Locational Reserve Examples

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OVERVIEW

The examples that follow illustrate the determination of locational reserve prices under the pricing mechanism that would be implemented when the reserve market reopens. In order to provide clarity in the examples, they have been simplified in a number of respects that need to be kept in mind. In particular:

- The examples take the unit commitment as given. Thus, the examples do not evaluate the economics of starting additional units to operate at minimum load to provide reserves. The SCUC program does make such an evaluation.
- The examples consider only availability bids for reserves rather than simultaneously optimizing the energy and reserve schedules of these units. Thus, the examples implicitly assume that no opportunity costs are incurred in scheduling reserves.

CASE I

Resource Bids

		Quantity	Bid	Schedule	As-Bid Cost
East On-Line Spin					
Unit	A	400	0	400	-
	B	150	10	150	1,500.00
	C	100	20	50	1,000.00
	D	200	30	0	-
Total				600	
West On-Line Spin					
	E	200	25	0	-
East 10 Minute Reserves					
	F	200	0	200	-
	G	250	1	250	250.00
	H	200	2	150	300.00
	I	200	3		-
Total				600	
West 10 Minute Reserves					
	J	50	1	0	-
East 30 Minute Reserves					
offline	K	200	0.5	200	100.00
on-line	L	100	0.75	70	52.50
offline	M	100	1	0	-
offline	N	200	2	0	-
Total				270	
West 30 Minute Reserves					
on-line	O	100	0	100	-
on-line	P	200	0.5	200	100.00
on-line	Q	200	0.6	30	18.00
on-line	R	200	0.75		-
Total				330	
Total				**1800**	**3,320.50**

Requirements

	Minimum	Actual	Binding
East On-Line Spin	490	600	no
Total On-Line Spin	600	600	yes
East 10 Minute Reserves	1200	1200	yes
Total 10 Minute Reserves	1200	1200	yes
East 30 Minute Reserves	1470	1470	yes
Total 30 Minute Reserves	1800	1800	yes

Settlements

	Quantity	Price	Payments
East On-Line Spin	600	20	12,000
West On-Line Spin	0	18.6	-
East 10 Minute Reserves	600	2	1,200
West 10 Minute Reserves	0	0.6	-
East 30 Minute Reserves	270	0.75	203
West 30 Minute Reserves	330	0.6	198
Total	**1800**		**13,601**

CASE I

In this example:

- Price of on-line spin = $20/MW, set by unit C.
- Price of 10 minute reserves in East is $2/MW, set by unit H.
- Price of East 30 minute reserves is $0.75/MW, set by unit L.
- Price of West 30 minute reserves is $0.60, set by unit Q.
- West on-line reserves are not in merit for spin.

CASE II

Resource Bids

		Qty	Bid	Schedule	As-Bid Cost
East On-Line Spin					
	A	400	0	400	0
	B	150	10	90	900
	C	100	20	0	0
	D	200	30	0	0
	Total			490	
West On-Line Spin					
	E	200	5	110	550
East 10 Minute Reserves					
	F	200	0	200	0
	G	250	1	250	250
	H	200	2	200	400
	I	200	3	60	180
	Total			710	
West 10 Minute Reserves					
	J	50	1	0	0
East 30 Minute Reserves					
offline	K	200	0.5	200	100
on-line	L	100	0.75	70	52.5
offline	M	100	1	0	0
offline	N	200	2	0	0
	Total			270	
West 30 Minute Reserves					
on-line	O	100	0	100	0
on-line	P	200	0.5	120	60
on-line	Q	200	0.6	0	0
on-line	R	200	0.75		0
	Total			220	
Total				**1800**	**2,492.5**

Requirements

	Minimum	Actual	Binding
East on line	490	490	yes
Total on line	600	600	yes
East 10 Minute Reserves	1200	1200	yes
Total 10 Minute Reserves	1200	1310	no
East 30 Minute Reserves	1470	1470	yes
Total 30 Minute Reserves	1800	1800	yes

Settlements

	Quantity	Price	Payments
East Spin	490	10	4900
West spin	110	5	550
East 10 minute	710	3	2130
West 10 minute	0	0.5	0
East 30	270	0.75	202.5
West 30	220	0.5	110
Total	**1800**		**7,892.5**

CASE II

Case II is the same as Case I except that on-lines pinning reserves are available at $5/MW in West.

The Western spinning reserves displace Eastern spinning reserves down to the Eastern spinning reserve limit (490 MW). The economics of displacement are:

1MW West spin ($5) + 1MW East 10 minute reserve ($3) $\leq$

1MW East spin ($10) + 1 MW West 30 minute reserve($.50)

Thus, Western spinning reserves priced at $7.50/MW or less could displace up to 110MW of Eastern spinning reserves.

CASE III

Resource Bids

		Qty	Bid	Schedule	As-Bid Cost
East On-Line Spin					
	A	400	0	400	0
	B	150	10	150	1500
	C	100	20	100	2000
	D	200	30	100	3000
	Total			750	
West On-Line Spin					
	E	200	25	0	0
East 10 Minute Reserves					
	F	200	0	200	0
	G	250	1	250	250
	H	200	40	0	0
	I	200	50	0	0
	Total			450	
West 10 Minute Reserves					
	J	50	1	0	0
East 30 Minute Reserves					
offline	K	200	0.5	200	100
on-line	L	100	0.75	70	52.5
offline	M	100	1	0	0
offline	N	200	2	0	0
	Total			270	
West 30 Minute Reserves					
on-line	O	100	0	100	0
on-line	P	200	0.5	200	100
on-line	Q	200	0.6	30	18
on-line	R	200	0.75	0	0
	Total			330	
Total				**1800**	**7,020.5**

Requirements

	Minimum	Actual	Binding
East On-Line Spin	490	750	no
Total On-Line Spin	600	750	no
East 10 Minute Reserves	1200	1200	yes
Total 10 Minute Reserves	1200	1200	yes
East 30 Minute Reserves	1470	1470	yes
Total 30 Minute Reserves	1800	1800	yes

Settlements

	Quantity	Price	Payments
East On-Line Spin	750	30	22500
West On-Line Spin	0	0.6	0
East 10 Minute Reserves	450	30	13500
West 10 Minute Reserves	0	0.6	0
East 30 Minute Reserves	270	0.75	202.5
West 30 Minute Reserves	330	0.6	198
Total	**1800**		**36,400.5**

CASE III

Case III is like Case I except that the owner of units H and I has raised its reserve bid to $40 and $50.

The cheapest way to meet the 1200MW Eastern 10 minute reserve requirement is now to schedule 750MW on on-line spin units and 450 MW on off-line 10 minute reserve units. The market price of Eastern 10 minute reserve is set by unit D at $30.

Notes that if the Eastern 10 minute reserve requirements were reduced to 1199MW, 1 less MW of reserves would be scheduled on unit D, reducing the production cost by $30.

Western on-line units are not scheduled despite the high eastern on-line price because the value of western spin is only $0.60.

1MW West spin ($25 bid) + 1MW East 10 minute reserve ($30) = $55 $\leq$

1MW East spin ($30) + 1MW West 30 minute reserve ($0.60)

CASE IV

Resource Bids

		Qty	Bid	Schedule	As-Bid Cost
East On-Line Spin					
	A	400	0	400	0
	B	150	10	150	1500
	C	100	20	100	2000
	D	200	30	0	0
	Total			650	
West On-Line Spin					
	E	200	25	0	0
East 10 Minute Reserves					
	F	200	0	200	0
	G	250	1	250	250
	H	200	25	100	2500
	I	200	35	0	0
	Total			550	
West 10 Minute Reserves					
	J	50	1	0	0
East 30 Minute Reserves					
offline	K	200	0.5	200	100
on-line	L	100	0.75	70	52.5
offline	M	100	1	0	0
offline	N	200	2	0	0
	Total			270	
West 30 Minute Reserves					
on-line	O	100	0	100	0
on-line	P	200	0.5	200	100
on-line	Q	200	0.6	30	18
on-line	R	200	0.75	0	0
	Total			330	
Total				**1,800.0**	**6,520.5**

Requirements

	Minimum	Actual	Binding
East On-Line Spin	490	650	no
Total On-Line Spin	600	650	no
East 10 Minute Reserves	1200	1200	yes
Total 10 Minute Reserves	1200	1200	yes
East 30 Minute Reserves	1470	1470	yes
Total 30 Minute Reserves	1800	1800	yes

Settlements

	Quantity	Price	Payments
East On-Line Spin	650	25	16250
West On-Line Spin	0	0.6	0
East 10 Minute Reserves	550	25	13750
West 10 Minute Reserves	0	0.6	0
East 30 Minute Reserves	270	0.75	202.5
West 30 Minute Reserves	330	0.6	198
Total	**1800**		**30,400.5**

CASE IV

Case IV is like Case III except that units H and I have not raised their bids quite as much as in Case III.

The cheapest way to meet the 1200MW Eastern 10 minute reserve requirement is now to schedule 650MW on on-line units and 550MW on off-line units. The market price of Eastern 10 minute reserves is set by unit H at $25.

Note that if the eastern 10 minute reserve requirement were reduced by 1MW, the total production cost would be reduced by $25, which would also be the case if the Eastern spin requirement was reduced by 1MW.

CASE V

Resource Bids

		Qty	Bid	Schedule	As-Bid Cost
East On-Line Spin					
	A	400	0	400	0
	B	150	10	150	1500
	C	100	20	0	0
	D	200	30	0	0
	Total			550	
West On-Line Spin					
	E	200	15	50	750
East 10 Minute Reserves					
	F	200	0	200	0
	G	250	1	250	250
	H	175	2	175	350
	I	200	3	25	75
	Total			650	
West 10 Minute Reserves					
	J	50	1	0	0
East 30 Minute Reserves					
offline	K	200	0.5	200	100
on-line	L	100	0.75	70	52.5
offline	M	100	1	0	0
offline	N	200	2	0	0
	Total			270	
West 30 Minute Reserves					
on-line	O	100	0	100	0
on-line	P	200	0.5	180	90
on-line	Q	200	0.6	0	0
on-line	R	200	0.75	0	0
	Total			280	
Total				**1800**	**3,167.5**

Requirements

	Minimum	Actual	Binding
East On-Line Spin	490	550	no
Total On-Line Spin	600	600	yes
East 10 Minute Reserves	1200	1200	yes
Total 10 Minute Reserves	1200	1250	no
East 30 Minute Reserves	1470	1470	yes
Total 30 Minute Reserves	1800	1800	yes

Settlements

	Quantity	Price	Payments
East On-Line Spin	550	15	8250
West On-Line Spin	50	15	750
East 10 Minute Reserves	650	3	1950
West 10 Minute Reserves	0	0.5	0
East 30 Minute Reserves	270	0.75	202.5
West 30 Minute Reserves	280	0.5	140
Total	**1800**		**11,292.5**

CASE V

Case V is a variation on Case II in which there are some on-line reserves available at low cost in the West which partially displace Eastern reserves.

Because these West reserves are more expensive than the reserves offered by units A and B, only 50MW of on-line reserves are scheduled in the West and there is a state-wide market clearing price for spinning reserves of $15/MW.