TCC Expansion Awards for Controllable Devices: Initial Discussion

Prepared for NYISO Market Structures Working Group

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February 12, 2002

LECG
ECONOMICS
FINANCE

CONTROLLABLE DEVICES — Overview

The expansion TCC award process developed by the MSWG applies to the award of TCCs for free-flowing AC expansions.

However, many of the expansions proposed in New York involve controllable devices.

- DC Lines
- Phase Shifters
- FACTS Devices

The treatment of transmission expansions involving controllable lines must address:

- The pricing of schedules on controllable lines.
- The method for representing controllable lines in TCC feasibility tests.
- The method for defining TCCs supported by the transfer capability provided by controllable lines.
- The quantity and characteristics of the TCCs awarded for transmission expansions involving controllable lines.

It is likely that the economic value of controllable lines will generally be realized through the appropriate pricing of energy injected into and withdrawn from the controllable line.

There are, however, three situations in which this will not be the case and which need to be accounted for in the expansion TCC award process.

- Controllable lines whose post-contingency flows exceed their pre-contingency flows.
- Controllable lines whose outage is a binding contingency in the dispatch.
- Controllable lines controlled and scheduled by the ISO.

We begin by illustrating the pricing and settlements for transactions scheduled on a controllable line in the situation in which the use of the controllable line is not scheduled by the ISO and the outage of the line is not a binding contingency.

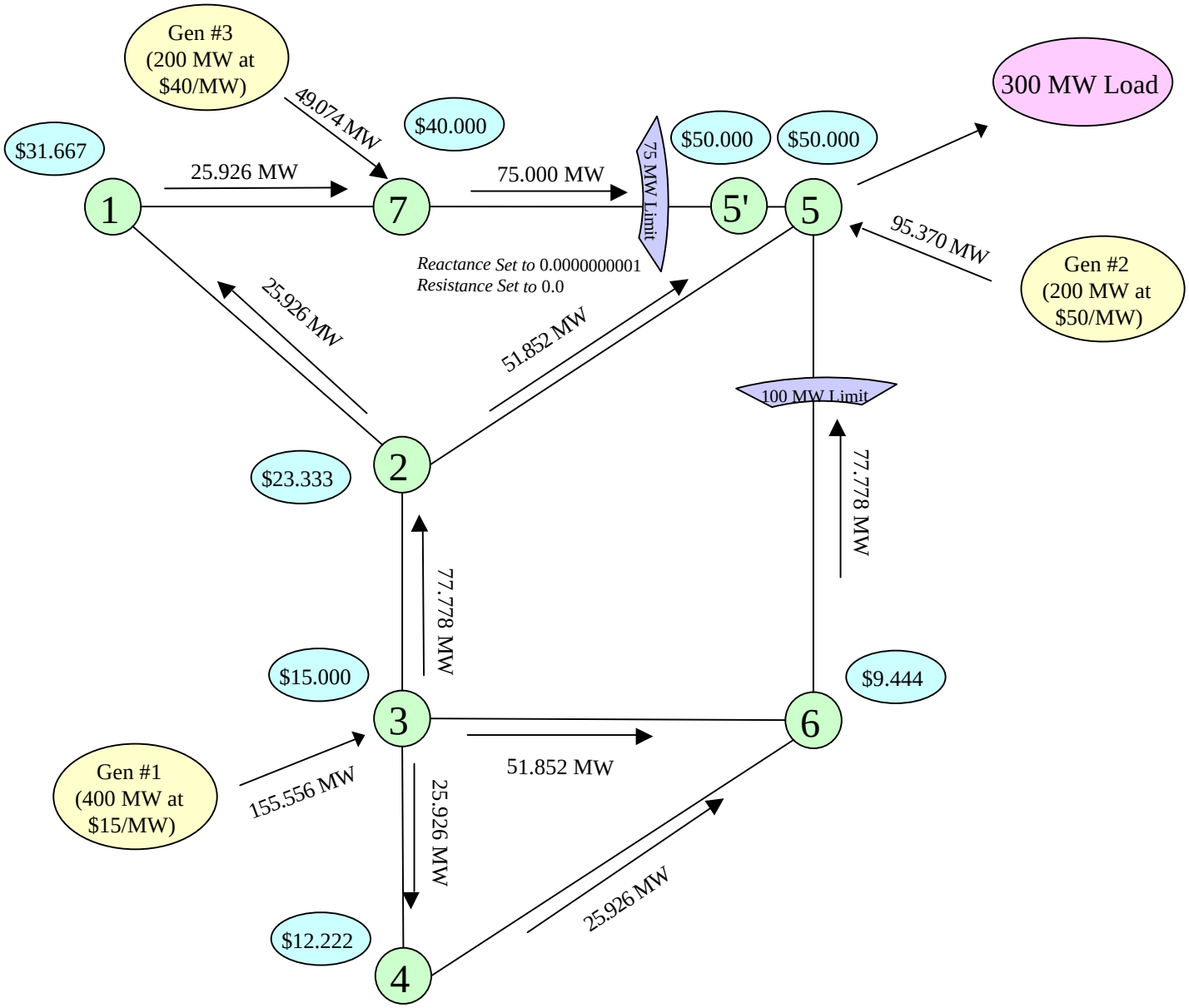
Most DC lines and some PAR controlled lines will fall in this category.

Base Case

It is proposed that if use of a controllable line is scheduled by market participants, then the schedules on the controllable line would be settled by pricing withdrawals from the grid (injections to the controllable line) at the LBMP price at the point of withdrawal and pricing injections to the grid from the controllable line at a proxy bus price at the point of injection.

The proxy bus price at the point of injection would be calculated using the standard LBMP formula.

Scenario 1 Figure 1



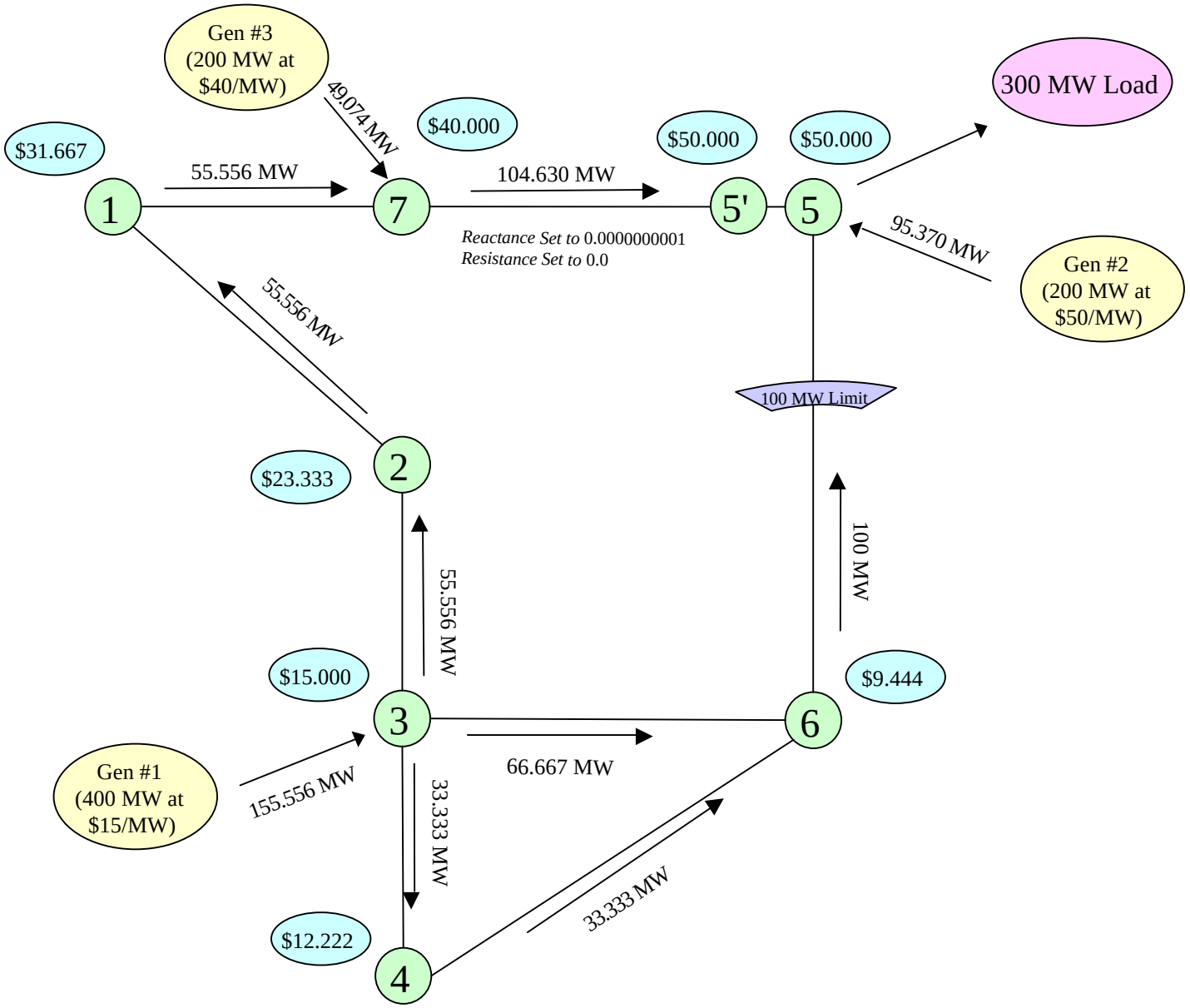
BASE CASE

Scenario 1 illustrates the pricing of a controllable line (line 7-5) whose use is scheduled by market participants.

- Generation is located at 3, 7 and 5, while all load is located at Bus 5.
- There is a 100 post-contingency limit on the flows on line 6-5.
- There is a 75 MW limit on the base flows on the controllable line.

The transmission system is congested with a price of $15 at Bus 3 and $50 at Bus 5.

Scenario 1 Figure 2 (Line 2-5 Outage)

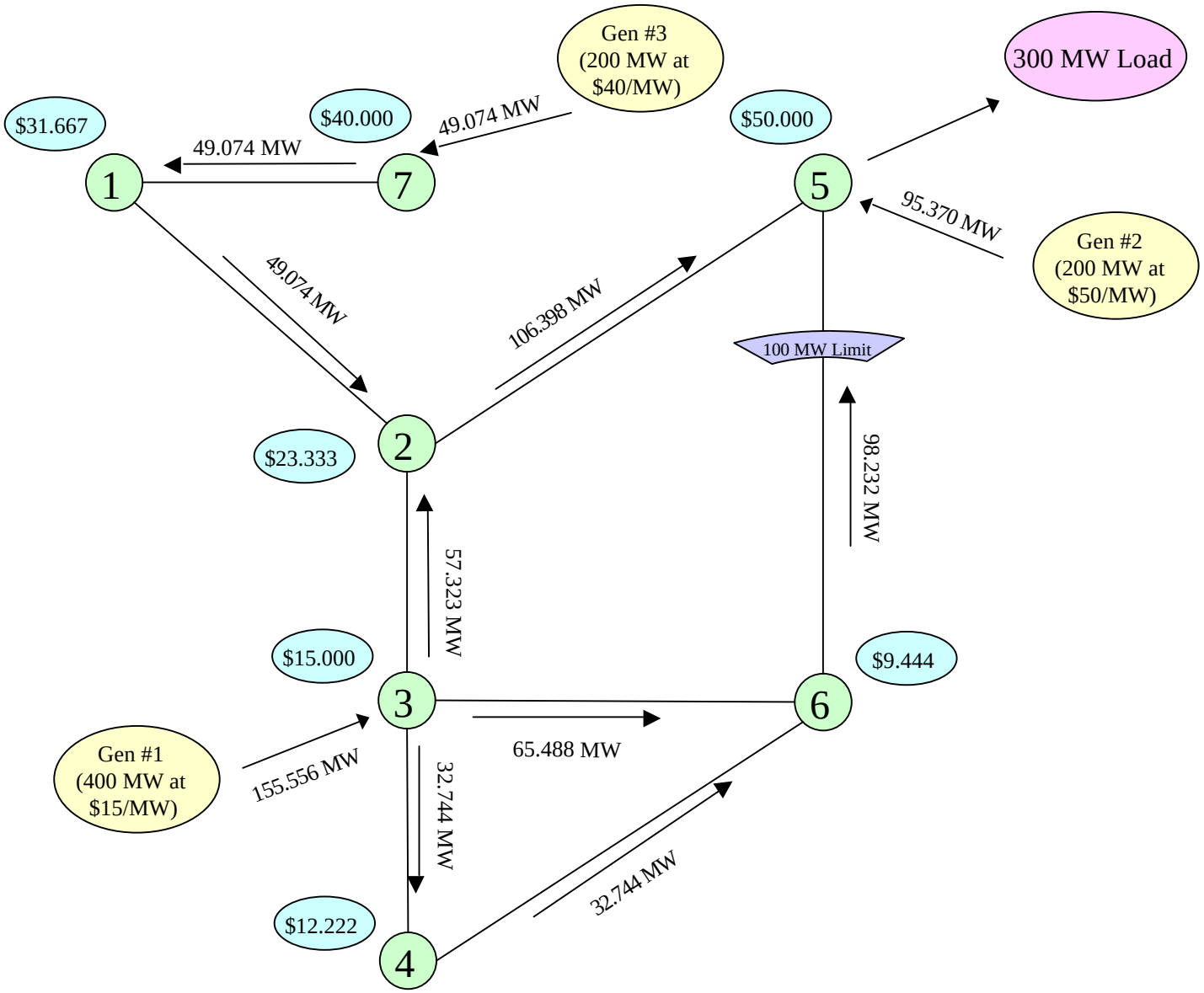


BASE CASE

The transmission system is constrained because flows on line 6-5 are at the limit in the contingency in which line 2-5 is out.

- Injections cannot be increased at Buses 3 or 7 without overloading 6-5 in the contingency or exceeding the limit on the controllable line.

Scenario 1 Figure 3 (Line 5-7 Outage)



BASE CASE

In Scenario 1, the outage of the controllable line is not a binding contingency. Since usage of the controllable line is not scheduled by the ISO, the ISO would not see the constraint on the flows scheduled on the controllable line, but would see the schedules provided to it as the other constraint.

- The proxy bus price for energy delivered over the controllable line would therefore be the price at the delivery point.
- Market participants scheduling transactions on the controllable line would buy power at $40 and sell power at the $50 price at Bus 5'. This price difference would provide an incentive to fully schedule the controllable line.

Scenario 1, Table 4				
Contingency	**Data**	**Bus 7**	**Proxy 5**	**Generation 5**
All	Reference Bus Price	$50.00	$50.00	$50.00
Pre-Contingency	Shift Factor on 7-5	-1	0	0
	7-5 Shadow Price	$10.00	$10.00	$10.00
7-5 Contingency	Shift Factor on 7-5	-0.273	-0.273	0
	6-5 Shadow Price	$0.00	$0.00	$0.00
2-5 Contingency	Shift Factor on 6-5	0	0	0
	6-5 Shadow Price	$48.89	$48.89	$48.89
	LBMP	$40.00	$50.00	$50.00

BASE CASE

The prices at Buses 5, 7 and Proxy Bus 5 can be derived based on standard LMP equations.

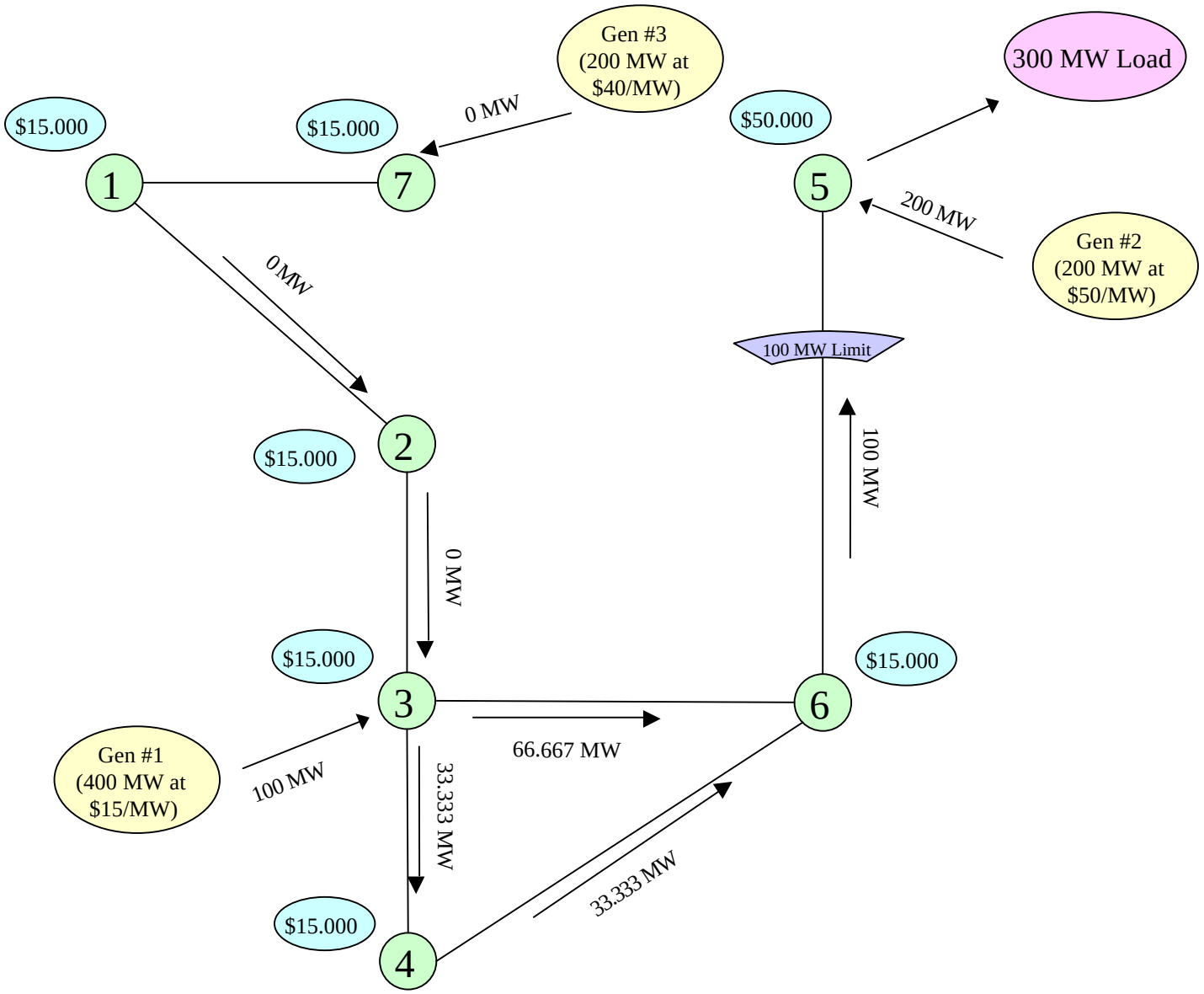
Post-Contingency Flows

POST-CONTINGENCY FLOWS

While LMP pricing of energy scheduled to flow on the controllable line would provide returns to the construction and operation of the controllable line when the system is congested, in this example energy pricing alone would not reflect the value of the total increase in transfer capability provided by the operation of the controllable line.

- The award of TCCs to the operator of the controllable line would be necessary to provide the correct expansion and operational incentives.

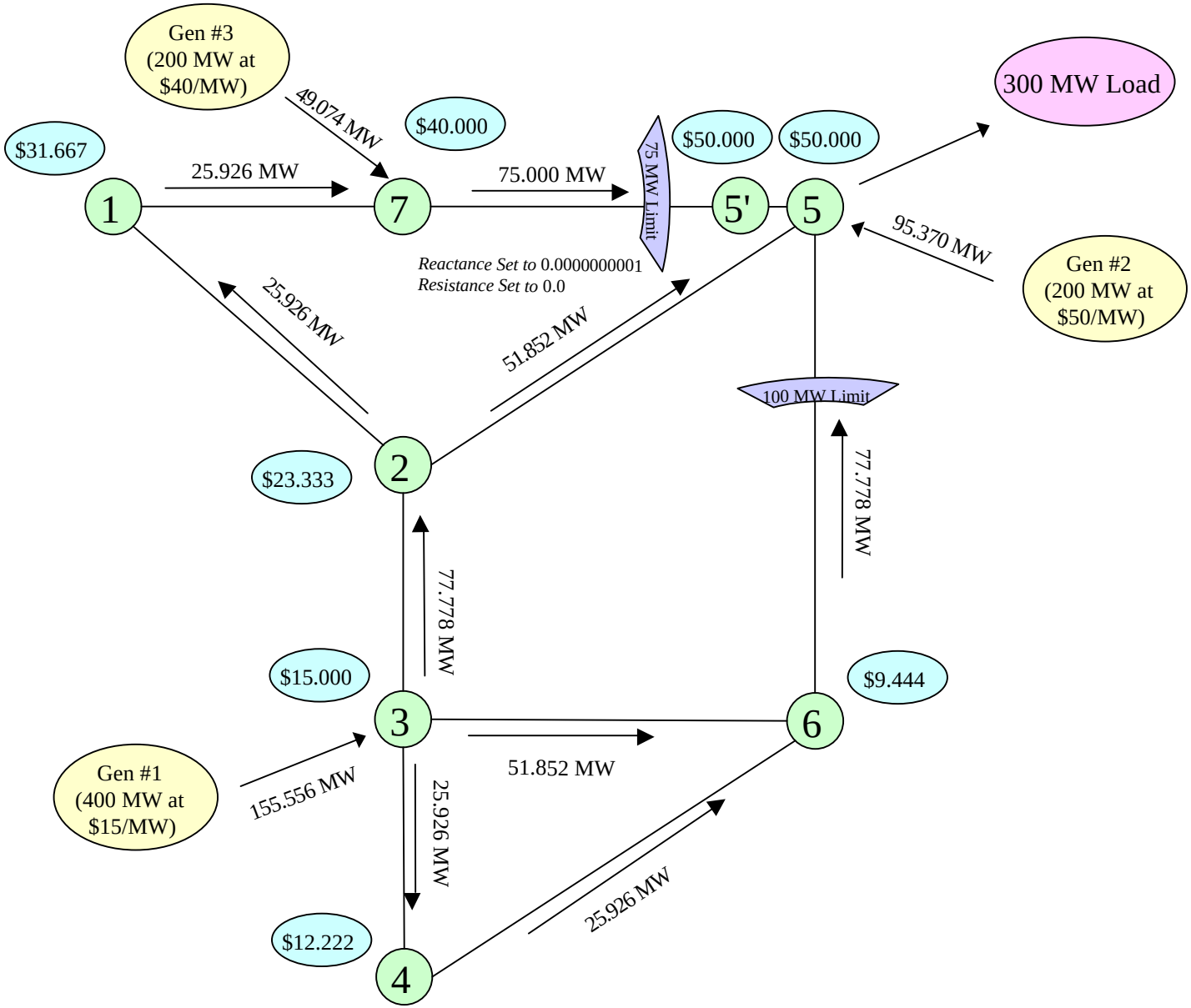
Scenario 1 Figure 5 (No 5-7 Line, Line 2-5 Outage)



POST-CONTINGENCY FLOWS

Absent the controllable line, transfer capability from Bus 3 to Bus 5 would be 100 MW, limited by the flows on line 6-5 in the contingency in which line 2-5 is out.

Scenario 1 Figure 1



POST-CONTINGENCY FLOWS

It can be seen that construction of the controllable line increases transfer for capability by more than the 75 MW scheduled to flow on the controllable line.

- In particular, because we have assumed that the controllable line is not operated to hold flows in the contingency, the construction of the line allows increased pre-contingency flows on lines 2-5 and 6-5.
- The overall increase in flows from the operation of the controllable line is 104.63 MW.

Scenario 1, Table 6			
	MWh	**Price ($)**	**Net ISO Revenues ($)**
Bus 3 Generating Injections	-155.556	15	-$2,333.40
Bus 7 Generation Injections	-49.074	40	-$1,962.96
Bus 7 Withdrawals	+75	40	+$3,000.00
Bus 5 Injections	-75	50	-$3,750.00
Bus 5 Generation Injections	-95.37	50	-$2,000.00
Bus 5 Load	300	50	+$15,000.00
Net Congestion Rents			$5,185.14
TCC 3-5	100	$35	-$3,500.00
Residual Congestion Rents			$1,685.14

POST-CONTINGENCY FLOWS

Moreover, it can be seen that if the controllable line were operated in this manner, the ISO would be able to:

- Settle energy scheduled on the controllable line at LMP prices; and
- Settle 100 3 to 5 TCCs at LMP prices

Without exhausting the congestion rents.

Scenario 1, Table 7			
TCC	**MW**	**Price/MW ($)**	**Value ($)**
3 to 7	25.926	$25	$648.15
3 to 5	29.63	$35	$1,037.05
Total			$1,685.20

POST-CONTINGENCY FLOWS

The construction of the controllable line would not only support payment of the difference between the Bus 7 and proxy bus price for the energy scheduled on the controllable line, it would also permit award of TCCs:

- 25.926 3 to 7
- 29.63 3 to 5

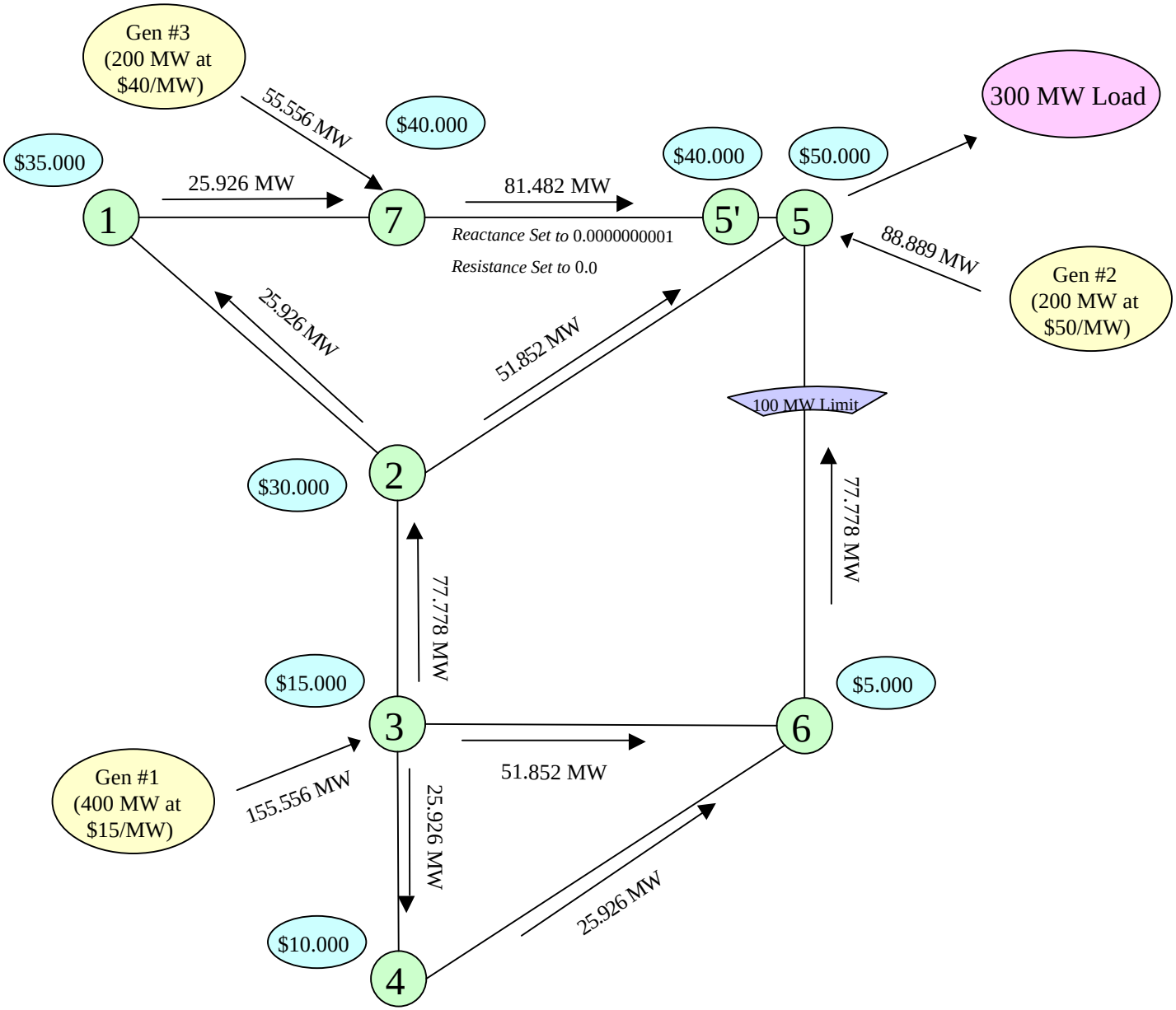
Outage of the Controllable Line as a Binding Contingency

CONTROLLABLE LINE OUTAGE

The second special case to be considered is the case in which the outage of the controllable line is a binding contingency.

- It is anticipated that controllable lines will normally be designed and operated to avoid this situation.
- Allowance for this possibility needs to be made in the pricing system and in the award of TCCs for controllable lines.

Scenario 2 Figure 8 (No Outages)

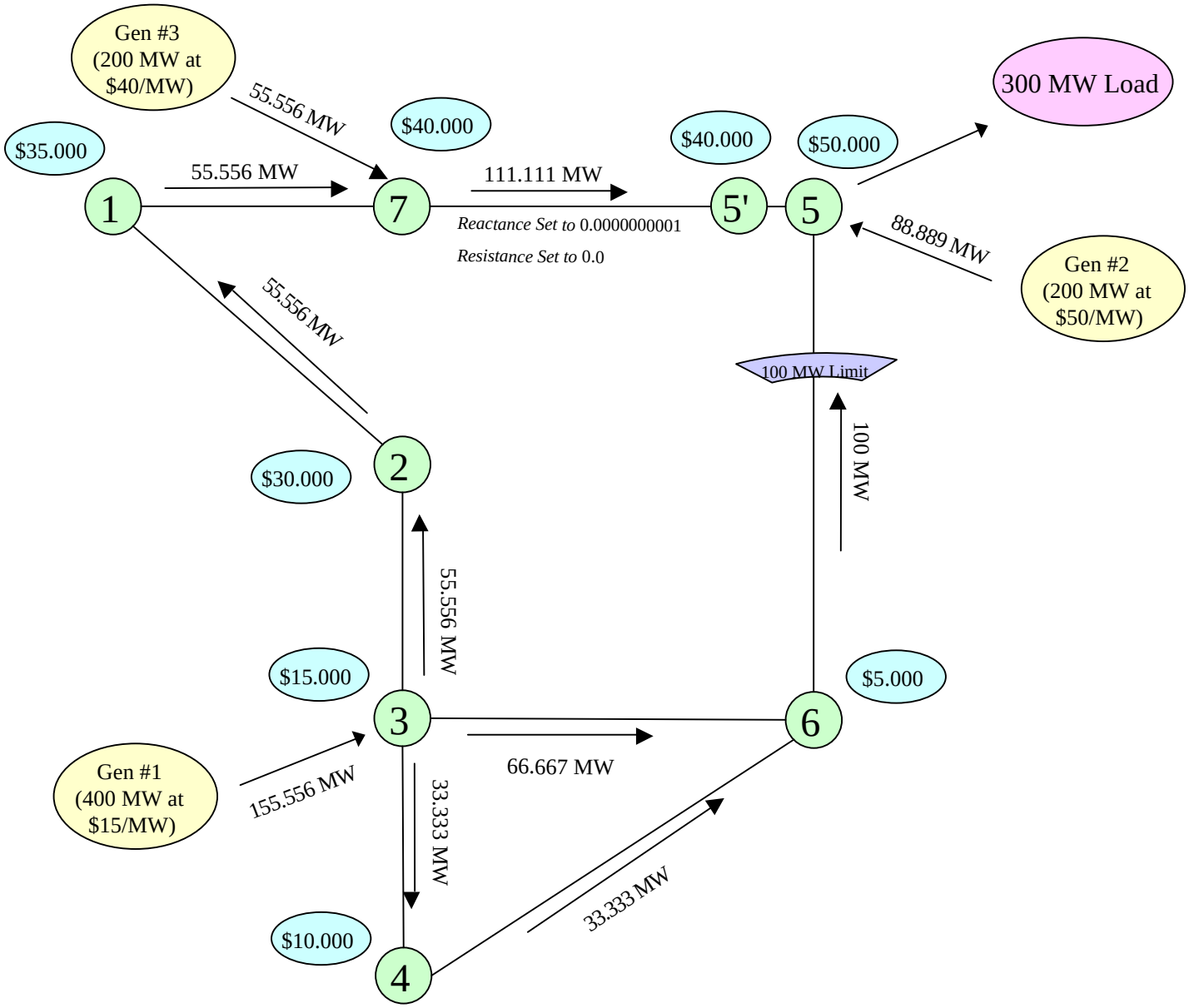


CONTROLLABLE LINE OUTAGE

In Scenario 2, it is assumed that the limit on the pre-contingency flows on line 7-5 is 100 MW rather than 75 MW.

The permits the higher pre-contingency flows shown above.

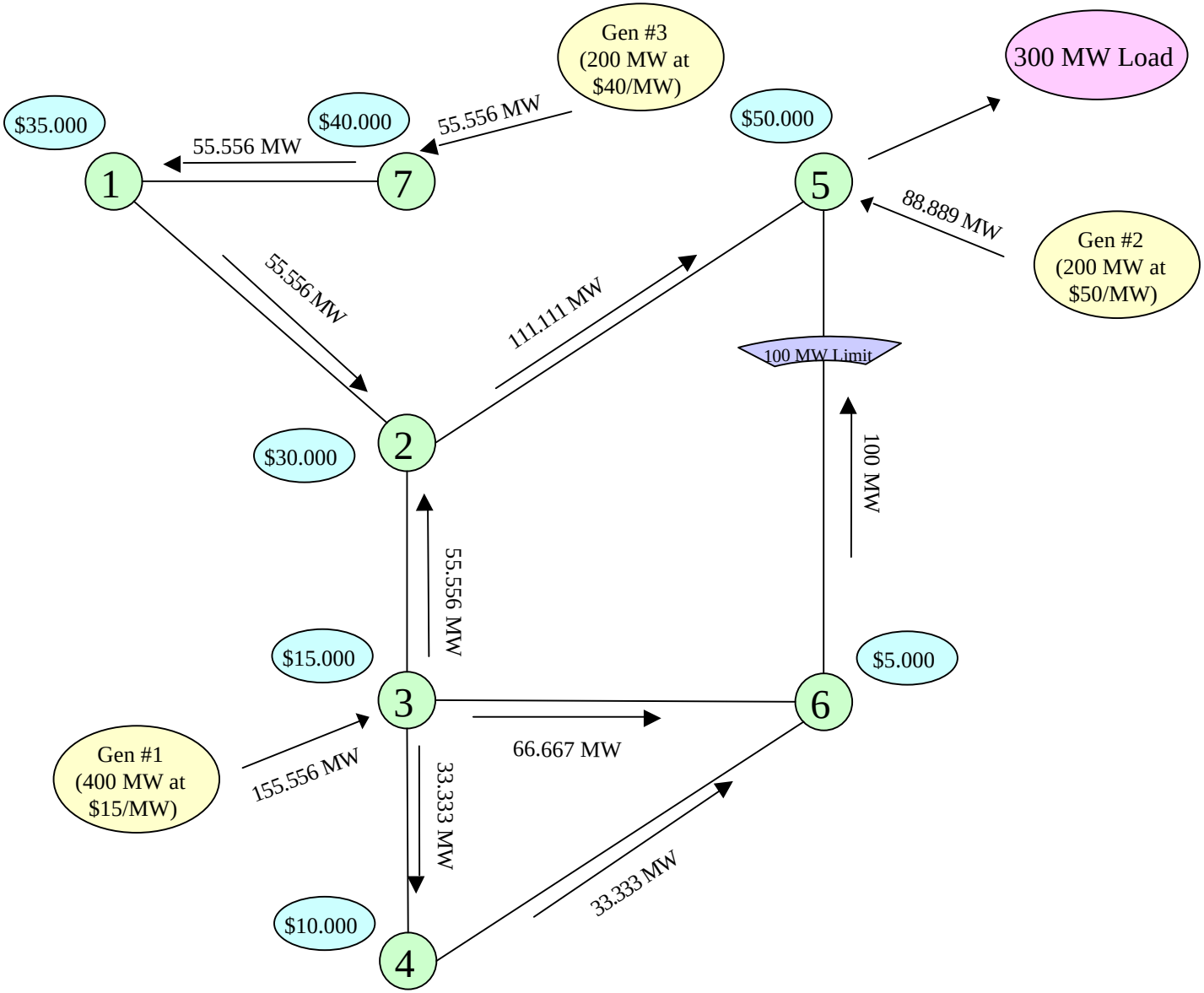
Scenario 2 Figure 9 (Line 2-5 Outage)



CONTROLLABLE LINE OUTAGE

The outage of the 2-5 line is still a binding constraint, with transfers limited by the post-contingency flows on line 6-5.

Scenario 2 Figure 10 (Line 5-7 Outage)



CONTROLLABLE LINE OUTAGE Scheduling Entity

In Scenario 2, however, the outage of the controllable line is also a binding contingency. As a result, the proxy price for deliveries over the controllable line would be less than the value of generation at Bus 5, because of the impact of schedules over the controllable line on the constraint in the contingency in which the controllable line is out.

Scenario 2, Table 11				
Contingency	**Data**	**Bus 7**	**Proxy 5**	**Generation 5**
All	Reference Bus Price	$50.00	$50.00	$50.00
Pre-Contingency	Shift Factor on 7-5	-1	0	0
	7-5 Shadow Price	$0.00	$0.00	$0.00
7-5 Contingency	Shift Factor on 7-5	-0.273	-0.273	0
	6-5 Shadow Price	$36.67	$36.67	$36.67
2-5 Contingency	Shift Factor on 6-5	0	0	0
	6-5 Shadow Price	$48.89	$48.89	$48.89
	LBMP	$40.00	$40.00	$50.00

CONTROLLABLE LINE OUTAGE

In the contingency in which the controllable line is out, the power scheduled to flow over the controllable line has the same impact on line 6-5 as generation at Bus 7.

Scenario 2, Table 12			
	MWh	**Price ($)**	**Net ISO Revenues ($)**
Bus 3 Generating Injections	-155.556	$15	-$2,333.34
Bus 7 Generation Injections	-55.556	$40	-$2,222.24
Bus 7 Withdrawals	+81.482	$40	+$3,259.28
Bus 5 Injections	-81.482	$40	-$3,259.28
Bus 5 Generation Injections	-88.889	$50	-$4,444.45
Bus 5 Load	300	$50	+15,000
Net Congestion Rents			$5,999.97
100 3-5 TCCs		$35	-$3,500.00
Residual Congestion Rents			$2,499.97
55.556 3-5		$35	$1,944.46
555.556 7-5		$10	$555.56
			$2,500.02

CONTROLLABLE LINE OUTAGE

If the schedules on the controllable line were settled using these pricing principles, the ISO would collect $6,000.00 in congestion rents.

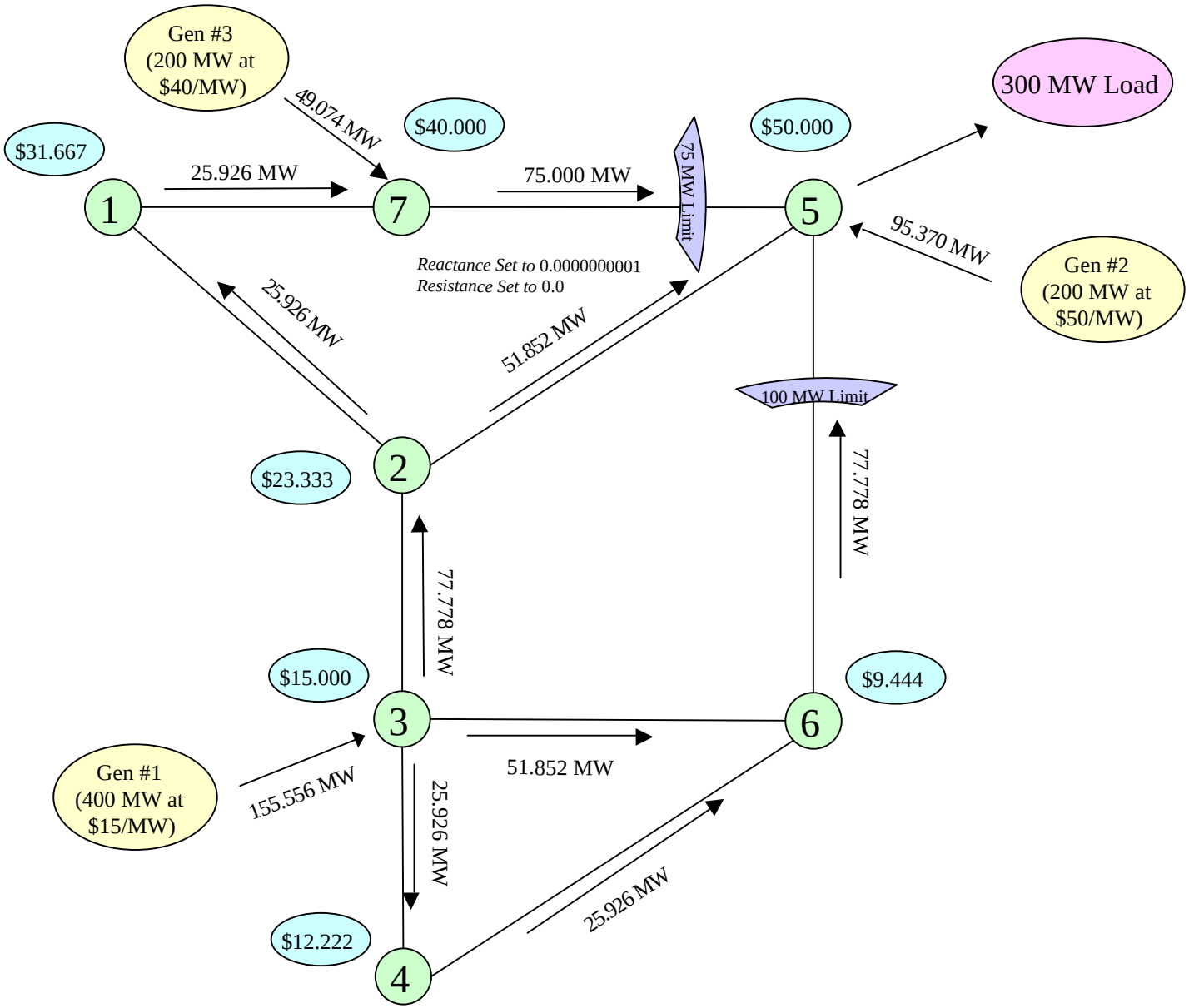
- $1,500 would be payable on 100 3 to 5 TCCs.
- $2,500 in residual congestion rents would be collected.
- These residual congestion rents could fund 55.556 3 to 5 and 55.556 7 to 5' TCCs.

ISO Scheduling

The third situation in which the award of TCCs would affect the economics of controllable lines would be if flows over the controllable line were scheduled by the ISO.

- In this circumstance, there would be no market participant schedules on these lines to settle at LMP prices.
- Expansion TCCs would be awarded in the normal manner to reflect the change in transfer capability permitted by the operation of the controllable line.

Scenario 1 Figure 1

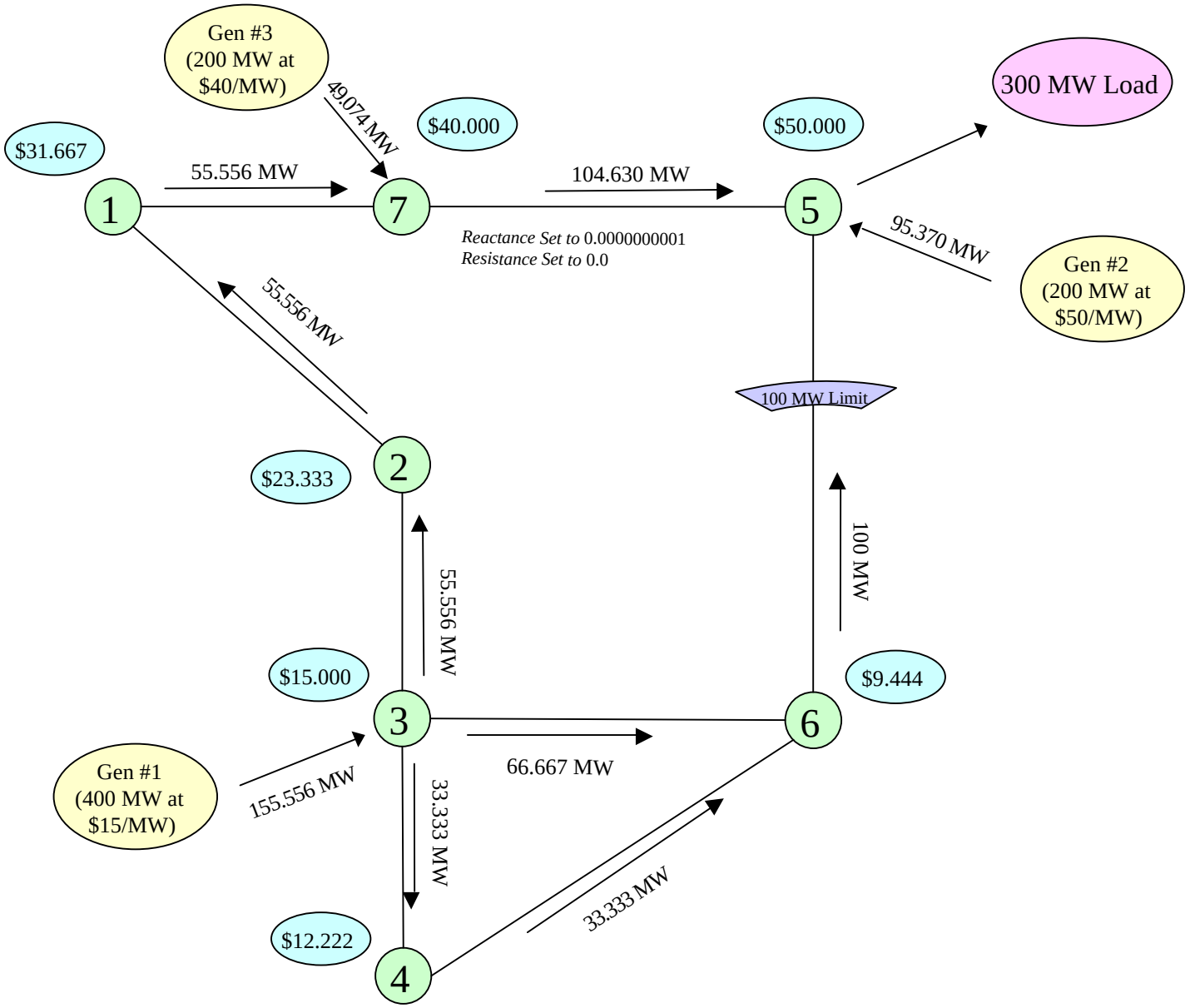


ISO SCHEDULING

The third scenario is identical to Scenario 1 but schedules on the controllable line are determined by the ISO. The illustration again assumes that generation is available for dispatch at Buses 3, 5 and 7.

- It is again assumed that there is a 75 MW limit on the pre-contingency flows over the controllable line that is binding in the least-cost dispatch.
- There are again two binding transmission constraints and three marginal generators.

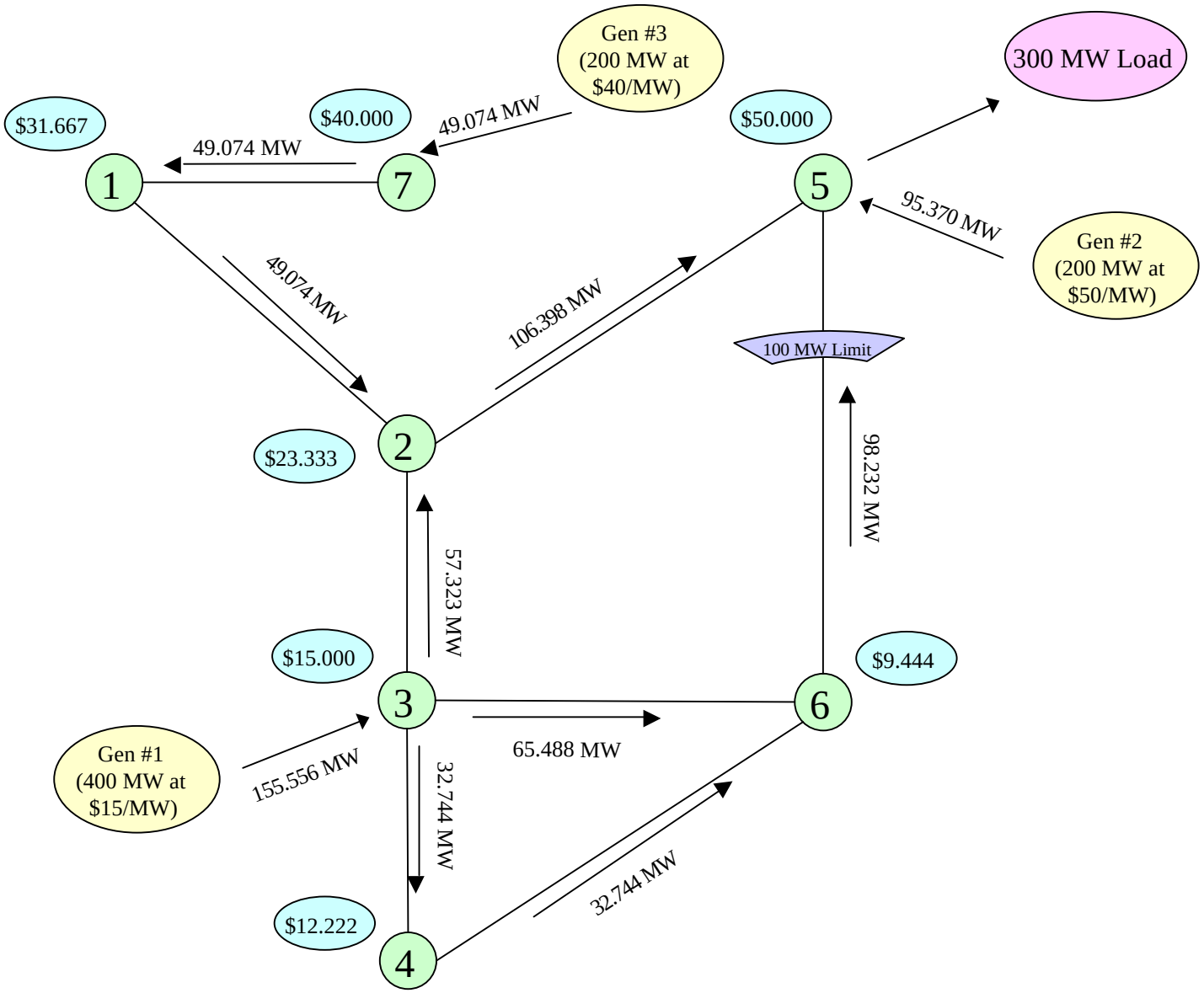
Scenario 1 Figure 2 (Line 2-5 Outage)



ISO SCHEDULING

The outage of Line 2-5 is again a binding contingency.

Scenario 1 Figure 3 (Line 5-7 Outage)



ISO SCHEDULING

The constraint on the controllable line limits the pre-contingency flows on this line such that its outage is not a binding constraint.

Scenario 3, Table 13			
	MWh	**Price ($)**	**Net ISO Revenues ($)**
Bus 3 Generating Injections	-155.556	$15	-$2,333.40
Bus 7 Generation Injections	-49.074	$40	-$1,962.96
Bus 7 Withdrawals	+75	$40	+$3,000.00
Bus 5 Load	300	$50	+$15,000.00
Net Congestion Rents			$5,935.14
100 3-5 TCCs	100	$35	-$3,500.00
Residual Congestion Rents			$2,435.14

ISO SCHEDULING

All injections and withdrawals would be settled at LMP prices.

- There would be no explicit settlement of ISO-determined schedules on the controllable line.
- The ISO would collect congestion rents of $2,435.14.

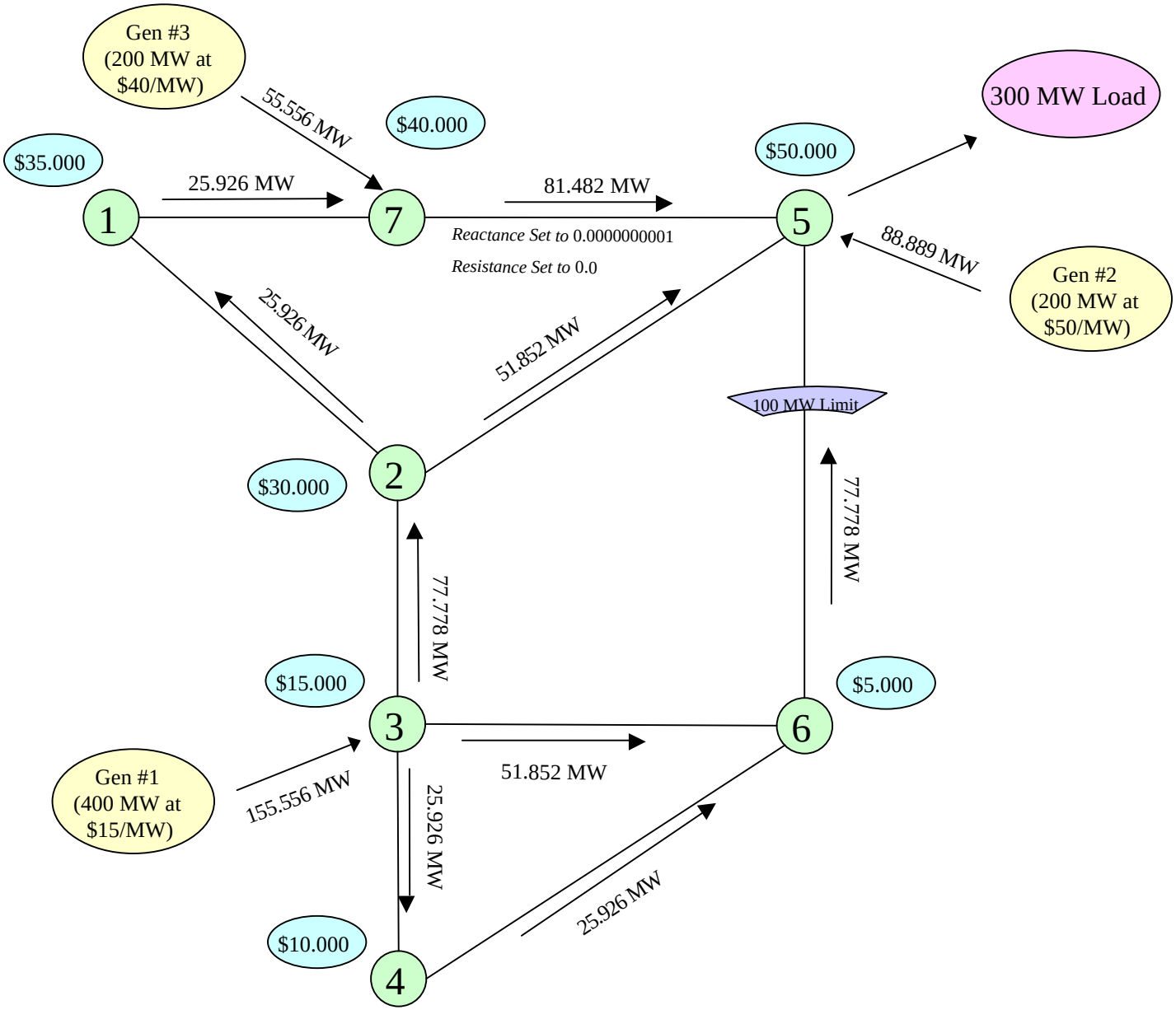
Scenario 3, Table 14			
TCC	**MW**	**Value/MW ($)**	**Value ($)**
3 to 5	55.556	$35	$1,944.46
7 to 5	49.074	$10	$490.74
Total			$2,435.20

ISO SCHEDULING

The construction of the controllable line would make it possible to award an additional 55.556 TCC from 3 to 5 and 49.074 TCC from Bus 7 to Bus 5.

- The solution to Scenario 1 shows that these TCCs would be simultaneously feasible.
- These TCCs would also be revenue-adequate.

Scenario 2 Figure 8 (No Outages)



ISO SCHEDULING

These pricing principles could also be applied to an ISO-scheduled controllable line in the second scenario.

Scenario 2, Table 12			
	MWh	**Price ($)**	**Net ISO Revenues ($)**
Bus 3 Generating Injections	-155.556	$15	-$2,333.34
Bus 7 Generation Injections	-55.556	$40	-$2,222.24
Bus 5 Generation Injections	-88.889	$50	-$4,444.45
Bus 5 Load	300	$50	+15,000
Net Congestion Rents			$5,999.97
100 3-5 TCCs		$35	-$3,500.00
Residual Congestion Rents			$2,499.97
55.556 3-5		$35	$1,944.46
555.556 7-5		$10	$555.56
			$2,500.02

ISO SCHEDULING

As in the market participant scheduled scenario, the ISO would collect $6,000 in congestion rents, which could fund 155.556 3-5 TCCs and 55.556 7-5 TCCs.