# Active Resource Integration Project
## Overview and Roadmap

**National Grid IWG Presentation**
December 15, 2022

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# Introduction to Active Resource Integration

ARI: Active Resource Integration is critical to enable National Grid to increase distributed generation (DG) interconnections by actively managing DG to mitigate peak capacity constraints

This project was filed within the Niagara Mohawk Power Corporation rate case to demonstrate capabilities of increasing distribution solar deployment in areas with low hosting capacity via curtailment

This pilot is one of many steps in advancing National Grid's DERMS platform strategy while addressing current and near-term DER customer challenges

Active Resource Integration will be introduced initially to solve a single substation thermal constraint to test the capabilities of the solution and the viability of this technology as an alternative interconnection solution

This pilot will be tested at one location within National Grid Upstate NY Service Territory

# Candidate location historically challenged to interconnect more DG

1. Peterboro substation is in NMPC load zone C-2
2. The substation is a 2 bank, firm capacity design with 8 feeders connected
3. The current hosting capacity of the station is (27.5 MVA) with (27.5) MW of firm Distributed Generation installed
4. Active Resource Integration is looking to connect an additional 15 MW [54% increase over current hosting capacity criteria] of flexible distributed generation to the Peterboro Substation. A substation constraint was chosen as it is generally a more cost-efficient solution than targeting a feeder constraint.
5. The application of ARI applied at this location will defer the need for a substation bank upgrade. This will allow for the additional 15 MW to connect at the substation for a more feasible cost by receiving dispatch from NG and actively curtailing their flexible projects

# Critical that customers can model how alternative interconnection options may impact their project

**From early stakeholder engagement we heard:**

1. Developers need sufficient information on National Grid's curtailment analysis to understand project impacts prior to proceeding with an interconnection agreement.

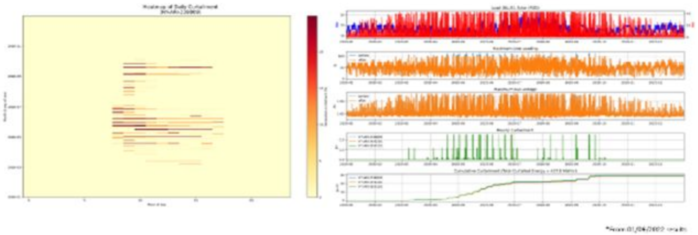
2. Developers need to provide sufficient information to the project's financiers to ensure they are comfortable that the project will generate sufficient revenues to service debt.

3. National Grid needs flexibility to curtail projects when necessary to maintain system reliability.

**Therefore, we plan to provide pilot participants:**

Results of multiple studies under standard study scenarios using the methodology detailed below. The results will show:

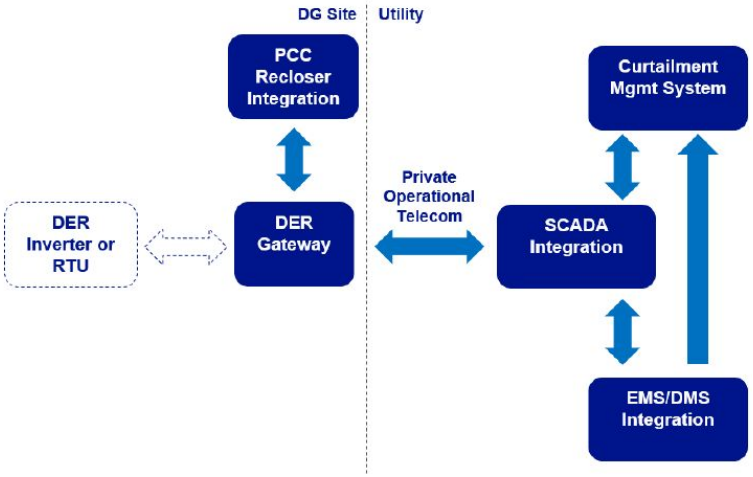
- A detailed description of the constraint being studied
- Hourly curtailment expected during the pilot period
- Hourly curtailment expected with post pilot (no new flexible projects interconnected)
- Hourly curtailment expected at total flexible DG capacity enrolled to maintain target max curtailment



# Technology is key to deploy actively managed connection solutions

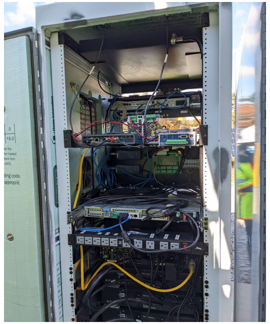
**Functionality to be implemented, tested and refined as part of this pilot:**

- Real-time communication of automated dispatch signals (e.g. export limits) to DG on-site controller
- Loss of communication detection between centralized utility system and DG
- Integration with Company utility PCC recloser for underperformance protection assurance
- Step towards standardizing dispatch communications and interface with DER (e.g. IEEE 1547-2018, interface documents, data needs)




**Feasibility evident in peer utility experience and reviewed with industry experts:**

EPRI
DUKE ENERGY
Scottish & Southern Electricity Networks
AVANGRID



Deployment at Company owned Solar site (MA)

Deployment at a non-wire alternative site (NY)

# Alignment with National Grid's DERMS platform strategy

ARI will inform National Grid's approved DERMS investigation project from its NMPC rate case and overall DERMS platform development

**2022-2024***

**ARI Pilot (Minimum Viable Product)**

- Develops alternative connection studies, documentation and integration practices with standardization in mind
- Automates real-time operational dispatch of DER for system thermal constraints
- Gains insight learned from managing initial participant sites

**Expand product coverage across our network**

**Diversify interconnection offering to other DERs**

**Improved customer and operator awareness**

**Deeper integration with utility enterprise systems**

**Scale and Evolve**



*Timeline subject to change

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# Flexible Interconnection

## Comparing the Rules of Curtailment and Estimating Curtailment

IWG Meeting
December 15, 2022


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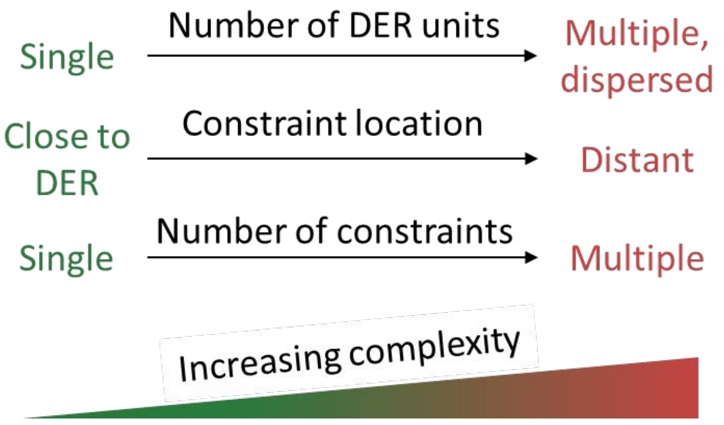
# Rules of Curtailment

**Basic Strategies**

- Time-differentiated maximum export schedules
- Binary logic (export / no-export)

**Advanced Curtailment Strategies**

- Minimize and distribute curtailment equitably across multiple DERs
- LIFO and Pro-rata are most common strategies used by early adopter utilities to date.

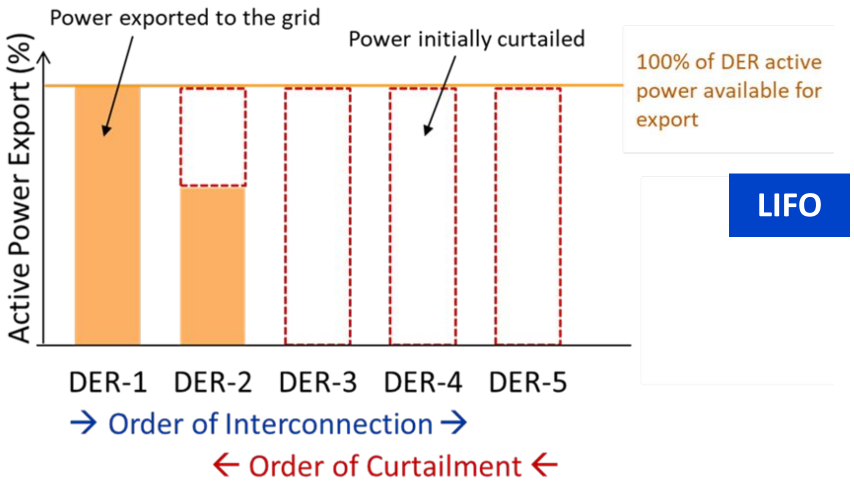



| Curtailment Logic | Description |
|---|---|
| Last-in-first-out (LIFO) | DER units are curtailed in the reverse order in which they applied for connection to the network. |
| Pro-rata | All DER units are curtailed in proportion to each DER’s contribution to network constraints. |
| Competitive bidding | DER units with the lowest bids to use network capacity are required to curtail. |
| Emissions-based priority | DER units with the highest emissions are curtailed first. |

*Rules of Curtailment*

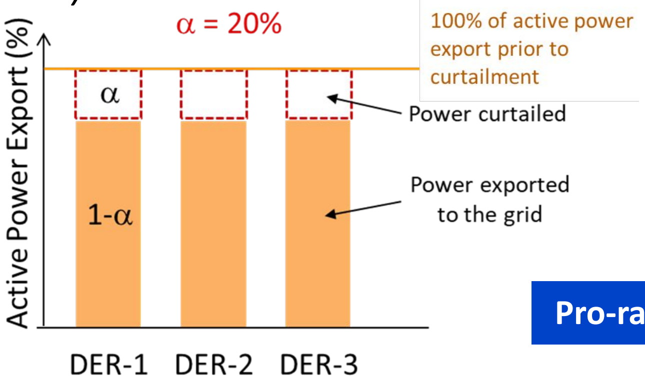
# Last-In-First-Out (LIFO) vs. Pro-Rata

DER generators contributing to a constraint are curtailed in the **reverse order in which they applied for connection** to the network.

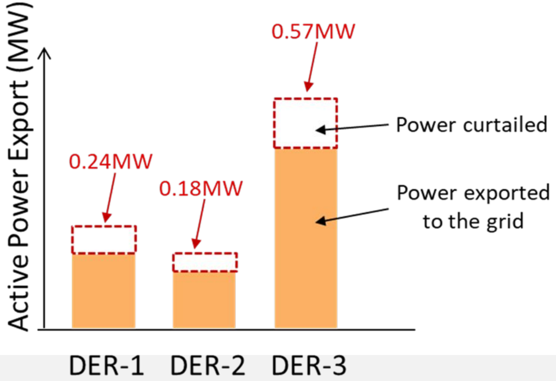



LIFO

DER generators contributing to a constraint are curtailed **proportionally to a reference parameter** *(e.g, active power export right before curtailment)*




Pro-rata



*Rules of Curtailment*

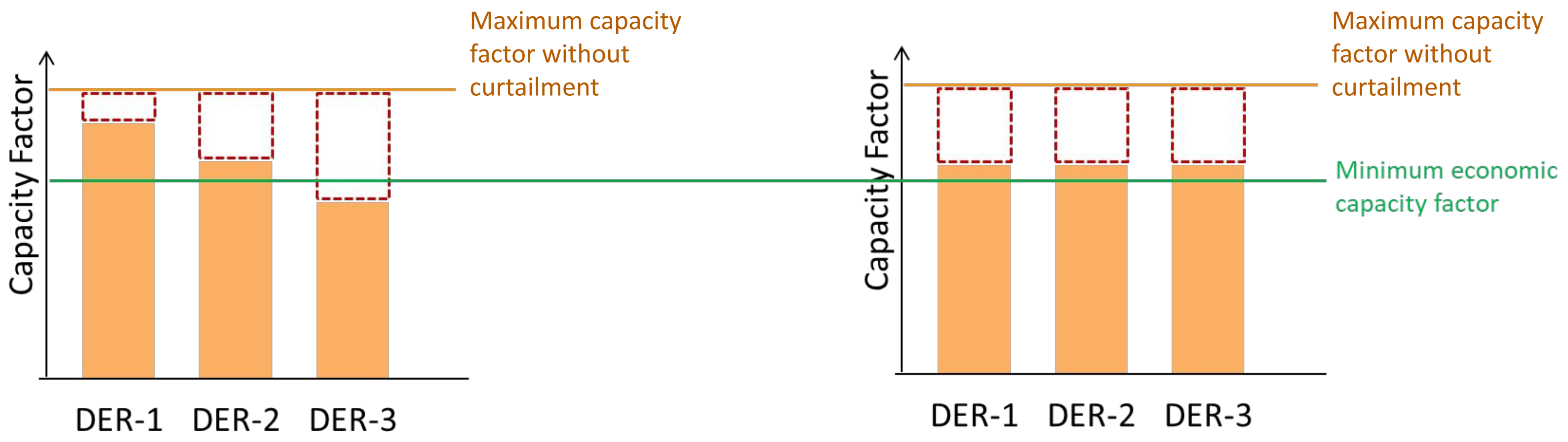
# Comparison: *LIFO vs. Pro-Rata*

**LIFO**

- Higher financial certainty for developers (early connectors)
- Potential for gaming of priority rules

**Pro-rata**

- Potential for greater DER interconnection and higher network utilization
- Shared incentives to co-finance upgrades



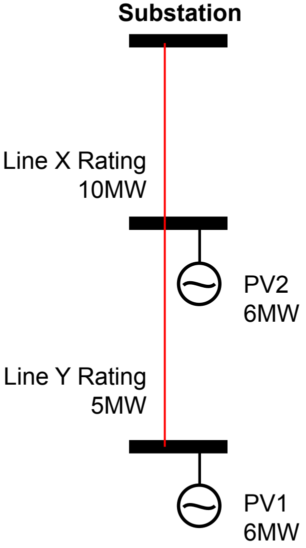

**For more information: EPRI white paper, Principles of Access for Flexible Interconnection – Rules of Curtailment**

*Coordinated Curtailment of Multiple DERs under Multiple Constraints*

# An Illustrative Simple Example

LIFO Priority Order: PV1 > PV2

(i.e., PV2 will be curtailed before PV1)




*Case 1*

| Constraint Evaluation | Curtailment (MW) | | Generation (MW) | |
|---|---|---|---|---|
| | ΔPV1 | ΔPV2 | PV1 | PV2 |
| Line X | 0 | 2 | 6 | 4 |
| Line Y | 1 | 0 | 5 | 4 |

*Case 2*

| Constraint Evaluation | Curtailment (MW) | | Generation (MW) | |
|---|---|---|---|---|
| | ΔPV1 | ΔPV2 | PV1 | PV2 |
| Line Y | 1 | 0 | 5 | 6 |
| Line X | 0 | 1 | 5 | 5 |

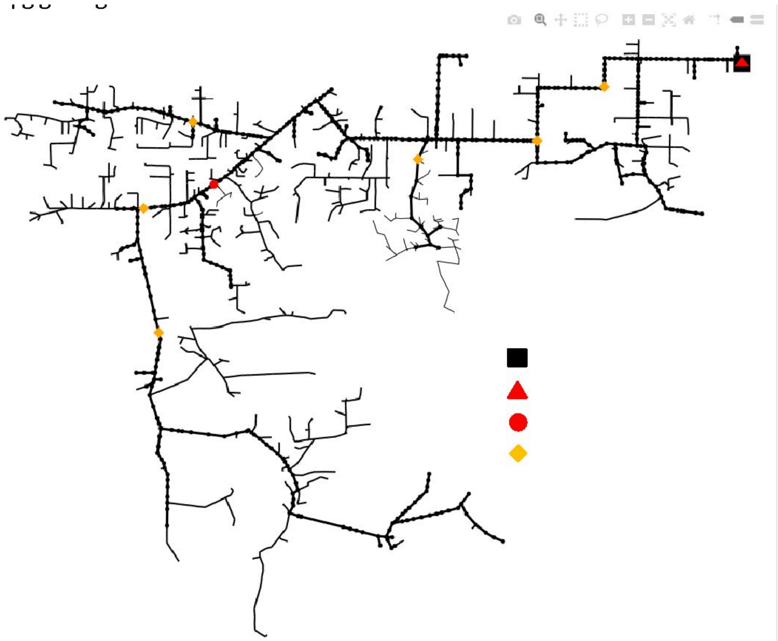
**Sequential evaluation □ inconsistent, non-optimal result**

## Coordinated Curtailment of Multiple DERs under Multiple Constraints

# Case Setup

- 8 feeders from one substation
- 4 Pilot PV installations considered for ARI control
- Both thermal and voltage constraints evaluated on
  - Substation transformers
  - 1500 mainline buses
  - 1600 mainline lines

| PV Plant ID | Network ID | Rated kVA | Type |
|---|---|---|---|
| DER a | Feeder 2 | 2,900 | Firm |
| DER b | Feeder 2 | 4,000 | Firm |
| DER 1 | Feeder 3 | 5,000 | Flex |
| DER c | Feeder 4 | 5,000 | Firm |
| DER 2 | Feeder 4 | 5,000 | Flex |
| DER d | Feeder 5 | 2,000 | Firm |
| DER 3 | Feeder 5 | 5,000 | Flex |
| DER e | Feeder 6 | 5,000 | Firm |
| DER f | Feeder 7 | 3,250 | Firm |
| DER g | Feeder 8 | 3,000 | Firm |
| DER 4 | Feeder 8 | 5,000 | Flex |



** Not the real circuit diagram. Only shown for illustration purpose.*

**QSTS Assessment using Utility Provided Annual Profile Data**

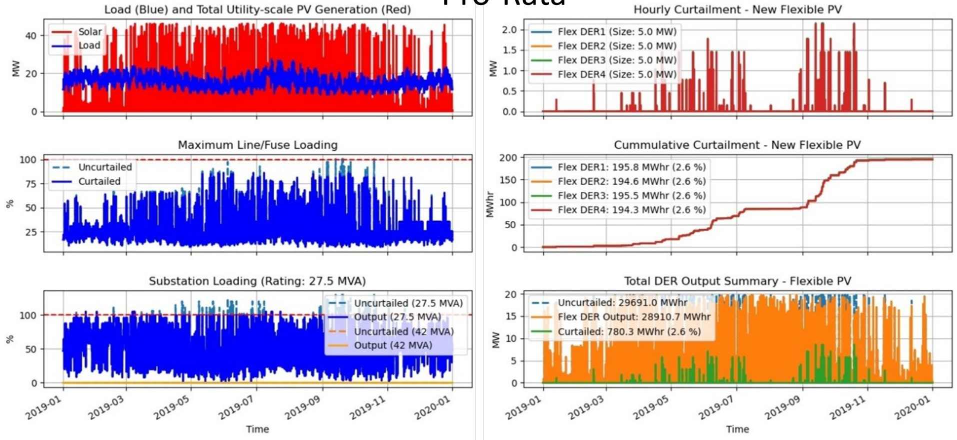
## *Coordinated Curtailment of Multiple DERs under Multiple Constraints*

# Results

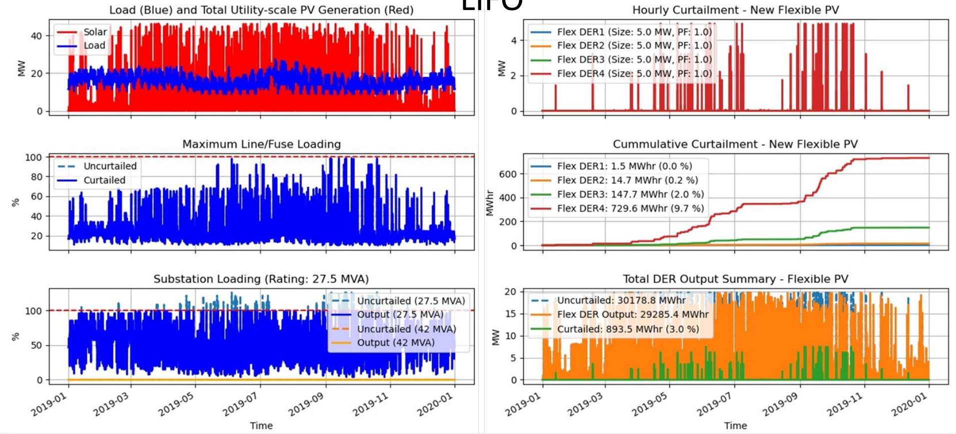
| Dispatch Scheme | Constraint Scenario | N-1 [sub Tx[2]] | Flexible DER PF | Annual Energy Curtailed (%) DER 1 | DER 2 | DER 3 | DER 4 | Overall |
|---|---|---|---|---|---|---|---|---|
| Pro-rata | Thermal[1] | N | Unity | 0.0 | 0.0 | 0.0 | 0.0 | **0.0** |
| Pro-rata | Thermal | Y | Unity | 2.6 | 2.6 | 2.6 | 2.6 | **2.6** |
| Pro-rata | Overvoltage | N | Unity | 0.5 | 1.4 | 0.0 | 14.7 | **4.1** |
| Pro-rata | Overvoltage | N | Non-unity | 0.0 | 0.0 | 0.0 | 0.0 | **0.0** |
| LIFO | Thermal | Y | Unity | 0.0 | 0.2 | 2.0 | 9.7 | **3.0** |
| LIFO | Overvoltage | N | Unity | 0.1 | 2.1 | 0.4 | 15.4 | **4.5** |
| Local (Annual[3]) | Thermal | Y | Unity | 16.7 | 16.4 | 16.6 | 16.4 | **16.5** |
| Local (Monthly[4]) | Thermal | Y | Unity | 11.7 | 11.6 | 11.7 | 11.6 | **11.7** |

[1] *Evaluated on both substation transformers and feeder lines*
[2] *The larger of two substation transformers out of service*
[3] *One fixed export limit applied to each DER throughout the whole year*
[4] *Fixed export limit updated each month*

Pro-Rata




LIFO



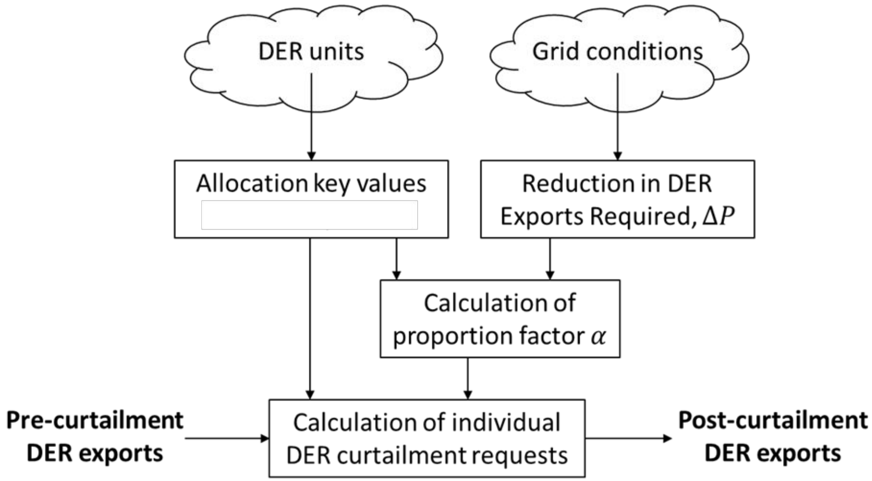
# Backup Slides

## *Rules of Curtailment*

# Pro-Rata – *Curtailment Calculations*

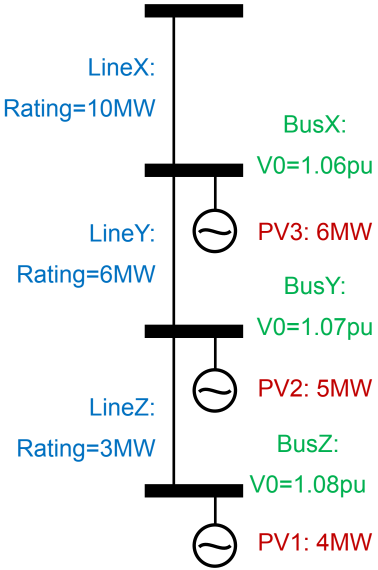
DER Active Power Curtailed = Proportion Factor α *(same for all DERs)* x Allocation Key Value *(specific to each DER)*

- Examples of **allocation keys**:
  - Active power export
  - Maximum active power available for export
  - DER nameplate
  - *Combination of multiple factors*
- **Proportion factor α**
  - Updated every time a curtailment event occurs, to ensure total export reduction needed is met



*Coordinated Curtailment of Multiple DERs under Multiple Constraints*

# Problem Formulated as QP Optimization




$$\min f(x) = q^T x + \frac{1}{2} x^T Q\, x$$

$$q = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix} \qquad Q = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$Bx \leq b$, $x$ refers to curtailed power

$$\begin{array}{l} \text{Line X} \\ \text{Line Y} \\ \text{Line Z} \\ \text{Bus X} \\ \text{Bus Y} \\ \text{Bus Z} \\ \text{PV1} \\ \text{PV2} \\ \text{PV3} \end{array} \begin{bmatrix} -1 & -1 & -1 \\ -1 & -1 & 0 \\ -1 & 0 & 0 \\ -0.002 & -0.002 & -0.002 \\ -0.004 & -0.004 & -0.002 \\ -0.006 & -0.004 & -0.002 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} \leq \begin{bmatrix} 10 - 15 \\ 6 - 9 \\ 3 - 4 \\ 1.05 - 1.06 \\ 1.05 - 1.07 \\ 1.05 - 1.08 \\ 4 \\ 5 \\ 6 \end{bmatrix}$$

| | PV1 | PV2 | PV3 | Total |
|---|---|---|---|---|
| **Curtailment (MW)** | 3.21 | 2.14 | 1.07 | 6.43 |
| **Generation (MW)** | 0.79 | 2.86 | 4.93 | 8.57 |

**Automated to Work with Commercial Software (e.g., CYME)**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