



Regulation Up/Down Introduction

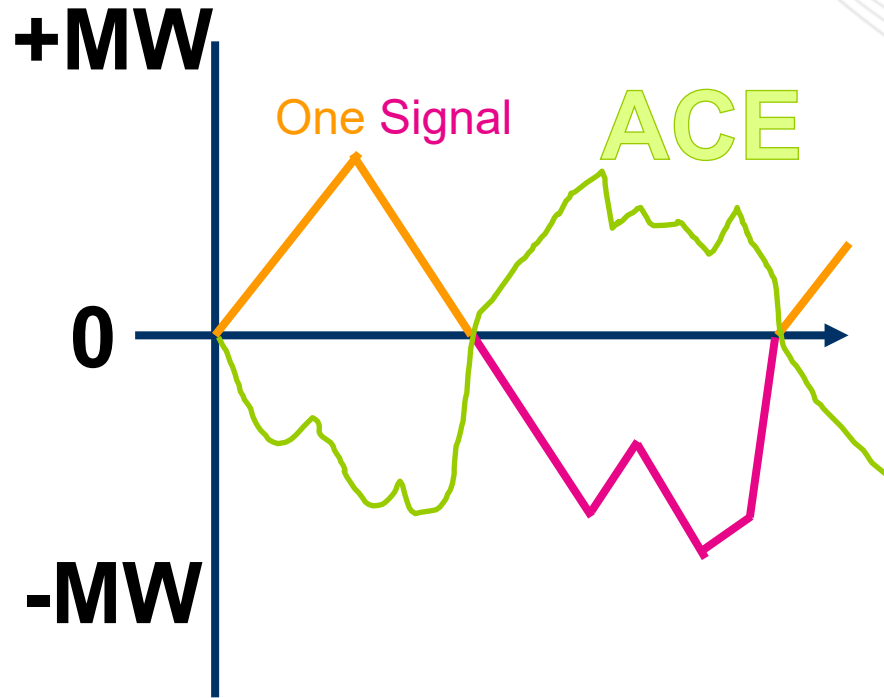
Zhenyu Fan

Real-Time Market Operations

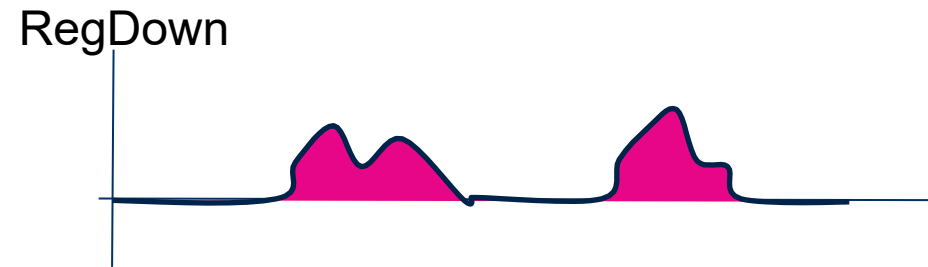
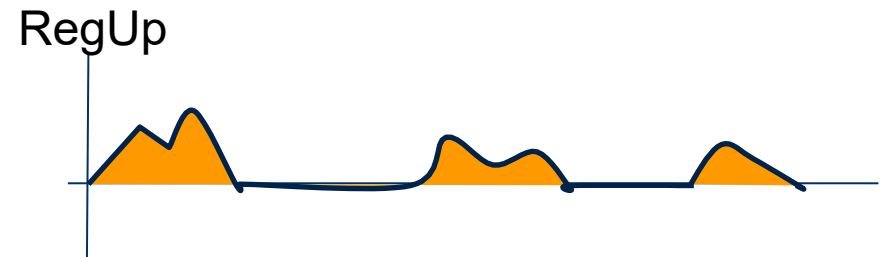
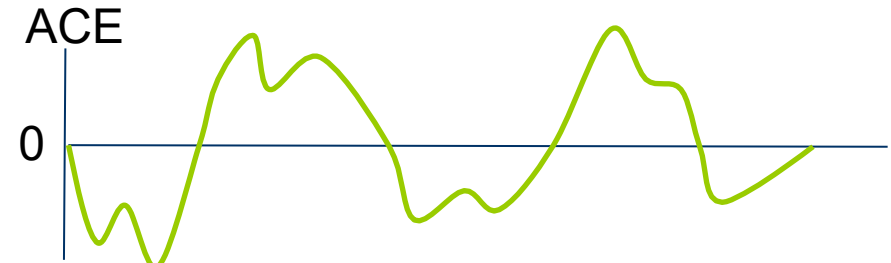
Regulation Market Design Senior Task Force

January 24, 2023

	PJM S.Q.	Reg Up/Down
Signal	2	1
Requirement	1	2 (can be the same)
Product	1	2
Clearing Price	1	2 (can be the same)
Commitment	ASO, one hour ahead	TBD
Deployment/Pricing	RT	RT

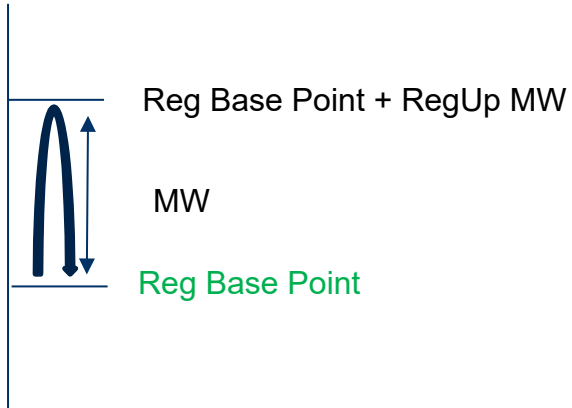


(Orange = RegUp, Pink = RegDown)

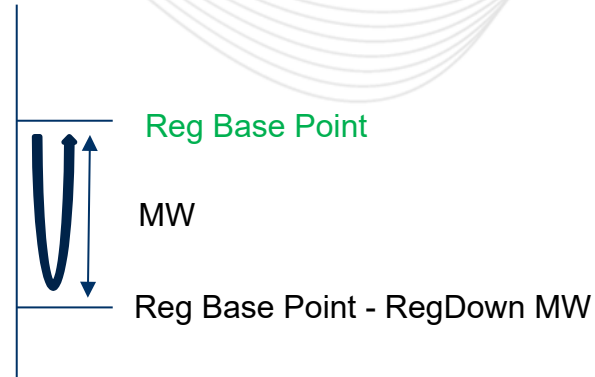


Regulation Up/Down Clearing – Flexibility/Variability

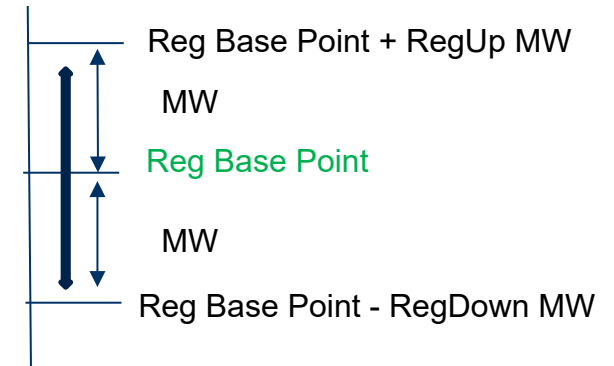
RegUp



RegDown

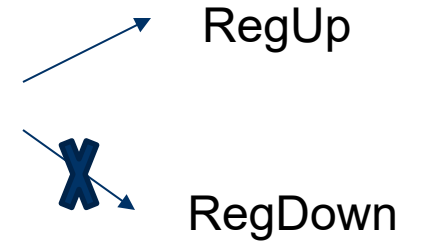


RegUp & RegDown

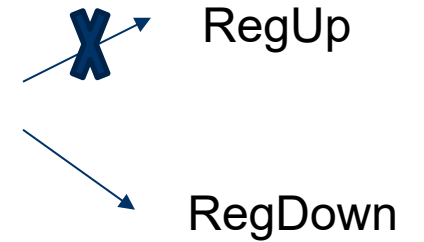


	RegUp	RegDown
Unit A	10 MW	0 MW
Unit B	0 MW	10 MW
Unit C (S.Q.)	10 MW	10 MW
Unit D	15 MW	5 MW

LOC: lower base point uneconomically



Uplift: raise base point uneconomically

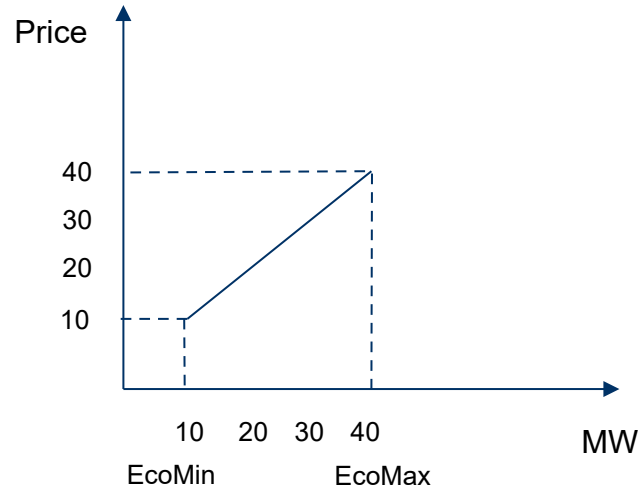


Directional Products



	RegUp	RegDown
LOC	Y	N/A
Uplift	N/A	Y

Reg MW = 10MW (Bi-Directional)



Eco range = Reg band

Scenario	LMP	Reg Base Point	LOC/Uplift
1	5	20	15
2	20	20	0
3	30	30	0
4	40	30	10
5	70	30	40

RegUp MW = RegDown MW = 10MW

Scenario	LMP	Reg Base Point	RegUp LOC	RegDown Uplift
1	5	20	0	15
2	20	20	0	0
3	30	30	0	0
4	40	30	10	0
5	70	30	40	0

Can it fulfil 20 MW requirement for both directions? No. But...



More Examples on LOC for Up and Down (same 20 MW work)

RegUpMW	15			
RegDownMW	5		RegUp	RegDown
Scenario	LMP	Reg Base Point	LOC	Uplift
1	5	15	0	10
2	20	20	0	0
3	30	25	5	0
4	40	25	15	0
5	70	25	45	0

RegUpMW	20			
RegDownMW	0		RegUp	RegDown
Scenario	LMP	Reg Base Point	LOC	Uplift
1	5	10	0	0
2	20	20	0	0
3	30	20	10	0
4	40	20	20	0
5	70	20	50	0

RegUpMW	5			
RegDownMW	15		RegUp	RegDown
Scenario	LMP	Reg Base Point	LOC	Uplift
1	5	25	0	20
2	20	25	0	5
3	30	30	0	0
4	40	35	5	0
5	70	35	35	0

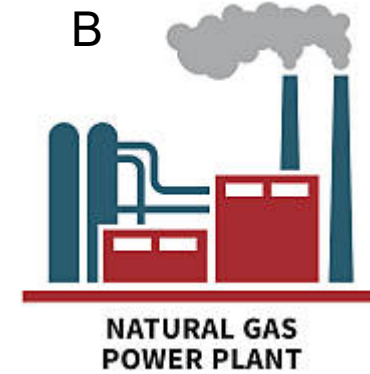
RegUpMW	0			
RegDownMW	20		RegUp	RegDown
Scenario	LMP	Reg Base Point	LOC	Uplift
1	5	30	0	25
2	20	30	0	10
3	30	30	0	0
4	40	40	0	0
5	70	40	0	0

Two Units Example (Bi-directional)

A	MW	Offer Price
EcoMin	10	10
	20	20
	30	30
EcoMax	40	40
Reg offer	15	0



B	MW	Offer Price
EcoMin	10	50
EcoMax	30	150
Reg offer	10	0



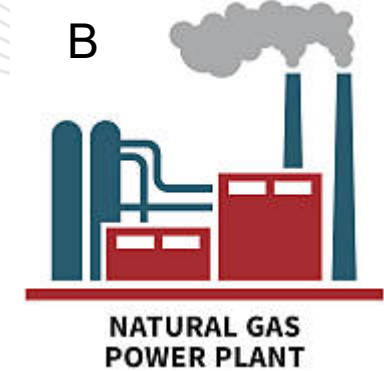
Scenario	Load	Reg Req	Energy (MW)		Reg (MW)		LOC (Price \$/MWh)		Total Production Cost (\$)
			A	B	A	B	A	B	
1	50	5	35	15	5	0	40	0	3950
2	50	20	30	20	10	10	70	0	6400

Two Units Example (Reg Up/Down)

A	MW	Offer Price
EcoMin	10	10
	20	20
	30	30
EcoMax	40	40
RegUp offer	30	0
RegDown offer	30	0



B	MW	Offer Price
EcoMin	10	50
Ecomax	30	150
RegUp offer	20	0
RegDown offer	20	0



Assume Requirement RegUp=RegDown

Scenario	Load(MW)	Reg Req(MW)	Energy (MW)		Reg Up (MW)		Up LOC (\$/MWh)		Reg Down (MW)		Down LOC (\$/MWh)		Total Production Cost (\$)
			A	B	A	B	A	B	A	B			
1	50	5	40	10	0	5	0	0	5	0	0	0	2500
2	50	20	40	10	0	20	0	0	20	0	0	0	2500



Compared with Bi-directional design:

- Less Energy Cost
- Less Regulation/LOC Cost

- Differentiate system needs – Different Up/Down Requirements
- Promote new market entry
- Provide flexibility of supply
- Potential decrease on system production cost, LOC and clearing price
- Potential implementation complexity in Operation and Market



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