# Probabilistic Locality Exchange Factor Analysis

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**DRAFT – Do Not Distribute**

# Overview

Objective
Methodology
Initial Results Review
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# Objective

Develop an approach to determining a Probabilistic Locality Exchange Factor that:

- Gives stable and predictable results
- Can be repeated for any capacity sale from any Locality

# Probabilistic LEF Methodology

1) Update System Topology and Set System at IRM / all LCRs
2) Model the Capacity Sale, including an offsetting reduction of capacity in the neighboring region making the purchase. The offsetting reduction in capacity will ensure that the total system capacity does not increase as a result of the sale.
3) Add to zones of excess west of Total East (A, C, D) until the IRM is satisfied
4) Iteratively shift from zones of excess west of Total East to GHI until the LOLE from Step 1 is met
5) Calculate a Probabilistic Locality Exchange Factor:

$$Probablistic\ LE\ Factor = 1 - \frac{GHIJ\ Replacement\ Capacity}{Total\ Contract\ Size}$$

# Initial Sensitivities

Two topologies were proposed (details of each can be found in the appendix)

- Contract Topology
- Reserve Sharing Topology

The following sensitivities were initially considered off of each topology in order to help evaluate the stability and robustness of the model:

- Baseline Sale Case – 47.8% UPNY-SENY Backflow
- 0% UPNY-SENY Backflow (100% flow from G to CT)
  - *Intuitively this case should result in 0% fungibility in ROS*
- 100% UPNY-SENY Backflow (100% flow from G to F to WMA)
  - *Intuitively this case should result in 100% fungibility in ROS*

# Initial Sensitivity Results

## Fungibility Results

| Case | Fungibility |
|---|---|
| **Contract Topology** | |
| Baseline Sale Case | 52.6% |
| 0% UPNY-SENY Backflow | 39.3% |
| 100% UPNY-SENY Backflow | 63.6% |
| **Reserve Sharing Topology** | |
| Baseline Sale Case | 47.2% |
| 0% UPNY-SENY Backflow | 38.1% |
| 100% UPNY-SENY Backflow | 51.8% |

## Discussion

- Using both topologies the fungibility in Rest of State is approximately 50%
- The extreme edge case sensitivities both result in Locality Exchange Factors other than the intuitive result
- These edge cases will be investigated using the Reserve Sharing Topology.
  - This topology better reflects the operation of capacity sale by allowing the exporting generator to provide capacity as a first priority to the neighboring region and when not needed, be available to serve NY.

# Initial Results - **100% UPNY-SENY Backflow**

## Reserve Sharing Topology

**Intuitive Result:** 100% Fungibility in Rest of State

**Actual Result:** 51.8% Fungibility in Rest of State

**Possible Causes:**

1) Maintaining an IRM in ICAP terms results in a net loss of UCAP
2) Shifting into A,C,D causes some capacity to be bottled by constraints which do not receive any backflow benefits from the sale, diminishing its value
3) ISONE capacity reduction

# Determination of the causes for counter-intuitive results

## *100% UPNY-SENY Backflow Case*

1) Base Case
2) Allow the export unit to serve only ISONE
3) Reduce ISONE Capacity to offset the purchase from NY
4) Account for backflow on UPNY-SENY when the export unit is serving ISONE
5) Allow the export unit to serve both ISONE and NYISO
6) **Add replacement capacity to A, C, D**

    ***The LOLE in this case is expected to be at or near Base Case Levels***

7) **Add replacement capacity to A, C, D in UCAP**

    ***This will test the impact of maintaining the IRM in ICAP terms***

8) **Add replacement capacity to Zone F in UCAP**

    ***This will test the impact of congestion within Rest of State***

**Cases 4-8 were run w/ and w/o ISONE capacity reduction**

# Initial Results - **0% UPNY-SENY Backflow**

## Reserve Sharing Topology

**Intuitive Result:** 0% Fungibility in Rest of State

**Actual Result:** 38.1% Fungibility in Rest of State

**Possible Causes:**

A net increase in capacity available to serve NY during some Loss of Load Events because:

1) The export unit was unavailable to NY in the Base Case - the perfect replacement capacity is always available
2) The export unit is available to serve NY in the Sale Case in addition to the replacement capacity

# Determination of the causes for counter-intuitive results

## *0% UPNY SENY Backflow Case*

1) Base Case
2) Allow the export unit to serve only ISONE
3) Reduce ISONE Capacity to offset the purchase from NY
4) Account for backflow on UPNY-SENY when the export unit is serving ISONE
5) Allow the export unit to serve both ISONE and NYISO
6) **Add replacement capacity to G**

   ***The LOLE in this case is expected to be at or near Base Case Levels***

7) **Disallow flow from the export unit to NYISO**

   ***This will identify how often the export unit can be used in addition to the capacity replacement to improve reliability beyond base case levels***

**Cases 6&7 were run with perfect capacity replacement, as well as in-kind replacement (imperfect capacity with the EFORd of the export unit)**

# Conclusions

# A reduction of capacity in the region receiving the sale is necessary

*Without a reduction of capacity in the receiving region there is a net increase in system capacity resulting in greater than 100% fungibility in ROS.*

In order to give predictable results the amount of capacity removed must be stable

- Removing capacity only when the receiving region's LOLE is less than criteria makes fungibility a function of that region's starting point
- Removing capacity only until the external area's LOLE returns to base case levels would make fungibility a function of
  1) The external region's LOLE – See capacity value appendix
  2) The size of the external region – See capacity value appendix
  3) The location of replacement capacity in NY

***It is recommended that capacity be removed equal to the size of the sale in UCAP***

# The assumption of perfect capacity replacement results in higher than expected fungibility

- Perfect capacity replacement is always available, therefore total system capacity is increased during loss of load events where the export unit was unavailable in the base case.
- In the IRM / LCR process, the assumption of perfect capacity shifting does not have as significant an impact because the perfect capacity is used as a proxy for all generators in the zone, not any single generator.

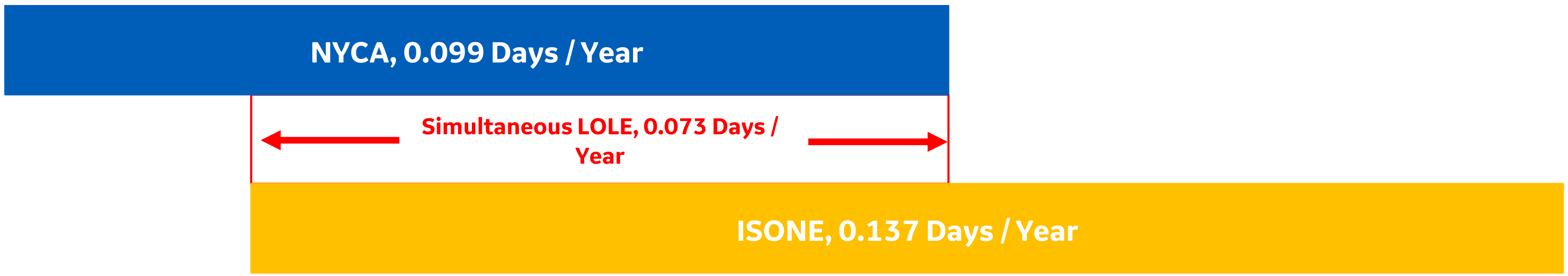
Because modeling replacement capacity divided across multiple zones with a consistent forced outage rate is not easily done in MARS, ***the perfect capacity assumption will be maintained for this analysis, however, resolving this issue would put downward pressure on fungibility***.

# NYCA and ISONE LOLE are highly correlated

## 74% of NYCA loss of load events occur simultaneously to ISONE loss of load events

Some fungibility should be expected in the 0% Backflow Case because for those hours where the export unit is available to NY, the replacement capacity can be put in Rest of State.

**NYCA and ISONE Simultaneous Loss of Load**



# Other Conclusions

- Maintaining the IRM in ICAP terms results in net loss of UCAP, however this has a minimal impact on fungibility
- Shifting into A,C,D causes some capacity to be bottled by constraints which do not receive any backflow benefits from the sale, this effect is insignificant
- There is a small subset of loss of load events (<3% of events) where the export unit can be used to improve reliability without any capacity replacement

***No action is recommended to address any of these minor impacts***

# Final Fungibility Results

| Case | 0% UPNY-SENY Backflow | Baseline Sale Case | 100% UPNY-SENY Backflow |
|---|---|---|---|
| Contract Topology, "Switchable" ISONE Load | 39.3% | 52.6% | 63.6% |
| Reserve Sharing Topology, ICAP Load | 38.1% | 47.2% | 51.8% |
| Reserve Sharing Topology, UCAP Load | 52.3% | 59.0% | 63.9% |
| Reserve Sharing Topology, No Load | >100% | >100% | >100% |

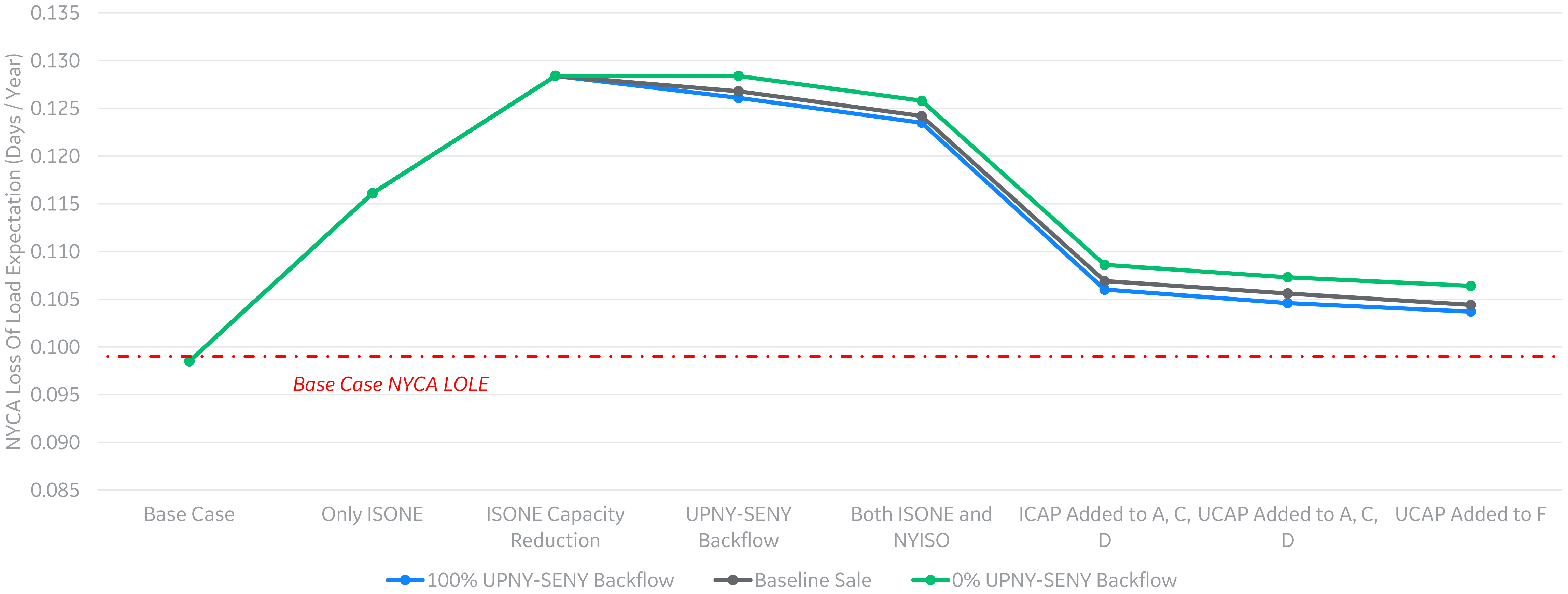
- Calculating a Probabilistic Locality Exchange Factor adds complexity and unpredictability
- The error introduced by the perfect capacity assumption cannot be easily addressed and biases these results upwards – addressing this issue would decrease fungibility
- Additional research would be necessary to address the varied issues identified with this approach

*The probabilistic method introduces uncertainty and does not give results which differ significantly from the 47.8% found using the current deterministic method.*

# Analysis

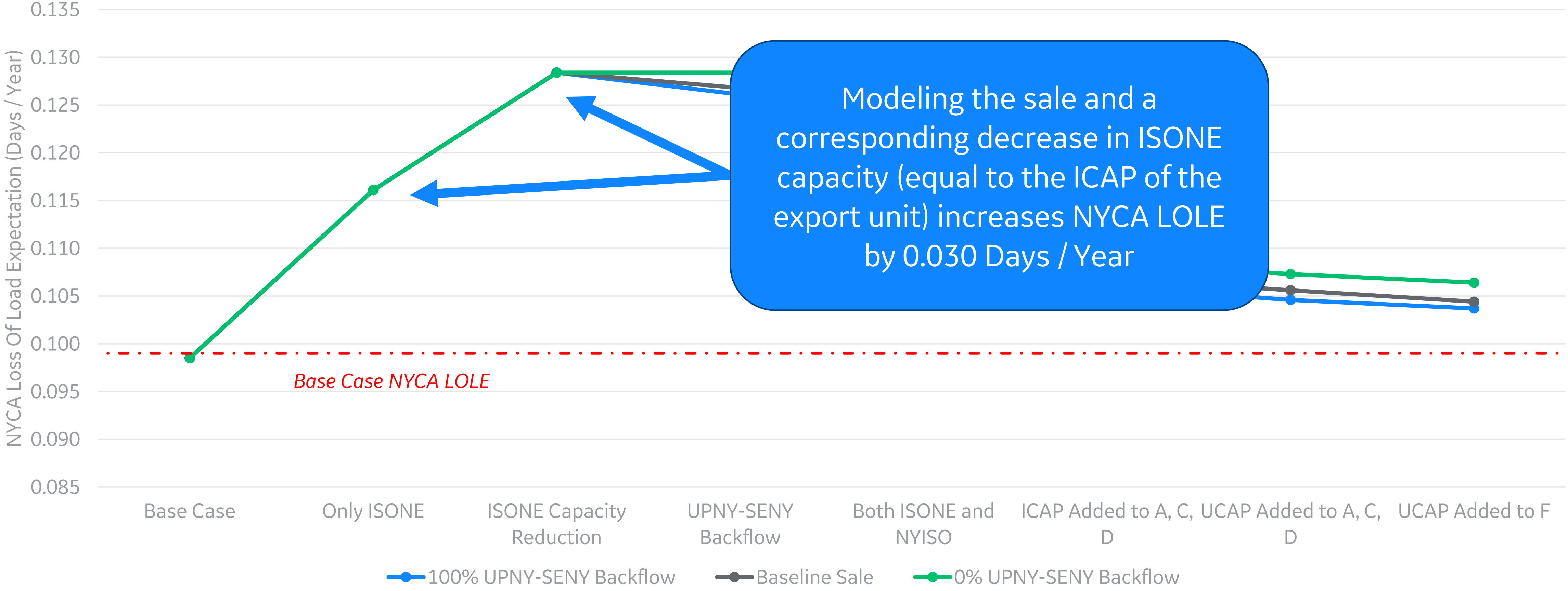
# 100% UPNY-SENY Backflow

## Reserve Sharing Topology



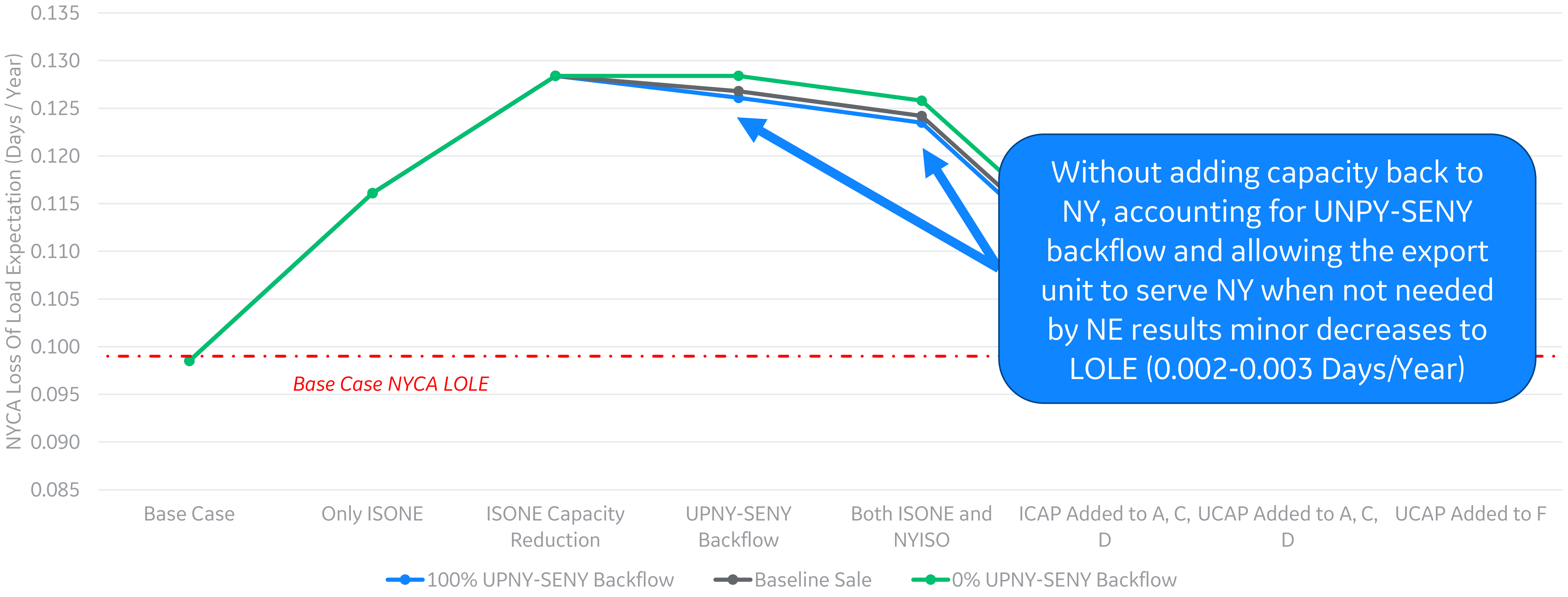
# 100% UPNY-SENY Backflow

## Reserve Sharing Topology



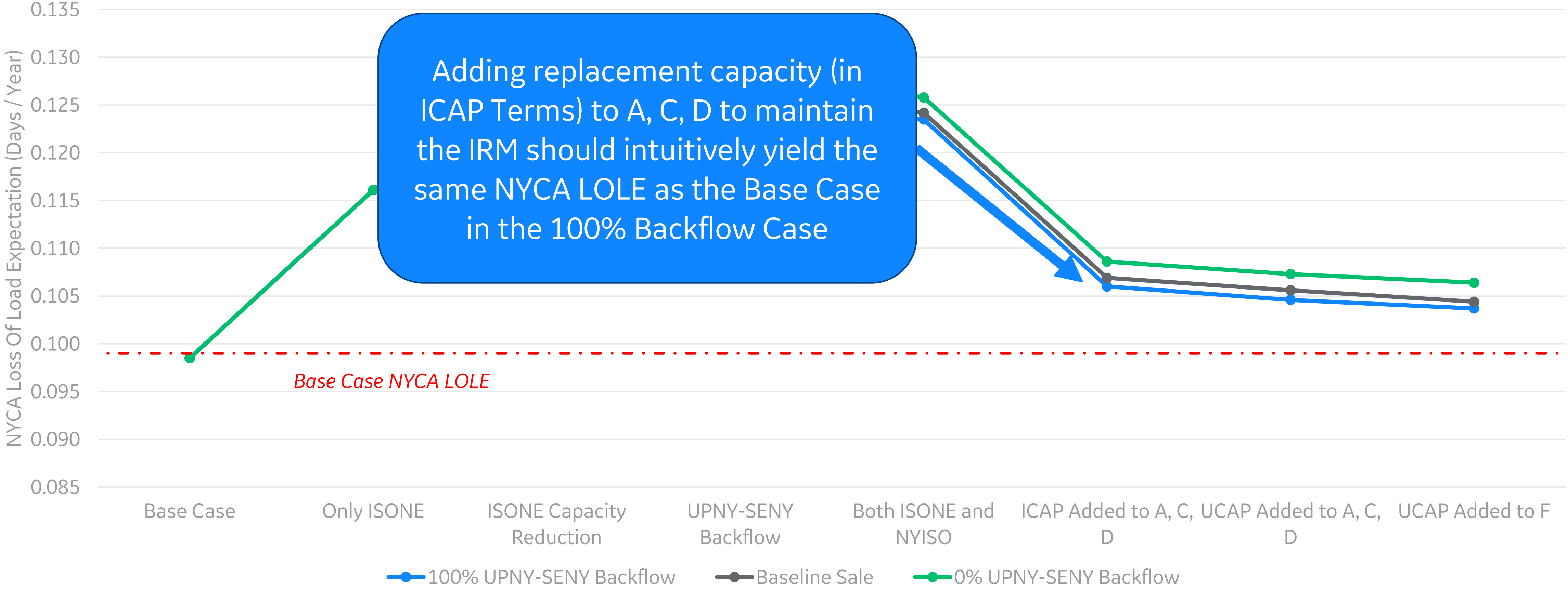
# 100% UPNY-SENY Backflow

## Reserve Sharing Topology



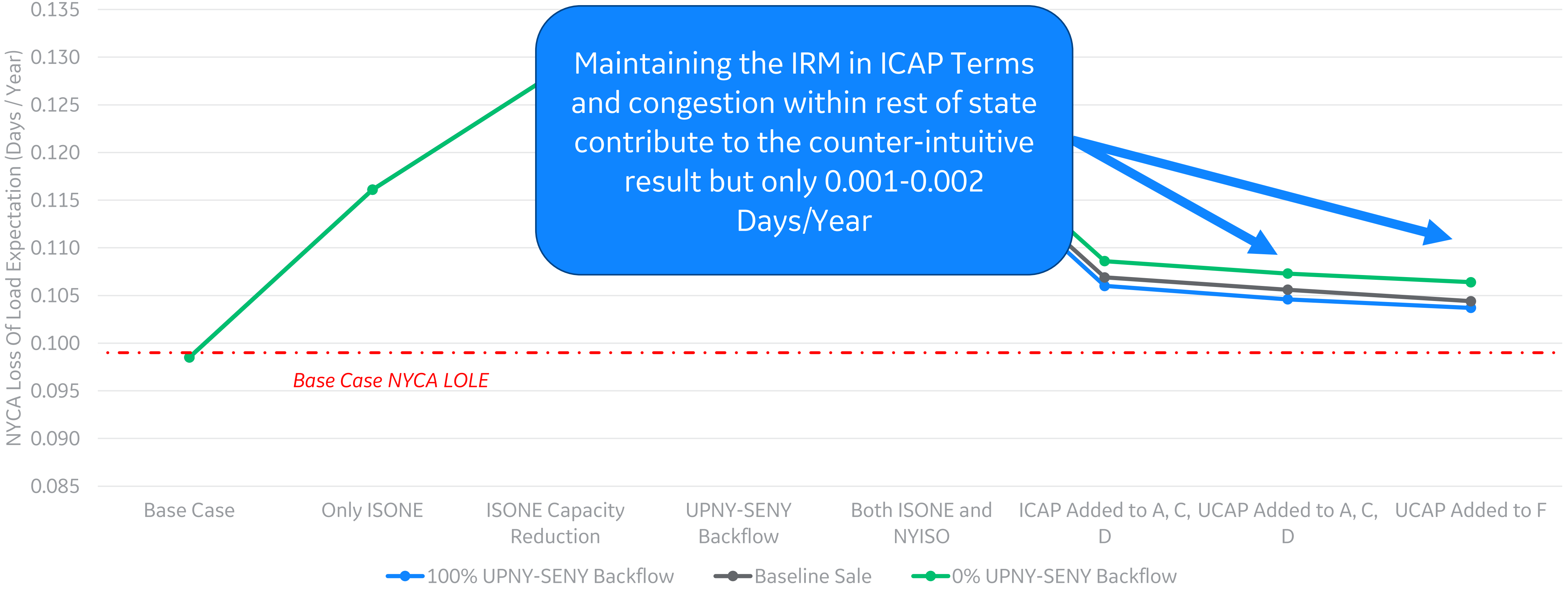
# 100% UPNY-SENY Backflow

## Reserve Sharing Topology



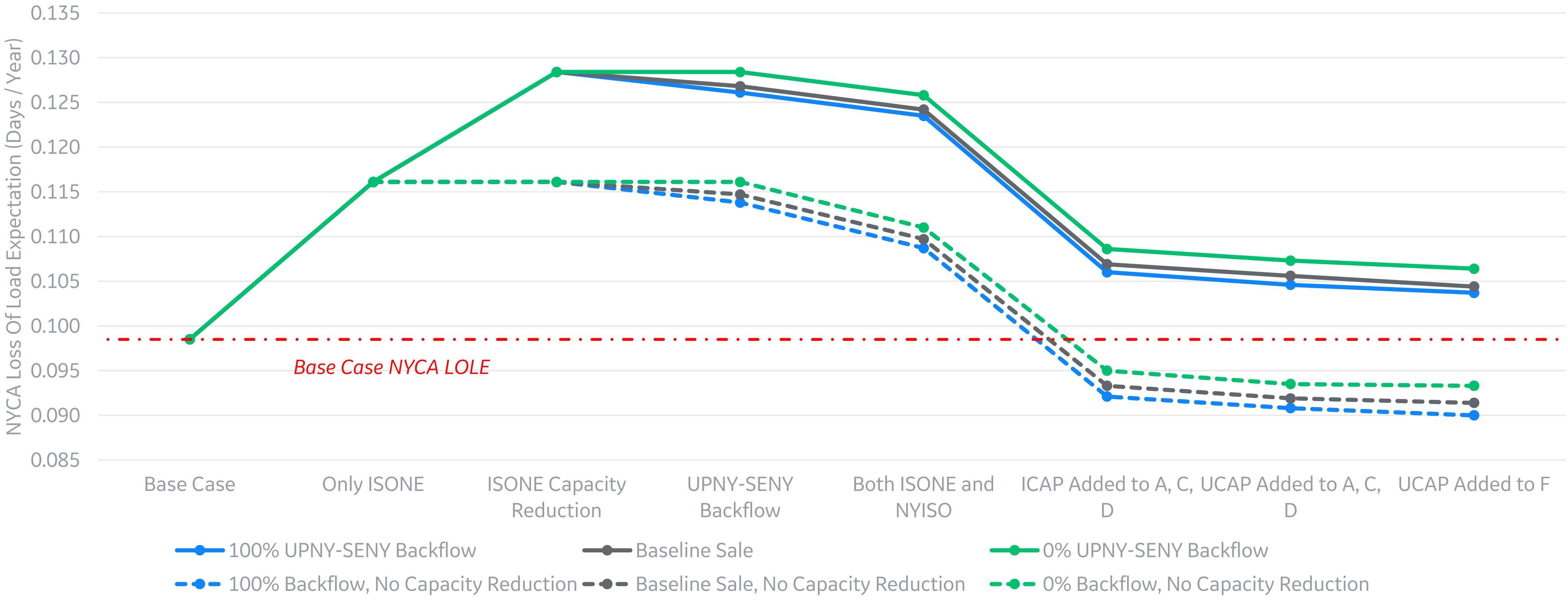
# 100% UPNY-SENY Backflow

## Reserve Sharing Topology



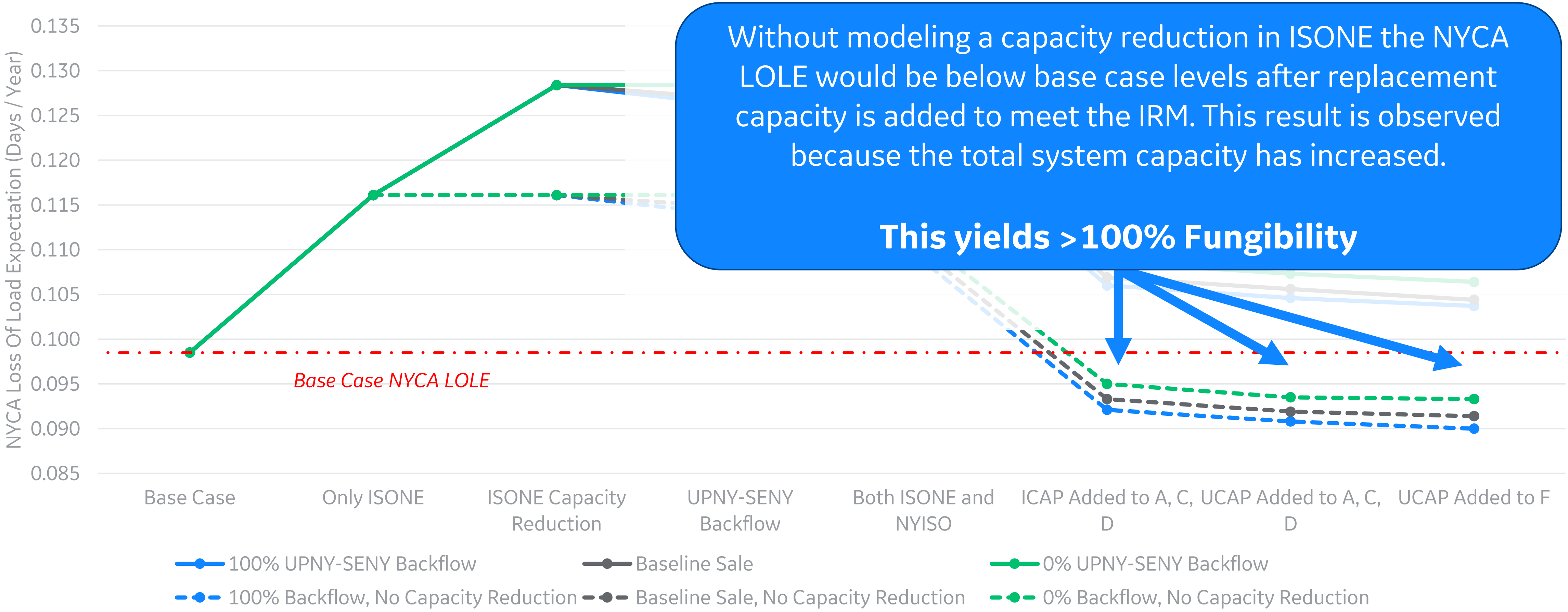
# 100% UPNY-SENY Backflow

## Reserve Sharing Topology



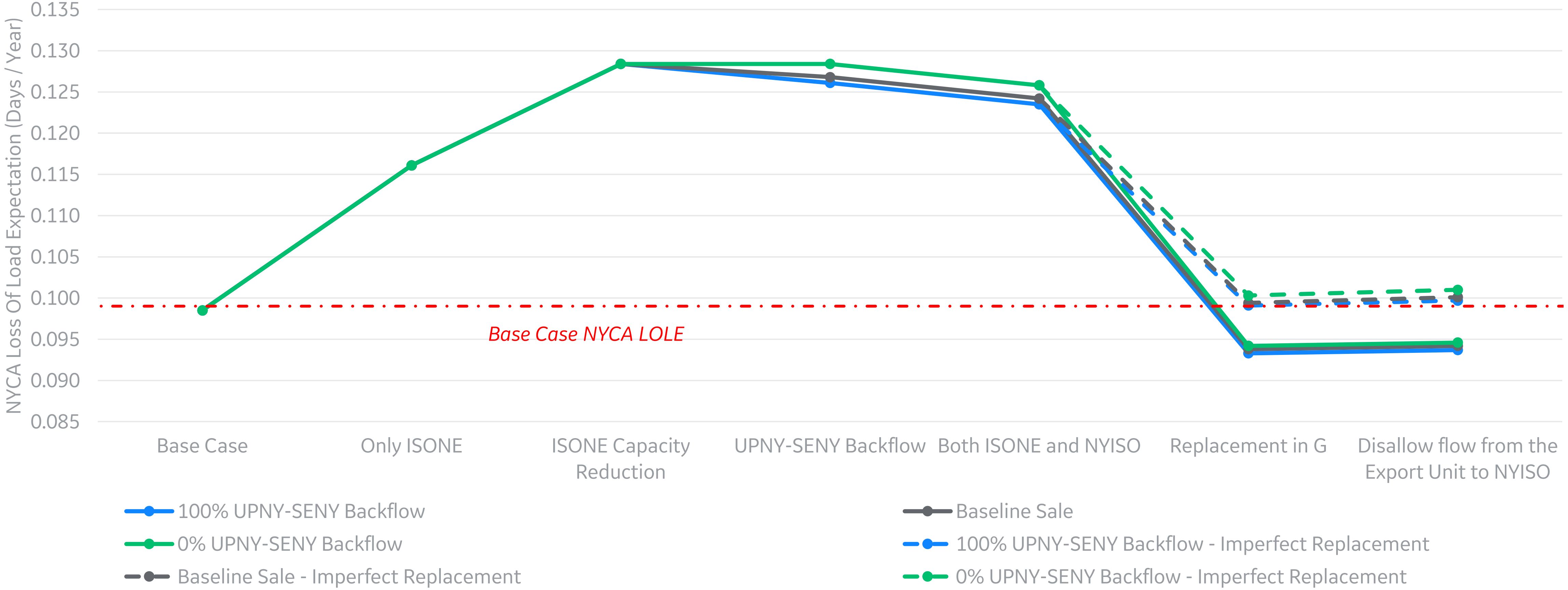
# 100% UPNY-SENY Backflow

## Reserve Sharing Topology



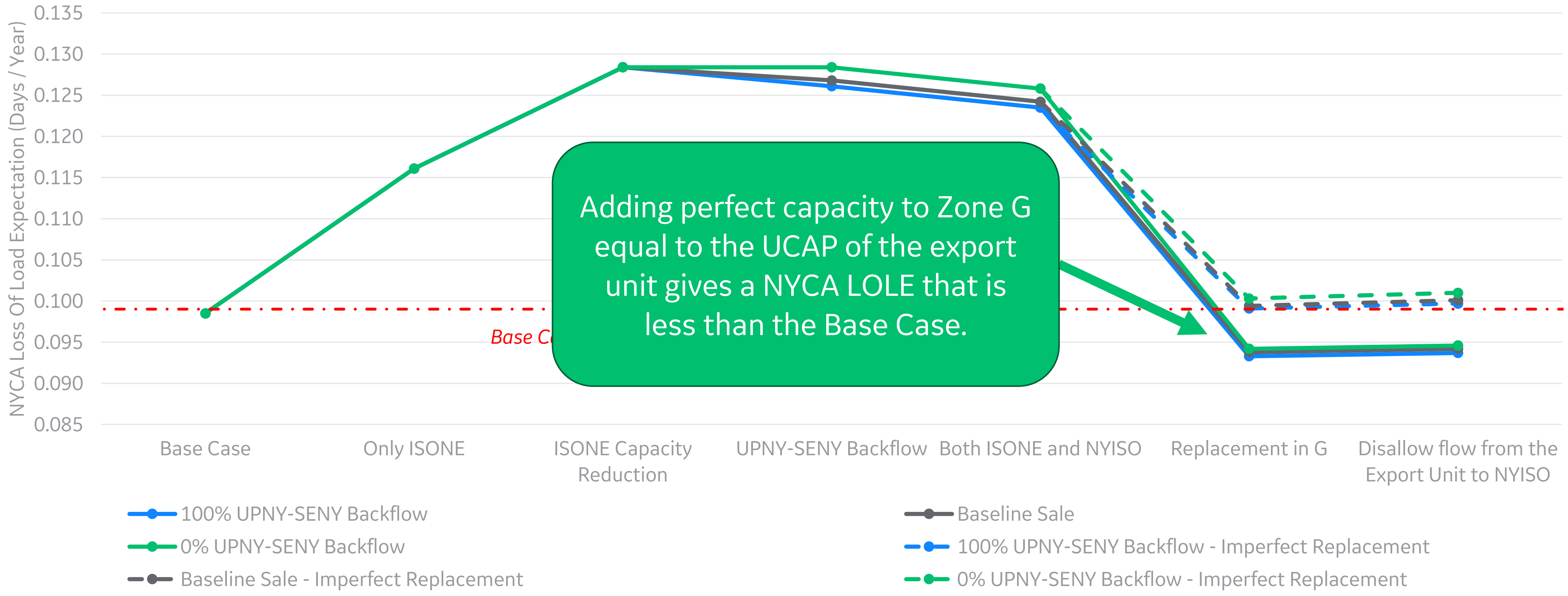
# 0% UPNY-SENY Backflow

## Reserve Sharing Topology



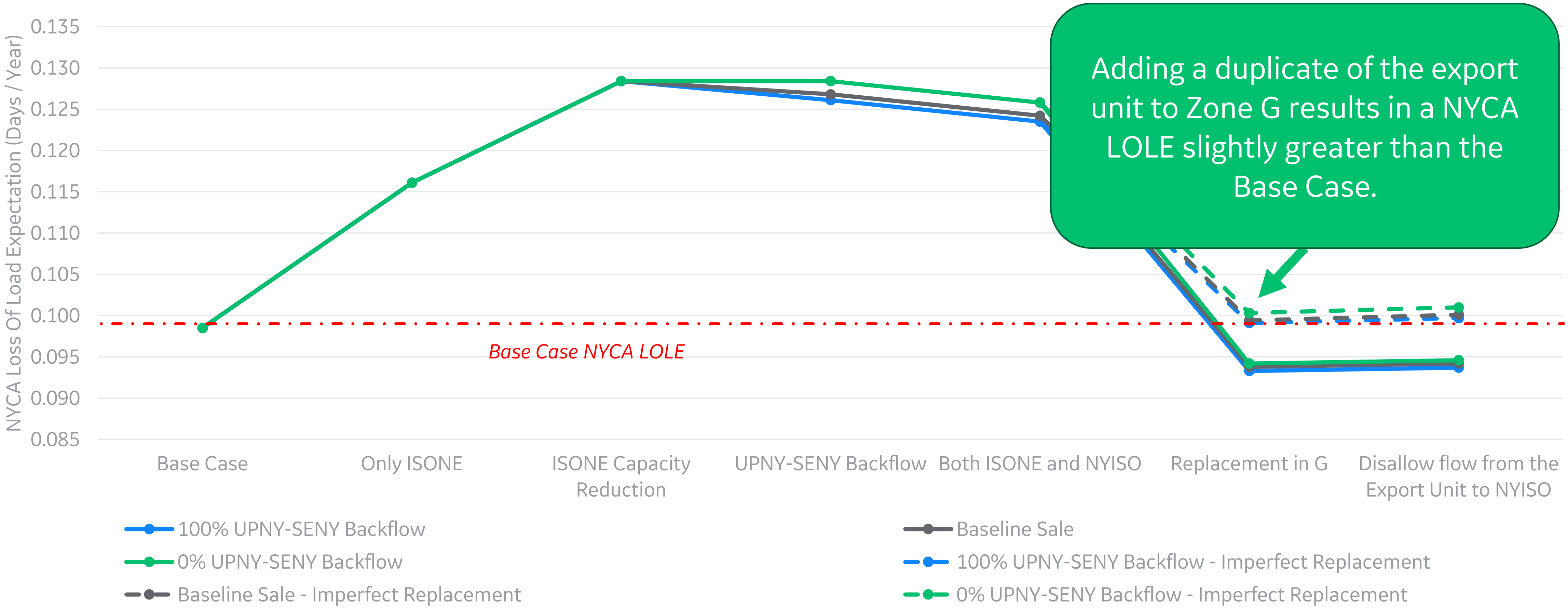
# 0% UPNY-SENY Backflow

## Reserve Sharing Topology



# 0% UPNY-SENY Backflow

## Reserve Sharing Topology



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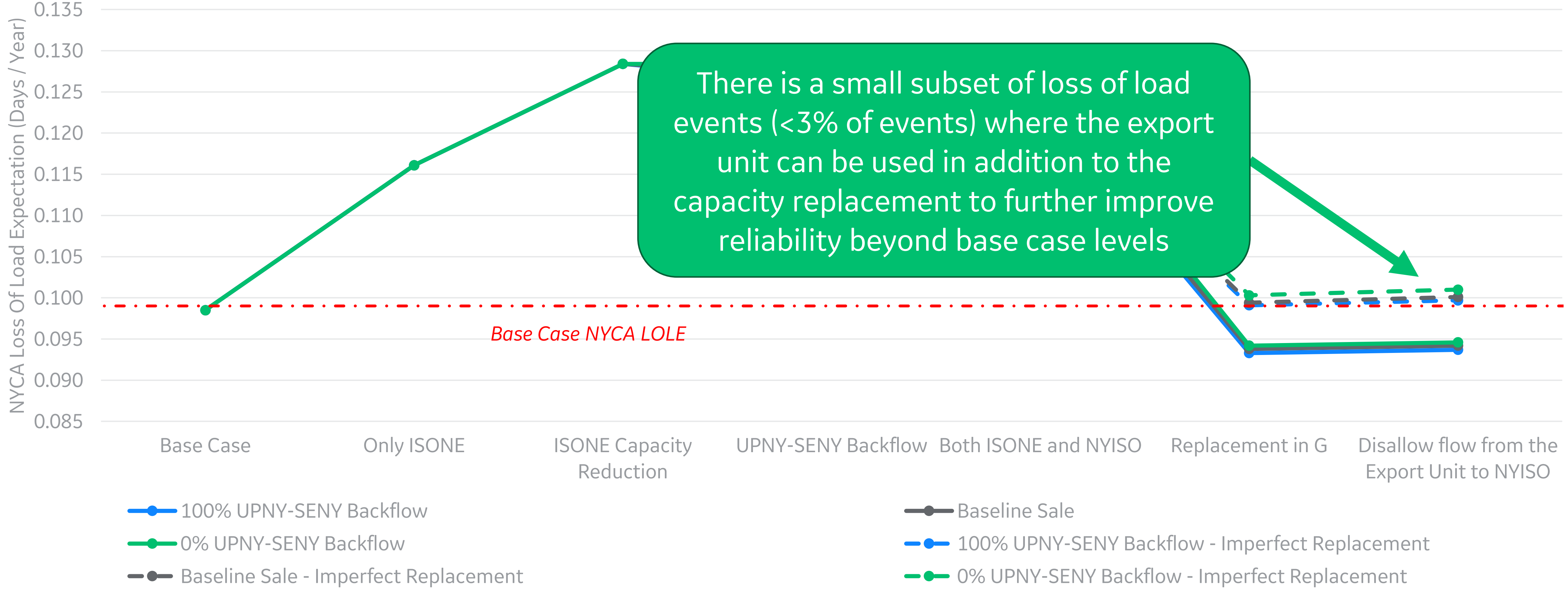
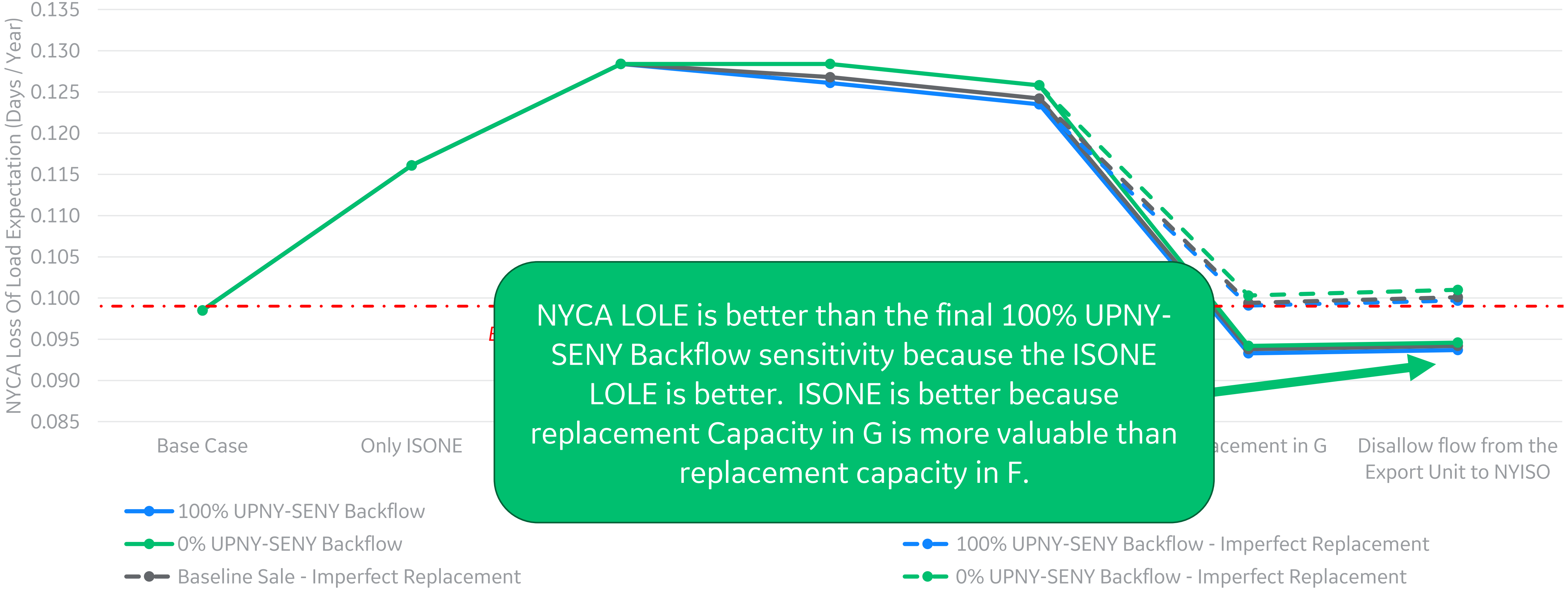


# 0% UPNY-SENY Backflow

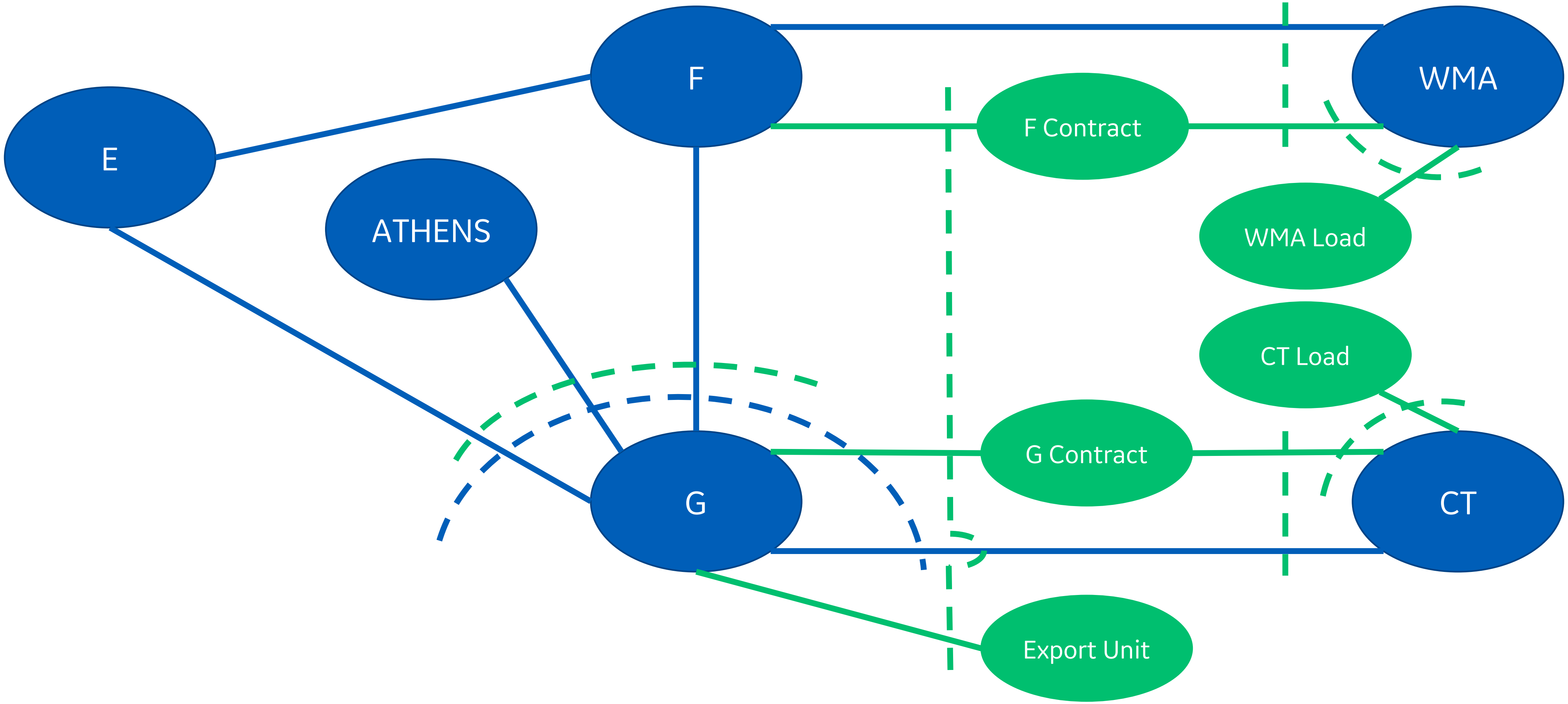
## Reserve Sharing Topology



# Contract Topology

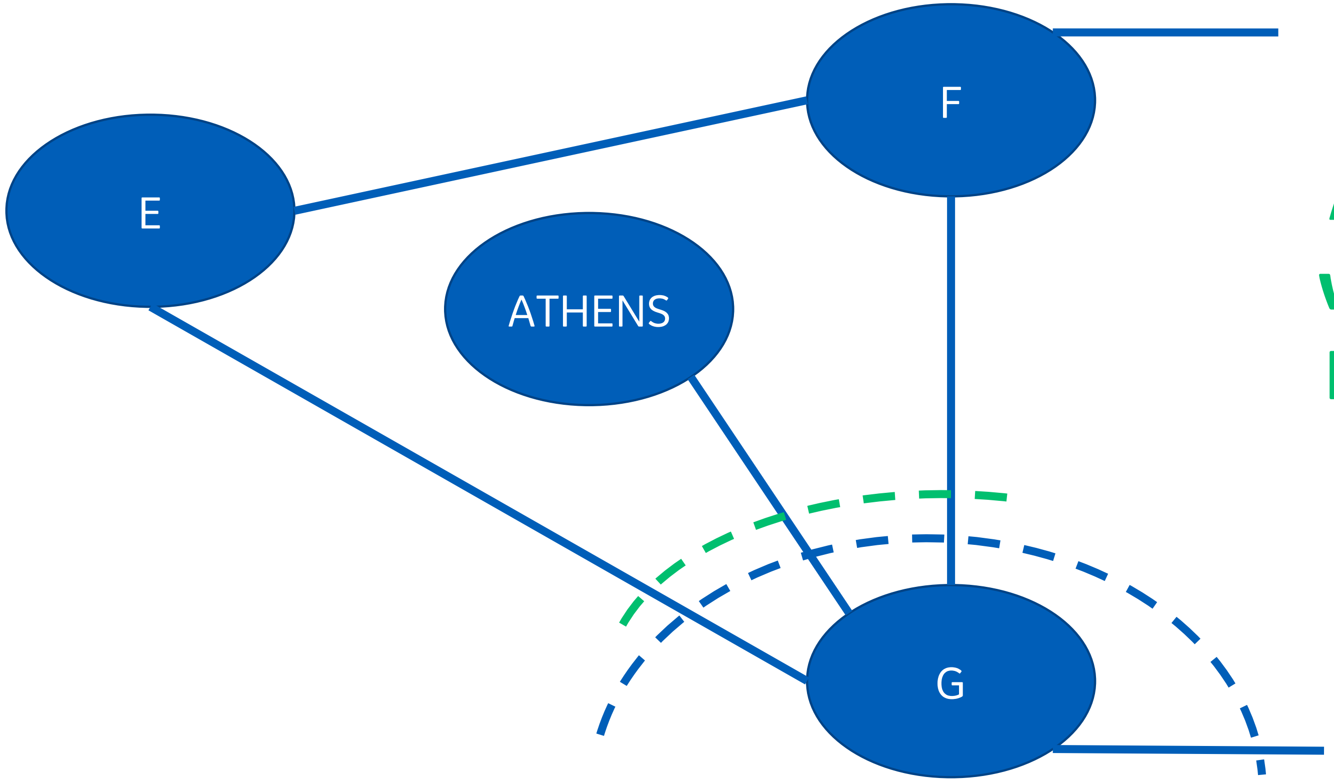
# F&G to ISONE Topology

## Contract Topology



# F&G to ISONE Topology

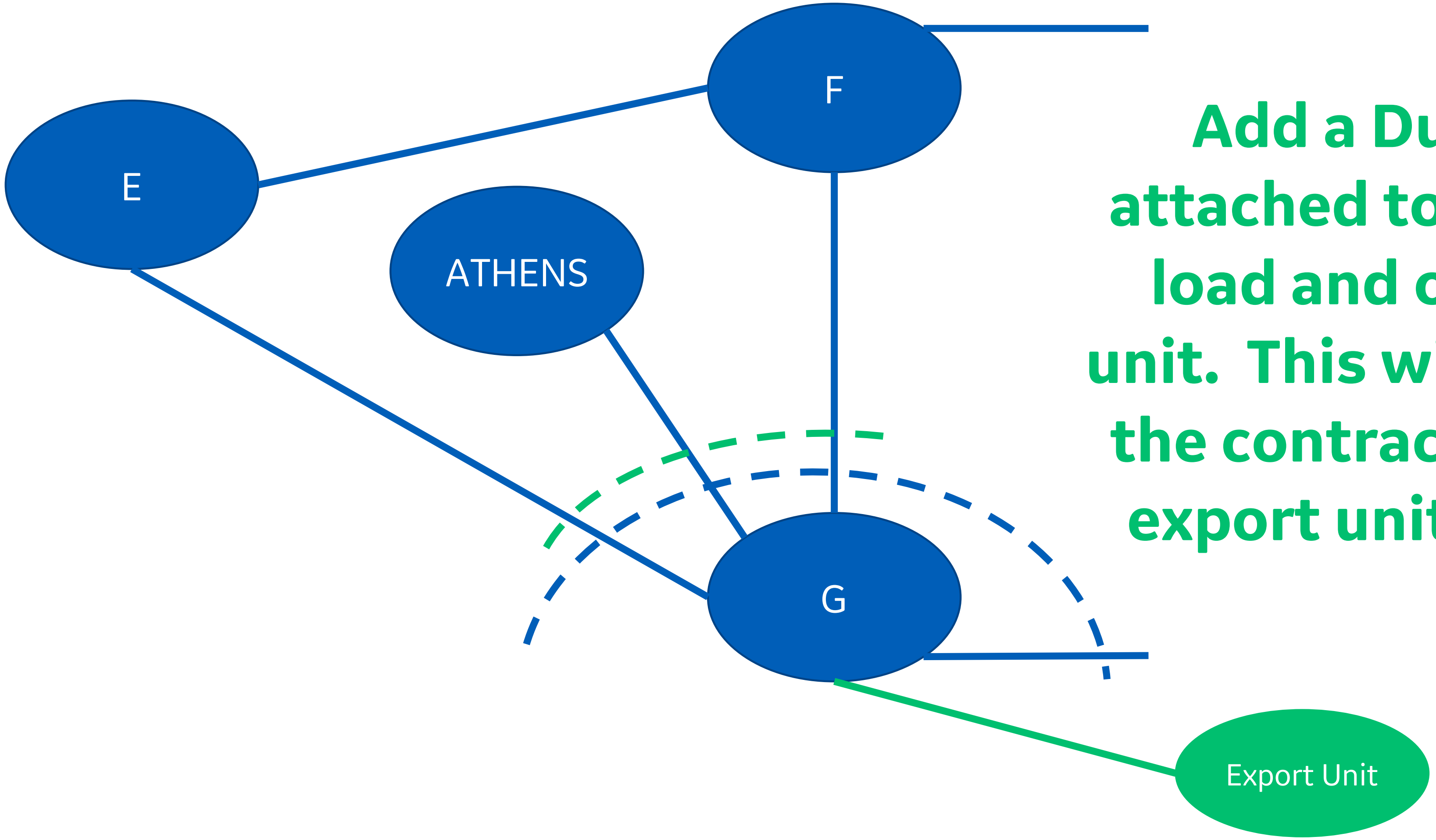
## Contract Topology – New York Only UPNY-SENY Interface




**Add an open interface which crosses only the NY components of the existing UPNY-SENY interface.**

# F&G to ISONE Topology

## Contract Topology – Export Unit Bubble



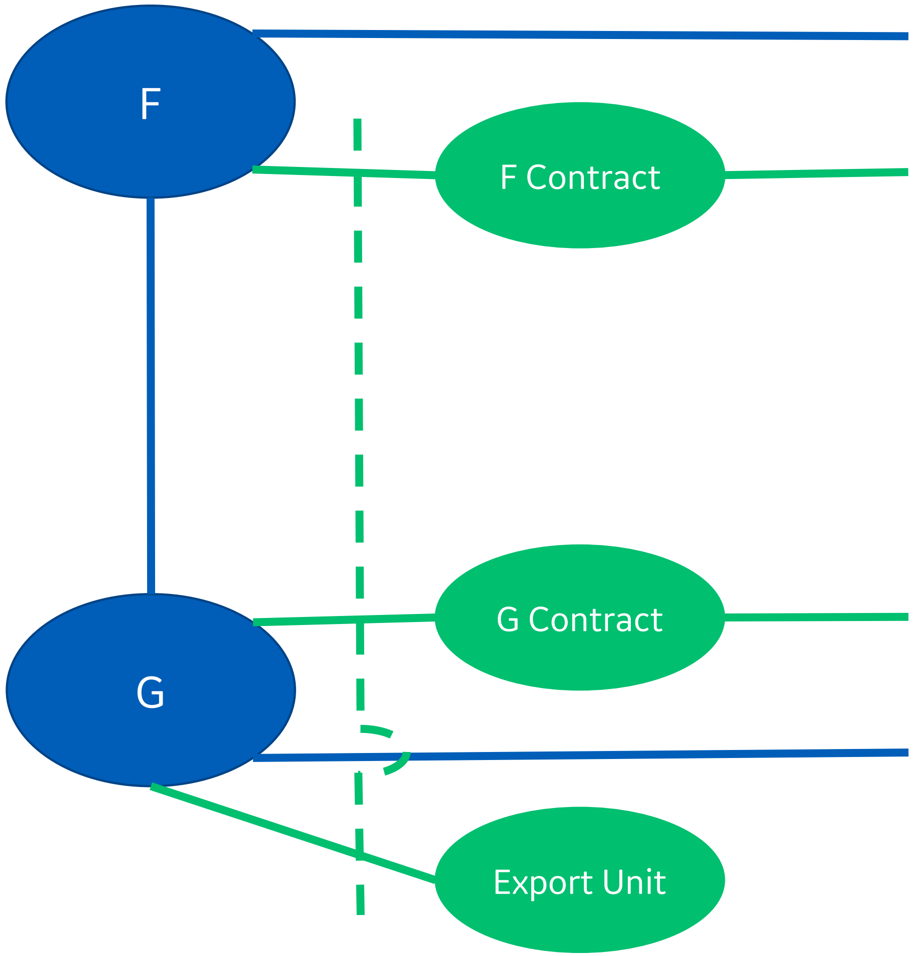

**Add a Dummy Bubble attached to Zone G with no load and only the export unit. This will allow us to cut the contract flow when the export unit is unavailable.**

# F&G to ISONE Topology

## Contract Topology – Contract Balance

**Balance the flow out of the export unit bubble and across the F and G contract paths.**

**For example, if the export unit is unavailable, the contract path flows will be held to zero because flow from the dummy bubble to Zone G is zero.**

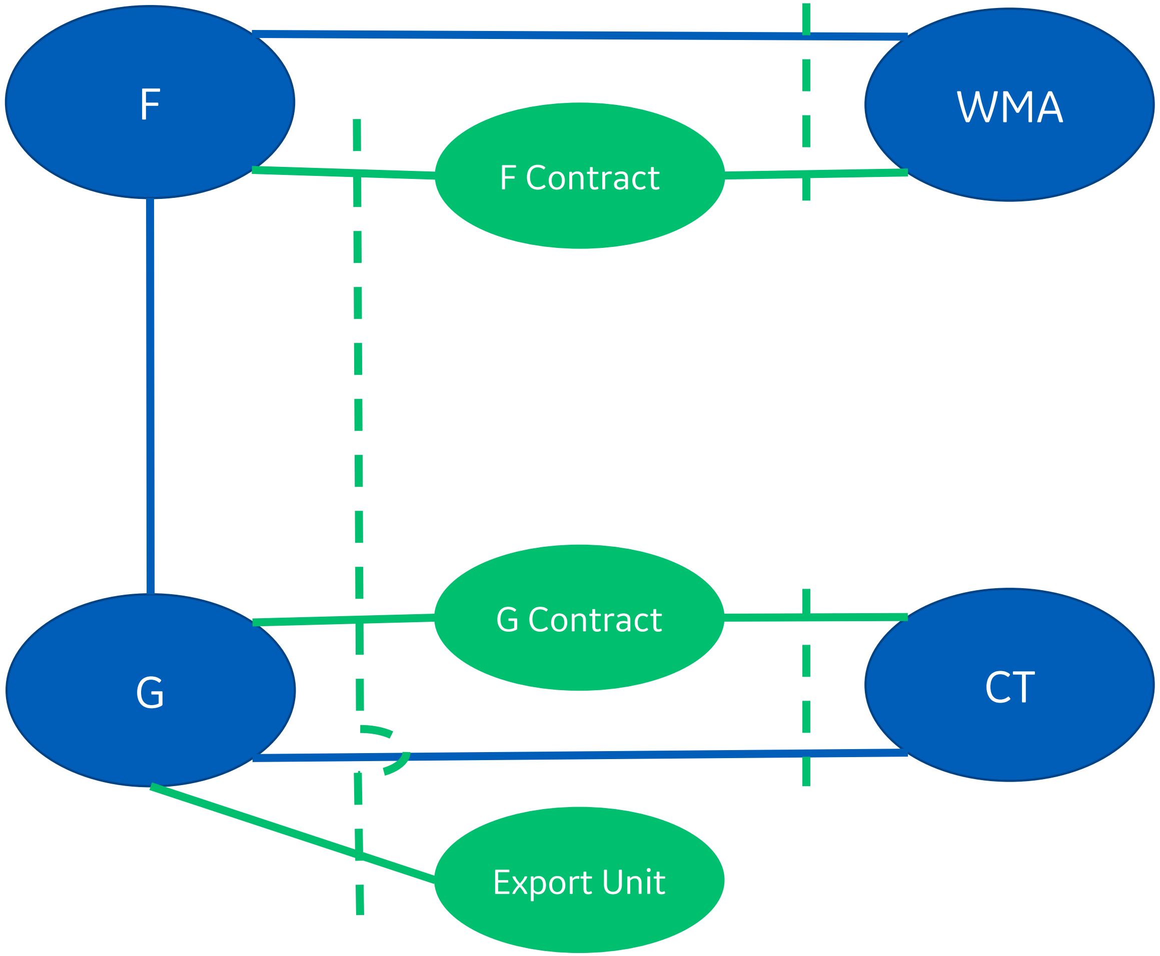


# F&G to ISONE Topology

## Contract Topology – NY to ISONE Limits

**F and F Contract joint flow to WMA is held to the same limit as F to WMA in the base topology**

**G and G Contract joint flow to CT is held to the same limit as G to CT in the base topology**



# F&G to ISONE Topology

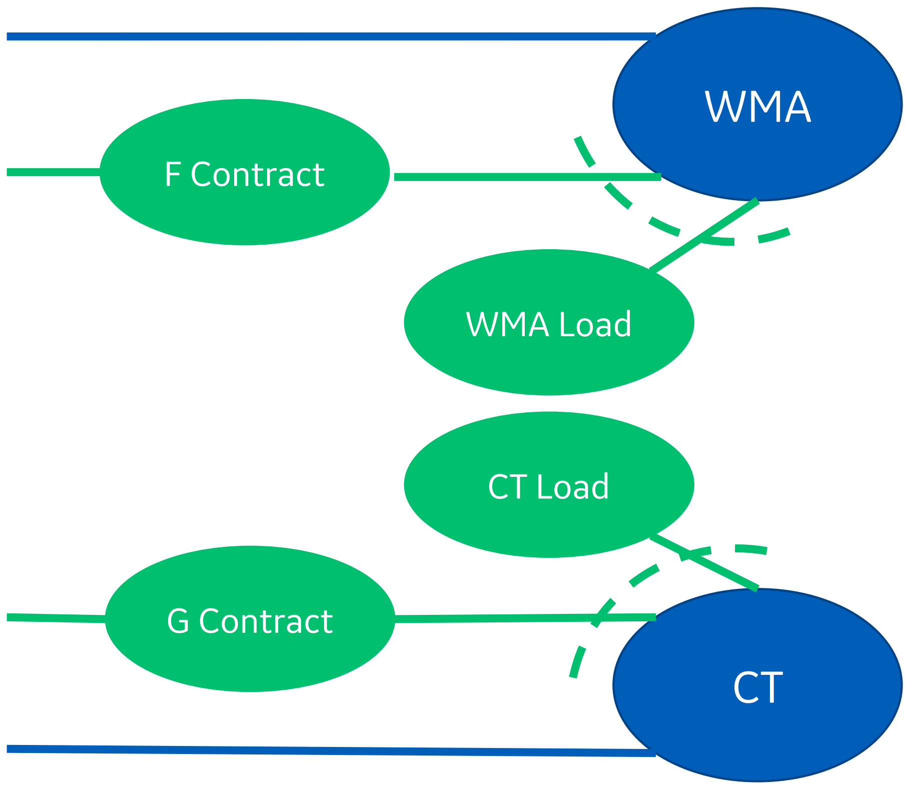
## Contract Topology – Capacity Reduction

**Add WMA and CT Load Bubbles as a proxy for a capacity reduction**

**Load = Contract Size X Capacity Split %**

**If the export unit is unavailable, the contract will not flow. The joint interfaces added will not allow flow from CT and WMA to the load bubbles if the contract is not flowing.**

**This will only reduce ISONE capacity if the contract is delivered**



# F&G to ISONE Topology

## Contract Topology Limits

| Name | Sending Area | Interfaces<br>Receiving Area | Positive Limit | Negative Limit |
|---|---|---|---|---|
| EXPORT_G | Export Unit | Zone G | 9,999 | 0 |
| G_GCONT | Zone G | G Contract | Contract Size * G to CT % | 0 |
| GCONT_CT | G Contract | CT | Contract Size * G to CT % | 0 |
| F_FCONT | Zone F | F Contract | Contract Size * F to WMA % | 0 |
| FCON_WMA | F Contract | WMA | Contract Size * F to WMA % | 0 |
| WMA_WMAL | WMA | WMA Load | 9,999 | 0 |
| CT_CTL | CT | CT Load | 9,999 | 0 |

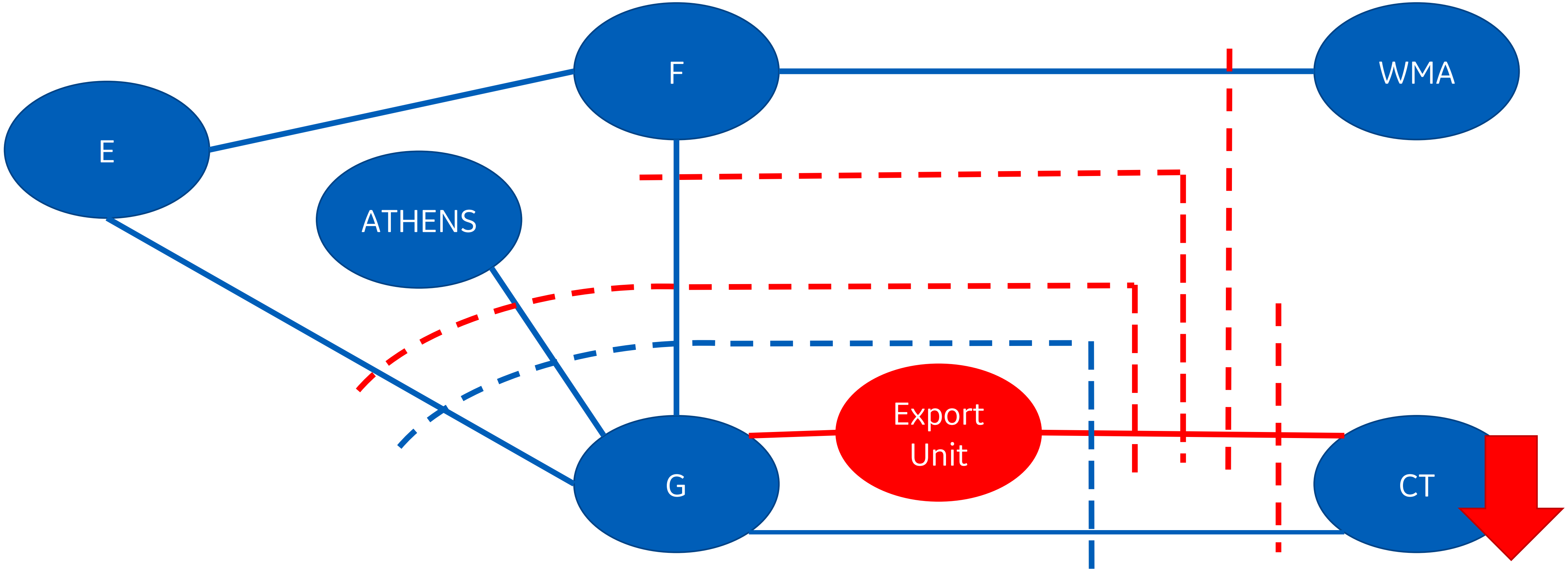
**Interface Groups**

| Name | Interface Grouping | Positive Limit | Negative Limit |
|---|---|---|---|
| NYSENY | (Marcy South) + (Athens to G) + (F to G) | 5,500 | 1,999 |
| CON_BAL | (F to F Contract) + (G to G Contract) - (Export Unit to G) | 0 | 0 |
| ALLF_WMA | (F to WMA) + (F Contract to WMA) | 784 | 800 |
| ALLG_CT | (G to CT) + (G Contract to CT) | 727 | 600 |
| WMALDBAL | (F Contract to WMA) - (WMA to WMA Load) | 0 | 0 |
| CT_LDBAL | (G Contract to CT) - (CT to CT Load) | 0 | 0 |

# Reserve Sharing Topology

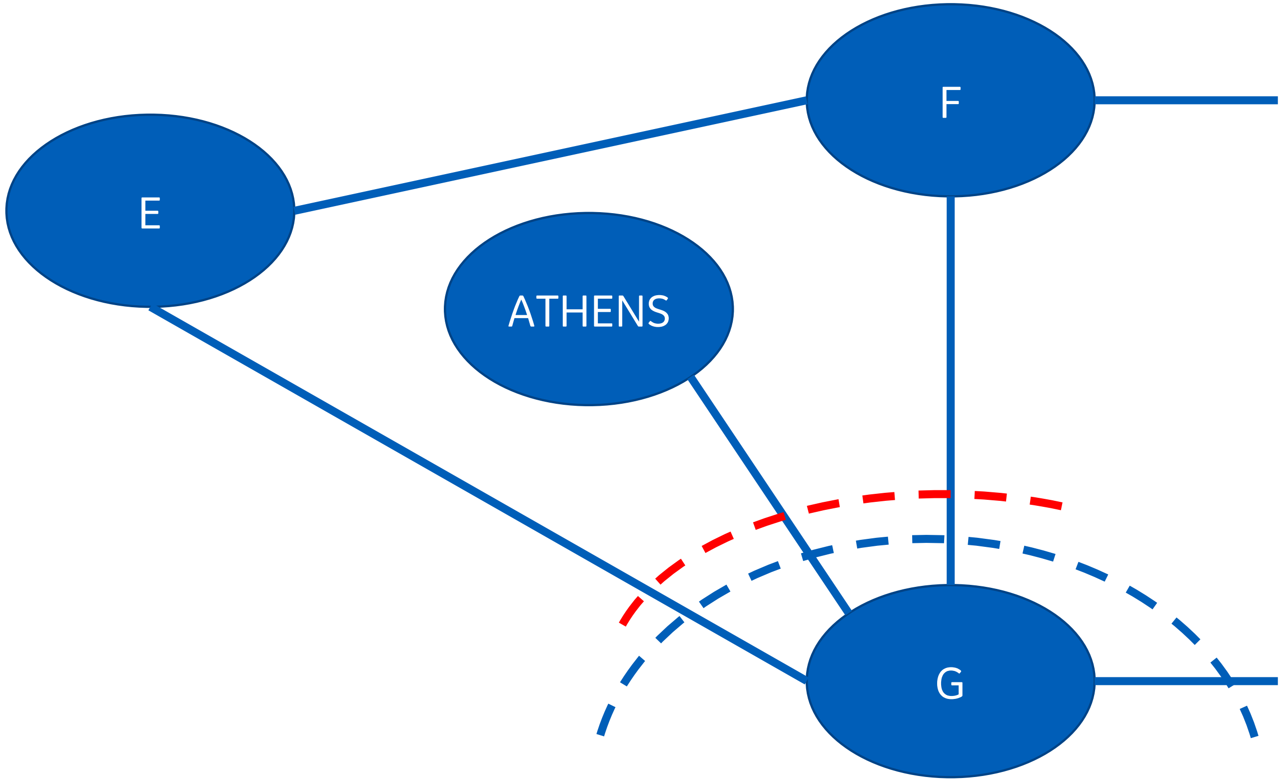
# F&G to ISONE Topology

## Reserve Sharing Topology



# F&G to ISONE Topology

## Reserve Sharing Topology – NY Only UPNY-SENY Interface

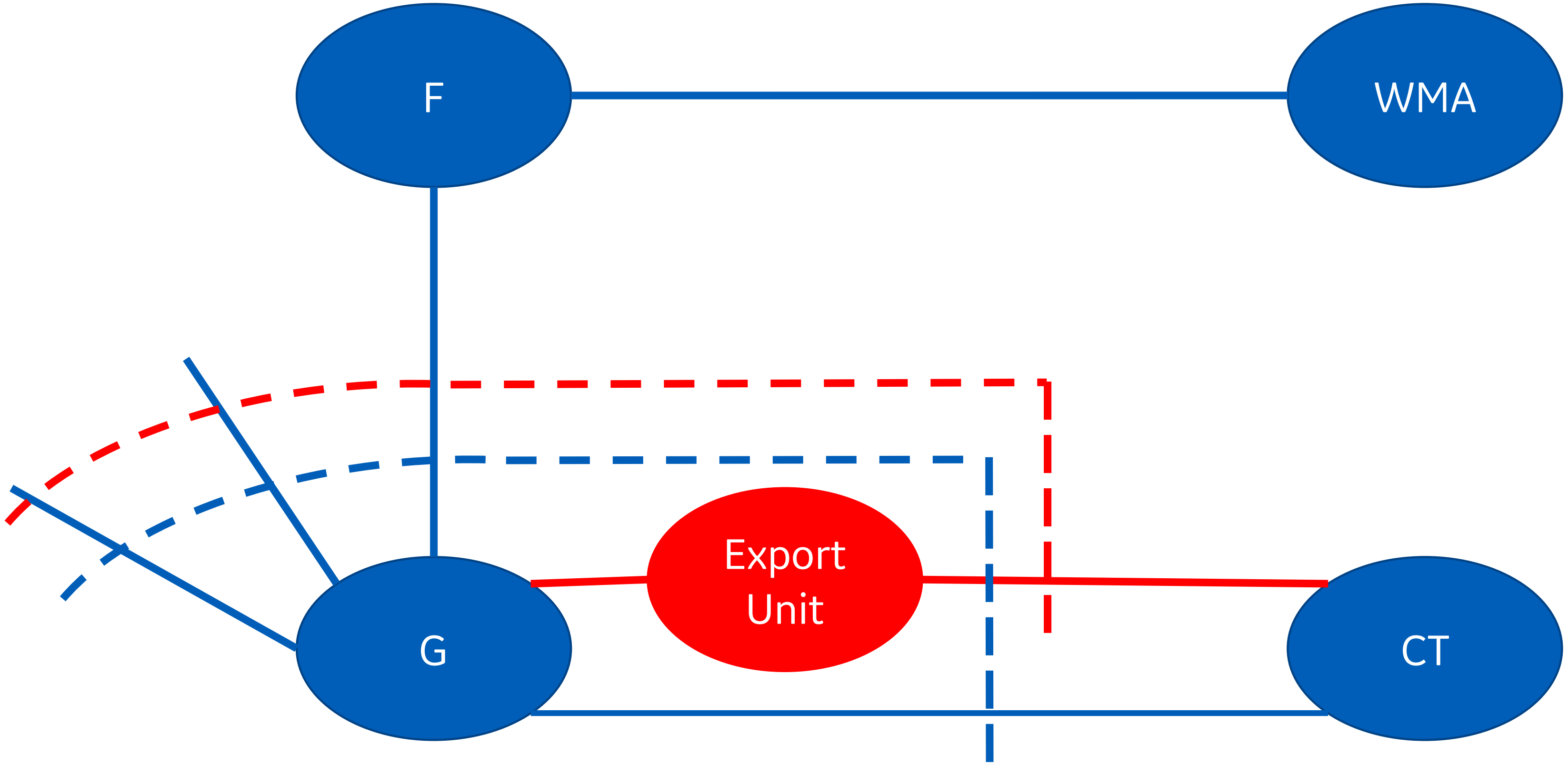



**Add an open interface which crosses only the NY components of the existing UPNY-SENY interface.**

# F&G to ISONE Topology

## Reserve Sharing Topology – Export Unit Pool

**Add a new pool containing only the export unit. Assign the reserve sharing priority out of this pool to ISONE first and NYISO second.**

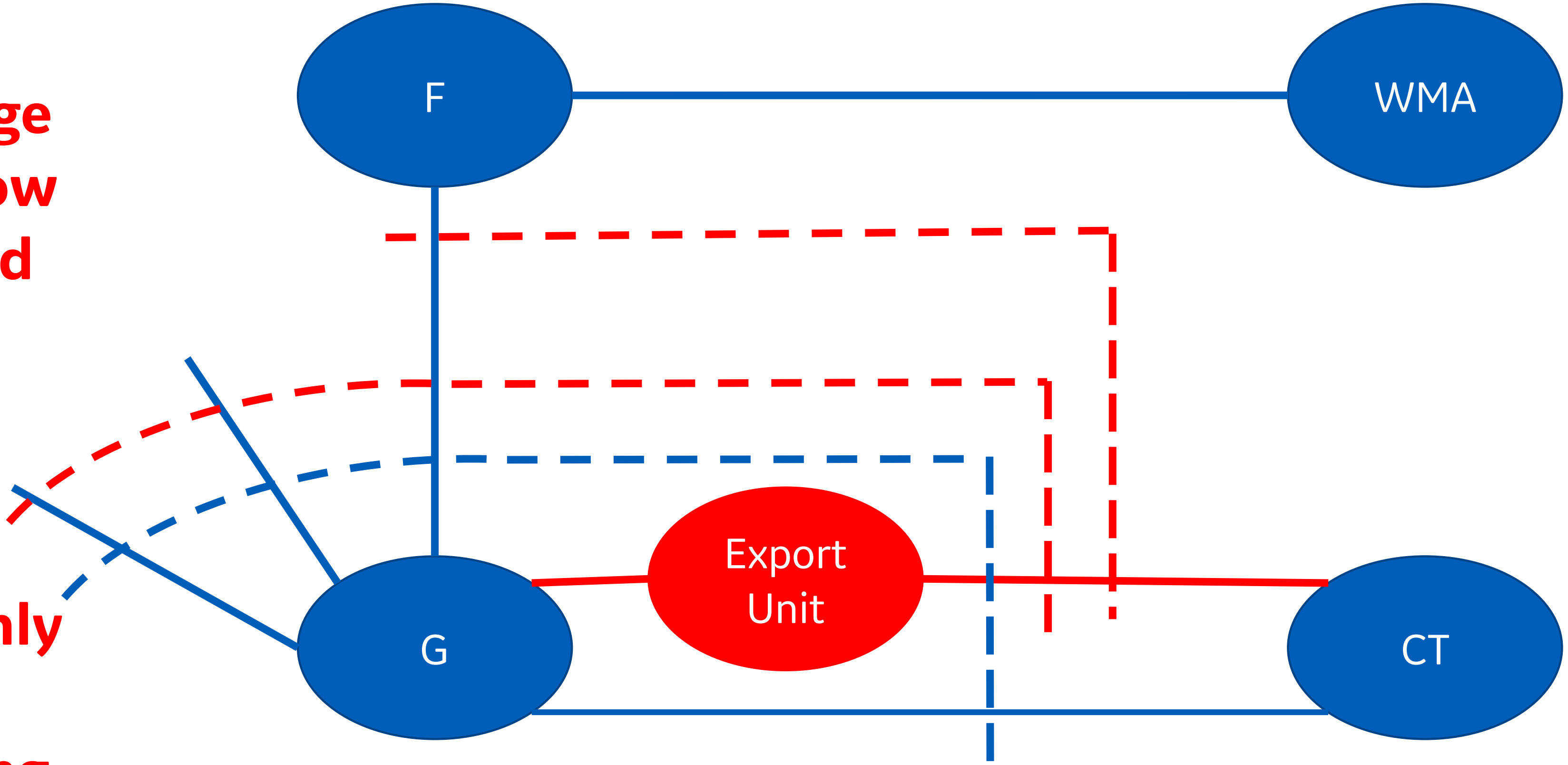


# F&G to ISONE Topology

## Reserve Sharing Topology – Unload Capital - Hudson Valley

**Subtract the appropriate percentage of export unit to CT flow out of UPNY-SENY and Capital to Hudson Valley.**

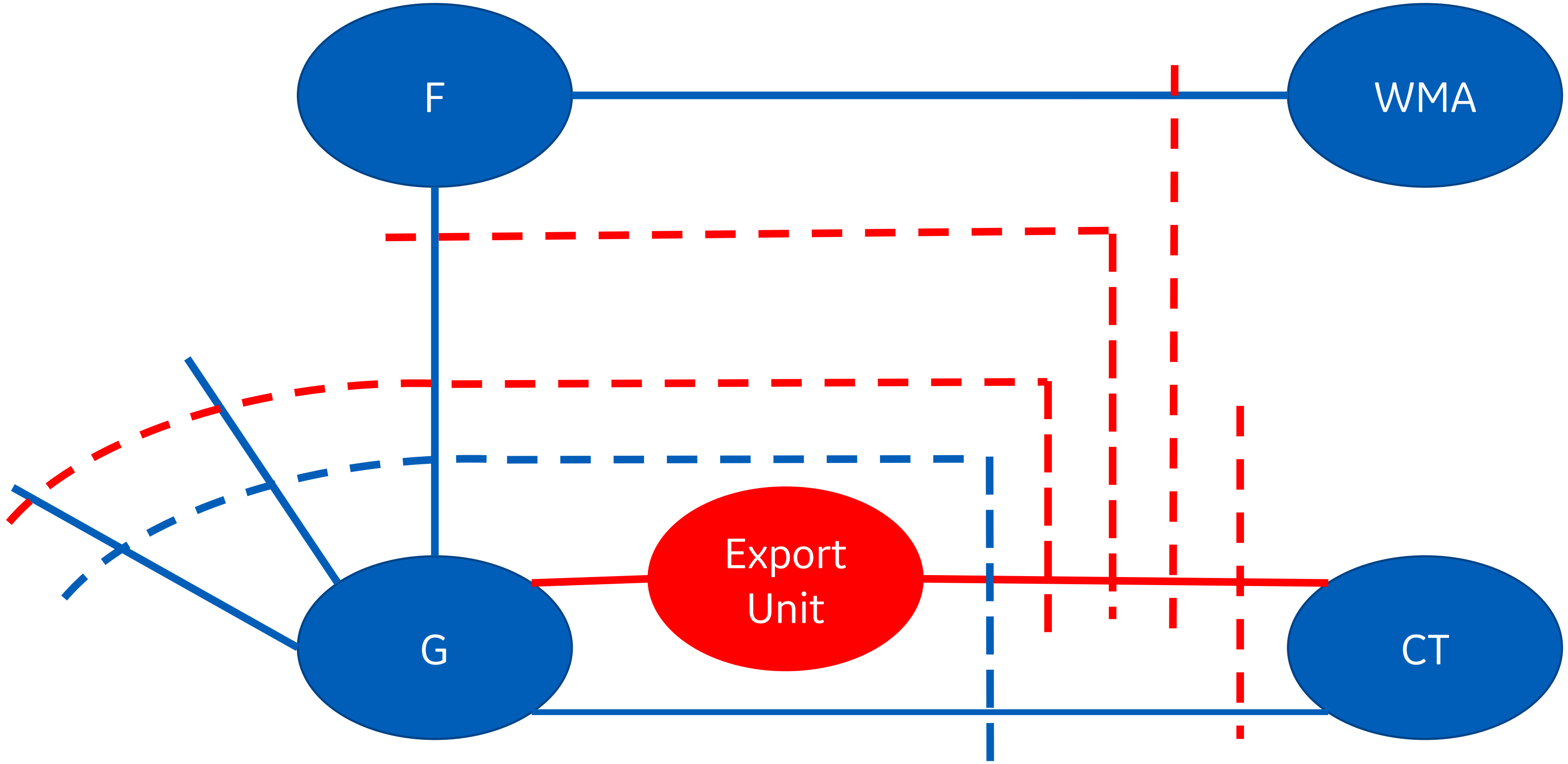
**Using this approach these interfaces are only adjusted when the export unit is supplying power to ISONE.**



# F&G to ISONE Topology

## Reserve Sharing Topology – NY to ISONE Limits

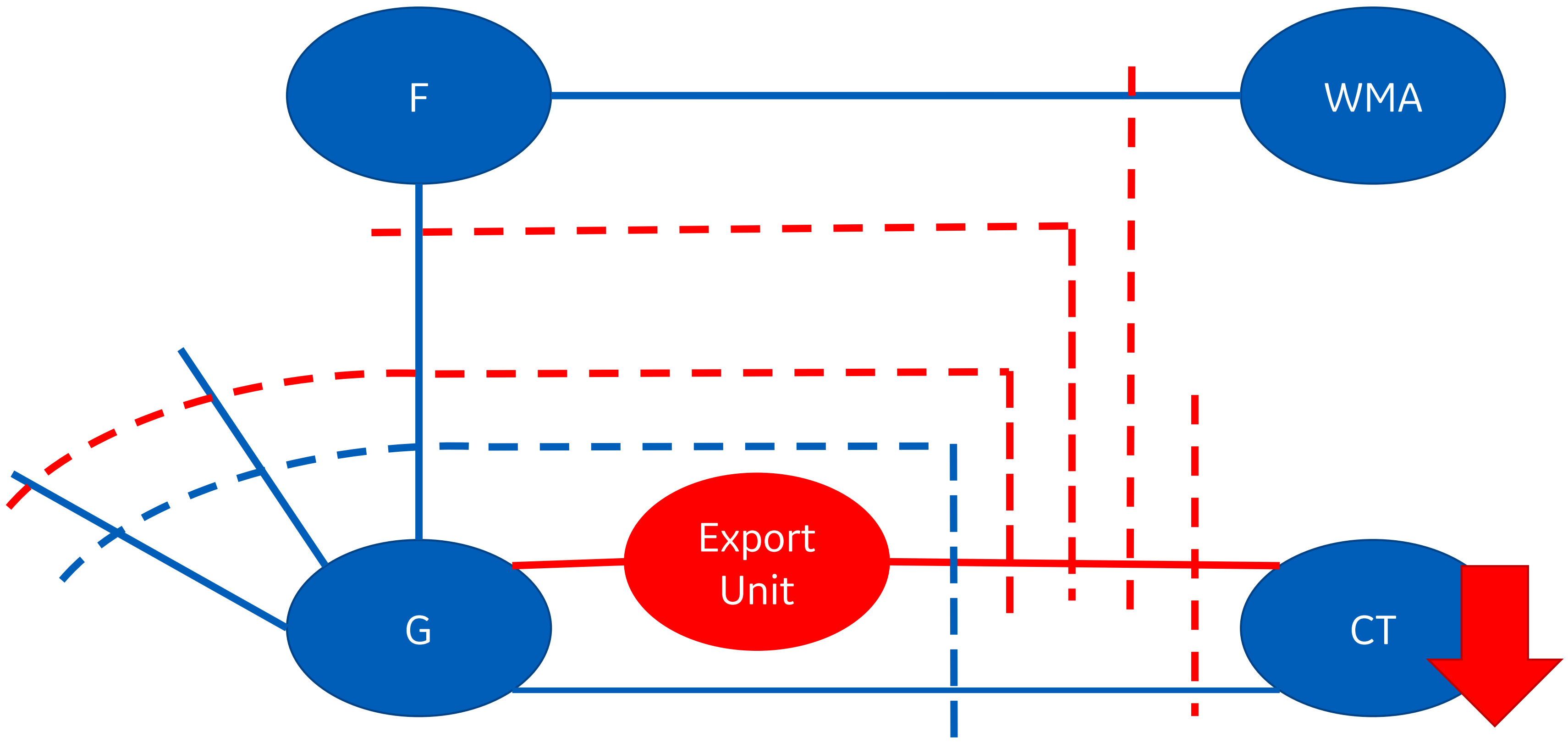
**Add the appropriate percentages of export unit to CT flow to the F to WMA and G to CT interfaces.**



# F&G to ISONE Topology

## Reserve Sharing Topology – ISONE Capacity Reduction

**Reduce Connecticut capacity.**



# F&G to ISONE Topology

## Reserve Sharing Topology

| Interfaces | | | | |
|---|---|---|---|---|
| **Name** | **Sending Area** | **Receiving Area** | **Positive Limit** | **Negative Limit** |
| EXPORT_G | Export Unit | Zone G | 9,999 | 0 |
| EXPORT_CT | Export Unit | CT | 9,999 | 0 |

| Interface Groups | | | |
|---|---|---|---|
| **Name** | **Interface Grouping** | **Positive Limit** | **Negative Limit** |
| NYSENY | (Marcy South) + (Athens to G) + (F to G) - (XX% of Export Unit to CT) | 5,500 | 1,999 |
| CAP_HUDV2 | (F to G) - (XX% of Export Unit to CT) | 3,450 | 1,999 |
| ALLF_WMA | (F to WMA) + ([1-XX%] of Export Unit to CT) | 784 | 800 |
| ALLG_CT | (G to CT) + (XX% of Export Unit to CT) | 727 | 600 |

# Capacity Value

# Capacity Value of a Traditional Thermal Generator

Len Garver, IEEE Transactions on Power Apparatus and Systems, Volume PAS-86, Issue 8, Aug 1966

*Capacity value is the amount of perfect capacity replacement needed to return the system to its baseline LOLE after removing a unit from the system.*

$$CV = c - m \ln\left(\left(1 - \sum_i EFORd_i\right) + \sum_i EFORd_i e^{c/m}\right)$$

$CV$ = Capacity Value

$c$ = Capacity

$m$ = Characteristic System Slope $\quad m = \dfrac{\Delta Load}{\ln(\Delta LOLE)}$

$EFORd$ = Effective Forced Outage Rate at the Time of Demand

$i$ = Capacity States

# Capacity Value of a Traditional Thermal Generator

Len Garver, IEEE Transactions on Power Apparatus and Systems, Volume PAS-86, Issue 8, Aug 1966

**Characteristic System Slope**

$$\lim_{m \to \infty} CV = c \times (1 - EFORd)$$

Factors that impact System Slope

- A more reliable system has a larger system slope
- Larger systems have larger system slopes

**Capacity Value vs System Slope, 8% EFORd**