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IRM Anchoring Method

The Case for Establishing a Free-Flowing Equivalent IRM

For the New York Control Area

Prepared for the
Joint NYSRC-NYISO
Resource Adequacy Issues Task Force

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Note from the Authors

This information was originally distributed to the NYSRC Executive Committee (EC) and discussed during their July 14, 2006. This slightly modified version of our whitepaper therefore reflects the inclusion of certain clarifications, corrections and other input received from the EC participants.

Consistent with regulated wholesale electric markets in New York, utilities depend on developers to provide sufficient resources that will satisfy necessary capacity obligations and maintain system reliability. Moreover, investors base their decisions on risk and return on capital not on reliability studies. To ensure the continued reliability of the system, markets must provide appropriate incentives so resources get built when and where they are needed.

In light of the current market based paradigms, the authors firmly believe that it is critical to provide proper economic incentives in order to maintain resource adequacy requirements. However, the request of the New York State Reliability Council Executive Committee was to focus the discussion on reliability. Therefore, this paper will not address the need to integrate proper market designs with reliability needs or other market design considerations.

Introduction

In transmission-constrained systems, resource adequacy criteria are maintained through the combined use of Locational Capacity Requirements (LCRs) and system-wide Installed Reserve Margin (IRM) requirements. In New York's transmission constrained electric system, there are many combinations of IRMs and LCRs for New York City and Long Island that equally satisfy the resource adequacy criteria and deliver a Loss of Load Expectation (LOLE) of 0.1 day/year.

The selection of an IRM with corresponding LCRs from several IRM/LCR pairs is currently based on qualitative assessments and engineering judgment. The broad rationalization of why one combination of capacity requirements is superior to all others can only be upheld if it is consistent with the NYSRC's obligation to establish resource adequacy requirements after *considering system limitations*. Although transmission limits are appropriately modeled in determining all IRM-LCR pairs that satisfy the criteria, the basis for those limitations needs to be considered and their risk or challenges to system reliability should be assessed and mitigated.

The effect of LCRs upon the *deliverability of capacity* is not easily explained. The issue is made exceedingly more complicated when attempting to examine this relationship in terms of an IRM that includes both locational and capacity from outside the constrained zone. Specifically, assessing the reliability impacts that minimal LCRs impose on the bulk power system using IRM does not, as shall be discussed later, enhance our understanding of capacity assistance to the constrained zone or utilization of the transmission system into the constrained zone.

The Unified Method

Prior to determining which IRM and corresponding LCRs should be used as minimum requirements, it's important to understand the method used to achieve 0.1 LOLE for the New York Control Area (NYCA). Because the "as found" NYCA is less than 0.1 LOLE (more reliable), "excess" capacity needs to be removed from the NYCA. The process currently used to remove excess capacity from the NYCA and establish various IRM levels is called the "Unified Method".

Under the Unified Method, a specific amount of capacity is removed from "capacity rich" zones (currently Zones A, C, and D) in order to achieve a predetermined IRM level[1]. After this virtual removal of capacity, the NYCA may still be below 0.1 LOLE. In order to drive the NYCA to 0.1 LOLE, capacity is then "shifted" out of Zones' J and K and into Zones A, C, and D. Because capacity from Zones J and K isn't removed from the NYCA but merely shifted to other zones, the overall IRM level does not change.

The NYISO's Revised Locational Installed Capacity Requirements Study report for the 2006 - 2007 Capability Year provides the following data;

[1] For example, if the system has 22% installed capacity in excess of its peak load and a 19% IRM is desired then 3% of system wide capacity would be removed from Zones A, C and D only.

Zone	Capacity	Load
A	5,155	2,771
B	1,017	1,914
C	6,680	3,080
D	1,512	1,155
E	1,022	1,496
F	3,924	2,193
G	3,423	2,242
H	2,070	618
I	13	1,802
J	10,364	11,630
K	5,767	5,348
Totals	**40,947**	34,249
	Coincident Peak	**33,295**

NYCA Capacity Requirement	**18%**
NYCA Capacity Obligation	**39,288**
Total NYCA Actual Installed Capacity	**40,947**
Difference between NYCA Actual Capacity and Obligation	**1,659**
Zone J Locational Capacity Requirement	**80%**
Zone J Locational Capacity Obligation	**9,304**
Zone K Locational Capacity Requirement	**99%**
Zone K Locational Capacity Obligation	**5,295**
Total Locational Capacity Obligation	**14,599**
Total Actually Installed Capacity in Zone J and K	**16,131**
Difference between Zones J and K Actual Capacity and Obligation	**1,532**

One of the many IRM-LCR pairs that satisfy LOLE criteria under the Unified Method is an 18% IRM with 80% LCR for Zone J and 99% LCR for Zone K. Based on the above data, the NYCA peak load forecast is 33,295 MW and the NYCA capacity obligation at 18% is 39,288 MW[2]. The difference between actual NYCA installed capacity (40,947 MW) and the NYCA capacity obligation (39,288 MW) is 1,659 MW[3]. Thus, 1,659 MW is removed from Zones A, C and D in the initial step of the Unified Method.

Multiplying an 80% LCR for Zone J and 99% LCR for Zone K by their corresponding peak loads results in locational capacity obligations of 9,304 MW and 5,295 MW for

[2] NYCA obligation = (1+.18% IRM) x Statewide Peak Load

[3] 40,947 MWs – 39,288 MWs = 1,659 MWs

Zones J and K, respectively[4]. The difference between the combined *actual installed* capacity (steel in the ground) in Zones J and K (16,131 MW) and the combined locational capacity *obligation* of Zones J and K (14,599 MW) is 1,532 MW.

Shifting 1,532 MW of installed capacity out of Zones J and K and into Zones A, C and D will result in 0.1 LOLE for the NYCA — with no change in the initial IRM level. Therefore, at an 18% IRM and corresponding LCRs, NYCA LOLE is maintained essentially with all installed capacity in Zones A-I intact and 1,532 MW of capacity *removed* from Zones J and K.

Another important consideration of the Unified Method is that it is impossible, given the current method, to shift more installed capacity from Zones J and K than actually exists. Under the Unified Method, installed capacity is first removed out of Zones A, C and D. If the NYCA LOLE is below 0.1, installed capacity is then shifted out of Zones J and K until a 0.1 LOLE is achieved.

The Impact of Transmission Constraints

Prior to selecting an IRM from numerous IRM-LCR pairs that equally satisfy reliability criteria, it is necessary to understand how transmission limitations influence the LCR / IRM relationship. When transmission limits are dynamically modeled, and constraints become binding, the amount of upstream capacity needed to serve downstream load will vary. For example, if it is assumed the transmission system is

[4] locational obligation = LCR x Zonal Peak Load

free from transmission constraints, then1 MW of capacity located anywhere could reliably serve 1 MW of load anywhere on the system[5].

Essentially, the LOLE value of 1 MW of capacity for the theoretical Free Flowing system, and is the same everywhere (ignoring the impact of reserve sharing). However, as dynamic transmission limits vary due to the probabilistic nature of generation and transmission elements, the import capability into constrained areas will also vary. Therefore, all capacity may not be deliverable for all hours of the year – even though the overall system continues to meet regional resource adequacy criterion.

The amount of import capacity needed to serve constrained load is also influenced by locational capacity levels. As IRM levels increase, the corresponding LCRs are reduced and the constrained zones rely more on imports to serve their load. However, the tradeoff between IRM and LCR are not one-for-one or linear.

For example, Appendix A shows that 1 MW of capacity located in the combined Zones of J and K is equal, in terms of LOLE benefit, to approximately 1.3 MW of capacity located in Zones A-I[6]. At current IRM and LCR levels, approximately 30% more capacity from Zones A-I would therefore be required to reliably serve 1 MW of

[5] Ignoring transmission losses

[6] Based on an 18% IRM requirement for 2006 – 2007 Capability Year.

Load in Zones J and K. Said another way, it takes 130 MWs of Zones A-I installed capacity to replace 100 MWs of installed capacity located in Zone J and K. *Thus,*

whenever there is a need for capacity in Zones J and K, the capacity assistance required from Zones A–I may be disproportionately large.

If the NYCA system were completely free of transmission constraints, or *Free Flowing*, 1 MW of energy generated on the system could serve 1 MW of load anywhere else on the system. If the physical state of the system could be maintained free from transmission constraints, an increase in constrained load will only increase the capacity obligation (MW) and not the capacity requirements (%). This result was approximated[7] in the 2005-2006 study[8] with the use of locational capacity (i.e., a Free Flowing *Equivalent* IRM)[9].

At the Free Flowing Equivalent IRM, the mathematical meaning of an approximate one-for-one relationship between constrained load and external capacity assistance is consistent with a physical system where essentially all the effects of transmission constraints have been accounted for but essentially eliminated with downstream

[7] See Appendix B; At the Free Flowing Equivalent IRM (15.9%), 1 MW of “constrained” load could be served by 1.04 MW of capacity from Zones A – I, provided the corresponding LCRs for Zones J and K were increased to 88% and 104%.

[8] While the 2005 IRM contained database errors and fewer dynamic transmission limits, the focus here is to show the mathematical assessment of LCRs and capacity assistance.

[9] Page 8 of the NYISO’s Locational Installed Capacity Requirement Study For 2005-2006 Capability Year. “At the “free flow” or unconstrained statewide IRM of approximately 15.9% the Long Island zone calculated locational requirement was slightly over 104% while the New York City zone [] approached 88%. These results are defined as the free flowing or unconstrained locational capacity equivalent – i.e., the free flowing equivalent.”

capacity[10]*.* Indeed, the data in Appendix B shows that the slope of the line segment that corresponds to a 15.9% and 16% IRM as measured with Zones A-I capacity and Zones J and K capacity is approximately 45 degrees[11]. This mathematical definition is consistent and compatible with the physical state of a system that is fully deliverable. Therefore, TAN 45 and its associated benefits of providing a one-for-one relationship exist only at the Free Flowing Equivalent IRM

A potential criticism of the Free Flowing Equivalent IRM is that it may result in a resource adequacy requirement that cannot be satisfied with existing resources. However, under the current method, no point on the IRM-LCR curve is a result of adding more capacity to Zone J or adding more capacity to Zone K than is planned to exist. Therefore, this is not a valid concern for the IRM study year.

The general concern of demand outpacing supply and the volatility of capacity requirements is valid for years beyond the IRM study year, but this is not exclusive to the Free Flowing Equivalent IRM; this is also a valid concern with any other IRM anchoring method.

For example, the NYISO recently performed a study showing that if NYPA's Poletti unit (located in Zone J) were to retire, the installed capacity in Zone J would fall

[10] Note that the Free Flowing *Equivalent* IRM significantly differs from an actual Free Flowing system in that the former completely considers the impact of existing transmission constraints.

[11] Note that while the designation of the X and Y axis is in MWs' as opposed to percentage and the axes are in zonal capacity as opposed to IRM and specific locational requirements. All the values can easily be converted back in to a percentage IRM and LCR.

below 80%[12]. Hence, an IRM anchored by the TAN 45 IRM approach could also have resulted in an LCR for Zone J that exceeds the future supply actually available in Zone J. Furthermore, the NYSRC and NYISO should carefully examine the potential reliability issues associated with simply increasing the IRM to achieve a lower, but physically attainable, LCR in order to maintain LOLE criteria.

Unless the intent of New York's resource adequacy policy was to extract the overall reliability benefits from the 1,532 MW of "excess" locational installed capacity[13] (e.g. unaccounted capacity margin to LOLE criteria, minimize imports across constraints, etc.) but not consider all the locational capacity that exists in minimum locational installed capacity requirements (e.g. intentionally create latent installed reserves), it is ill-advised to ignore, as is currently the case, the reliability improvements that increased locational capacity requirements provide.

The "TAN 45 IRM" Anchoring Method

The current 18% IRM requirement[14] was determined as the point equal to the intersection between the IRM vs. LCR curve[15] and a tangent with an inclination of –

[12] See NYSRC Executive Committee meeting #85 minutes
http://www.nysrc.org/ecmeetingminutes.asp

[13] KeySpan, the largest generator in the city, has about 2,250 megawatts of capacity to sell, or 23 percent of the total. Astoria Generating has about 2,000 megawatts, or 20 percent. For NRG, the numbers are 1,356 megawatts and 14 percent. Together, they command about 54 percent of all capacity available in the city and the NYISO Tariff restricts the sale of this capacity to entities outside the New York City locality.

[14] An 18% IRM requirement is in fact the IRM of choice selected by the NYSRC. See EC Special Meeting # 2, 2006; http://www.nysrc.org/ecmeetingminutes.asp

[15] The curve used in the TAN 45 IRM approach was developed with the Unified Method and is defined by IRM on the X-axis and an LCR on the Y-axis.

45 degrees (the “TAN 45 IRM” approach). However, at this requirement there is a disproportionate amount of capacity assistance required from Zones A–I to serve the constrained load in Zones J and K. As Appendix A shows, the current requirements based on TAN 45 IRM approach actually requires 1.3 MW of import capacity to equal the LOLE value of 1.0 MW of locational capacity. Furthermore, there are several qualitative reliability concerns associated with this IRM requirement.

The first concern with a TAN 45 IRM approach is that it artificially increases both the IRM and LCR requirements for a number of changes that directly impacts the reliability needs of the constrained zones. For example, a slight reduction in transfer capability to a constrained zone would result in an increase in both IRM and LCR.

In this example the NYCA may satisfy resource adequacy criteria; however, (1) *it is incomprehensible to have a resource adequacy policy that raises capacity requirements upstream of and due to a degrading transmission interface, and (2) it is inconceivable how increasing imports across a degrading transmission interface is more reliable than relying on additional installed capacity interconnected downstream of the constraint.*

This ill-considered approach is counter-productive to effective resource adequacy design. Locking into a method for establishing an IRM that raises both IRM and LCR simultaneously undermines sound engineering judgment and may create unintended consequences.

TAN 45 IRM approach poses additional reliability challenges. Based on recent voltage studies performed, the NYISO concluded that voltage-based transfer limits primarily affecting the UPNY/SENY, UPNY/ConEd, Dunwoodie South and Y49/Y50 interfaces are degrading[16]. Given the uncertainty of these evolving voltage based transfer limit studies and the fact that other equally reliable IRM / LCRs exist, needlessly challenging the accuracy of those studies by needlessly increasing the reliance on imports is unwarranted. However, establishing a lower IRM, which maintains reliability and minimizes the likelihood of operating at the voltage based transfer limits in the Hudson Valley corridor, is of primary interest.

The one-for-one result at TAN 45 of a curve defined by IRM (%) on the X-axis and LCR (%) on the Y-axis does not address a reliability concern but rather, depicts economic tradeoffs. The mathematical meaning of TAN 45 as a single point on the IRM-LCR curve defines a relationship where a one-percent change in IRM equates to a one-percent change in LCR. This relationship ensures that changes in LSE *capacity obligations* are one-for-one — but not the capacity assistance needed to reliably serve constrained load. In fact, the capacity assistance needed to serve incremental increases in load within Zones J and K at the TAN 45 point is disproportionately large.

Therefore, IRM and LCR requirements established under TAN 45purposefully incorporates a sizeable economic impact and perpetuates a “reliability subsidy” as opposed to a construct designed to primarily address reliability concerns.

[16] Page 39 of NYSRC New York Control Area Installed Capacity Requirements for the Period May 2006 through April 2007

TAN 45 IRM Does Not Adhere to Policy 5

The authors recognize that the NYSRC's Policy 5 ("Procedure for Establishing NYCA Installed Capacity Requirements") needs revisions to better reflect the Unified Method. However, a long standing fundamental underpinning of Policy 5 and recurring statement in past NYSRC IRM study reports is where locational capacity requirements (LCRs) are to be set appropriately so as to ensure that transmission constraints, both into a zone and internally within a zone, are considered and do not impact NYCA capacity requirements"[17]. The context for this policy can be seen in the following Policy 5 excerpt:

> ***3.5.5 Locational Capacity Requirements***
>
> *"[…] Intra-zonal transmission constraints are addressed in the annual NYISO Locational Installed Capacity study for determining LSE ICAP requirements. The statewide ICR study considers intra- zonal transmission constraints through the modeling of locational capacity requirements of constrained zones. This ensures that transmission constraints, both into a zone and internally within a zone, are considered and do not impact NYCA capacity requirements".*

The last phrase, *"… and do not impact NYCA capacity requirements."* is of importance here. Based on prior analysis and the well-accepted fact that a lower IRM can be achieved if LCRs properly take account of intra-zonal transmission constraints, the TAN 45 IRM anchor clearly does not adhere to this policy

[17] http://www.nysrc.org/pdf/Policies/Policy5-0Final.pdf

prescription. Even if the application of this policy statement is open to broad interpretation, it's hard to imagine a policy reading that concludes that TAN 45 IRM results are more acceptable and superior to the Free Flowing Equivalent IRM. Such a conclusion would be misleading from both a policy and technical standpoint.

Conclusion

The selection of an IRM with corresponding LCRs from several IRM-LCR pairs that satisfy applicable reliability rules is based on qualitative assessments and engineering judgment. Locking into a method, such as the TAN 45 IRM approach, undermines sound engineering judgment and may create unintended reliability consequences. In order to properly address reliability issues of the physical system, and avoid the ill-considered consequences of needlessly increasing capacity assistance in unconstrained zones, **a Free Flowing Equivalent IRM should be adopted** and the utilization of needed capacity in constrained zone(s) should be accounted for.

Combining the Unified Method with TAN 45 IRM, NYCA resource adequacy criteria is maintained by relying essentially on all installed capacity resources in Zones A-I and ignoring 1,532 MW of capacity in Zones J and K. However, it is ill-advised to over rely on imports through the Lower Hudson Valley transmission corridor and ignore the superior reliability benefits provided by the 1,532 MW of capacity interconnected downstream of this transmission constrained area. This rationale is a fundamental underpinning to the guiding principles established in NYSRC's Policy 5 discussion of Locational Capacity Requirements.

Importantly, the capacity assistance required from Zones A–I can be disproportionately larger than a specified amount of capacity need in Zones J and K. It has been shown that at the current 18% IRM, not all capacity in Zones A-I is deliverable to constrained zones for all hours. At an 18% IRM it takes approximately 1.3 MW of capacity from Zones A-I to replace 1 MW of capacity located in Zones J and K. However, at the Free Flowing Equivalent IRM, 1 MW of "constrained" load can be served by 1 MW of capacity from Zones A–I.

Conversely, the mathematical meaning of TAN 45 as a single point on the IRM-LCR curve defines a relationship where a one-percent change in IRM equates to a one-percent change in LCR. This relationship ensures that changes in LSE *capacity obligations* are one-for-one, but not the capacity assistance needed to reliably serve constrained load. Therefore, the one-for-one result at TAN 45 of a curve defined by IRM (%) on the x-axis and LCR (%) on the y-axis does not actually address a reliability concern but rather, depicts an economic tradeoff.

Because TAN 45 raises both IRM and LCR simultaneously — and the Unified method ignores the superior reliability benefits of 1,532 MW of existing capacity in the constrained zones (at the TAN 45 point), it is counterproductive to have a resource adequacy policy that: 1) raises capacity requirements upstream of a constraint due to load growth within the constrained area or due to other factors that affect a constrained zone reliability needs, and 2) satisfies reliability criteria by increasing the need for imports across a constrained interface rather than increasing the locational capacity requirements.

Therefore, the purely administrative TAN 45 IRM approach cannot be justified on its technical nor economic merits and should be abandoned in favor of the Free Flowing Equivalent IRM.

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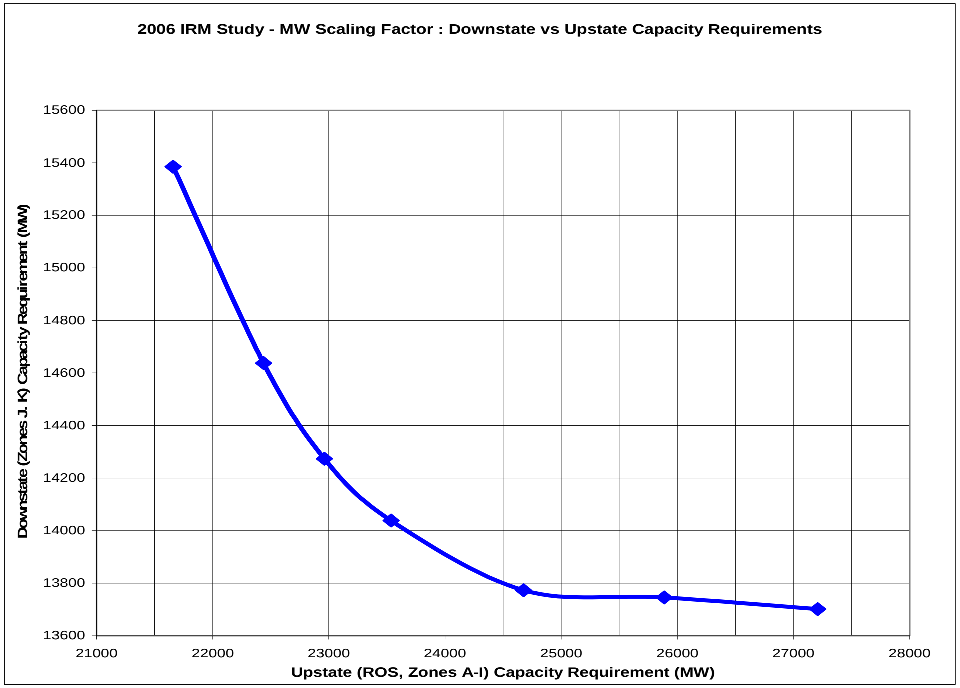
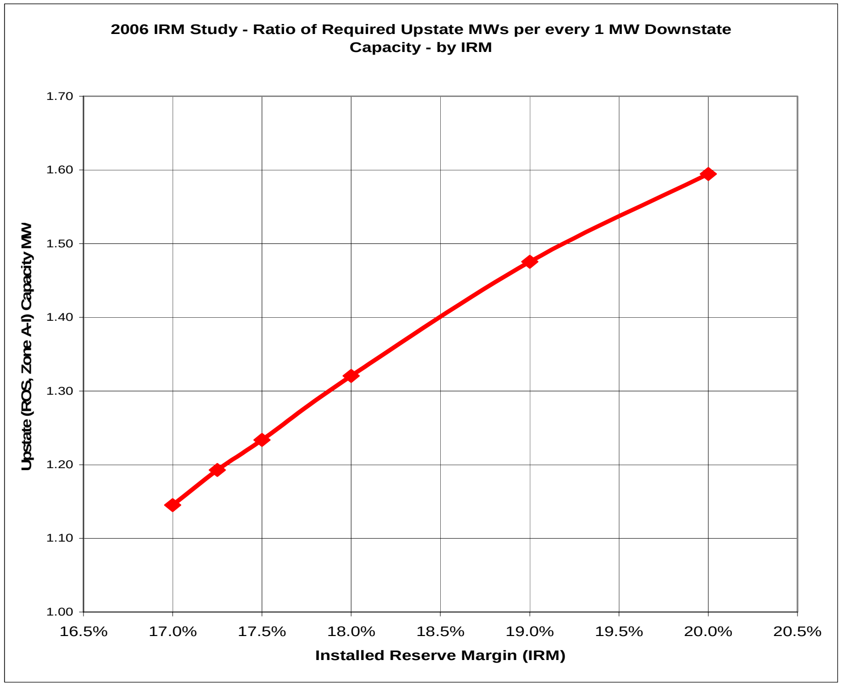
Appendix A

Appendix A 2006 IRM and LCR Study

LI Peak	5,348
NYC Peak	11,630
NYCA Peak	33,295

A	B	C	D	E	F	G	H	I	J	K	L	M
		B*LI Peak		B*NYC Peak	C+E	(1+A*NYCA Peak) - F	Increase in Col G	Increase in Col F	Col H / Col I			Set Y (Col J) = 1 and solve for X
IRM	Zone K LCR	LCR K (MW)	Zone J LCR	LCR J (MW)	Constrained Capacity	Zone A- I Capacity (MW)	Increase in Zone A- I Capacity (MW)	Zone J & K Capacity Reduction	Y/X	Change in Y / Change in X	Arc Tan (K) Degree	1 MW of LCR is equivalent to ??? MW of ROS
16.50%	107.8%	5765	89.1%	10362	16127	22661	0	0				
17.00%	102.0%	5455	81.9%	9525	14980	23975	1314	1148	0.87	-0.87	**-41.13**	**1.15**
17.25%	101.2%	5412	81.0%	9420	14832	24206	1545	1295	0.84	-0.64	**-32.59**	**1.19**
17.50%	100.3%	5364	80.3%	9339	14703	24419	1757	1425	0.81	-0.61	**-31.33**	**1.23**
18.00%	99.1%	5300	79.7%	9269	14569	24719	2058	1558	0.76	-0.45	**-24.03**	**1.32**
19.00%	97.9%	5236	78.6%	9141	14377	25244	2583	1751	0.68	-0.37	**-20.10**	**1.48**
20.00%	96.6%	5166	77.4%	9002	14168	25786	3125	1960	0.63	-0.39	**-21.09**	**1.59**





Appendix B

Appendix B 2005 IRM and LCR Study

LI Peak	5,231
NYC Peak	11,315
NYCA Peak	31,962

A	B	C	D	E	F	G	H	I	J	K	L	M
		B*LI Peak		B*NYC Peak	C+E	(1+A*NYCA Peak) - F	Increase in Col G	Increase in Col F	Col H / Col I			Set Y (Col J) = 1 and solve for X
IRM	Zone K LCR	LCR K (MW)	Zone J LCR	LCR J (MW)	Constrained Capacity	Zone A- I Capacity (MW)	Increase in Zone A- I Capacity (MW)	Zone J & K Capacity Reduction	Y/X	Change in Y / Change in X	Arc Tan (K) Degree	1 MW of LCR is equivalent to ??? MW of ROS
15.90%	104.20%	5451	87.80%	9935	15385	21659	0	0				
16.00%	103.10%	5393	81.70%	9244	14638	22438	780	748	0.96	-0.96	**-43.80**	**1.04**
16.50%	100.90%	5278	79.50%	8995	14274	22962	1304	1112	0.85	-0.69	**-34.80**	**1.17**
17.56%	99.00%	5179	78.30%	8860	14038	23536	1878	1347	0.72	-0.41	**-22.28**	**1.39**
20.30%	97.60%	5105	76.60%	8667	13773	24678	3019	1613	0.53	-0.23	**-13.10**	**1.87**
24.00%	97.30%	5090	76.50%	8656	13746	25887	4228	1640	0.39	-0.02	**-1.28**	**2.58**
28.00%	97.10%	5079	76.20%	8622	13701	27210	5551	1684	0.30	-0.03	**-1.92**	**3.30**