Congestion Management at PJM ISO

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PJM Energy Market

- Pricing system is based on locational marginal pricing (LMP)
- LMP's reflect the marginal cost of supplying the next increment of electricity demand
- LMPs include opportunity cost of using the transmission system during congestion
- Participants pay congestion cost based on day-ahead market LMPs

Hedging for Congestion

- During congestion
  - Generation resources are dispatched out of economic merit order to control the the flow(s) on the congested facility(ies)
  - LMP spread can be significantly different
- Operating conditions & congestion are unknown until the last minute
- Financial Transmission Rights (FTR) provide a mechanism for hedging against congestion costs

Financial Transmission Right (FTR)

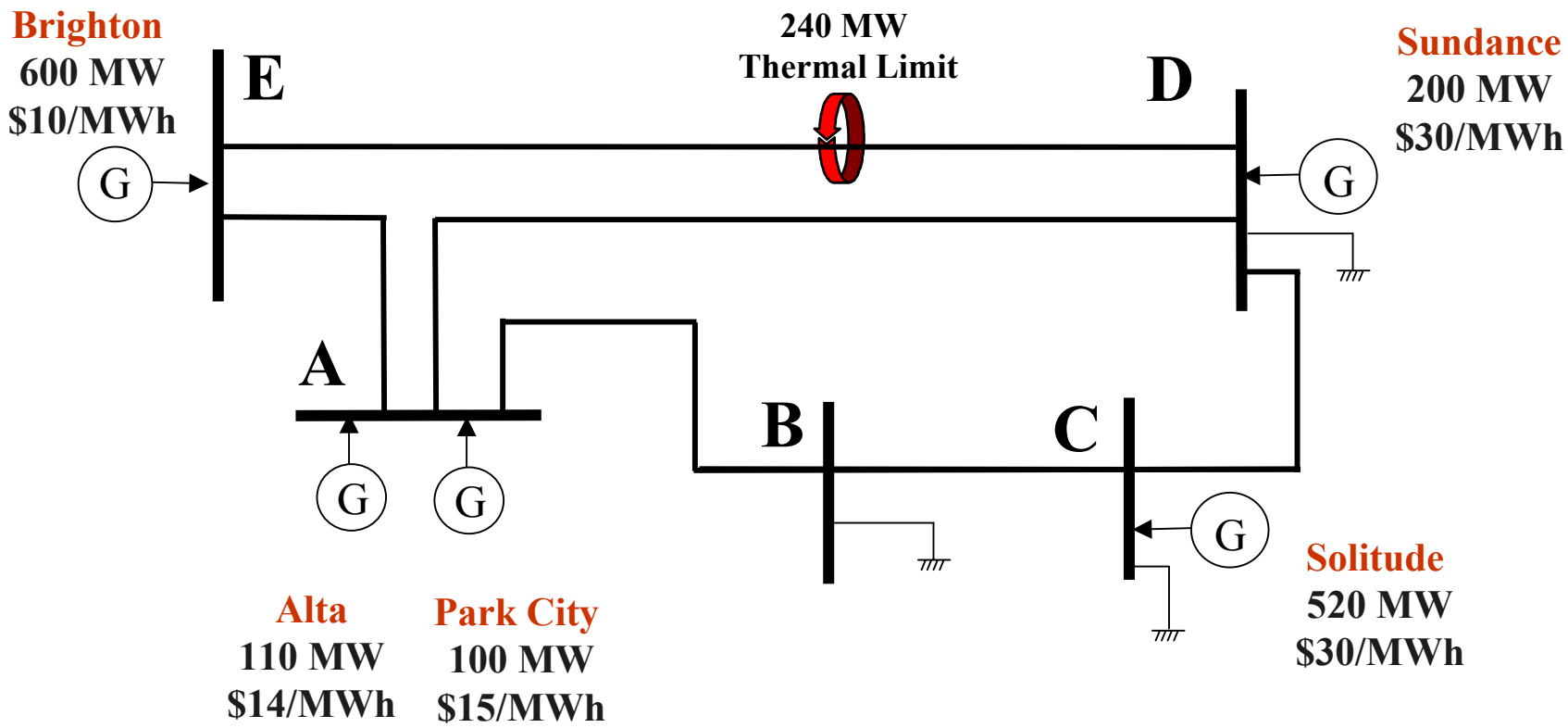
- An FTR is is defined from a point of receipt to a point of delivery
- FTRs can be designated to and from any single bus, hub, zone, aggregate or interface bus for which LMP values are calculated
- Economic value of an FTR is determined by
  - By the difference in the hourly LMP (day-ahead) values at its source and sink
  - By its MW reservation
  - Is independent of the actual energy delivery (thus, the terminology “Financial”)

Financial Transmission Right (FTR)

- An FTR (in PJM's current FTR Auction System)
  - can be a benefit (credit if in the direction of the congestion)
  - can be a liability (debit if in the opposite direction of the congestion)
- FTRs at PJM ISO can be (currently) acquired by
  - Network Integration Transmission Service
  - Firm Point-to-Point Service
  - Monthly FTR Auction
  - Secondary Market

5 Bus Example

From PJM FTR Auction Training Guide



Annual Commitments

Participant	Generation (MW)	Load (MW)	Fixed FTRs		
			Amount (MW)	Sink	Source
Generator Brighton	400 MW to LSE B 200 MW to LSE C		-	-	-
LSE B		400 from E	400	B	E
LSE C		150 from C 200 from E	- 200	- C	- E
LSE D		220 from C 130 from D 70 from A	220 - -	D - -	C - -
Generator Sundance	130 MW to LSE D		-	-	-
Generator Alta	70 MW to LSE D		70	D	A
Generator Solitude	220 MW to LSE D 150 MW to LSE C		-	-	-

Case 1: System Load = 669

No congestion (229MW flow over branch E – D)

Bus	Generator	MWh Available	Bid Price	Load (MW)	Actual Dispatch (MW)	LMPs
E	Brighton	600	$10/MWh	0	600	$14/MWh
A A	**Alta** Park City	**110** 100	**$14/MWh** $15/MWh	**0**	**69**	**$14/MWh**
C	Solitude	520	$30/MWh	223		$14/MWh
D	Sundance	200	$30/MWh	223		$14/MWh
B	-	-	-	223		$14/MWh

Case 2: System Load = 900

A: Transmission limits not enforced

B: Transmission limits enforced

Bus	Generator	MWh Available	Bid Price	Load (MW)	Actual Dispatch for A (MW)	LMPs for A	Actual Dispatch for B (MW)	LMPs for B
E	Brighton	600	$10/MWh	0	600	$30/MWh	600	$10.44/MWh
A A	Alta **Park City**	110 100	$14/MWh $15/MWh	0	110 100	$30/MWh	110 **67**	 **$15.00/MWh**
C	Solitude	520	$30/MWh	300		$30/MWh		$23.51/MWh
D	**Sundance**	200	$30/MWh	300	**90**	**$30/MWh**	**123**	**$30/MWh**
B	-	-	-	300		$30/MWh		$21.14/MWh

FTRs as a Hedging Mechanism

Cases / FTR Info	1	2 (with different FTR holding)		
		0 MW	200 MW	300 MW
Transaction	223 MW	300 MW		
LMP Difference	0. $/MW	10.70 $/MW (= 21.14 $/MW – 10.44$/MW)		
Generation Payment	$ 3122	$ 3132 (= 300 MWh * 10.44 $/MWh)		
Load Charge	$ 3122	$ 6342 (= 300 MWh * 21.14 $/MWh)		
Congestion Cost	$ 0.	$ 3210 (= 300 MWh * 10.70 $/MWh)		
FTR Credit	N/A	$ 0.	$ 2140.	$ 3210.
Final Balance	$ 0.	($ 3210.)	($ 1070.)	$ 0.

Monthly Auction Timeline

- 2 weeks prior to start of auction month
  - FTR requests for network source changes are suspended
  - Estimates of residual FTRs are posted
  - Participants start submitting bids
- 1 week prior to start of auction month
  - Auction closes
- Within 2 business days
  - PJM carries out the auction and posts results
- Beginning of auction month
  - Suspended FTR change requests start being processed

FTR Auction Solution

- Power flow
  - DC solution (losses are ignored)
  - PARs for regulating MW flow
- Contingency analysis
  - Using contingency ratings
- Simultaneous Feasibility Test
  - Enforcing the normal and contingency constraints (normal branch and post-contingency branch and interface ratings)
  - Ensuring the auction is revenue adequate
- Optimization
  - Security constrained optimization problem
  - Objective function maximizes the revenue

Monthly FTR Auction Example

Bid Number & Type	Amount (MW)	Price ($/MW)	Source Number	Sink Number
Buy	40	5.00	A	D
Buy	10	4.00	E	B
Buy	10	4.00	A	D
Buy	10	4.00	E	C
Sell	10	2.00	E	C
Sell	10	6.00	A	D

Auction Results

Bid Number & Type	Amount (MW)	Price ($/MW)	Source Number/LMP	Sink Number/LMP	Clearing Price LMP Δ	Cleared FTR (MW)
Buy	40	5.00	A/ $1.52/MW	D / $6.52/MW	$5.00/MW	28.1
Buy	10	4.00	E/ $0.00/MW	B/ $ 3.57/MW	$3.57/MW	10.0
Buy	10	4.00	A/ $1.52/MW	D / $6.52/MW	$5.00/MW	0.0
Buy	10	4.00	E/ $0.00/MW	C/ $4.35/MW	$4.35/MW	0.0
Sell	10	2.00	E/ $0.00/MW	C/ $4.35/MW	$4.35/MW	10.0
Sell	10	6.00	A/ $1.52/MW	D / $6.52/MW	$5.00/MW	0.0

Analysis of Output

Bid Number & Type	Amount (MW)	Price ($/MW)	Source Number/LMP	Sink Number/LMP	Clearing Price LMP Δ	Cleared FTR (MW)
Buy	**40**	**5.00**	**A/ $1.52/MW**	**D / $6.52/MW**	**$5.00/MW**	**28.1**
Buy	10	4.00	E/ $0.00/MW	B/ $ 3.57/MW	$3.57/MW	10.0
Buy	10	4.00	A/ $1.52/MW	D / $6.52/MW	$5.00/MW	0.0

- Marginal FTR BID (Amount Paid = $140.5 = 28.1 * 5.0)
- Questions :
  - Was there a bid price at which we could get all the MW we bid for?
  - How much could we reduce the bid price and retain the same amount of MW?
- For analysis :
  - Vary the bid price and re-run the auction

Analysis of Output

Bid Number & Type	Amount (MW)	Price ($/MW)	Source Number/LMP	Sink Number/LMP	Clearing Price LMP Δ	Cleared FTR (MW)
Buy	40	5.00	A/ $1.52/MW	D / $6.52/MW	$5.00/MW	28.1
Buy	**10**	**4.00**	**E/ $0.00/MW**	**B/ $ 3.57/MW**	**$3.57/MW**	**10.0**
Buy	10	4.00	A/ $1.52/MW	D / $6.52/MW	$5.00/MW	0.0
Buy	10	4.00	E/ $0.00/MW	C/ $4.35/MW	$4.35/MW	0.0

- Successful FTR Bid (Amount Paid = $35.7 = 10. * 3.57)
- Questions :
  - How much more MWs could we bought at the same clearing price?
- For analysis :
  - Set the bid price to clearing price, the MW amount to a large value and re-run the auction

Analysis of Output

- Identifying attractive paths with low market activity
  - Compare the marginal prices of all injections and withdrawals
- Identifying constraints that have the largest impact upon the prices
  - Locational marginal price breakdown by congested facilities
- Analysis of unsuccessful bids
  - How much more should we have bid?

Nexant's GridSmart

- Analytical tools via the Internet
  - Load Forecasting tool (All major ISO Regions)
  - FTR Tool (Simulation Tool for PJM's FTR Auction)
- Powered by well-proven technologies
  - Extensive energy industry expertise world-wide
  - Proprietary software used by ISOs and utilities
- ASP model
  - Managed data collection, cleansing and maintenance
  - Centralized hosting & management
  - Tool, functionality and technology update
  - Elimination of expensive in-house expertise

Nexant's GridSmart

- Input data that require real-time and/or frequent updates
- Comprehensive and consistent data
- Preparation of large amount of data of different origin, format, etc.
- Fast and smart what-if analysis
- Output analysis and hand-holding by engineers and/or consultants

Next Generation FTR Auction System @ PJM

- Two types of FTRs
  - Obligation (as it exists today)
  - Options - Its hourly economic value is zero when the designated path is in the direction opposite to the congested flow
- New mechanism for acquiring FTRs
  - Annual auction
  - Monthly auction
  - Second market

Next Generation FTR Auction System @ PJM

- New mechanisms for awarding FTRs
  - Multi-period : multiple base-cases across a single optimization timeframe
    - 24 Hour, on-peak, off-peak
    - separate time intervals - summer, winter
  - Multi-round (4 rounds)
    - 25% of the feasible FTR capability of the PJM system will be awarded
- Auction Revenue Rights (ARRs): the mechanism to distribute the proceeds of the Annual FTR Auction to Load Serving Entities and to Firm Transmission customers