOLE – daily
      - LOLH (hourly LOLP)
      - EUE – expected unserved energy
  - The method chosen for performing the study was to accommodate the specific question that CPUC was trying to answer

Other methodologies NYISO has reviewed

- **Energy and Environmental Economics**
  - Capacity and Flexibility Needs under Higher Renewables (2015)
    - Suggests that there is a planning problem regarding resource adequacy
    - Refers to RECAP approach used in modeling ELCC
  - E3/Calpine ELCC Modeling (2016)
    - ELCC Study used to determine the value of resources added to the system
  - The method chosen for performing the study was to accommodate the specific question that CPUC was trying to answer
- **CAISO**
  - Calpine/E3 ELCC Proposal: Overview and Answers to Stakeholder Questions (2017)
    - ELCC Study used to determine the value of resources added to the system
  - The method chosen for performing the study was to accommodate the specific question that CPUC was trying to answer

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Other methodologies NYISO has reviewed

- CAISO
  - Effective Load Carrying Capacity and Qualifying Capacity Calculation Methodology for Wind and Solar Resources (2014)
    - CPUC Staff Proposal to conduct ELCC for wind and solar resources to determine the value of the resources
  - Potential Energy Division Staff Proposal: Adoption of Simplified ELCC Methodology (2015)
    - Suggests different approaches to incorporate ELCC values
      - e.g. simplified ELCC methods, monthly ELCC values, hybrid approach
  - Energy Division Revised Proposal Monthly LOLE and Monthly ELCC (2017)
    - ELCC Study used to determine the value of resources added to the system, specifically wind and solar

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Next Steps

- Continue discussions at ICAPWG

Feedback/Questions?

- Email additional feedback to: ztsmith@nyiso.com and deckels@nyiso.com

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Appendix

SCRs and ELRs

- Current MW levels of SCRs and ELRs participating in the NYISO markets
  - SCRs – 1276.3 MW (as of May 2018)
  - ELRs – 5546.6 MW (as of March 2018)

References

1. http://www.nysrc.org/pdf/Reports/2018%20IRM%20Study%20Appendices%20%20Final%2012_08_2017_V2.pdf
2. https://www.geenergyconsulting.com/sites/gecs/files/GE%20MARS%20Brochure.pdf
3. http://nysrc.org/pdf/Reports/IRM%20White%20Papers/Multiple%20Load%20Shape%20%205_29_13%20Final.pdf
4. http://www.nyiso.com/public/webdocs/markets_operations/services/market_training/workshops_courses/Training_Course_Materials/Installed_Capacity_MT_305/2_%20Amount%20of%20Capacity%20Required.pdf

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- Operating open, fair and competitive wholesale electricity markets
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