An approach to model Stability Limits on units in Markets

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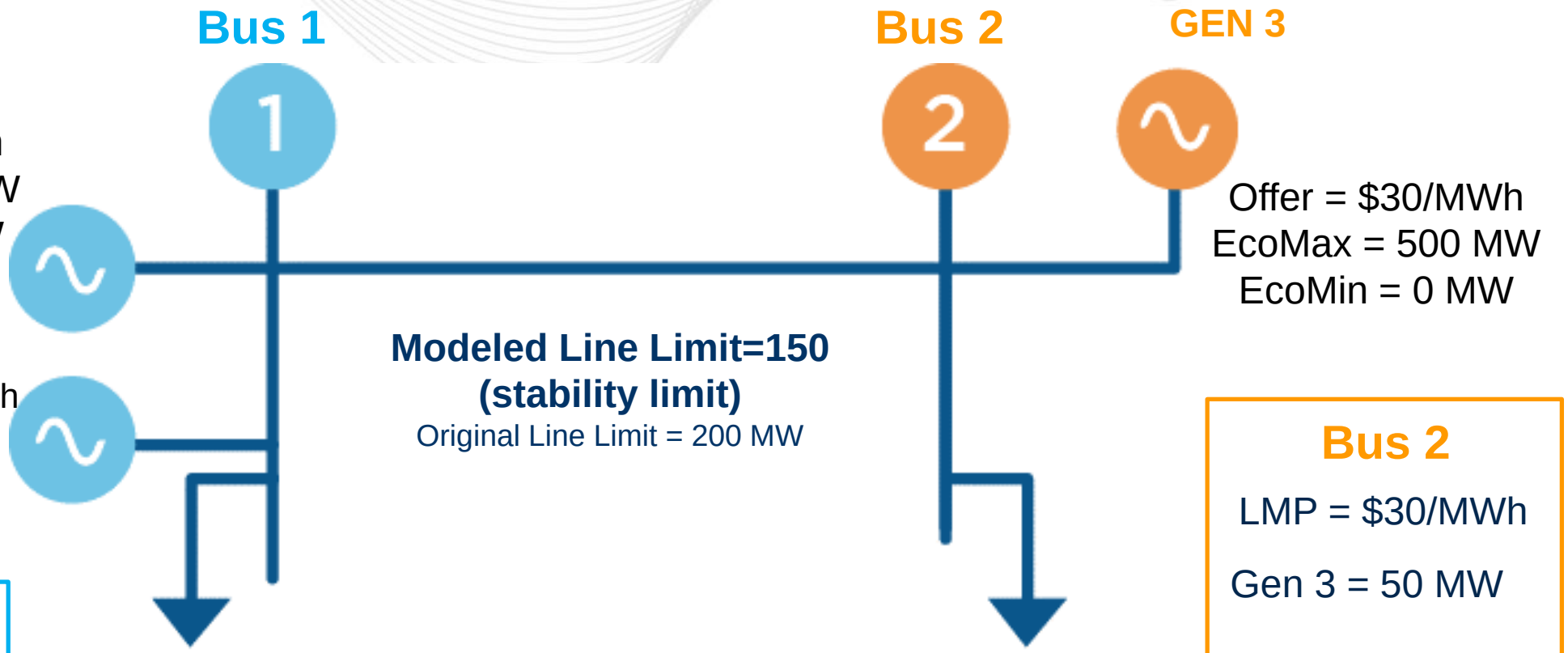
An approach to model Stability Limits

- The stability limits can be modeled as “generator output constraint” for Stability restricted units.
  - The sum of MWs from stability restricted units will not be more than stability limit regardless of virtual bidding. This constraint can also be modeled such that sum of energy MWs plus reserve MWs from stability restricted units will not be more than stability limit.
  - This type of constraint doesn’t directly affect the LMP.
  - The output of stability restricted units will be determined based on their offer curve and LMPs.
- PJM proposes using this new “generator output constraint” approach to model stability limitations going forward, rather than using thermal surrogates or requesting participants to lower their bid in operating limits.

Assumptions for Examples

- All units are assumed as committed. These examples are for a dispatch solution interval.
- The stability limit in all these examples is 150 MW.
- GEN1 and GEN2 are stability restricted units with stability limit of 150 MW.
- In thermal surrogate approach, the stability limit is modeled as thermal surrogate on transmission line by altering the original transmission line limit.
- In generator output constraint approach, the stability limit is modeled on total output MWs from stability restricted units i.e. GEN1 and GEN2.

Clearing Stability Restricted units with Dec in current Thermal Surrogate approach (Day Ahead Market)



Bus 1
LMP = $20/MWh
Gen 1 = 165 MW
Gen 2 = 10 MW
Dec. = 25 MW

Bus 2
LMP = $30/MWh
Gen 3 = 50 MW

Gen 2 has two step offer curve. First Step: 0 to 10 MW @ $0/MWh. Second Step: 10 to 200 MW @$25/MWh

Clearing Stability Restricted units in current Thermal Surrogate approach (Real Time Market)

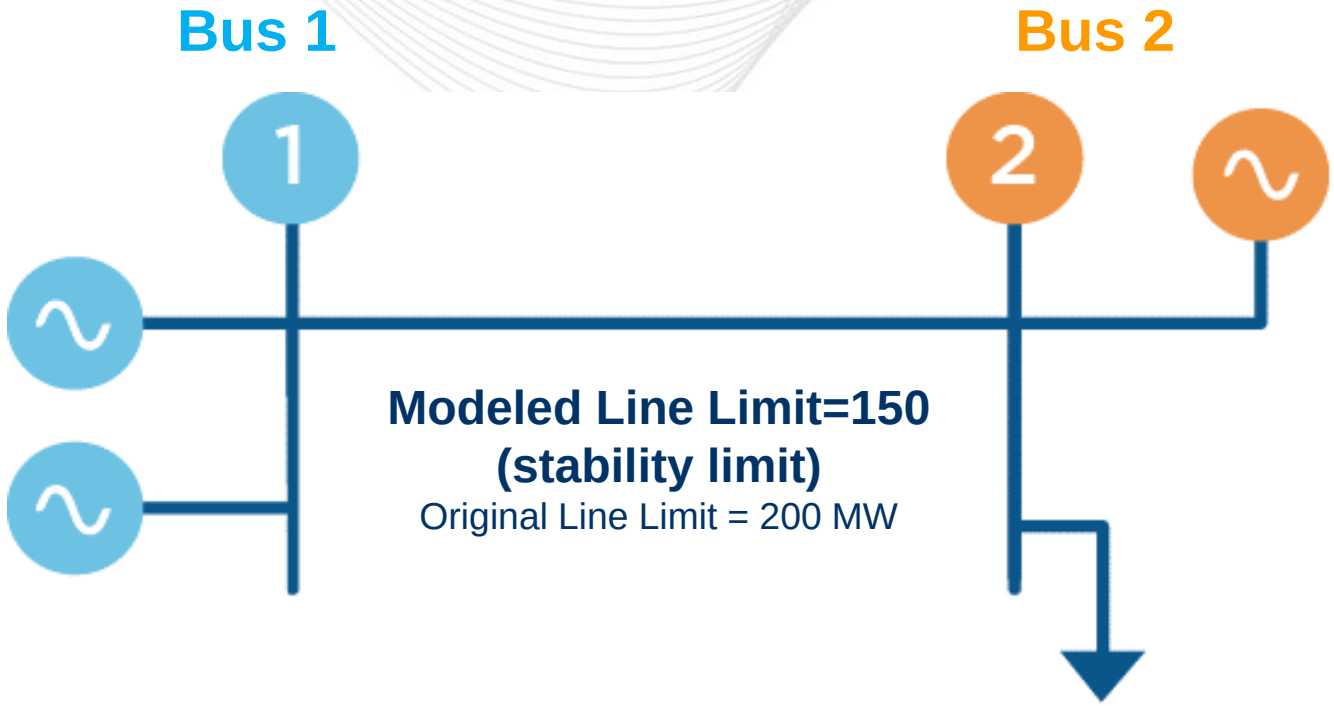
GEN 1
Offer = $20/MWh
EcoMax = 200 MW
EcoMin = 50 MW

GEN 2

Offer =	MW	$/MWh
	10	0
	200	25

EcoMax = 200 MW
EcoMin = 0 MW

Bus 1
LMP = $20/MWh
Gen 1 = 140 MW
Gen 2 = 10 MW

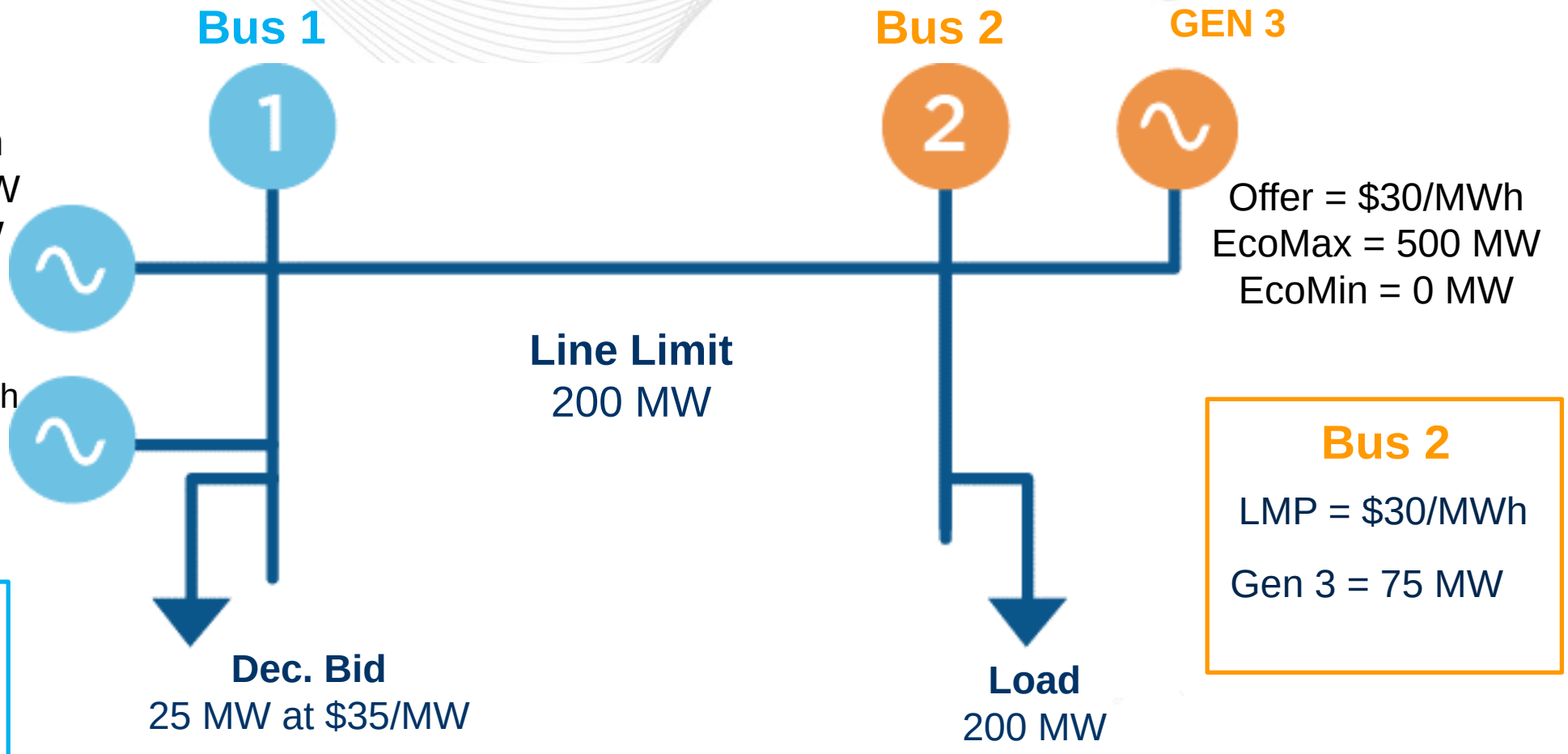


GEN 3
Offer = $30/MWh
EcoMax = 500 MW
EcoMin = 0 MW

Bus 2
LMP = $30/MWh
Gen 3 = 50 MW

Gen 2 has two step offer curve. First Step: 0 to 10 MW @ $0/MWh. Second Step: 10 to 200 MW @$25/MWh

Clearing Stability Restricted units with Dec in new approach (Day Ahead Market)



Generator Output Constraint: Gen 1 + Gen 2 <= 150 MW (the Stability Limit)

Gen 2 has two step offer curve. First Step: 0 to 10 MW @ $0/MWh. Second Step: 10 to 200 MW @$25/MWh

Clearing Stability Restricted units in new approach (Real-time Market)

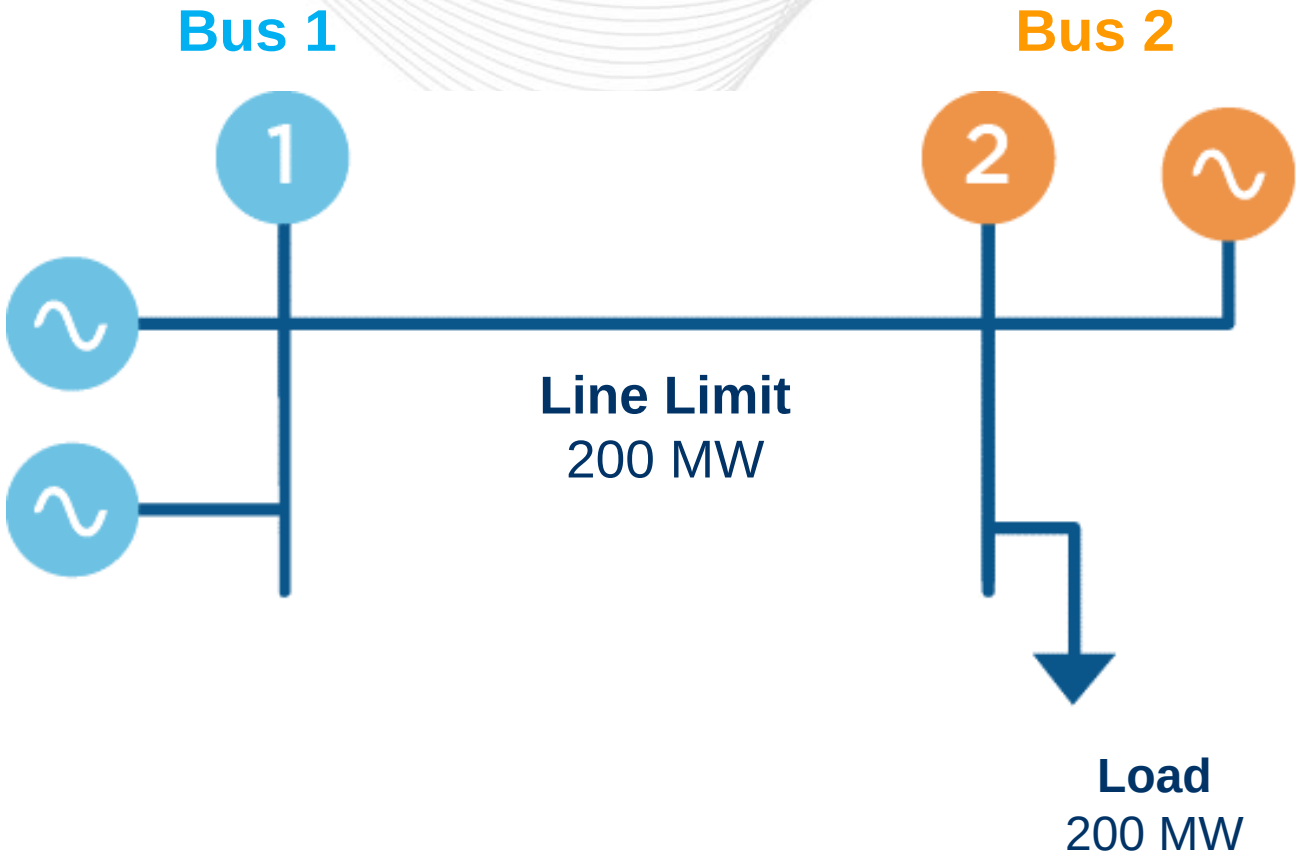
GEN 1
Offer = $20/MWh
EcoMax = 200 MW
EcoMin = 50 MW

GEN 2

Offer =	MW	$/MWh
	10	0
	200	25

EcoMax = 200 MW
EcoMin = 0 MW

Bus 1
LMP = $30/MWh
Gen 1 = 140 MW
Gen 2 = 10 MW



GEN 3
Offer = $30/MWh
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Bus 2
LMP = $30/MWh
Gen 3 = 50 MW

Generator Output Constraint: Gen 1 + Gen 2 <= 150 MW (the Stability Limit)

Gen 2 has two step offer curve. First Step: 0 to 10 MW @ $0/MWh. Second Step: 10 to 200 MW @$25/MWh

Key Take Always - Decrement Bids Example

Stability Restricted Units (150 MW Limit)	Thermal Surrogate Approach				Generator Constraint Approach				Offer Price ($/MWh)	EcoMin (MW)	EcoMax (MW)
	DA Cleared MW	DA LMP ($/MWh)	RT Cleared MW	RT LMP ($/MWh)	DA Cleared MW	DA LMP ($/MWh)	RT Cleared MW	RT LMP ($/MWh)			
Gen 1	165	20	140	20	140	30	140	30	20	50	200
Gen 2	10	20	10	20	10	30	10	30	25*	0	200

- Thermal Surrogate approach in Day Ahead & Real Time
  - May lead to day-ahead commitment of stability restricted units at an output level that is infeasible in real time; May lead to de-commitment of such resource in real time and corresponding eligibility for make whole payments.
  - Dispatch of stability restricted units are according to LMPs and offer curve.
- "Generator Constraint" approach in Day Ahead & Real Time
  - DA commitment of stability limited units is feasible in real time; hence no de-commitment of units in RT.
  - Dispatch of stability restricted units may not match the intersection of their offer curve and LMP.

*Gen 2 has two step offer curve. First Step: 0 to 10 MW @ $0/MWh. Second Step: 10 to 200 MW @$25/MWh

Impact of Options

	Status Quo 1 Parameter Reduction	Status Quo 2 Thermal Surrogate	Generator Constraint
LMP	No direct impact to LMP, unit LMP close to SMP (excluding other constraints)	Impacted, may impact non-related loads (higher or lower), generally lower LMP for stability limited units	No direct impact to LMP, unit LMP close to SMP (excluding other constraints)
Dispatch	Economically up to Parameter limit (eco max)	Adjusted thermal limit to control Stability limit, Security Constrained Economic Dispatch	Economically up to Stability limit (from TSA) LMP may not match incremental offer
Reserves / Regulation	Accurate accounting of reserves. Capacity above adjusted Eco Max will not be counted as reserves.	Capacity in excess of stability limit up to eco max may be inaccurately counted as reserves	Accurate accounting of reserves. Capacity in excess of stability limit will not be counted as reserves.
Virtual Bids	No impact from stability limit, bids can't cause the resource to be dispatched to an infeasible level	Virtual bids can cause stability limited resources to be dispatched to a level that is infeasible in RT	No impact from stability limit, bids can't cause the resource to be dispatched to an infeasible level
FTR Impacts	No impact	May impact funding: Thermal Surrogate for stability limitations not modeled in FTR	No impact

Apeendix

Clearing Stability Restricted units with Inc in current Thermal Surrogate approach (Day-ahead Market)

GEN 1
Offer = $20/MWh
EcoMax = 200 MW
EcoMin = 50 MW

GEN 2

Offer =	MW	$/MWh
	10	0
	200	25

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LMP = $20/MWh
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Clearing Stability Restricted units in current Thermal Surrogate approach (Real Time Market)

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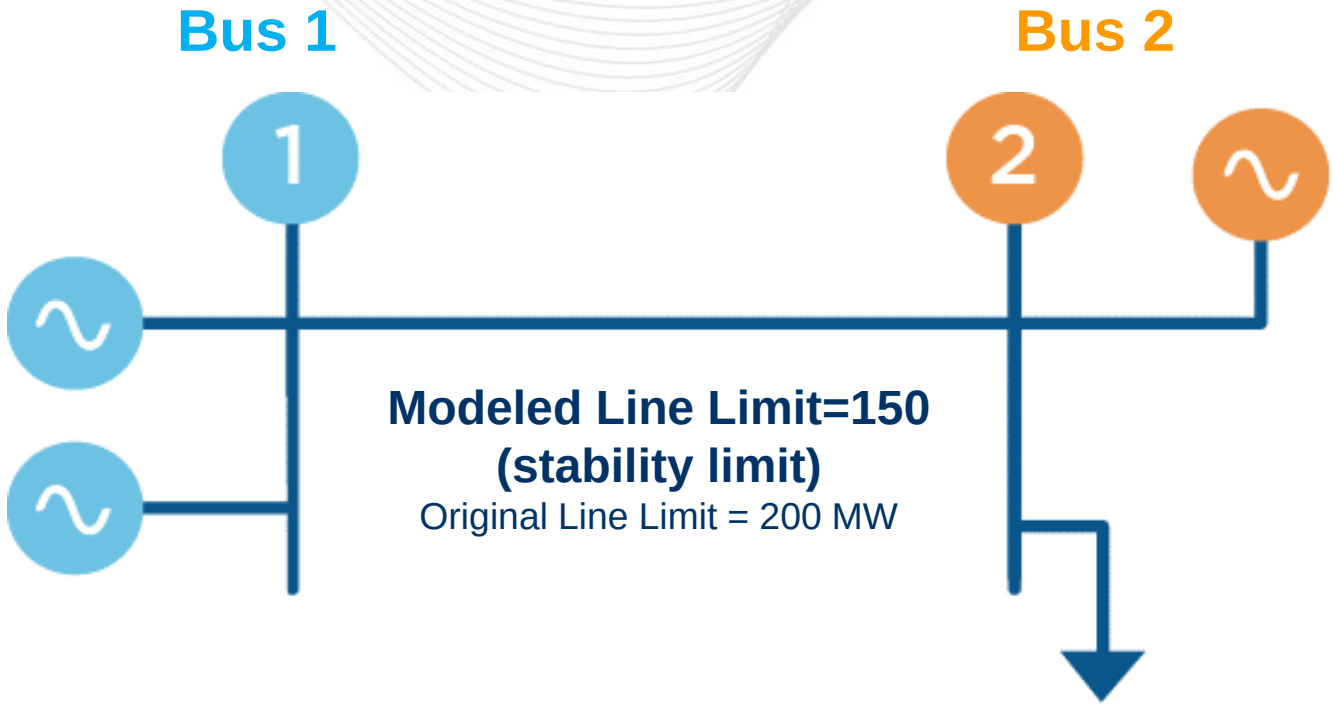

GEN 3
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Bus 2
LMP = $30/MWh
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Clearing Stability Restricted units with Inc in new approach (Day- ahead Market)

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EcoMax = 200 MW
EcoMin = 50 MW

GEN 2

Offer =	MW	$/MWh
	10	0
	200	25

EcoMax = 200 MW
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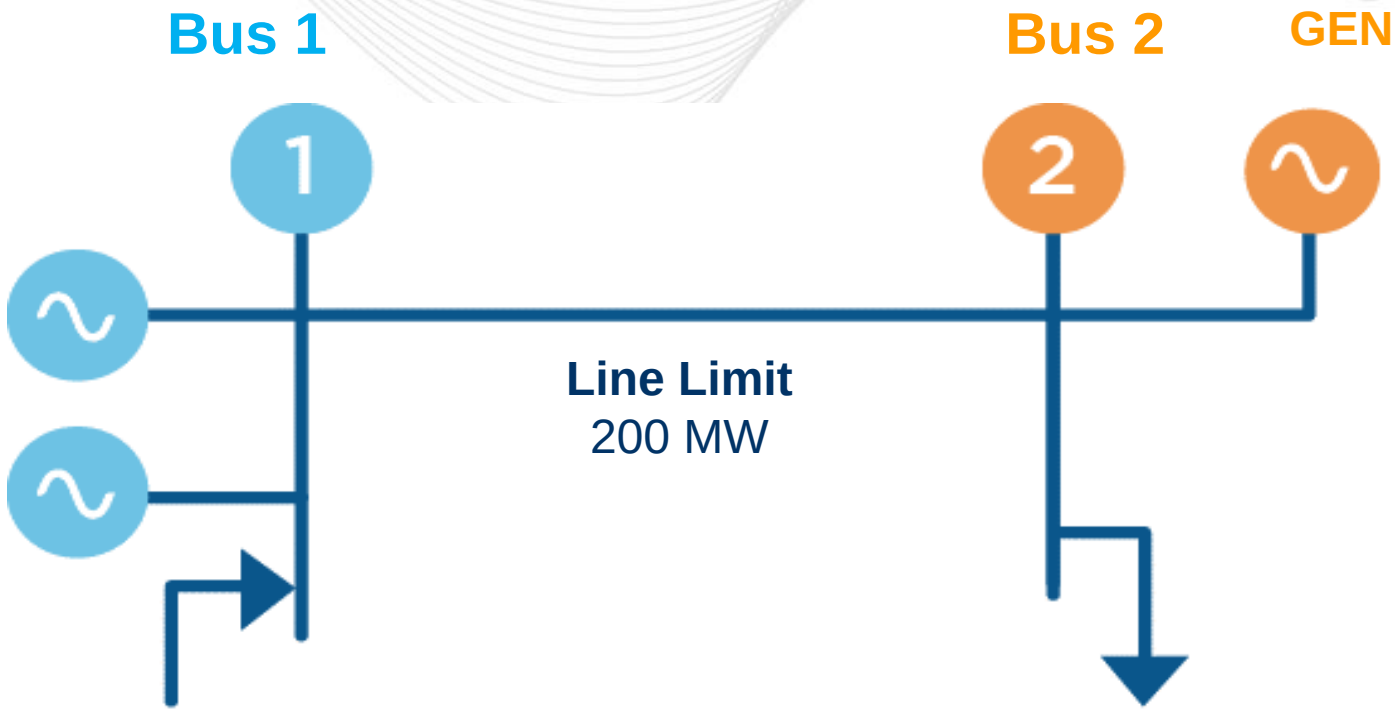

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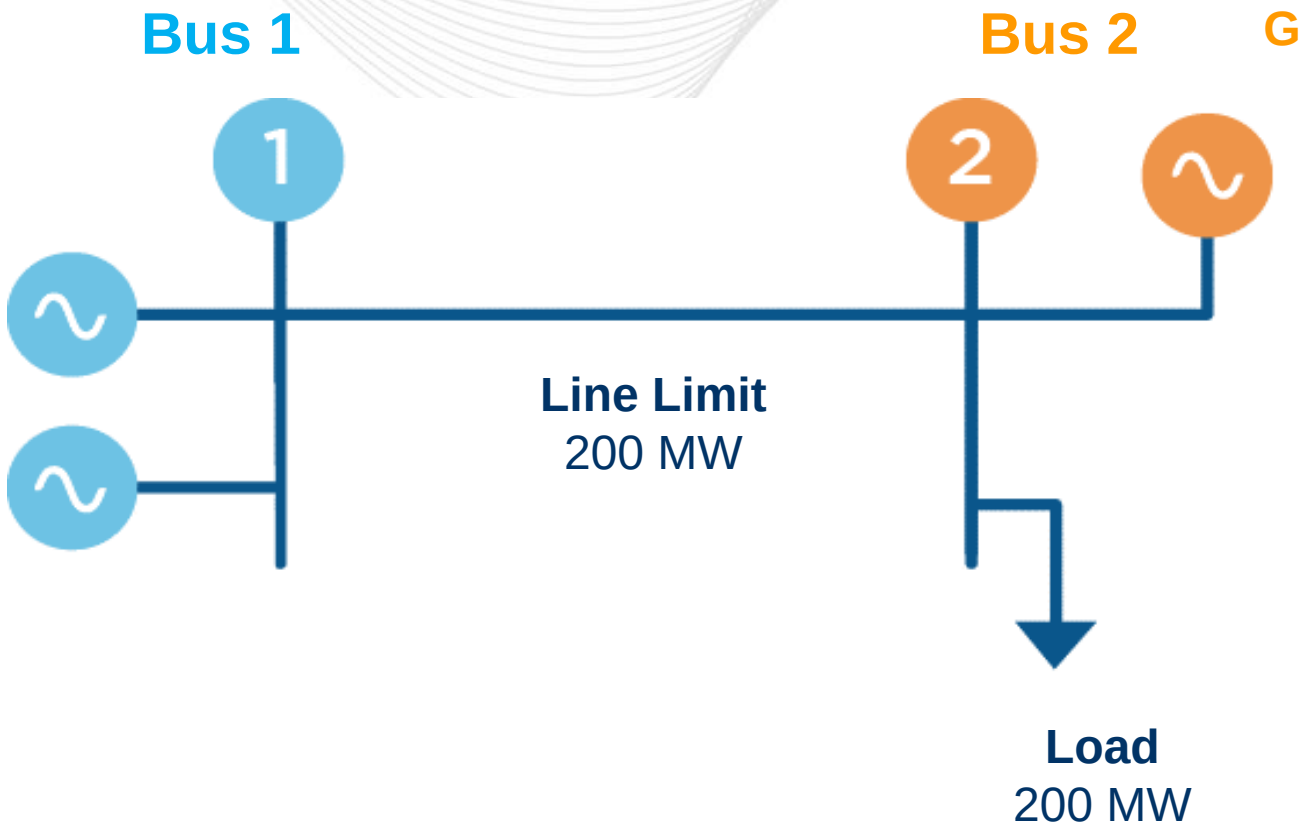

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