Dispatch Signal & Locational Marginal Pricing (LMP)

PJM State & Member Training Dept.

Objectives

Students will be able to:

- Identify how PJM dispatches & utilizes LMP

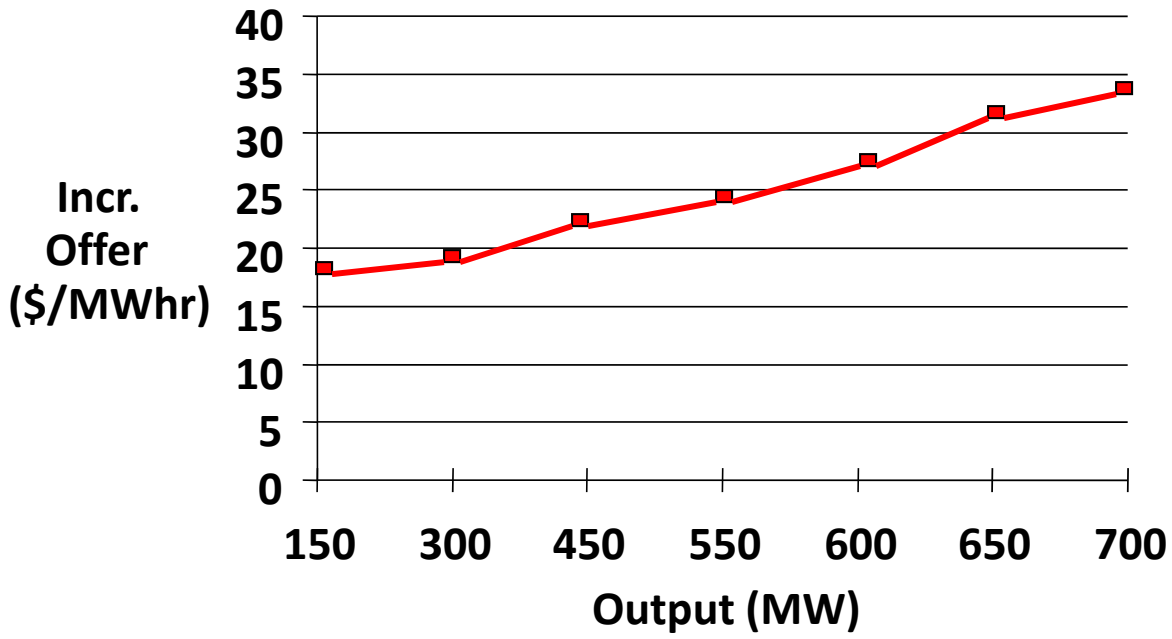
Dispatch Rate

- Economic control signal is called Dispatch Rate ($/MWh) or Economic Basepoint (MW)
- Moves operating point of generating unit to change MW output to assist ACE in returning to zero

    - If ACE<0, signal increases
    - If ACE>0, signal decreases

Incremental Offer Curve

Output	Offer
150	18.0
300	19.7
450	22.5
550	24.1
600	27.3
650	31.0
700	34.5



System Incremental Curve

Control Signal

$/MW

HR	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7	Unit 8	Unit 9	Total
20.0	20	20								150
21.0	33	35								178
22.0	57	58		20				20		225
23.0	77	79		36				21		283
24.0	96	98	14	48				38		350
25.0	108	109	81	60				48		462
26.0	119	120	159	73				58		585
27.0	126	126	222	82			12	65	20	677
28.0	132	132	274	89		12	17	71	31	770
29.0	135		312	95	12	22	27	77	41	853
30.0			348	101	14	31	34		49	921
31.0			375		22	38	40		57	977
32.0			398		31	42	44		63	1023

Load Demand = 853 MW
Dispatch Rate= $29/MWh

Computing the Dispatch Rate

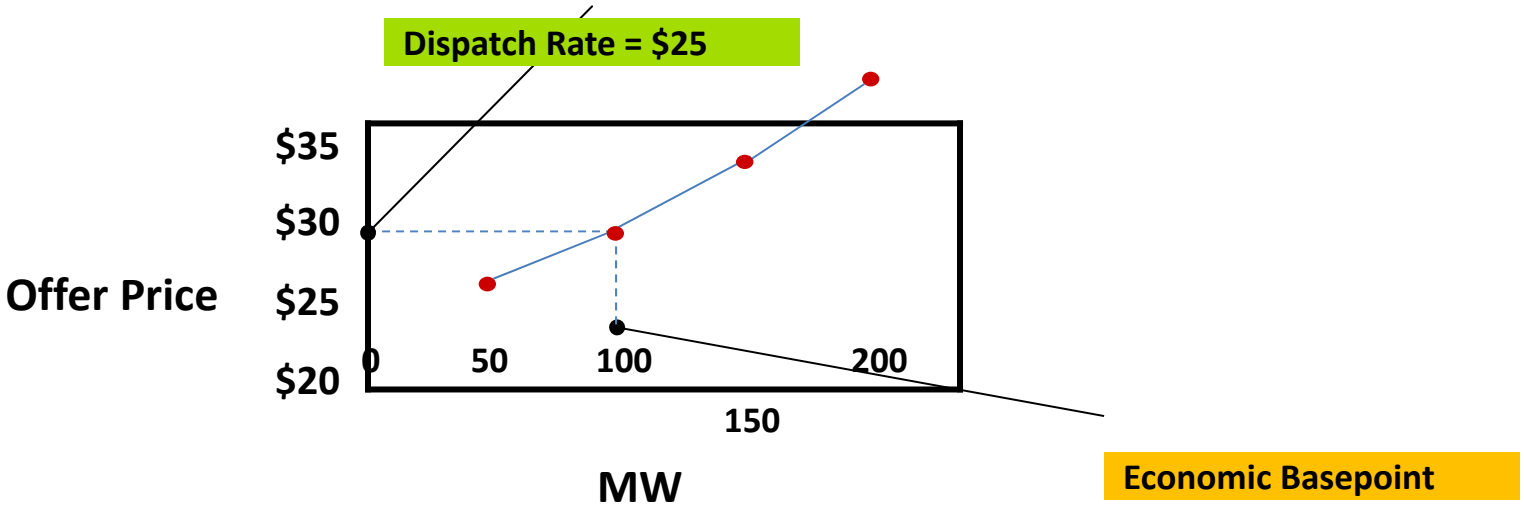
Definition: The **Dispatch Rate** is expressed in dollars per MWh, calculated and transmitted to each generator to direct the output level of all generation resources dispatched by PJM based on the incremental offer data which was previously received from the Generators

Generation Offers

Generating Unit # 1	Generating Unit # 2
Offer Price = $ 10.00 ----- 200 MW	Offer Price = $ 15.00 ----- 220 MW
$ 20.00 ----- 300 MW	$ 22.00 ----- 310 MW
$ 30.00 ----- 400 MW	$ 32.00 ----- 425 MW
$ 40.00 ----- 500 MW	$ 41.00 ----- 500 MW
$ 50.00 ----- 600 MW	$ 54.00 ----- 600 MW

Economic Basepoint

- The **Economic Basepoint** is the MW value sent to the generating unit that indicates to what level the unit should be loaded based on the economic dispatch solution and the units incremental price curve



Out of Merit Operation (Off Cost)

Dispatch Signal

$/MW

hr	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7	Unit 8	Unit 9	TOTAL
26.0	119	120	159	73				58		585
27.0	126	126	222	82			12	65	20	677
28.0	132	132	274	89		12	17	71	31	770
29.0	135		312	95	12	22	27	77	41	853
30.0			348	101	14	31	34		49	921
31.0			375		22	38	40		57	977

Load Demand = 853 MW
Zonal Dispatch Rate = $29/MWh

Manual Dispatch

Manual Dispatch

What is Manual Dispatch?

- Manual dispatch is when PJM has to take steps to manually determine which resource should be used to help resolve a constraint on the system
- Manual dispatch is used after all economic resources have been have been exhausted

Manual Dispatch

How does PJM perform Manual Dispatch?

- PJM must identify the amount of relief needed to resolve the constraint
- PJM uses a report from the PJM EMS to determine which resources would be effective in resolving the constraint
- PJM will contact the required resources and request the curtailment
- PJM will continually assess the constraint and make any necessary changes

LMP Basics

What is LMP?

- Locational Marginal Price

- Pricing method PJM uses to:
  - price energy purchases and sales in PJM Market
  - price transmission congestion costs to move energy within PJM RTO
  - price losses on the bulk power system

- Physical, flow-based pricing system:
  - how energy actually flows, NOT contract paths

How does PJM Use LMP?

- Generators get paid at generation bus LMP
- Loads pay at load bus LMP
- Transactions pay differential in source and sink LMP

Economic Dispatch Exercise

MW
$20

Capacity
200 MWs

Not Dispatched

MW
$15

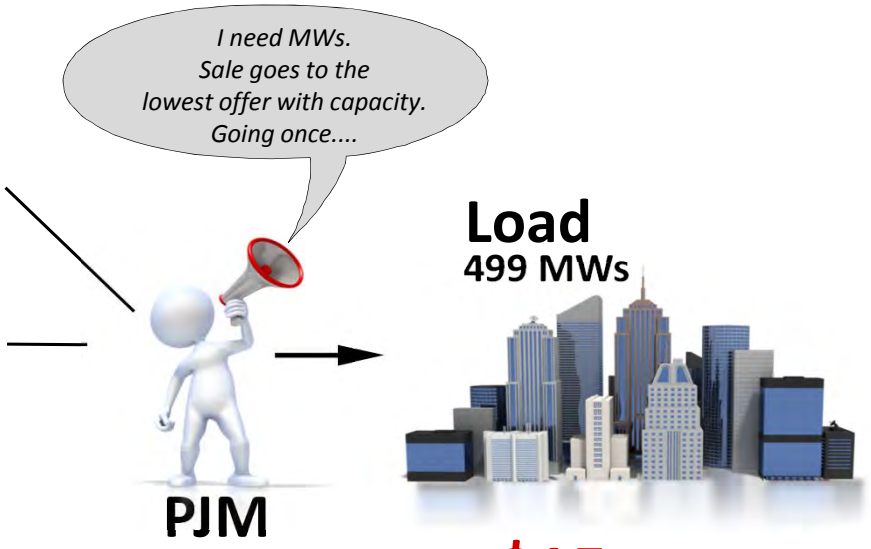
Capacity
200 MWs

199 MWs @ $15

MW
$10

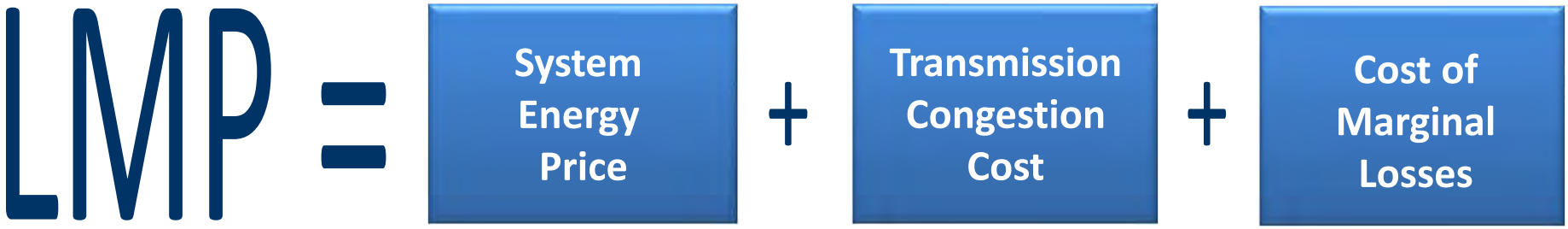
Capacity
300 MWs

300 MWs @ $10



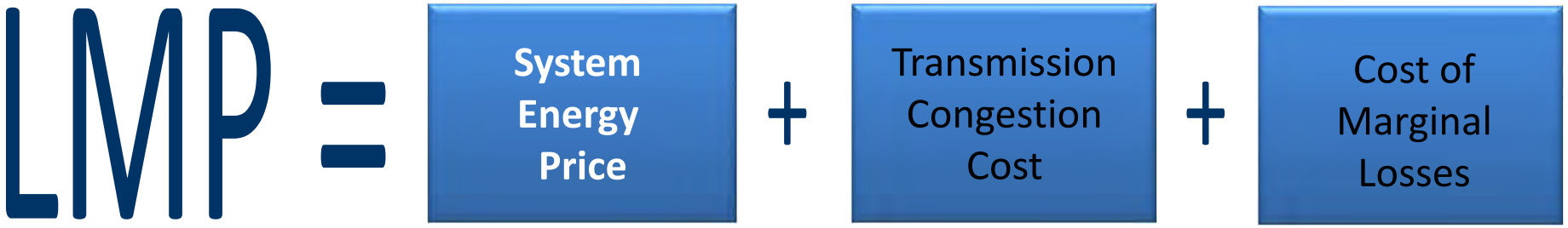
***LMP* = $15**

Locational Marginal Price



LMP is made up of 3 independent components

LMP Components - System Energy Price



☑ System Energy Price

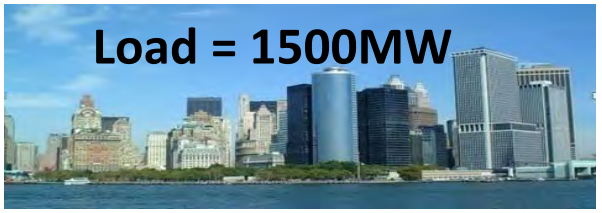
- Represents optimal dispatch ignoring congestion and losses
- Same price for every bus in PJM
- Calculated both in day ahead and real time

LMP Components - System Energy Price

Installed = 2,000 MW

Dispatch 1500 MW

Transmission path



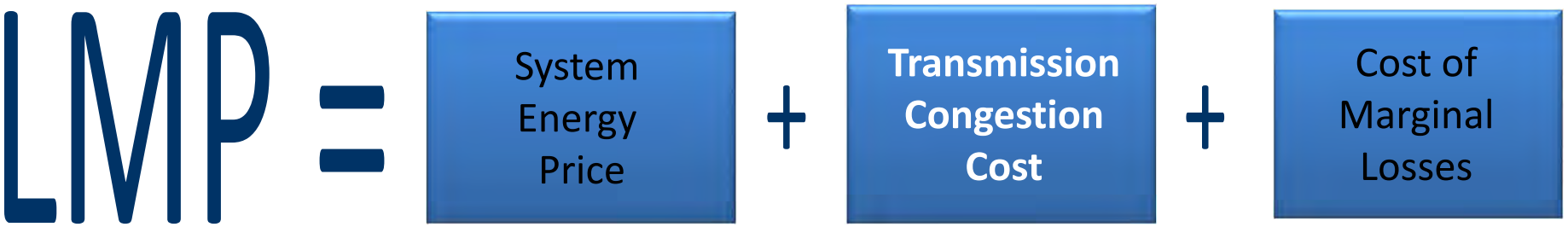
System Energy Price = $20
Congestion =
Losses =
LMP = $20

Installed = 700 MW

System Energy Price = $20
Congestion =
Losses =
LMP= $20

Note: *ignoring losses and congestion*

LMP Components - Congestion



☑ Congestion Price

- Represents price of congestion for binding constraints
  - Calculated using cost of marginal units controlling constraints and sensitivity factors on each bus
- Will be zero if no constraints
  - Will vary by location if system is constrained
- Calculated both in day ahead and real time

LMP Components - Congestion

System Energy Price =	$20
Congestion =	$30
Losses =	
LMP=	$50

Installed = 2,000 MW

Dispatch 1000 MW

Flow = 1000 MW

Limit = 1000 MW

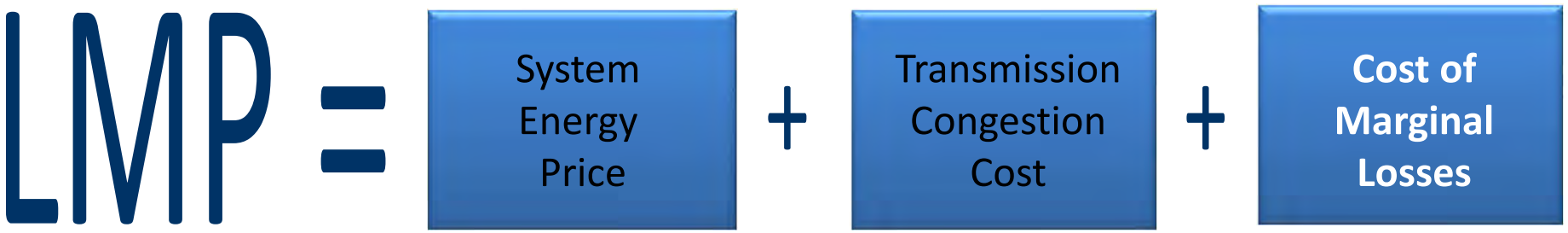
System Energy Price =	$20
Congestion =	$ 0
Losses =	
LMP =	$20

Dispatch 500 MW

Installed = 700 MW

Note: *ignoring losses*

LMP Components - Marginal Losses

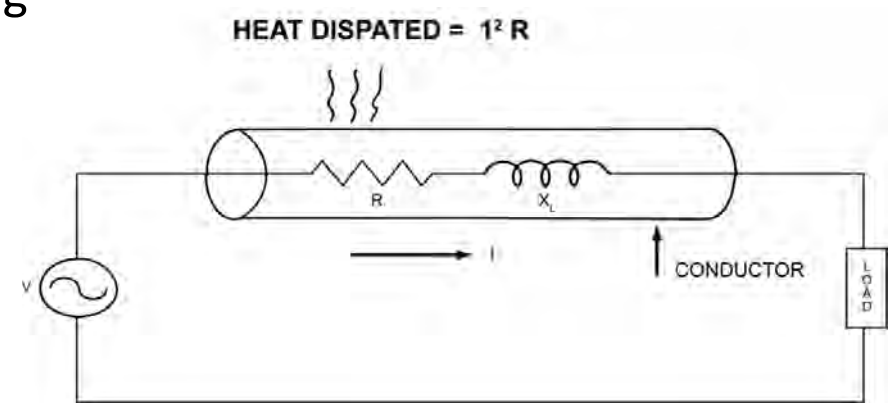


☑ Loss Price

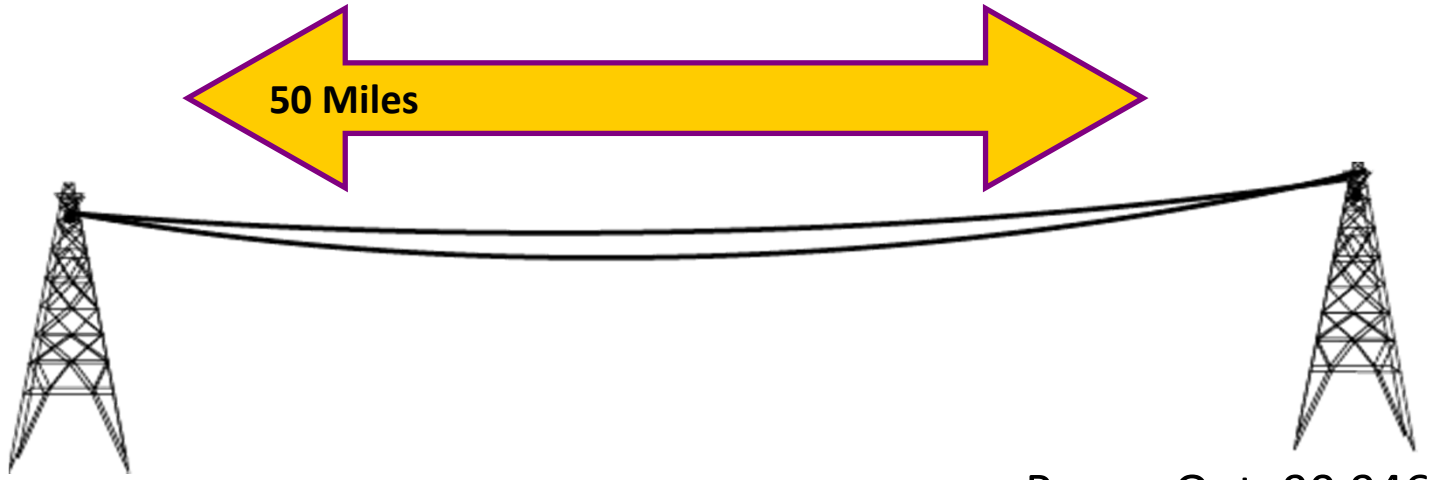
- Represents price of marginal losses
  - Calculated using penalty factors
  - Will vary by location
- Calculated both in day-ahead and real-time

Transmission Losses

- Real Power (MW) Losses
  - Power flow converted to heat in transmission equipment
  - Heat produced by current (I) flowing through resistance (R)
  - Losses equal to I2R
  - Heat loss sets the “thermal rating” of equipment
- Losses increase with:
  - Lower voltage
  - Longer lines
  - Higher current



Transmission Losses



Power In: 100 MW

Voltage In: 235 KV

Current In: 425.53 A

Power Out: 90.946 MW

Power Loss: 9.054 MW

Voltage out: 213.72 KV

Current Out: 425.53 A

LMP Components Marginal Losses

System Energy Price =	$20
Congestion =	$30
Losses =	$ 2
LMP=	$52

Installed = 2,000 MW

Dispatch 1010 MW

Flow = 1000 MW

Limit = 1000 MW

System Energy Price =	$20
Congestion =	$ 0
Losses =	($ 1)
LMP =	$19

Dispatch 520 MW

Installed = 700 MW

Note: *assume 2% (30mw) losses – allocation of losses in this example are theoretical*
Losses on a real system are optimized based on system topology

Questions?