PJM Markets 201

Production Cost Simulation

PJM State & Member Training Dept.

Objectives

Student will be able to:

- Evaluate operating parameter impacts through simulation using PJM's market optimization software
  - Interpret LMP components and draw conclusions regarding system performance
  - Apply generator operating parameters and estimate their impact on SCUC and SCED
  - Deduce the cause for units not being selected by the optimization

Simulation Environment

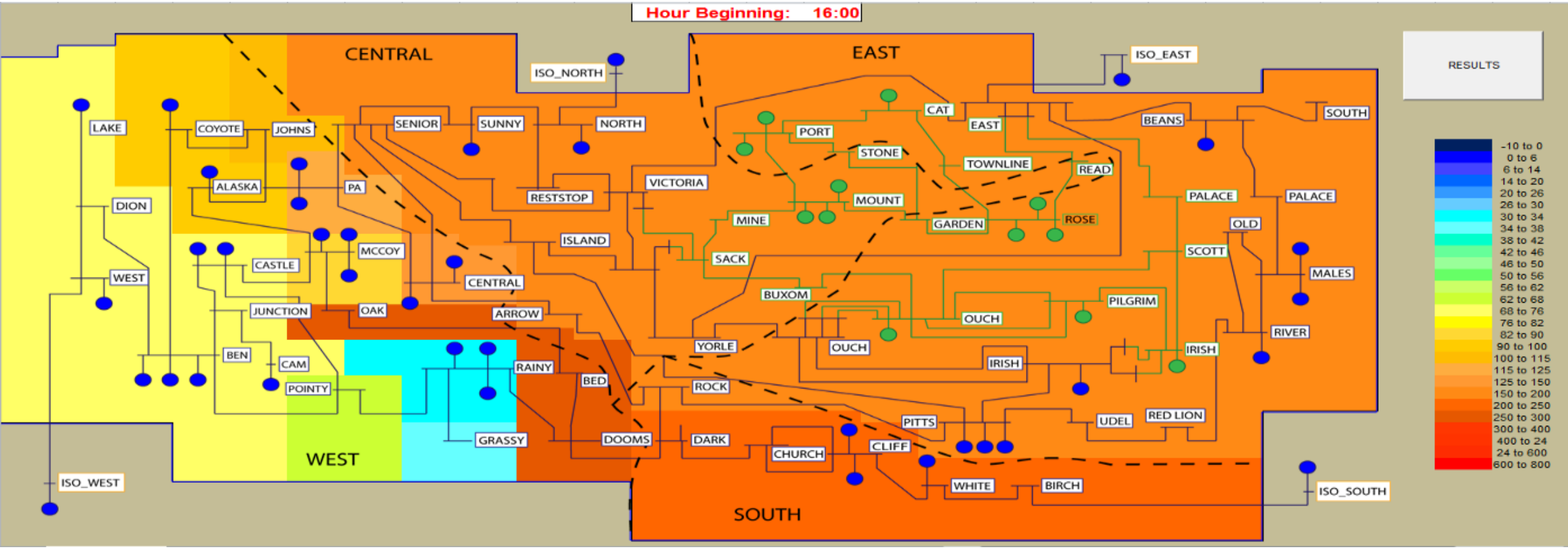
- Fictitious 64-bus market
- 6 Generation Operating Companies
  - Various generation types

What Are We Looking For?

- Draw conclusions about units based on LMP components
  - Effect on constraints
  - Contribution to marginal losses
- Investigate drivers for Day-Ahead Commitment
  - Why wasn't a unit picked up?
  - What characteristic can be modified to lower unit production costs?

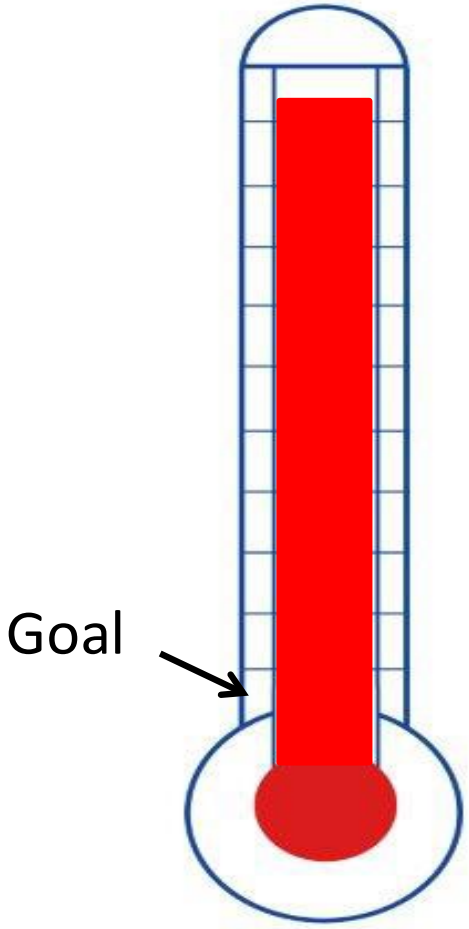
- How small unit parameter changes impact RTO Production Costs

System Contour Map



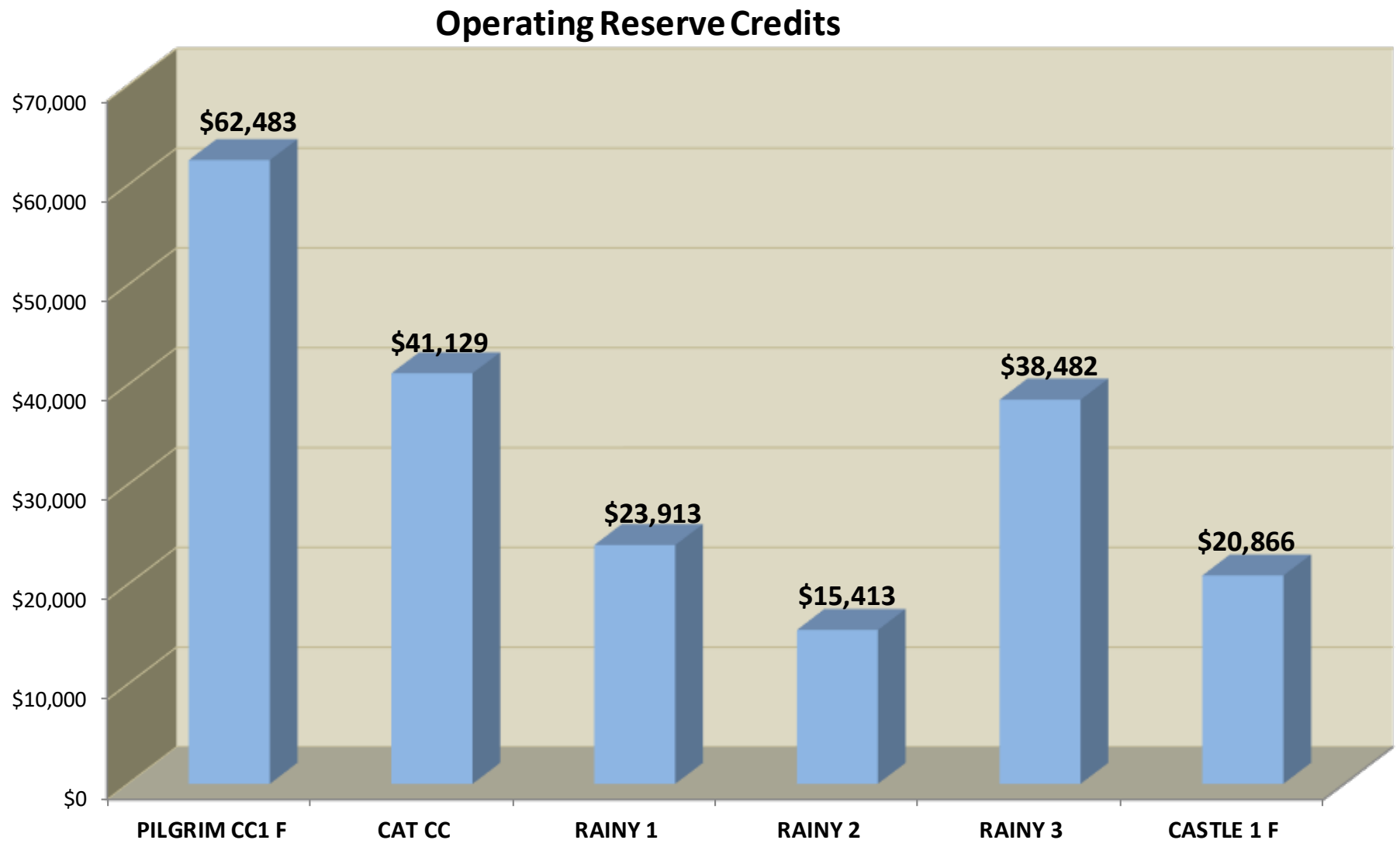
Base Case One: Pilgrim CC 1

Base Case System Bid Production Cost = $10,761,371



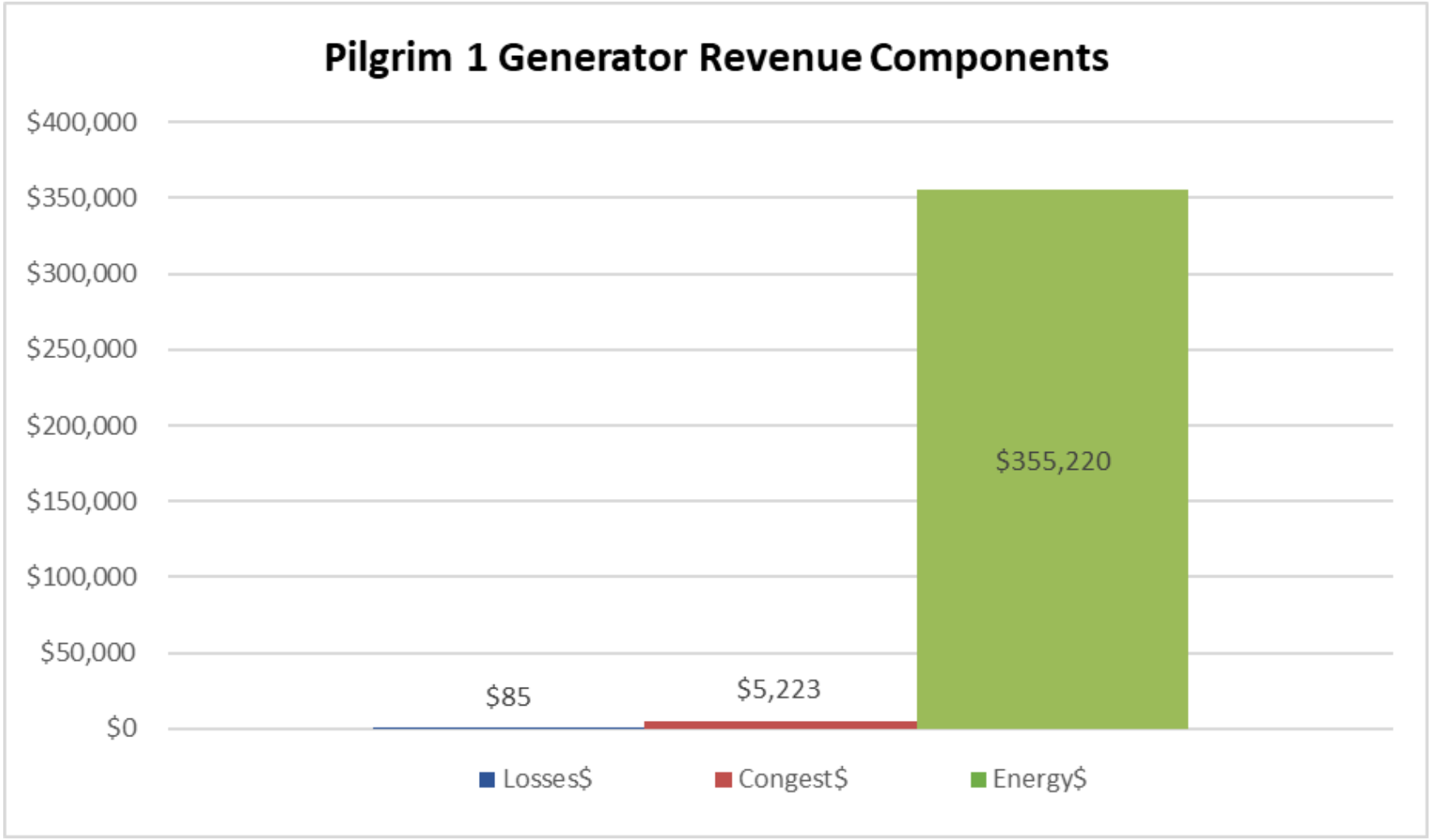
PJM Markets Objective Function
Minimize Total Production Cost

System Bid Production Cost = $10,761,371



LMP Components

Is Pilgrim 1 upstream or downstream from the constraint? Close or distant to the load center?



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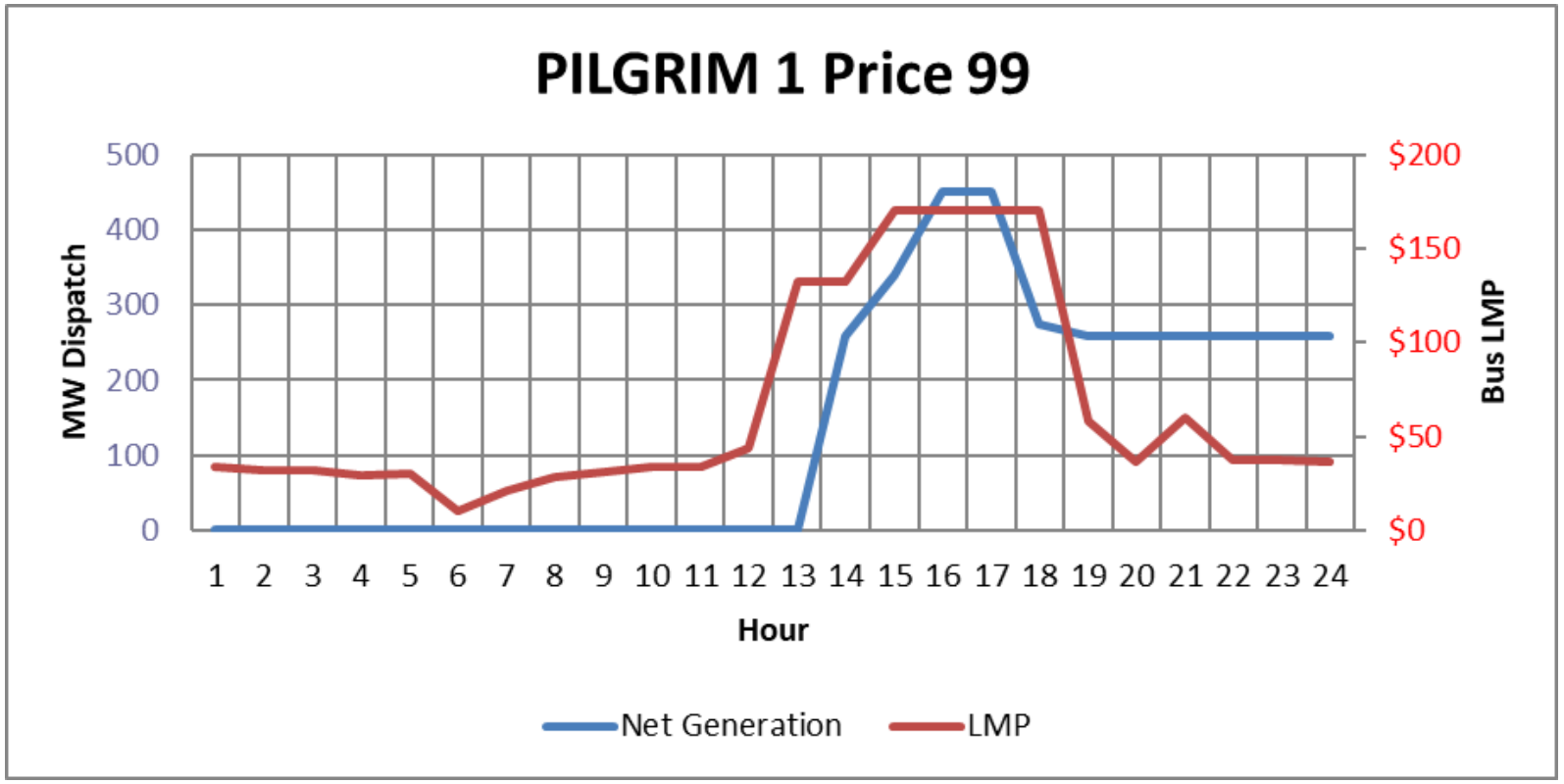
Pilgrim 1 Price 99 Schedule

The time is currently 2200. Should Pilgrim 1 be running?
Why is the unit running?

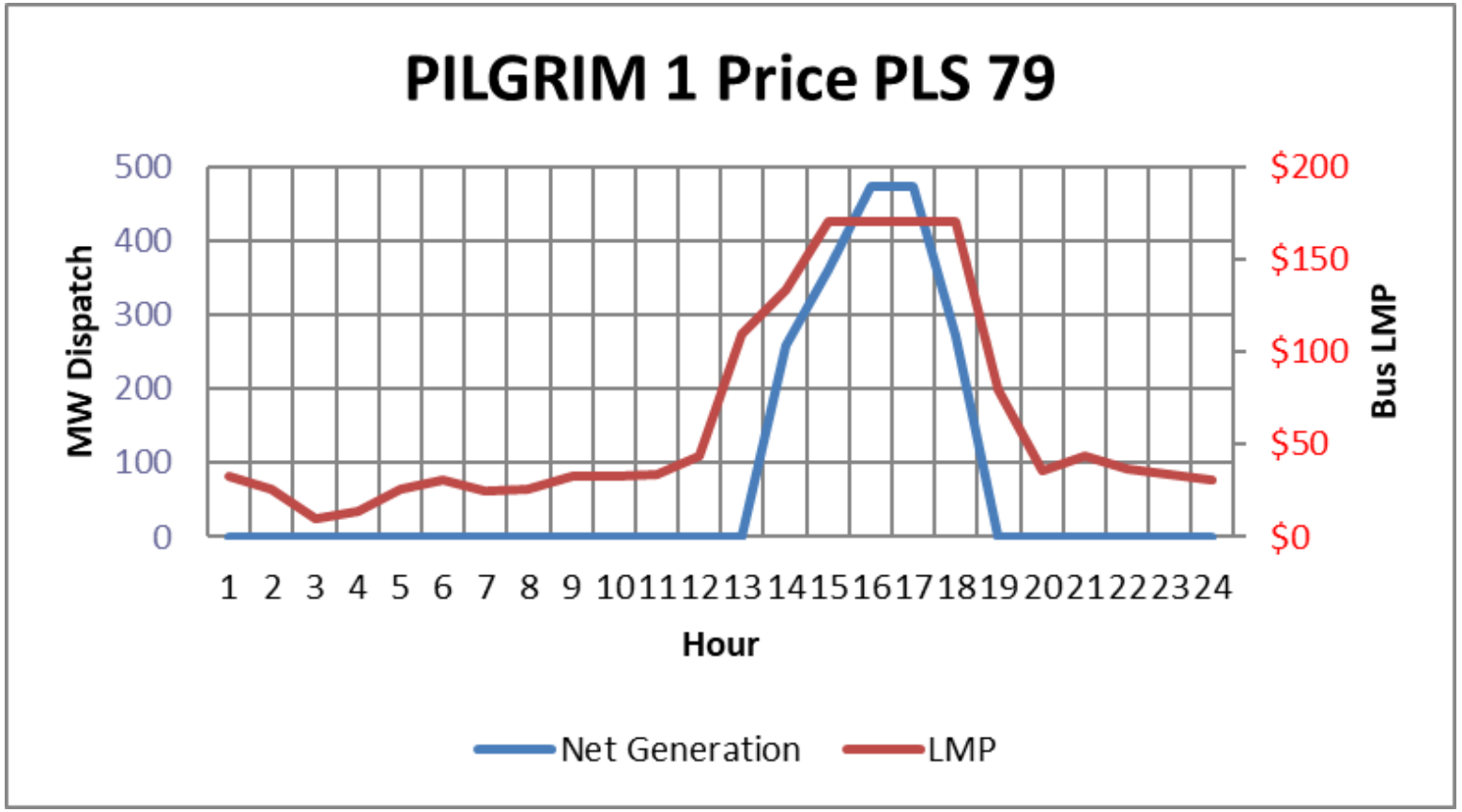


Pilgrim 1 Offer		
Segment	MW	Price
1	0	$ 15.00
2	258	$ 120.00
3	532	$ 170.00
4	818	$ 200.00

Pilgrim 1 Parameters		
Schedule Name	Price 99	Price PLS 79
Min Run Time (Hours)	12	4

Pilgrim 1 Price PLS 79 Schedule

What time would you expect for Pilgrim 1 to be released when committed on the Price PLS 79 Schedule?

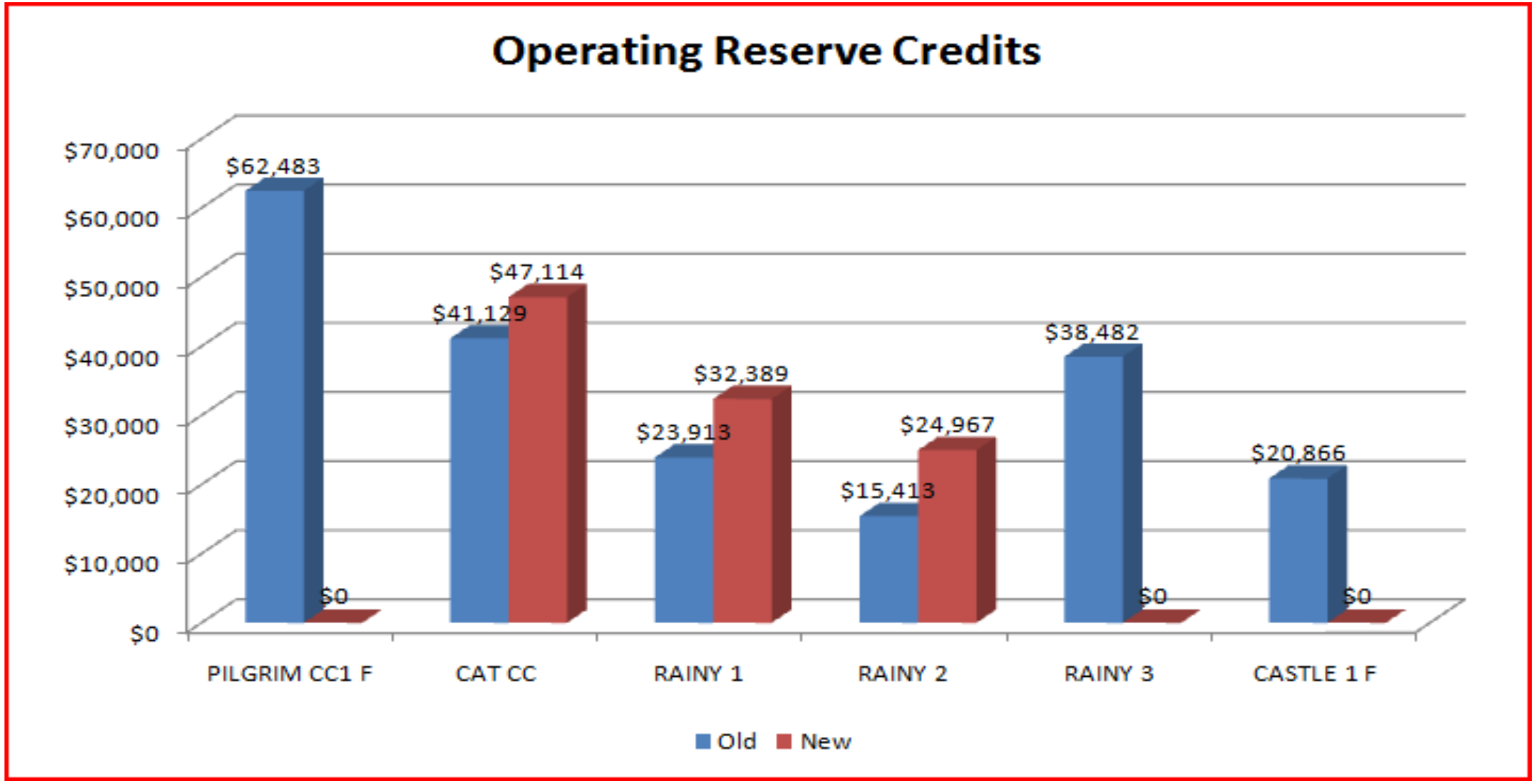


Pilgrim 1 Offer		
Segment	MW	Price
1	0	$ 15.00
2	258	$ 120.00
3	532	$ 170.00
4	818	$ 200.00

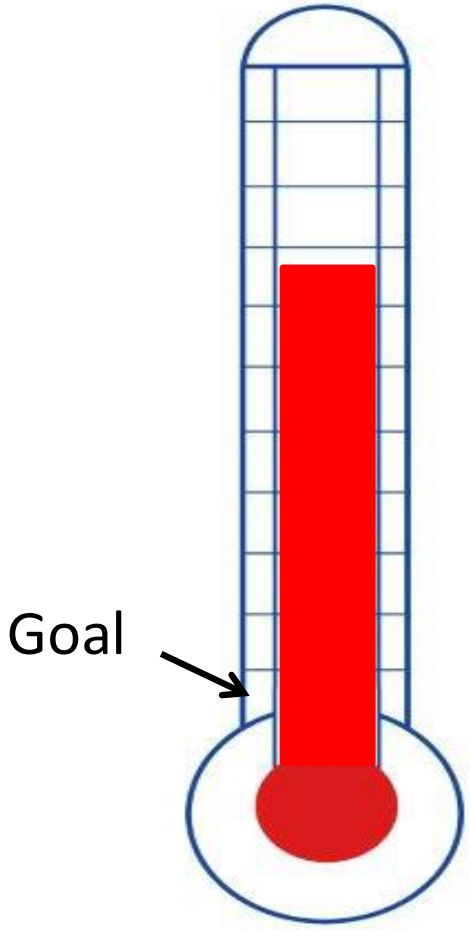
Pilgrim 1 Parameters		
Schedule Name	Price 99	Price PLS 79
Min Run Time (Hours)	12	4

Operating Reserve Credits

Pilgrim 1 does not receive any operating reserve credits when on Price PLS 79 Schedule.
The system operating reserve credit payment drops by $97,786.



New System Bid Production Cost = $10,497,846
Changed the Minimum Run Time Pilgrim 1



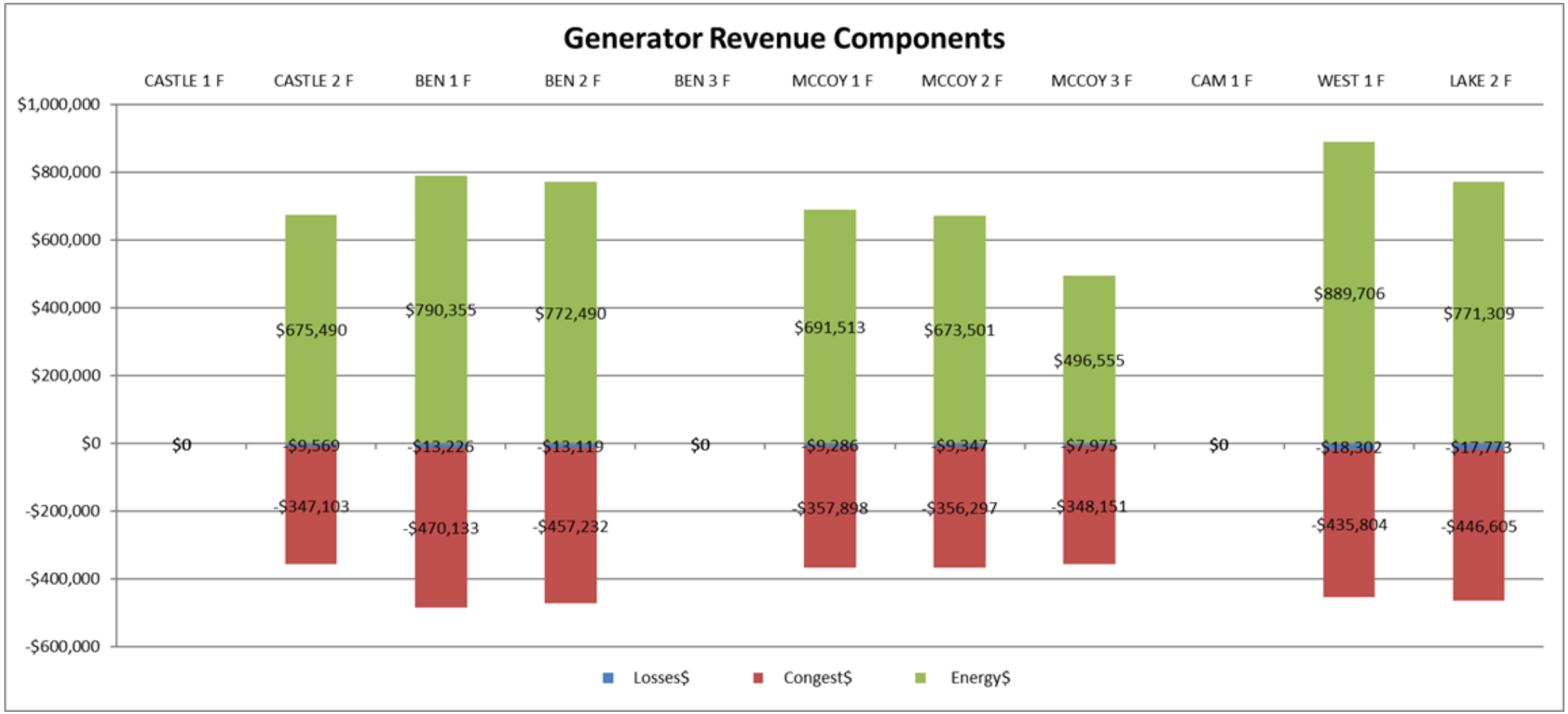
PJM Markets Objective Function
Minimize Total Production Cost

$10,761,371
-$264,000
$10,497,846

Case Two: Ben Units 1, 2, and 3

Superior Gen's Portfolio

What side of the constraint are the Ben units on? Raising generation at Ben has what impact on the constraint?



Ben Unit Parameters

Ben Station's Price 99 Parameters			
Unit Name	BEN 1	BEN 2	BEN 3
Min Run Time (Hours)	2	2	2
Min Down Time (Hours)	2	2	2
Cold Notification Time	0	0	0
Inter Notification Time	0	0	0
Hot Notification Time	0	0	0
Cold Startup Cost	$101,712.00	$101,712.00	$101,712.00
Inter Startup Cost	$ 76,652.00	$ 76,652.00	$ 76,652.00
Hot Startup Cost	$ 67,827.00	$ 67,827.00	$ 67,827.00
Cold Startup Time	0	0	0
Inter Startup Time	0	0	0
Hot Startup Time	0	0	0
Econ. Max	640	640	620
Econ. Min	550	550	560
No Load Cost	$ 3,500.00	$ 3,500.00	$ 3,500.00

Ben 3's Eco Min is higher

Units are committed at respective eco mins

- Ben 3's higher eco min drives the production cost rate higher
- Production Cost Rate = Production Cost/Committed MWs

Ben 3's Eco Max is less than the other two units

- No impact on unit commitment in this scenario

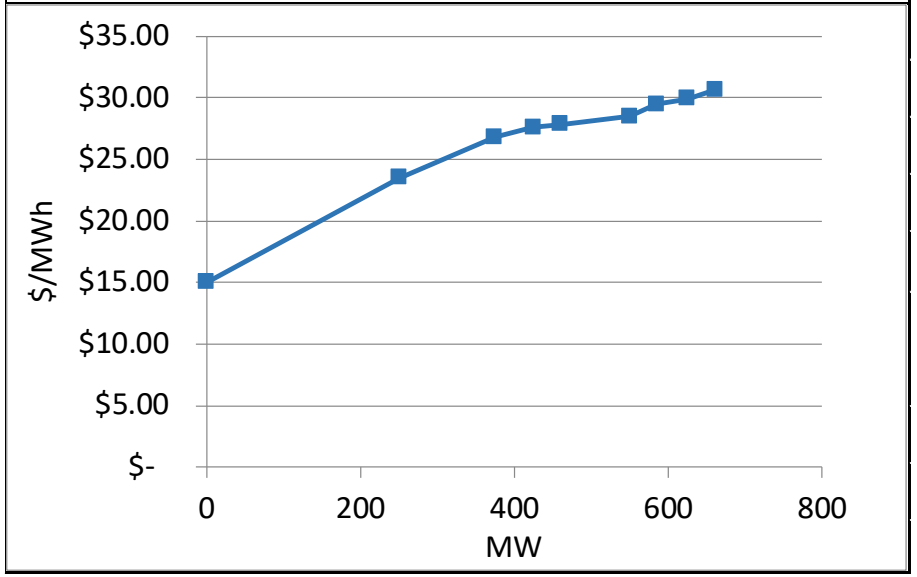
What happens when Ben 3 lowers the cold startup cost to $50k?

Ben 1 Total Production Cost, First Hour

Segment	MW	Price
1	0	$ 15.00
2	250	$ 23.48
3	375	$ 26.77
4	425	$ 27.58
5	460	$ 27.84
6	550	$ 28.47
7	585	$ 29.48
8	625	$ 29.90
9	662	$ 30.64

Eco Min is 550

Offer Curve

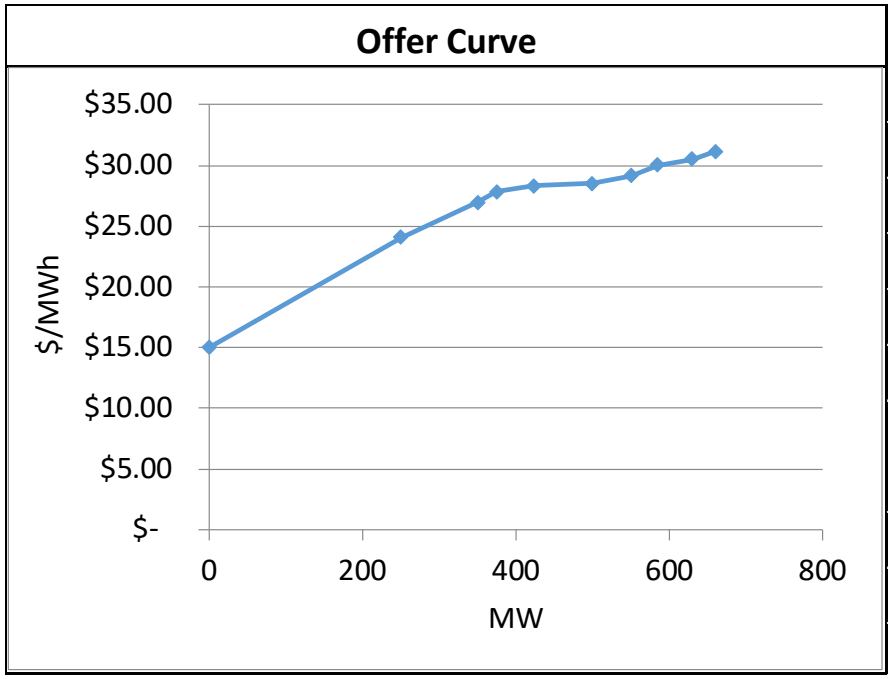


Ben 1 Production Cost at Eco Min (550 MW)			
Area	Area of Rectangle	Area of Triangle	Total
No Load			$3,500
1	3750	1060	4810
2	2935	205.625	3140.625
3	1338.5	20.25	1358.75
4	965.3	4.55	969.85
5	2505.6	28.35	2533.95
	Production Cost at Eco Min		**$16,313.18**
	Cold Start Up		$101,712.00
	Total Production Cost at Eco Min		**$118,025.18**
	Production Cost Rate at Eco Min		**$29.66**

Ben 2 Total Production Cost, First Hour

Segment	MW	Price
1	0	$ 15.00
2	250	$ 24.08
3	350	$ 26.96
4	375	$ 27.86
5	424	$ 28.31
6	500	$ 28.54
7	550	$ 29.17
8	585	$ 30.04
9	630	$ 30.52
10	661	$ 31.15

Eco Min is 550

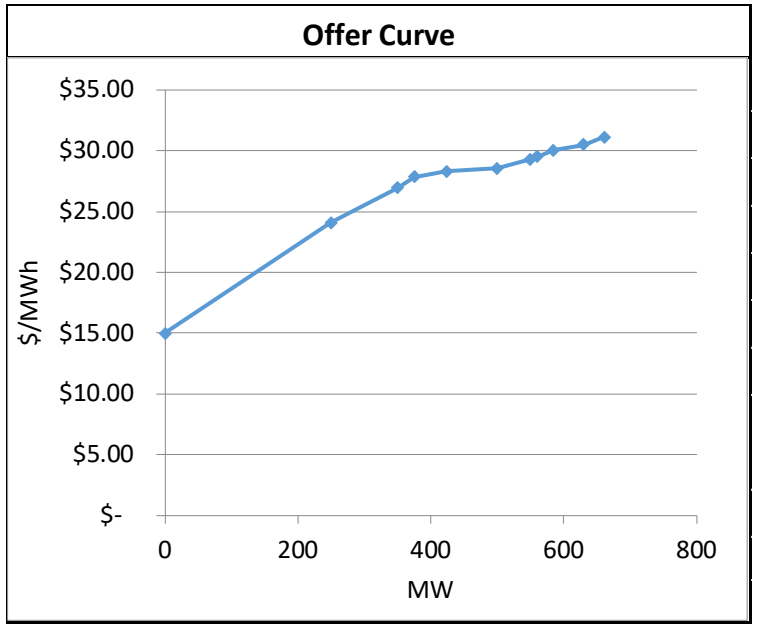


Ben 2 Production Cost at Eco Min (550 MW)			
Area	Area of Rectangle	Area of Triangle	Total
No Load			$3,500
1	3750	1135	4885
2	2408	144	2552
3	674	11.25	685.25
4	1365.14	11.025	1376.165
5	2151.56	8.74	2160.3
6	1427	15.75	1442.75
	Production Cost at Eco Min		**$16,601.47**
	Cold Start Up		$101,712.00
	Total Production Cost at Eco Min		**$118,313.47**
	Production Cost Rate at Eco Min		**$30.18**

Ben 3 Total Production Cost (Full Startup)

Segment	MW	Price
1	0	$ 15.00
2	250	$ 24.08
3	350	$ 26.96
4	375	$ 27.86
5	424	$ 28.31
6	500	$ 28.54
7	550	$ 29.30
8	560	$ 29.51
9	585	$ 30.04
10	630	$ 30.52
11	661	$ 31.15

Eco min is 560. How is the price calculated?



Ben 3 Production Cost at Eco Min (560 MW)			
Area	Area of Rectangle	Area of Triangle	Total
No Load			$3,500
1	3750	1135	4885
2	2408	144	2552
3	674	11.25	685.25
4	1365.14	11.025	1376.165
5	2151.56	8.74	2160.3
6	1427	19	1446
7	293	1.05	294.05
	Production Cost at Eco Min		**$16,898.77**
	Cold Start Up		$101,712.00
	Total Production Cost at Eco Min		**$118,610.77**
	Production Cost Rate at Eco Min		**$30.18**

Linear Interpolation to Determine the $/MW between 550 and 585 MW

$$\text{Slope} = m = \frac{d_y}{d_x} = \frac{rise}{run}$$

$$m = \frac{\$(30.04-29.30)}{MW(585-550)} = \$.021/\text{MW}$$

Therefore:

$$0.021 = \frac{(y_1-29.30)}{(560-550)}$$

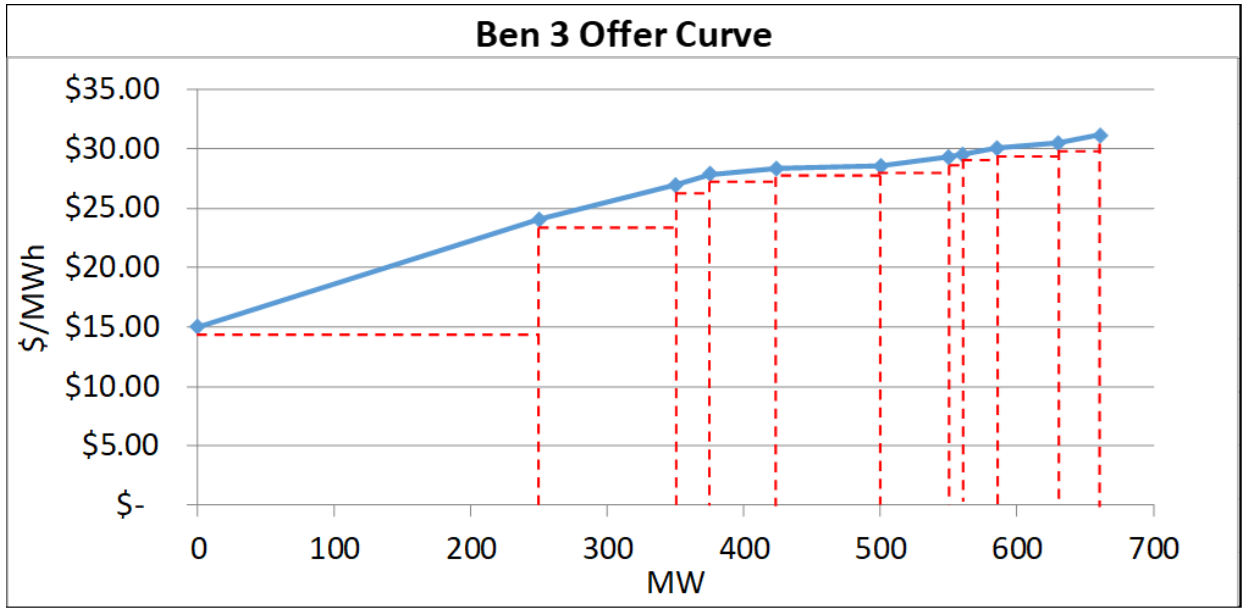
$$0.21 = (y_1 - 29.30)$$

y_1 = **29.51**

Ben 3 Total Production Cost (Reduced Start Up)

Segment	MW	Price
1	0	$ 15.00
2	250	$ 24.08
3	350	$ 26.96
4	375	$ 27.86
5	424	$ 28.31
6	500	$ 28.54
7	550	$ 29.30
8	560	$ 29.51
9	585	$ 30.04
10	630	$ 30.52
11	661	$ 31.15

Eco Min is 560



Ben 3 Production Cost at Eco Min with Reduced Start Up Cost			
Area	Area of Rectangle	Area of Triangle	Total
No Load			$3,500
1	3750	1135	4885
2	2408	144	2552
3	674	11.25	685.25
4	1365.14	11.025	1376.165
5	2151.56	8.74	2160.3
6	1427	19	1446
7	293	1.05	294.05
	Production Cost at Eco Min		**$16,898.77**
	Cold Start Up		$50,000.00
	Total Production Cost at Eco Min		**$66,898.77**
	Production Cost Rate at Eco Min		**$30.18**

Ben Unit’s Production Cost Rate

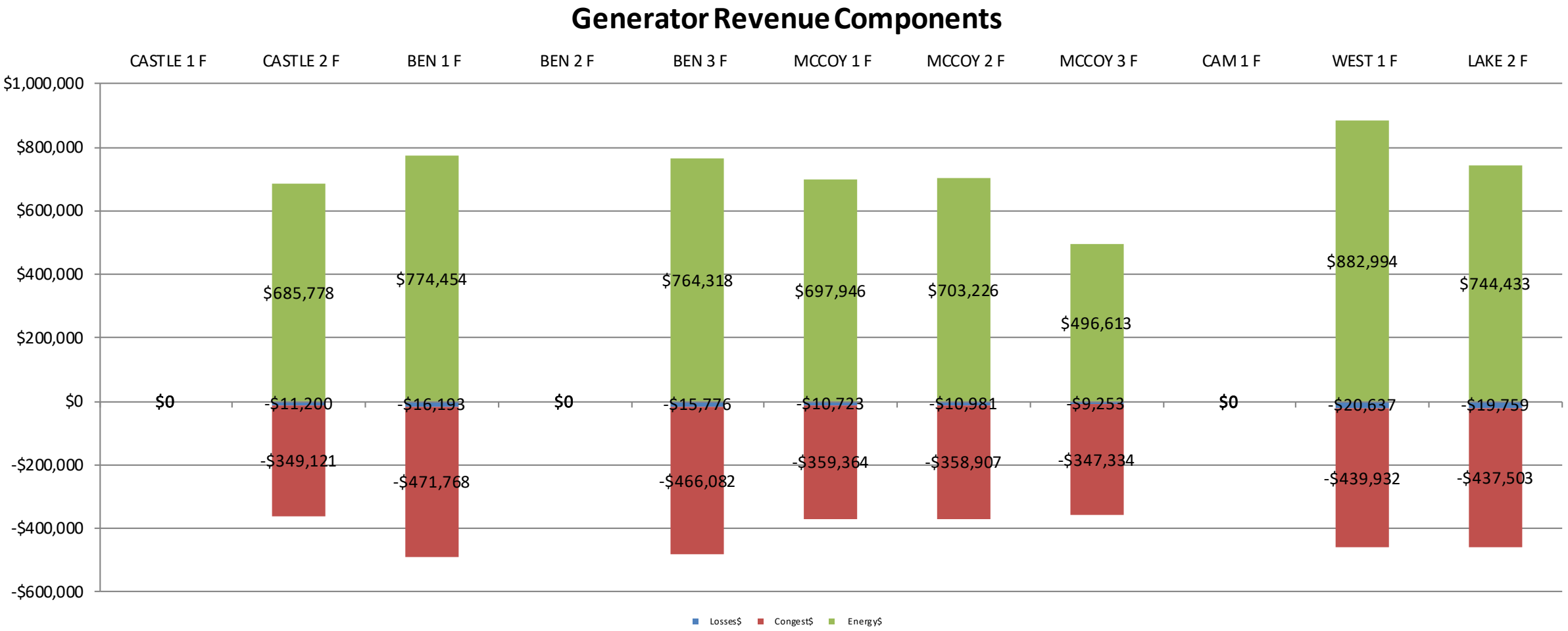
$$\text{Production Cost Rate} = \frac{\text{Production Cost}}{\text{Committed MWs}}$$

Ben Unit's Production Cost Rate			
Unit	**Production Cost**	**Eco Min MW**	**Production Cost Rate**
Ben 1	$16,313.18	550	$29.66
Ben 2	$16,601.47	550	$30.18
Ben 3	$16,898.77	560	$30.18

How can we use the production cost rate to explain why the Ben units are committed?

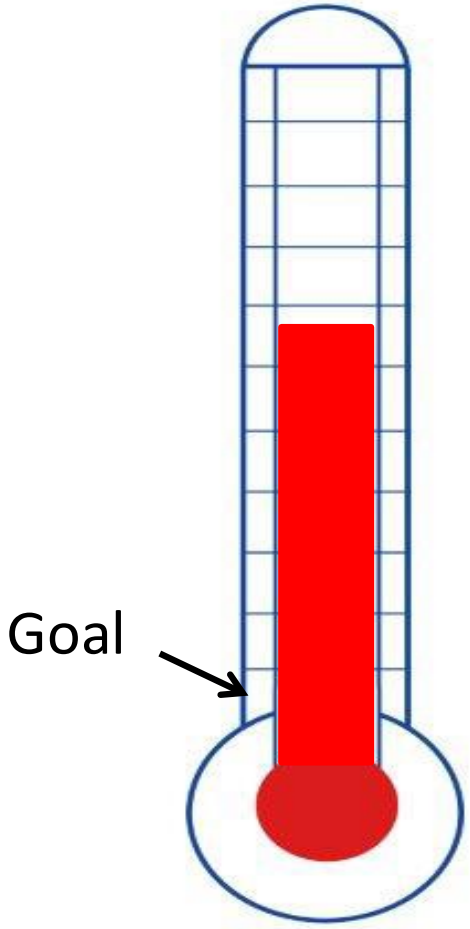
Superior Gen's Portfolio

Ben 3 clears in the Day-Ahead Market instead of Ben 2.



New System Bid Production Cost = $10,438,825

Changed the Cold Start Cost for Ben 3

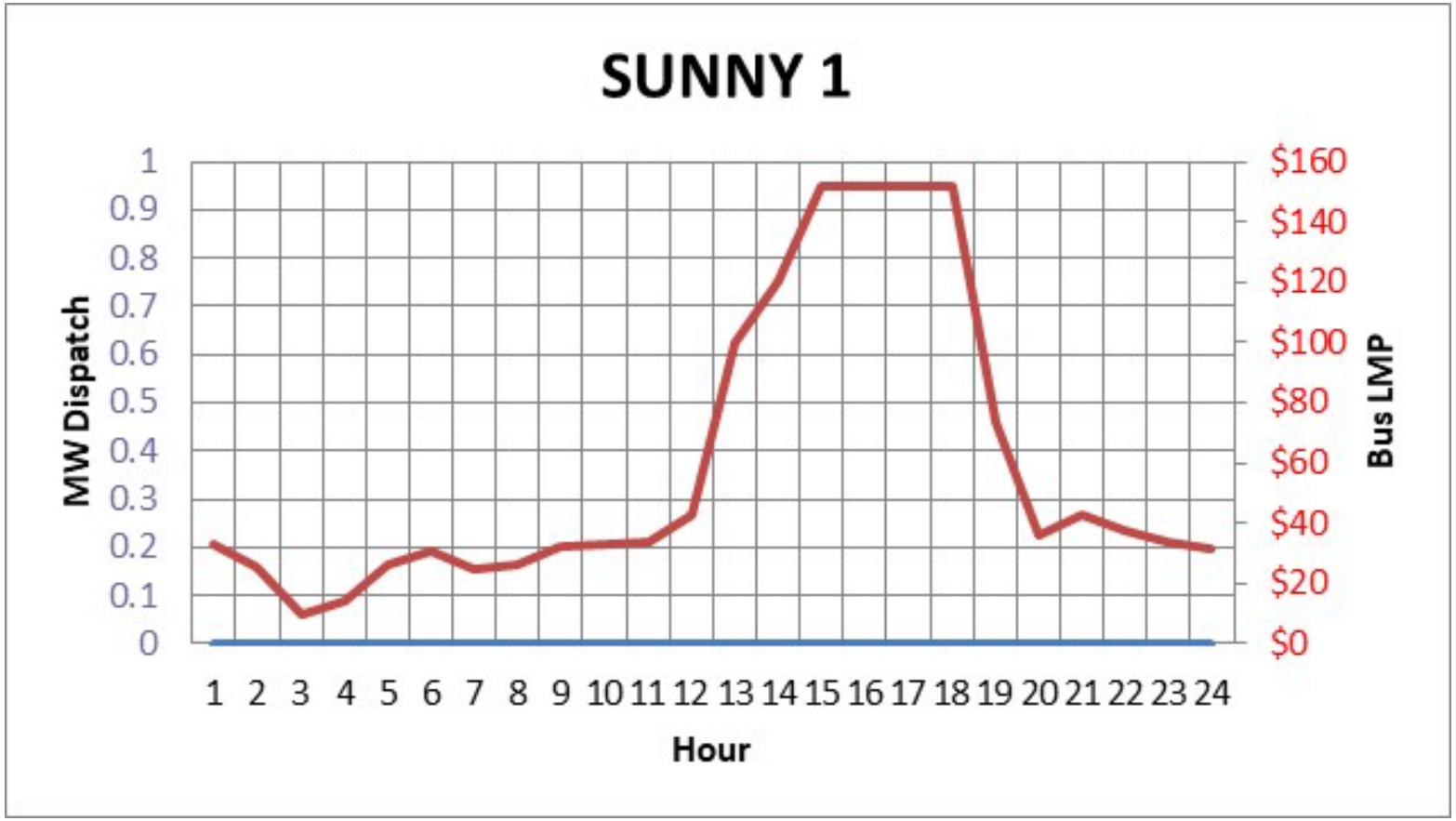


PJM Markets Objective Function
Minimize Total Production Cost

$10,761,371
-$264,000
-$59,000

Case Three: Sunny 1 CC

Sunny 1 Output vs LMP



Sunny 1 came offline at **midnight**.

At 0900, Sunny 1 is offered at $35 with a LMP of $150.

Why has the unit not been committed?

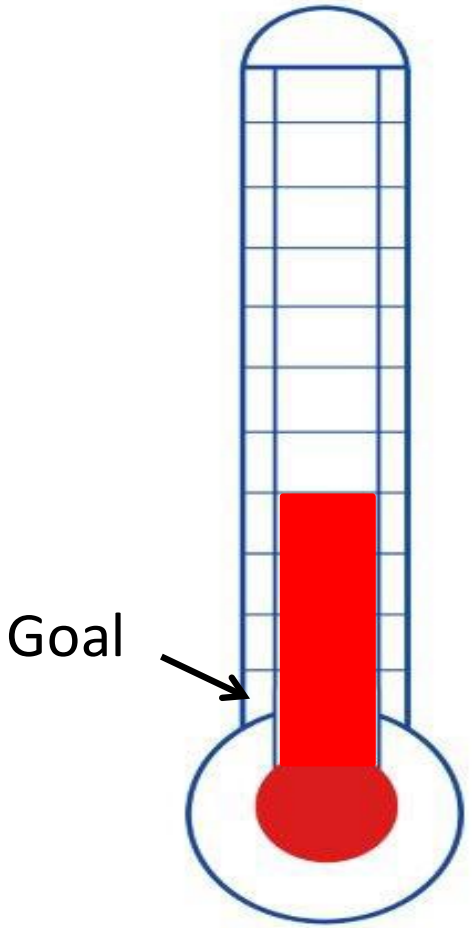
New System Bid Production Cost = $10,312,081

Changed the Sunny 1 Minimum Down Time

Sunny 1 Parameters		
Schedule Name	Price 99	Price PLS 79
Min Down Time (Hours)	24	4

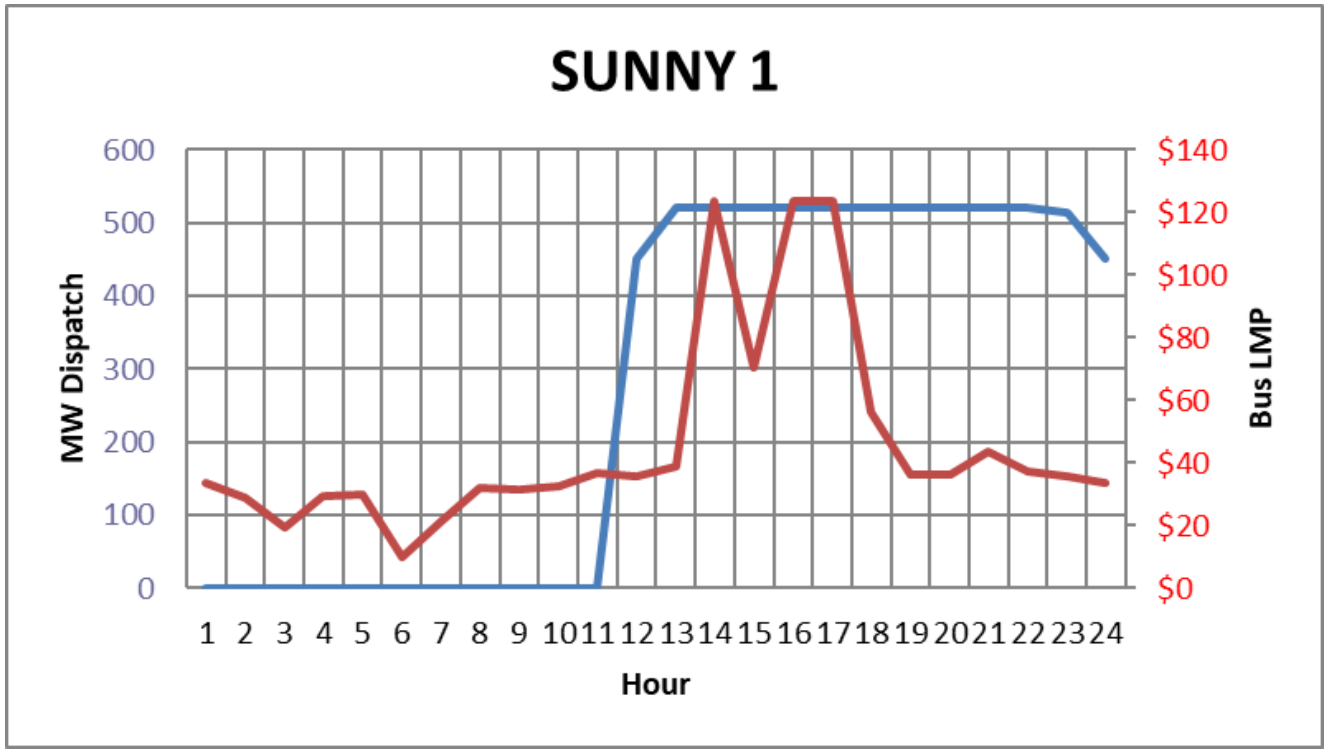
PJM Markets Objective Function
Minimize Total Production Cost

$10,761,371
-$264,000
-$59,000
-$127,000



New System Bid Production Cost = $10,312,081

Changed Sunny 1 Minimum Down Time



What happens to LMP when Sunny 1's minimum downtime is decreased?

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Case Four: Cliff 1 Nuclear Unit

Cliff 1 Day-Ahead Market Clearing

Cliff 1 Parameters	
Schedule Name	Price 99
Min Run Time (Hours)	24
Min Down Time (Hours)	24
Cold Notification Time	0
Inter Notification Time	0
Hot Notification Time	0
Cold Startup Cost	$ -
Inter Startup Cost	$ -
Hot Startup Cost	$ -
Cold Startup Time	28
Inter Startup Time	22
Hot Startup Time	10
Econ. Max	885
Econ. Min	885
No Load Cost	$908.84

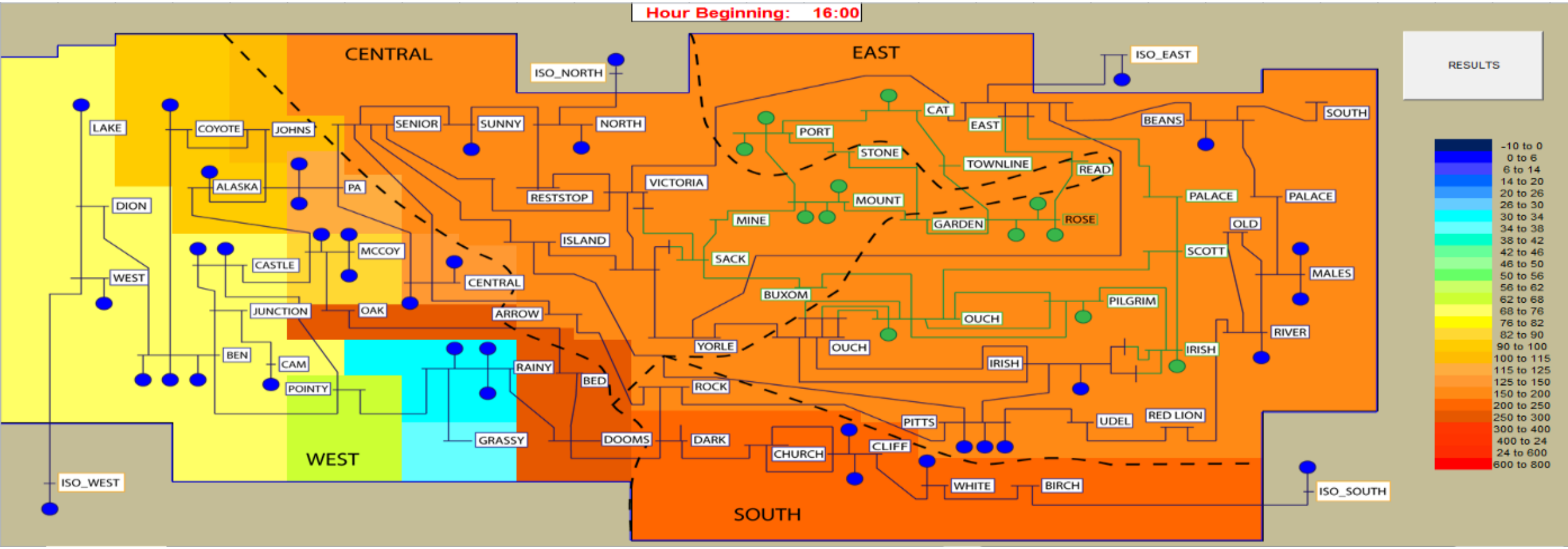
Cliff 1 Unit Hourly Availability	
Hour	Commit Status
HE 1	U
HE 2	U
HE 3	U
HE 4	U
HE 5	U
HE 6	U
HE 7	U
HE 8	U
HE 9	U
HE 10	U
HE 11	U
HE 12	U
HE 13	U
HE 14	U
HE 15	U
HE 16	U
HE 17	U
HE 18	U
HE 19	U
HE 20	U
HE 21	U
HE 22	U
HE 23	U
HE 24	U

The unit has just come back from a planned outage and did not clear in the Day-Ahead Market.

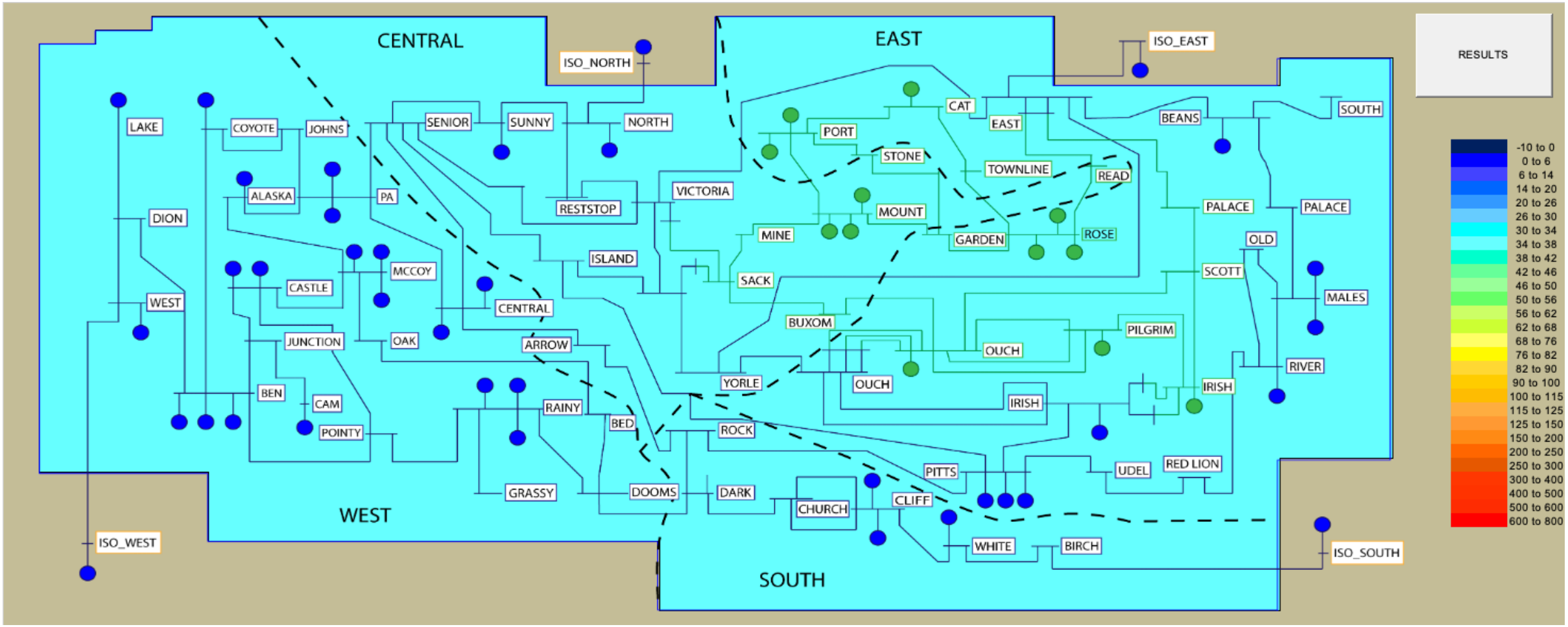
How does Saratoga Generation troubleshoot as to why Cliff 1 is not committed?

What change needs to happen for Cliff 1 to clear in the DA Market?

System Contour Map With Cliff 1 Unavailable

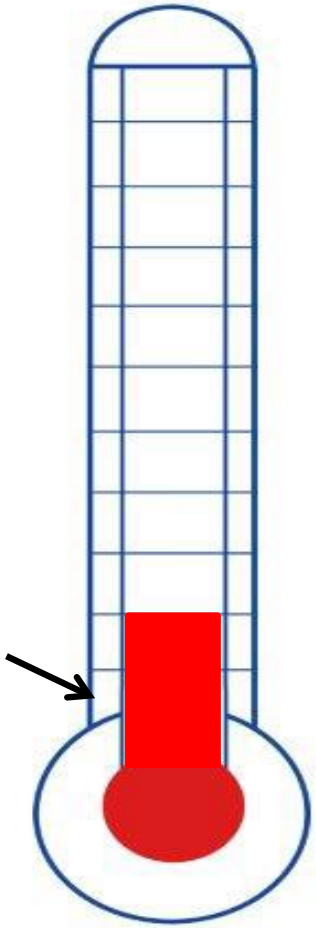


System Contour Map – With Cliff 1 Available



New System Bid Production Cost = $9,870,237

Changed the Availability of Cliff 1 Nuclear Unit



PJM Markets Objective Function
Minimize Total Production Cost

$10,761,371
-$264,000
-$59,000
-$127,000
-$442,000

$9,870,237

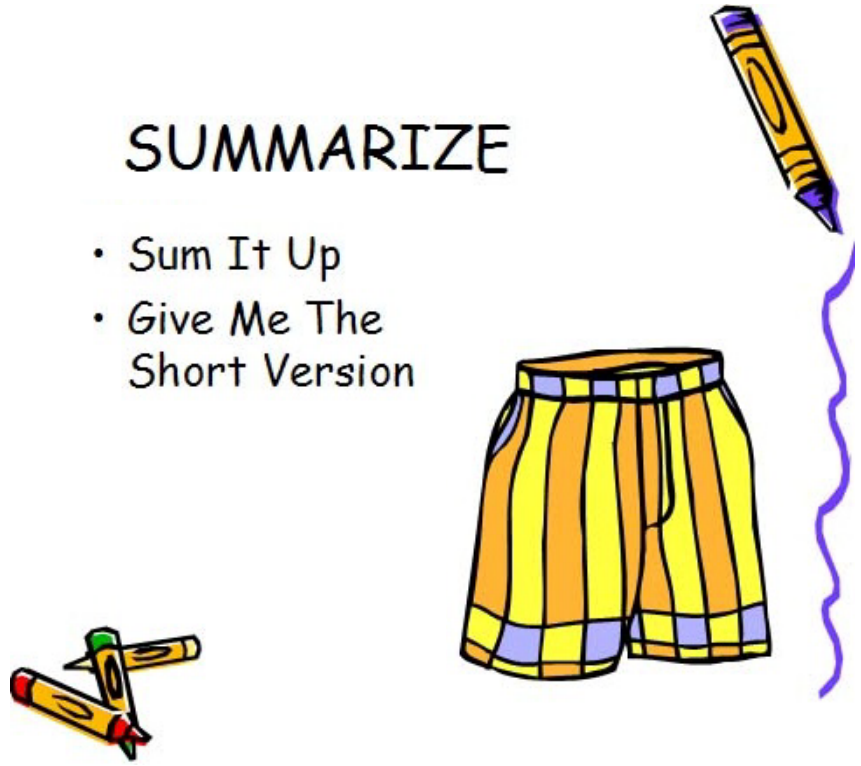
Total Reduction in Production Cost for all scenarios = $891,134

System Bid Production Cost = $9,870,237 **Dropped by $442,000**

- **Cliff 1 Nuclear (Saratoga Power Company)**
  a. Congestion goes away
  b. Total bid production costs dropped by $442k
  c. This will be investigated as withholding

Summary

- Total Bid Production Cost – Base Case
  - $10,761,371
- Four incremental changes
  - Operating Parameters
  - No changes to offer curves
- Total Bid Production Cost – Final Case
  - $9,870,237
  - 8% total reduction in costs
  - More improvements possible



Questions?

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