Demand Curve Implementation

This document is VERY DRAFT and is for discussion purposes only at this point.

Concepts

If we define:
R_{xy} to be the MW quantity of reserves scheduled on resource x that meets reserve requirement y;
REQ_y to be the MW level of reserve requirement y;
$SLACK_y$ as the amount by which we fail to meet reserve requirement y;

And where:
$R_{xy} \geq 0$ for all x and y
$SLACK_y \geq 0$ for all y

Then, every reserve constraint is modeled in the form:

$$\sum_x R_{xy} + SLACK_y \geq REQ_y$$

Even so called "hard constraints", i.e., reserve requirements that must be met at all cost, are converted into this form to ensure a feasible solution can be reached by the scheduling software.

The only difference between the representation of a "hard constraint" and a demand curve is the extent to which failing to meet the constraint, i.e., increasing the value of $SLACK_y$, affects the total cost of the schedules as represented by the objective function of the scheduling software. The objective function of the scheduling software includes a cost function, $C(SLACK_y)$, for each reserve constraint y, that represents the total cost of not meeting reserve requirement y by the quantity of MW defined as $SLACK_y$.

A "hard constraint" would have a very high cost associated with increasing the value of $SLACK_y$. Even increasing $SLACK_y$ from 0 MW to 1 MW might increase the objective function value by $65,000. A cost of this magnitude effectively ensures that if additional reserves are available that meet reserve requirement y, everything possible is done to secure and schedule those reserves.

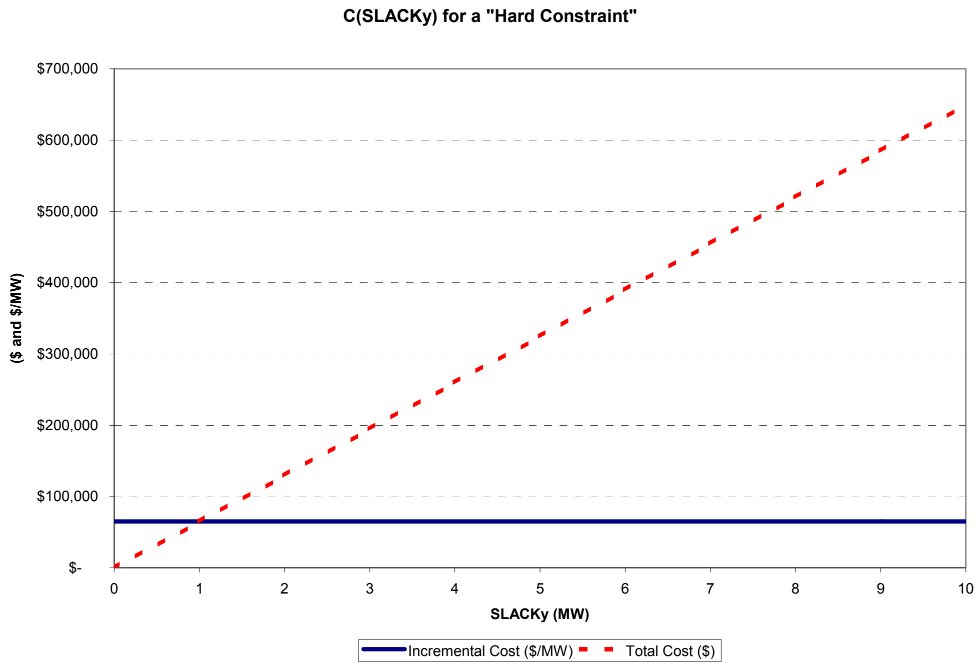

Figure 1

Even at very low values of SLACKy the objective function cost of failing to meet the reserve constraint gets very large.

A reserve demand curve just implies a different cost function C(SLACKy) in the objective function of the scheduling software that allows for a reserve requirement to not be met at costs much lower than $65,000.

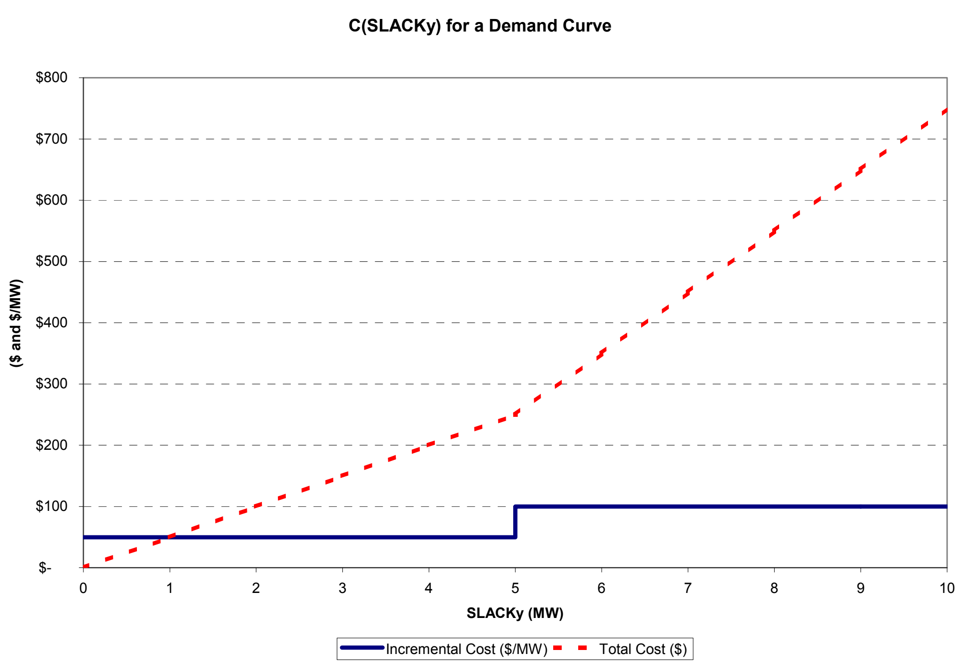

Figure 2

The C($SLACK_y$) cost function shown above is associated with a demand curve allows reserve requirement y to be violated if the cost of scheduling the last MW of reserves capable of meeting reserve requirement y exceeds $50. In this case the demand curve indicates that the perceived value of an incremental MW of reserves is $50. If it costs $65 to schedule the last MW of reserves it would be cheaper for the software to not schedule that last MW of reserves and instead incur the $50 cost associated with C($SLACK_y$).

If the reserve constraint is violated by more than 5 MW the C($SLACK_y$) cost shown above jumps to $100 and if the last MW of reserve scheduled still cost $65, it would be scheduled as the cost associated with increasing $SLACK_y$ exceeds the cost of scheduling the last MW of reserve scheduled.

Figure 3 represents the demand curve associated with Figure 2 if we assume that the reserve requirement is 50 MW and that the first 40 MW of the requirement are scheduled as long as the price does not exceed $1000.

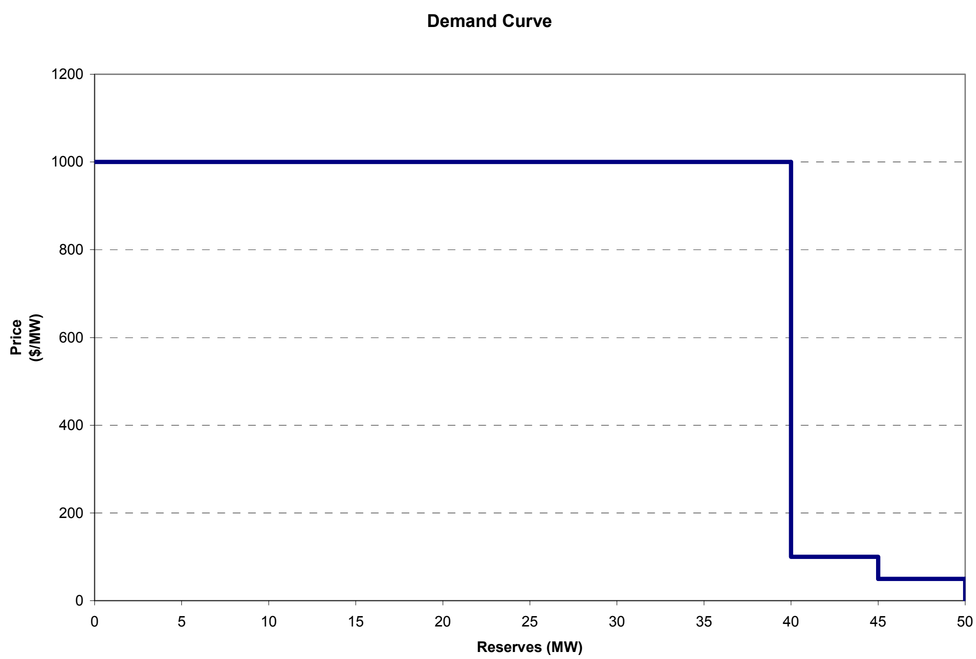

Figure 3

SCUC, RTC, RTD and RTD-CAM software will all support C(SLACKy) cost functions that are piecewise linear and of increasing slope. The derivatives of cost functions of this type, i.e., the incremental cost curves, are monotonically increasing block costs. All of the scheduling software packages are likely to represent the demand curves with the monotonically increasing block cost curves.

The scheduling software will support the use of different C(SLACKy) cost functions for commitment passes relative dispatch passes. It should be recognized however that any change to the cost function associated with the reserve constraints between the commitment and dispatch passes of any of the software systems implies an inconsistent valuation of that reserve.

The same construct will be applied to the regulation requirement in SCUC, RTC, RTD and RTD-CAM.

Implementation

The exact specification of how each reserve or regulation constraint will be modeled has not been finalized. Each demand curve or C(SLACK) cost function will be determined through the market committees with input from NYISO staff and market participants. These demand curves need to be derived keeping in mind that they should reflect the perceived value of scheduling each incremental MW of reserves.

Reserve demand curves or C(SLACK) cost functions need to be defined for each of the reserve and regulation constraints including:

- NYCA regulation
- NYCA 10-minute spinning reserve
- NYCA 10-minute total reserve
- NYCA 30-minute total reserve
- Eastern 10-minute spinning reserve
- Eastern 10-minute total reserve
- Eastern 30-minute total reserve
- LI 10-minute spinning reserve
- LI 10-minute total reserve
- LI 30-minute total reserve

If additional locational reserve or regulation requirements are added then demand curves or C(SLACK) cost functions will also be defined and added to all of the scheduling packages.

The definition of the demand curves or C(SLACK) cost functions needs to reflect the fact that the demand curves and cost functions cascade through reserve products and locations in much the same way as the reserve schedules and shadow prices do. [Explain more]

In Normal Operation

In normal operation of SCUC, RTC and RTD all reserve constraints will be active and modeled with demand curves or C(SLACK) cost functions. These cost functions will be applied consistently across all three models.

If the cost of scheduling additional reserves exceeds the perceived value of those reserves as defined by the demand curve or C(SLACK) cost functions then the reserves will not be scheduled and the reserve clearing price will be set consistent with the point on the demand curve or C(SLACK) cost function that was reached.

There are also some modes of RTD-CAM operation that will also run with the full set of reserve constraints modeled. The more typical mode of operation for RTD-CAM will be during reserve pickups or during reserve recovery periods.

During Reserve Pickups

When a reserve pickup is activated an RTD-CAM run is initiated.

The RTD-CAM run will include the NYCA, Eastern and LI 30-minute total reserve demand curves without modification.

Some of the reserve requirements may be removed in the RTD-CAM run. The 10-minute spinning reserve, 10-minute total reserve and regulation demand curves or C(SLACK) cost functions are all candidates for removal from the model.

Their removal is consistent with suspension of the regulation market and the period of time allowed for restoration of 10-minute spinning and 10-minute total reserves following a reserve pickup.

There is also a period of time allowed for the restoration of the 30-minute reserves, but it is important that not all reserve requirements are removed from scheduling and pricing. The removal of all reserve and regulation requirements might result in the reduction of energy prices at exactly the time when the system is in greatest need of additional resources. The removal of the 10-minute constraints will need to be carefully reviewed to ensure that price impacts of doing so are consistent with the desired price signals during reserve pickups.

During the Reserve Recovery Period

When the operator concludes the reserve pickup a period of reserve recovery commences.

During the reserve recovery period it is possible that any of RTD-CAM, RTD or RTC may be run encompassing a part or all of the reserve recovery period.

The reserve requirements that were removed during the RTD-CAM reserve pickup run are gradually restored over a period of time. Demand curves for the 10-minute spinning reserve and 10-minute total reserve constraints are introduced such that a gradually increasing quantity of the reserves is valued at high prices reflecting the desire to recover more and more reserves as the amount of time after the reserve pickup is terminated increases. The demand curve will recover more of the 10-minute spinning and total reserves if the cost of doing so is not more expensive than the rest of the defined demand curve.

For instance 10-minutes after the termination of the reserve pickup we may require that 200 MW of 10-minute spinning reserve and 400 MW of total 10-minute reserve be recovered. The spinning reserve demand curve will have $1000 for the first 200 MW and then have a significantly lower cost than that between 200 and 600 MW. The 10-minute total reserve demand curve will have 400 MW at $1000 and then significantly lower cost between 400 and 1000 MW.

As the time elapsed extends the quantity of $1000 valued reserves increases in the demand curves.

At the end of the recovery period the reserve demand curves or C(SLACK) cost functions return to their pre-reserve pickup levels.

What Might the Reserve Demand Curves Look Like?

I have made an attempt to illustrate what some potential demand curves might look like and provided some reasons behind their derivation. I have performed no quantitative or qualitative analysis to support these curve but provide these as a starting point for some discussion.

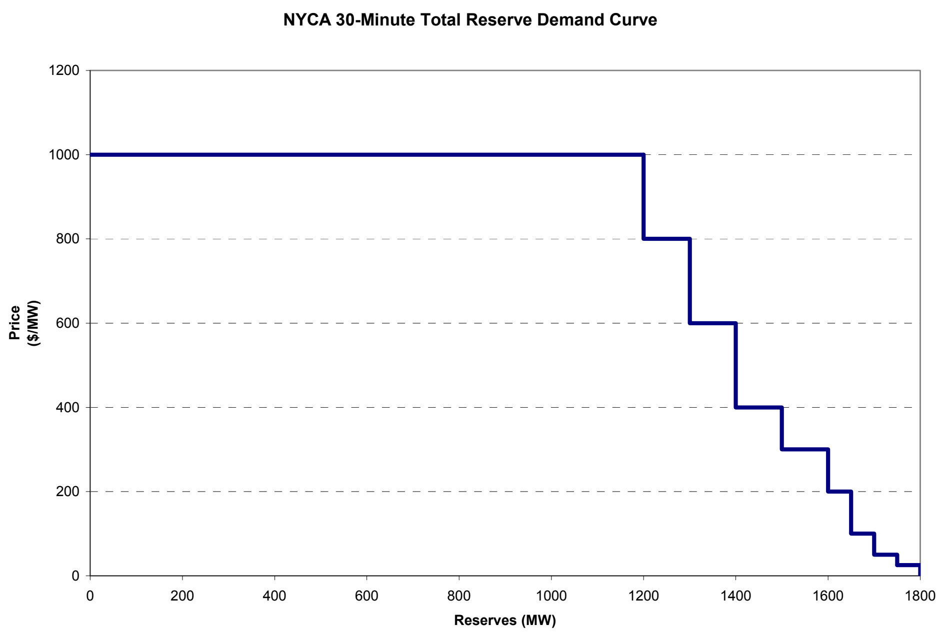

Figure 4

The NYCA 10-minute total reserve requirement is 1200 MW. This is considered to be a hard scheduling limit so it is likely that a high value, in this case $1000, be associated with that portion of the NYCA 30-minute total reserve demand curve shown in Figure 4.

The remainder of the demand curve reflects gradually decreasing value with the last 100 MW or so of 30-minute reserves valued at quite low prices indicating that the incremental value of the last reserve necessary to meet the requirement is not that high.

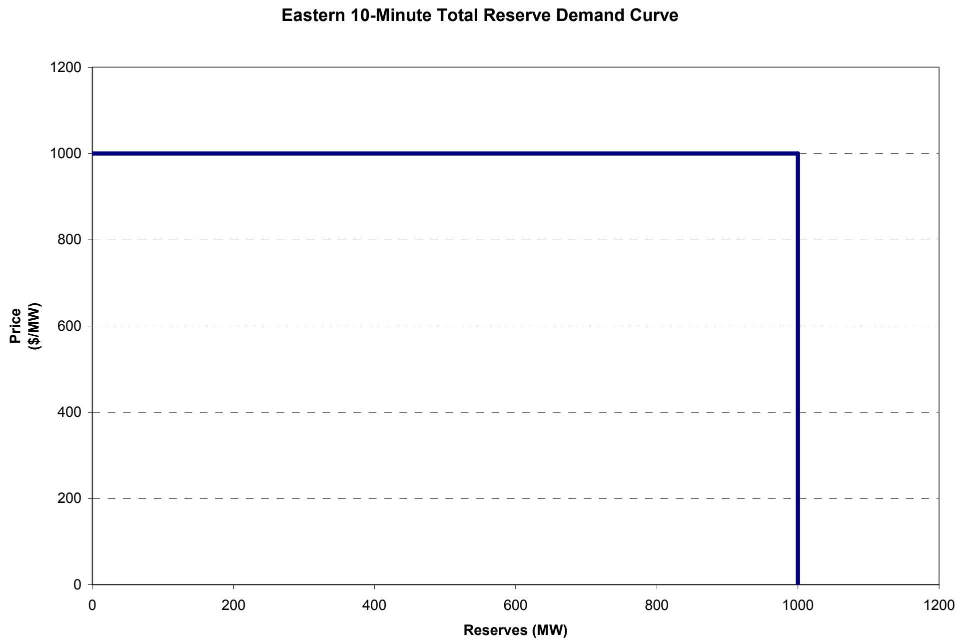

Figure 5

The Eastern 10 minute total reserve requirement is 1000 MW. This is considered to be a hard scheduling limit so it is likely that a high value is applied across the whole range of the reserve requirement as shown in Figure 5.

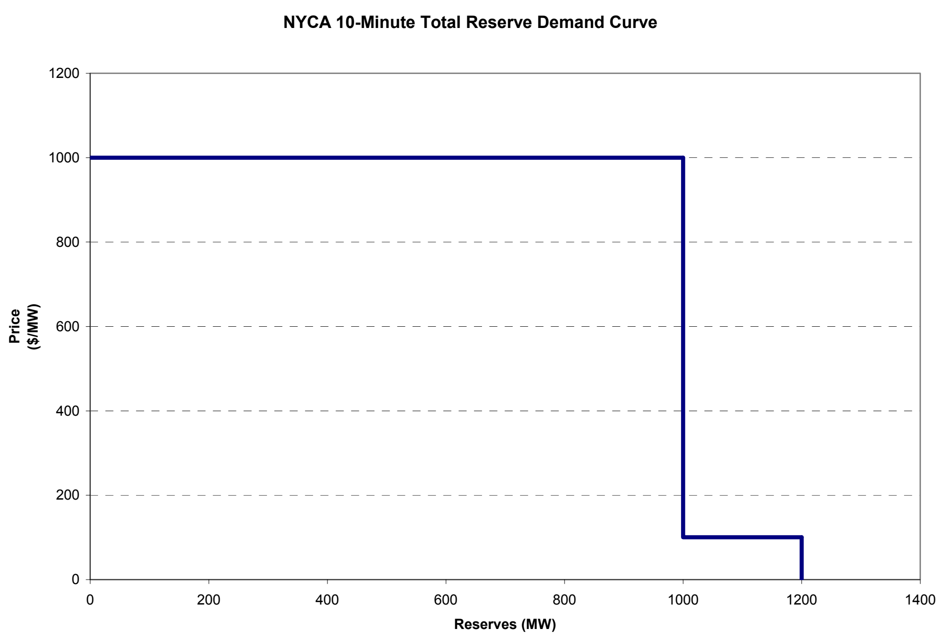

Figure 6

There may be some flexibility in the NYCA 10-minute total reserve requirement between the 1000 MW scheduled in the East (Figure 5) and the total 1200 MW requirement shown in Figure 6. In this case the additional 10-minute reserves are only purchased if the cost of doing so is less than $100.

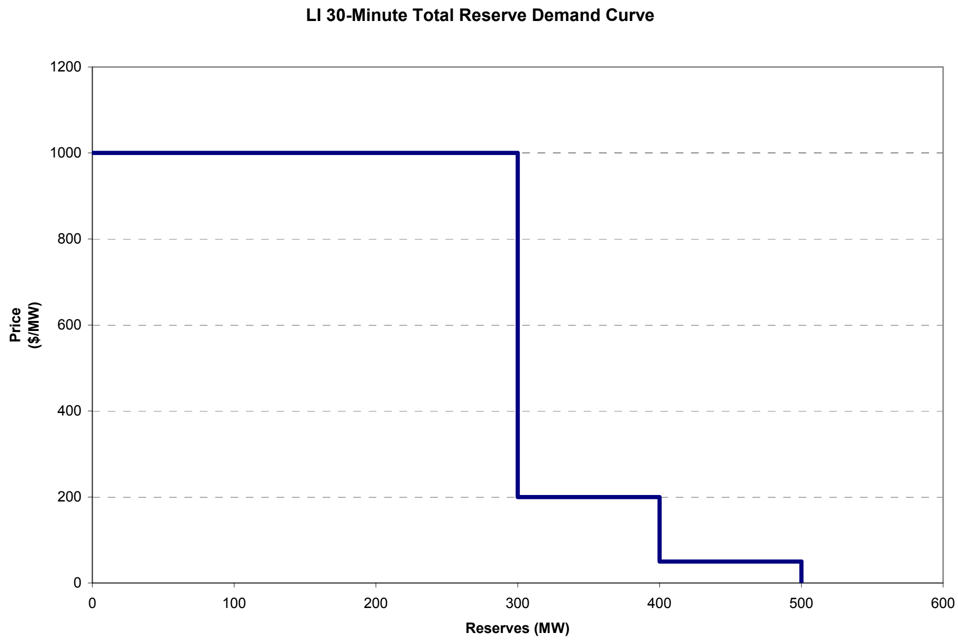

Figure 7

There may be some flexibility in the quantity of 30-minute total reserve scheduled in Long Island. In Figure 7, 300 MW must be scheduled at any cost. The remaining 200 MW is only scheduled if the costs of scheduling those reserves does not exceed the perceived value of carrying the reserves, $200 between 300 and 400 MW and $50 between 400 and 500 MW.