# DC Line Scheduling Design
# Two Settlement Examples

**Scott Harvey**

**NYISO Market Issues Working Group**

**April 19, 2022**

# Topics

- Background
- Two Settlement Examples
- Next Steps
- Appendix - March 16 examples with typos corrected

# Background

NYSERDA's Tier 4 REC initiative has driven the prioritization of this project, which will develop market participation rules for internal controllable lines. The energy market rules proposed in this presentation are designed to accommodate the Clean Path proposal that is being considered by the New York Public Service Commission.

- The project will culminate in a Market Design Concept Proposed (MDCP) by Q4 2022.

The purpose of today's presentation is to discuss examples illustrating the NYISO's thinking on Energy Market scheduling and settlement for internal controllable lines.

- The examples are intended to roughly illustrate the operation of the NYISO design in the context of an internal DC line.
- The NYISO design is intended to accommodate internal controllable lines with a range of different project structures.

The NYISO will return to future working groups to discuss more advanced settlement rules such as the applicability of make whole payments, the applicability of energy market power measures, and other operational procedures such as outage scheduling and transfer limit determination.

# Overview

The discussion in these slides and the examples that follow assume:

1. The NYISO optimizes flows over the DC line based on economic dispatch, meeting New York load at least as-bid cost, taking account of the incremental O&M costs and incremental losses of DC line operation.
2. The DC line owner will buy power at the LMP price at the source of the DC line and sell the power it delivers into Zone J at the LMP price at the sink of the DC line.
3. The DC line owner will retain the congestion rents generated by the operation of the line.
4. No TSC will be collected on withdrawals from the grid at the source of the DC line.
5. Any REC payments will occur outside the NYISO settlement system.
6. The NYISO design for internal controllable lines is intended to apply to flows in either direction on an internal DC line but we have not included any examples of that in these slides.

7. The outage of the DC line is not a binding contingency in the real-time dispatch.
8. The DC line sinks within a constrained generation pocket within Zone J.
9. There is no other transmission line receiving similar payments for delivery of power into Zone J from the same upstate region.
10. Tier 1 production will be divided into two categories. The first grouping of Tier 1 wind and solar resources ("Tier 1a") will be offered into the market at -$21, reflecting the value of its Tier 1 REC payments.
11. The second group of Tier 1 wind and solar resources ("Tier 1b") have a larger subsidy. Output from the Tier 1b generators is offered at -$21.5 to displace Tier 1a production on the margin.
12. Offshore wind production is offered into the market at –$44, reflecting the incentives of the offshore wind contracts. This is a very rough estimate which may not be accurate, but it is used to illustrate potential interactions between the offshore wind REC payments and the REC payments to other resources.

# Two Settlement Examples

# Two Settlement Examples

## Case 4A

In this section we work through several examples of the combined day-ahead market and real-time dispatch settlements.

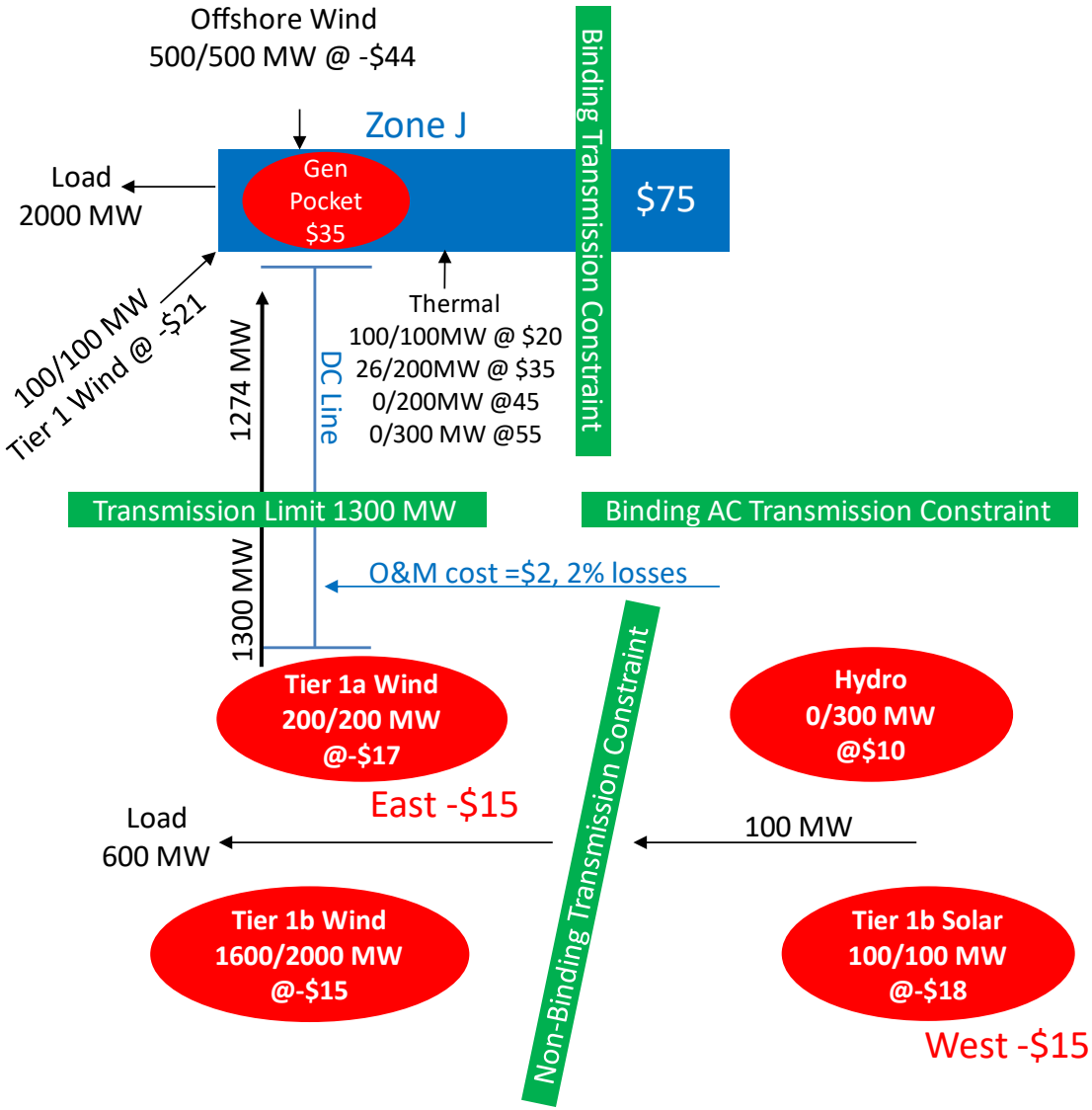
- Case 4A: In this case the DC line is fully utilized in the day-ahead market.
- Case 4B is a case in which the DC line is also fully utilized in real-time.
- Case 4C is a case in which wind and solar output upstate is low in real-time and the DC line is only partly utilized in real-time.
- Case 4D is a case in which the DC line is dispatched down out-of-merit in real-time by the NYISO so its real-time flows are less than its day-ahead market schedule.
- Case 5A: In this case the DC line is only partly scheduled in the day-ahead market.
- Case 5B is a case in which the DC line is fully utilized in real-time after being partly scheduled in the day-ahead market.

# Two Settlement Examples — Case 4A

Case 4A: In this case the DC line is fully utilized in the day-ahead market, with the price in Zone J set by thermal generation.

- The example used for cases 1, 2 and 3 has been modified to add multiple thermal resources inside Zone J, with varying offer prices. This slightly complicates the examples but better illustrates the price and production cost impacts of higher or lower levels of power flowing over the DC line.
- Offers submitted by renewable resources are assumed to be on the margin in the upstate region in the day-ahead market in case 4A.
    - The amount and level of these offers will reflect the degree of uncertainty regarding the level of real-time output. The example assumes that upstate wind and solar suppliers are somewhat optimistic in offering supply in the day-ahead market so that the DC line is fully scheduled.
    - The upstate offers that clear in the day-ahead market in this example could be virtual supply offers without changing the results of these examples for the DC line.

# Day Ahead Market – Line Full



# Two Settlement Examples — Case 4A-Day-Ahead

- The New York ISO would be revenue adequate in the day-ahead market with payments from load and payments for purchases by the DC line owner exactly covering payments to generation and payments for deliveries by the DC line.
- The scheduling of the DC line materially reduces day-ahead prices in the generation pocket, which would have been at least $75/MWh had the DC line not been available to deliver power, and also reduces the production cost of meeting load.
- The DC line owner would earn congestion rents attributable to meeting Zone J load with lower cost upstate supply.
- The DC line owner would not earn Tier 4 REC revenues in the day-ahead market, as the actual delivery to Zone J of qualifying renewable energy is required to earn Tier 4 RECs.

| | DC line net revenues | | | |
|---|---|---|---|---|
| MW | | | Prices | Payments |
| 1,300 | purchases | | -$15.00 | $19,500 |
| 1,274 | sales | | $35.00 | $44,590 |
| 1,274 | O&M Costs | | $2.00 | -$2,548 |
| | | | margin | $61,542 |

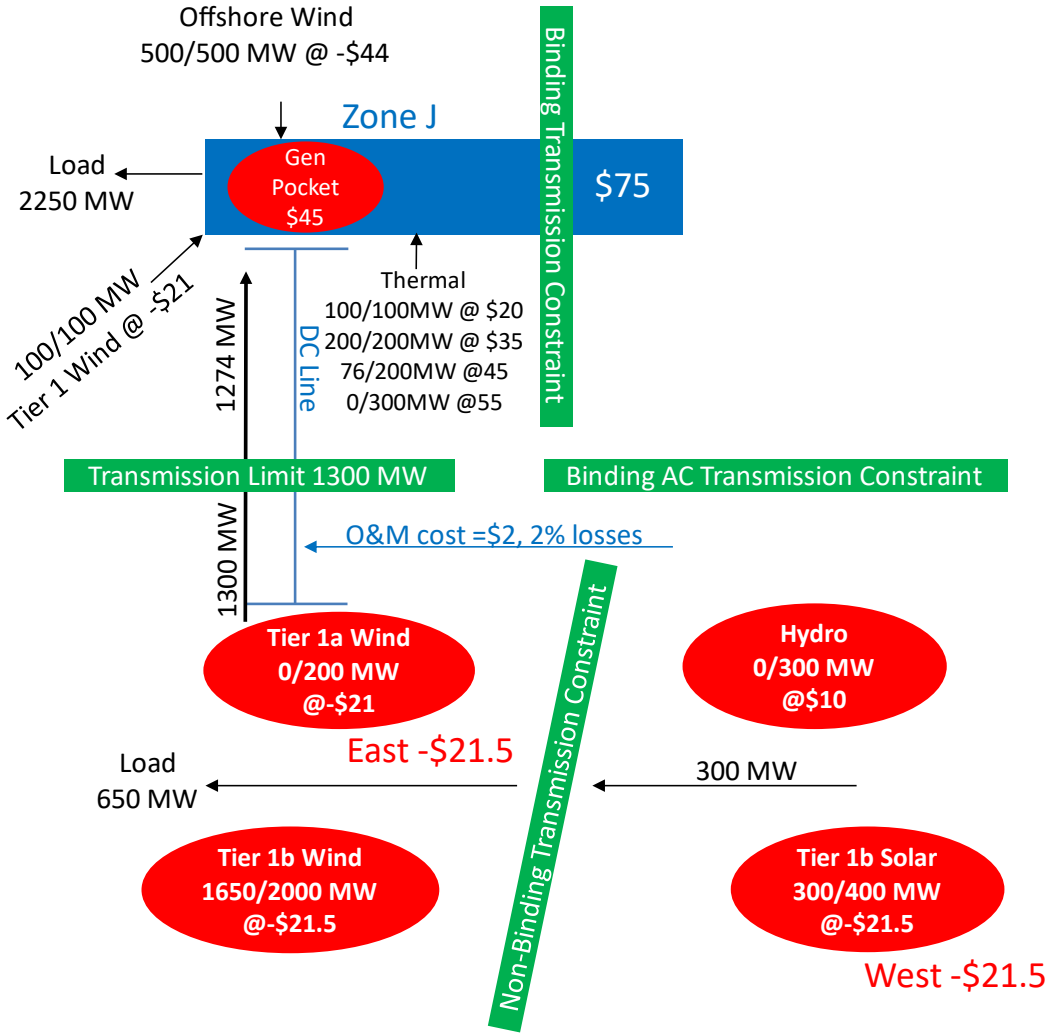
# Two Settlement Examples — Case 4B- Real-Time

Case 4B: In this example, the DC line is also fully scheduled in real-time. The price in zone J is set by thermal generation. Load is higher than expected in the day-ahead market with higher cost generation dispatched to meet Zone J load.

- Wind and solar resources are on the margin in the upstate region in real-time, with lower clearing prices than in the day-ahead market.
- The DC line owner would not earn any additional margins from the operation of the DC line in real-time, as there would be no differences between its day-ahead market and real-time schedules.

| | MW | | DC line real-time net revenues | | | | | |
|---|---|---|---|---|---|---|---|---|
| DAM | RT | Net RT | | | Prices | Payments | DAM | Total |
| 1300 | 1300 | - | purchases | | -$21.50 | $0 | $19,500 | $19,500 |
| 1274 | 1274 | - | sales | | $45.00 | $0 | $44,590 | $44,590 |
| 1274 | 1274 | - | O&M Costs | | $2.00 | $0 | -$2,548 | -$2,548 |
| | | | | | margin | $0 | $61,542 | $61,542 |

# Real-Time Dispatch – Line Full



# Two Settlement Examples — Case 4B-Real-Time

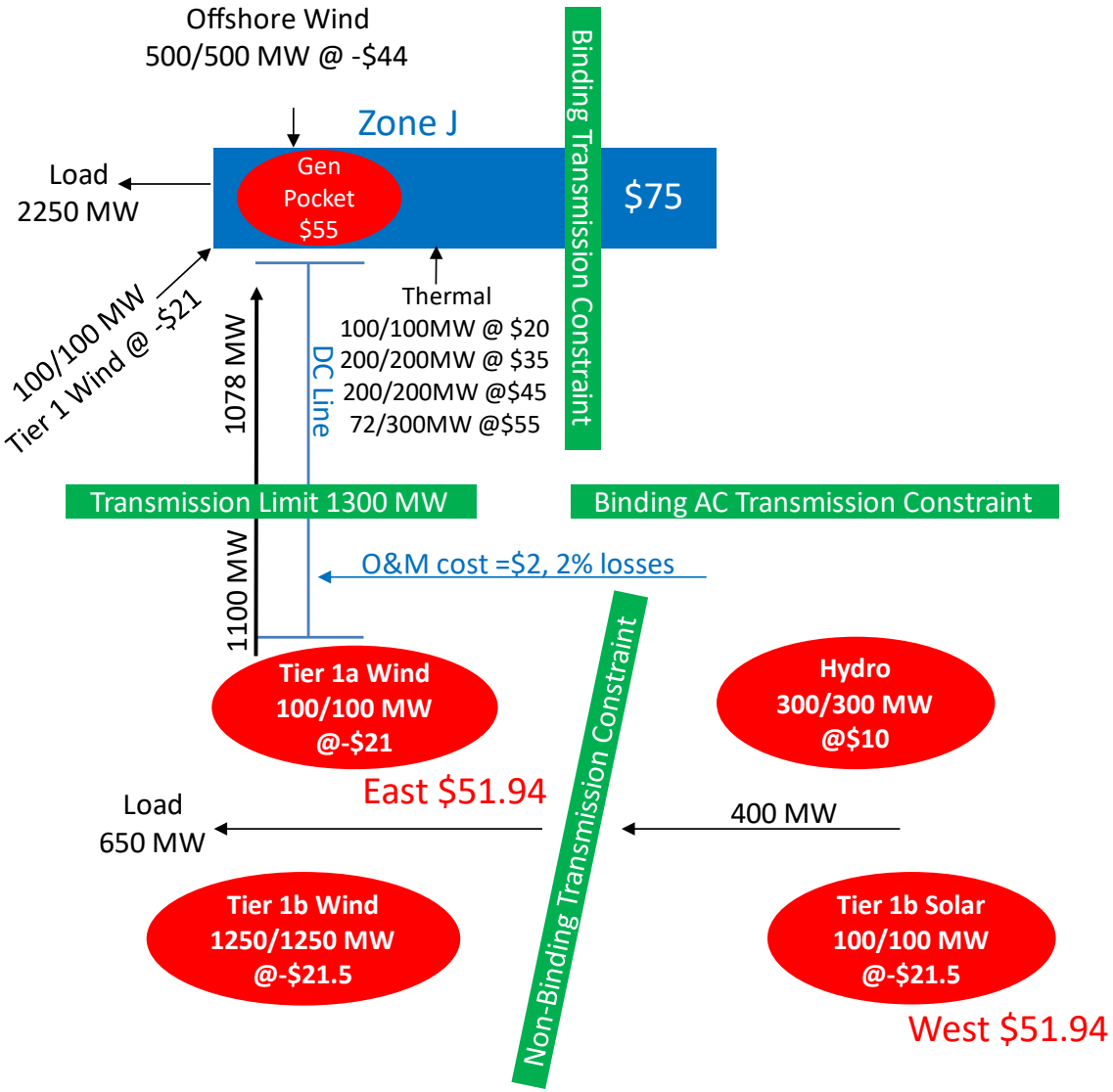
- The New York ISO would be revenue adequate in real-time, settling deviations from day-ahead market schedules at real-time prices.
- Tier 1 generators (or virtual suppliers) that cleared schedules in the day-ahead market are dispatched down in real-time. This outcome would profitable as they would buy back the power they sold at -$15/MWh in the day-ahead market at -$21.5/MWh in real-time.
- The DC line owner would earn Tier 4 REC revenues base on qualifying renewable energy production and DC line deliveries in real-time. The DC line owner's Tier 4 REC revenues would be completely independent of day ahead market schedules.
- Without the DC line the price in the generation pocket would have risen to at least $75/MWh set by imports from outside the generation pocket, so the operation of the DC line reduces both prices and the production cost of meeting load.
- In this case congestion was somewhat higher in real-time than day-ahead so, in retrospect, it would have been more profitable for the DC line owner to have scheduled lower flows in the day-ahead market and settled more flows at real-time prices. Had all DC line been scheduled entirely in real-time its margin would have been $82,732 rather than $61,542.

# Two Settlement Examples — Case 4C- Real-Time

Case 4C: This is an alternative scenario for real-time in which load is the same as in Case 4B but wind and solar output is lower in real-time than expected day-ahead and the DC line is not fully utilized.

- Wind, solar and hydro generation is fully dispatched in the upstate region, but with lower upper operating limits than in the day ahead market due to lower than expected wind and sun, and thermal generation is on the margin in Zone J.
- The Zone J price would determine the upstate price, with the upstate price set by the Zone J price ($55/MWh) less incremental O&M ($2/MWh) and cost of 2% losses on the DC Line ($1.06/MWh).
- Even though the DC line is not fully utilized, the operation of the DC line materially reduces prices in the generation pocket which would have been at least $75/MWh without the power delivered by the DC line and also reduces the production cost of meeting load.

# Real-Time Dispatch – Reduced Flows



# Two Settlement Examples Case 4C- Real-Time

Case 4C: The DC line owner would buy back 196 MW of its day-ahead market sales in Zone J at the real-time price, losing money, but would also sell back 200 MW upstate at the real-time price, making money. In addition, the line would avoid incremental O&M costs on the reduced flows.

- Overall the DC line owner would break even in real-time.
- In this case, the DC line owner is much better off having scheduled the line in the day-ahead market rather than waiting to schedule flows in real-time. Had the line been entirely scheduled in real-time the DC line owner would have earned 0 margin on its schedules.

| | MW | | DC line real-time net revenues | | | | | |
|---|---|---|---|---|---|---|---|---|
| DAM | RT | Net RT | | | Prices | Payments | DAM | Total |
| 1300 | 1100 | (200) | purchases | | $51.94 | $10,388 | $19,500 | $29,888 |
| 1274 | 1078 | (196) | sales | | $55.00 | -$10,780 | $44,590 | $33,810 |
| 1274 | 1078 | (196) | O&M Costs | | $2.00 | $392 | -$2,548 | -$2,156 |
| | | | | | margin | $0 | $61,542 | $61,542 |

# Two Settlement Examples — Case 4C- Real-Time

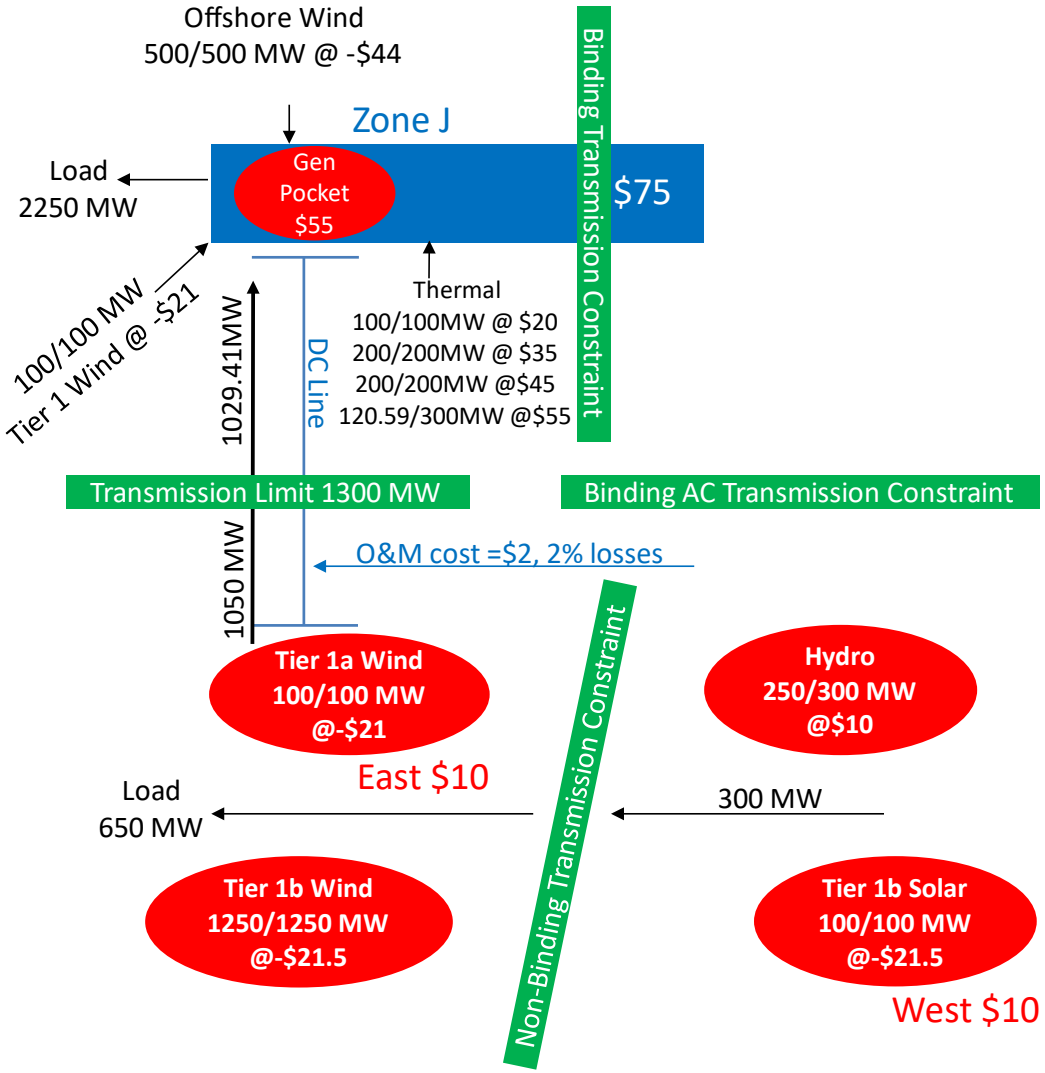
- Upstate wind and solar resources, as well as virtual suppliers, that were scheduled in the day ahead market, would settle deviations between day-ahead market schedules and real-time output at real-time prices, buying back 450 megawatts at $51.94/MWh, due to lower than expected output.
- The upstate resources and virtual suppliers would lose money on their day-ahead schedules and would have been better off not having cleared output in the day-ahead market.
- The DC line owner would earn additional revenues on its Tier 4 REC sales which would be unaffected by its day-ahead market schedules.

# Two Settlement Examples — Case 4D- Real-Time

Case 4D: This is an additional scenario for real-time in which the DC line is dispatched down out of merit to 1050 MW in real-time by NYISO operators to manage a constraint that is not modeled in the day-ahead market or in RTD.

- Thermal generation is on the margin in Zone J setting the price at $55/MWh as in the prior cases.
- Hydro generation is on the margin in Zone E, setting the Zone J price at $10/MWh.
- As in the preceding cases, even though the DC line is dispatched down out of merit in real-time below its economic operating point, prices in the generation pocket and the production cost of meeting load are materially lower than they would be if the DC line were not available.

# Real-Time Dispatch – Out of Merit Dispatch



# Two Settlement Examples Case 4D- real-Time

Case 4D: The out of merit dispatch in real-time would require the DC line owner to buy back 245 MW of its day-ahead market sales in Zone J at the real-time price, losing money. The DC line owner would also sell back 250 MW upstate at the real-time price, $10/MWh.

Overall the DC line owner would incur losses in real-time from the out-of-merit dispatch as shown in the table below, although the losses would be much lower than its day-ahead market profits. This might not have been the case had the scheduling of the DC line been less profitable in the day-ahead market.

| | MW | | DC line real-time net revenues | | | | | |
|---|---|---|---|---|---|---|---|---|
| DAM | RT | Net RT | | | Prices | Payments | DAM | Total |
| 1300 | 1,050 | (250) | purchases | | $10 | $2,500 | $19,500 | $22,000 |
| 1274 | 1,029.41 | (245) | sales | | $55 | -$13,452 | $44,590 | $31,138 |
| 1274 | 1,029.41 | (245) | O&M Costs | | $2 | $489 | -$2,548 | -$2,059 |
| | | | | | margin | -$10,463 | $61,542 | $51,079 |

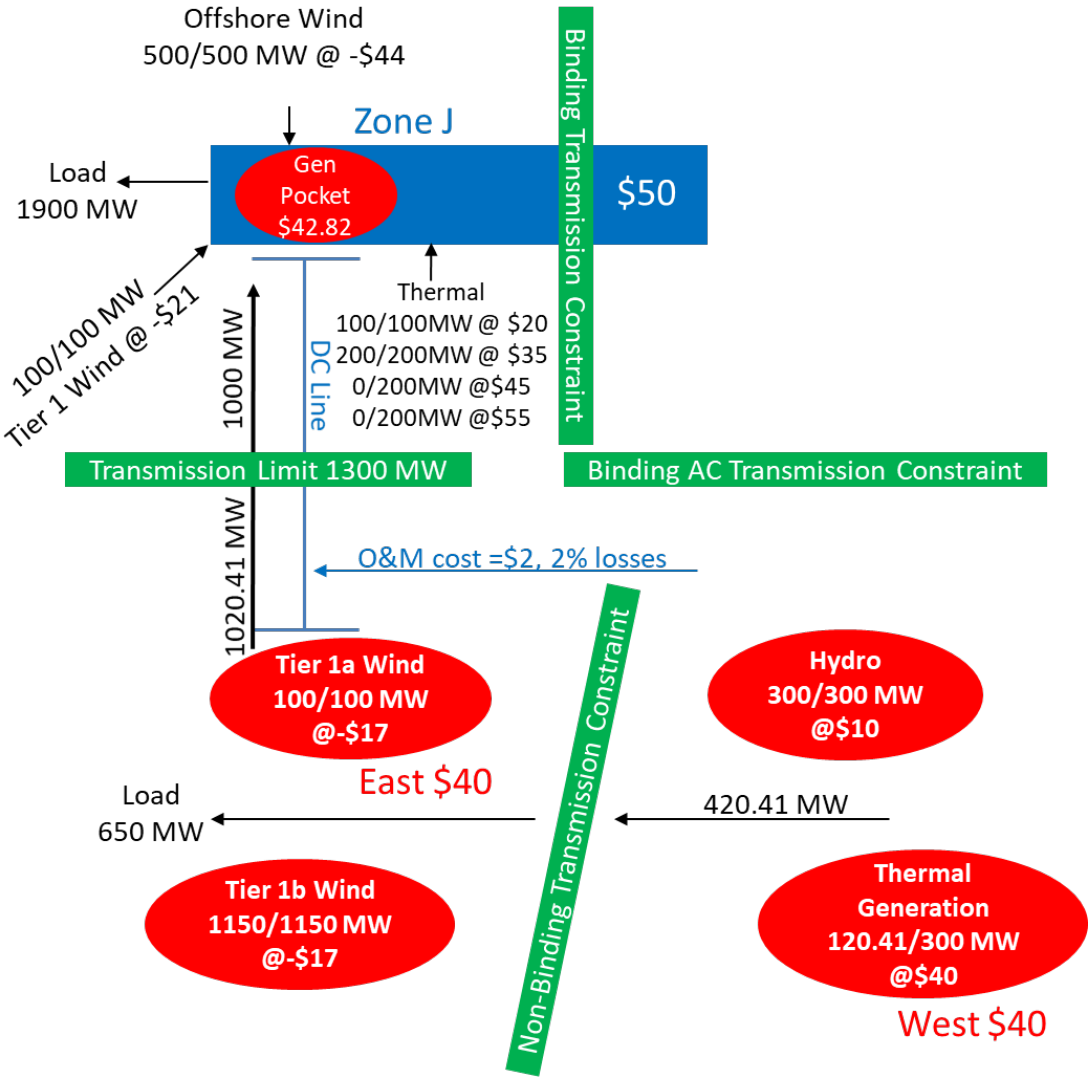
# Two Settlement Examples — Case 5A-Day-Ahead

Case 5A: This case is the reverse of case 4A. The DC line is partly scheduled in the day-ahead market, with the price in Zone J set by the thermal generation that is on the margin in the upstate region ($40/MWh + $2/MWh O&M + $.82 cost of 2% losses).

- The DC line does not earn any margin on the output scheduled in the day-ahead market in this example. However, the output scheduled on the DC line in the day-ahead market materially reduces the price in Zone J.

| | DC line net revenues | | | |
|---|---|---|---|---|
| MW | | | Prices | Payments |
| 1,020.41 | purchases | | $40.00 | -$40,816.40 |
| 1,000 | sales | | $42.82 | $42,820 |
| 1,000 | O&M Costs | | $2 | -$2,000 |
| | | | | $4 |
| | | | margin/MWh | $0.00 |

# Day-Ahead Market –DC line partly full

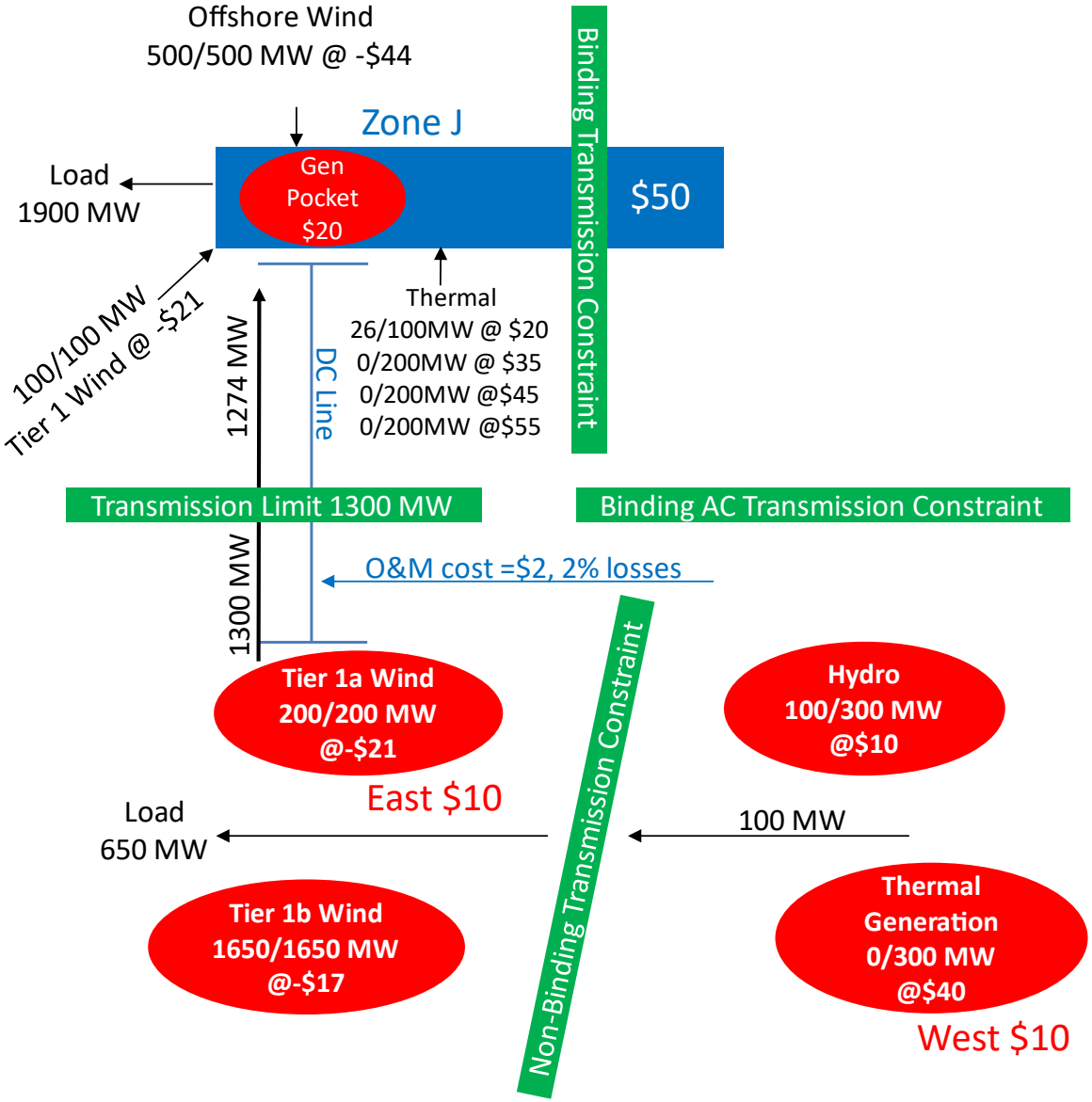


# Two Settlement Examples — Case 5B- Real-Time

Case 5B: In real-time wind output is high in the upstate region and low cost hydro is on the margin upstate rather than thermal generation as was the case in the day-ahead market.

- Wind and solar generation is fully dispatched in the upstate region, and low cost thermal generation is on the margin in Zone J.
- With the high wind and solar output upstate, the DC line is fully utilized in the real-time dispatch.

# Real-Time Dispatch – line full



# Two Settlement Examples — Case 5B- Real-Time

Case 5B: Upstate wind and solar resources in the upstate region, as well as virtual suppliers, that were scheduled in the day ahead market, settle deviations between day-ahead market schedules and real-time output at real-time prices, with upstate wind generators selling an additional 500 MW at the real-time price.

- The DC line owner would buy additional power in the upstate region at $10/MWh and sell the output in Zone J for $20, incurring additional losses and O&M costs on the incremental volume, earning a margin on its real-time schedules.
- In this case the DC line owner would have been better off scheduling lower flows in the day-ahead market, and scheduling more flows in real-time at real-time prices.

| | MW | | DC line real-time net revenues | | | | | |
|---|---|---|---|---|---|---|---|---|
| DAM | RT | Net RT | | | Prices | Payments | DAM | Total |
| 1,020.41 | 1300 | 279.59 | purchases | | $10.00 | -$2,796 | -$40,816 | -$43,612 |
| 1000 | 1274 | 274 | sales | | $20.00 | $5,480 | $42,820 | $48,300 |
| 1000 | 1274 | 274 | O&M Costs | | $2.00 | -$548 | -$2,000 | -$2,548 |
| | | | | | margin | $2,136 | $4 | $2,140 |

# Next Steps

April, May: Continued discussions on Energy Market design (ICAPWG/MIWG)

May, June: Capacity Market design discussions (ICAPWG/MIWG)

June, July: Discuss any open items (ICAPWG/MIWG)

July, August: Consumer Impact Analysis discussions (ICAPWG/MIWG)

End of Q4: Market Design Concept Proposed

# Appendix

Previous Presentations

- 2/3/22: Kick-Off presentation discussing project scope and timeline
  - 2/3/22 MIWG Presentation
- 3/16/22: Energy Market Design Real-Time Scheduling and Settlement Examples
  - 3/16/22 MIWG Presentation

# Appendix
# March 16 examples- Typos Corrected

# Overview

The NYISO's DC line operation design proposal has the following implications.

- The economic dispatch will be system least-cost given the offers of the resources.
- Wind and solar generators that receive Tier 1 or other REC subsidies are expected to submit negative offers to ensure that their generation is not dispatched down before other resources with higher costs or lower subsidies.
- In periods in which the DC line is fully utilized, the DC line owner will receive congestion rents for delivering power into Zone J.

If the DC line is not fully utilized, prices in either Zone J or E (upstate) can be set by the price of power at the source or sink of the line and the cost of flows over the DC line.

- If the NYISO schedules the DC line based on its variable O&M costs, the DC line owner will just recover its costs in the price difference between the source and sink of the DC line, with the difference in prices equaling the DC line's variable costs.

# Constrained DC Line Examples

# Constrained DC Line

This cases considered in this section are:

- Case 1: Project generation output is less than the flows on the DC line and thermal generation is on the margin in Zone E.
- Case 2: Project generation output exceeds the flows on the DC line, but thermal generation is on the margin in Zone E.

# Constrained DC Line

## Case 1

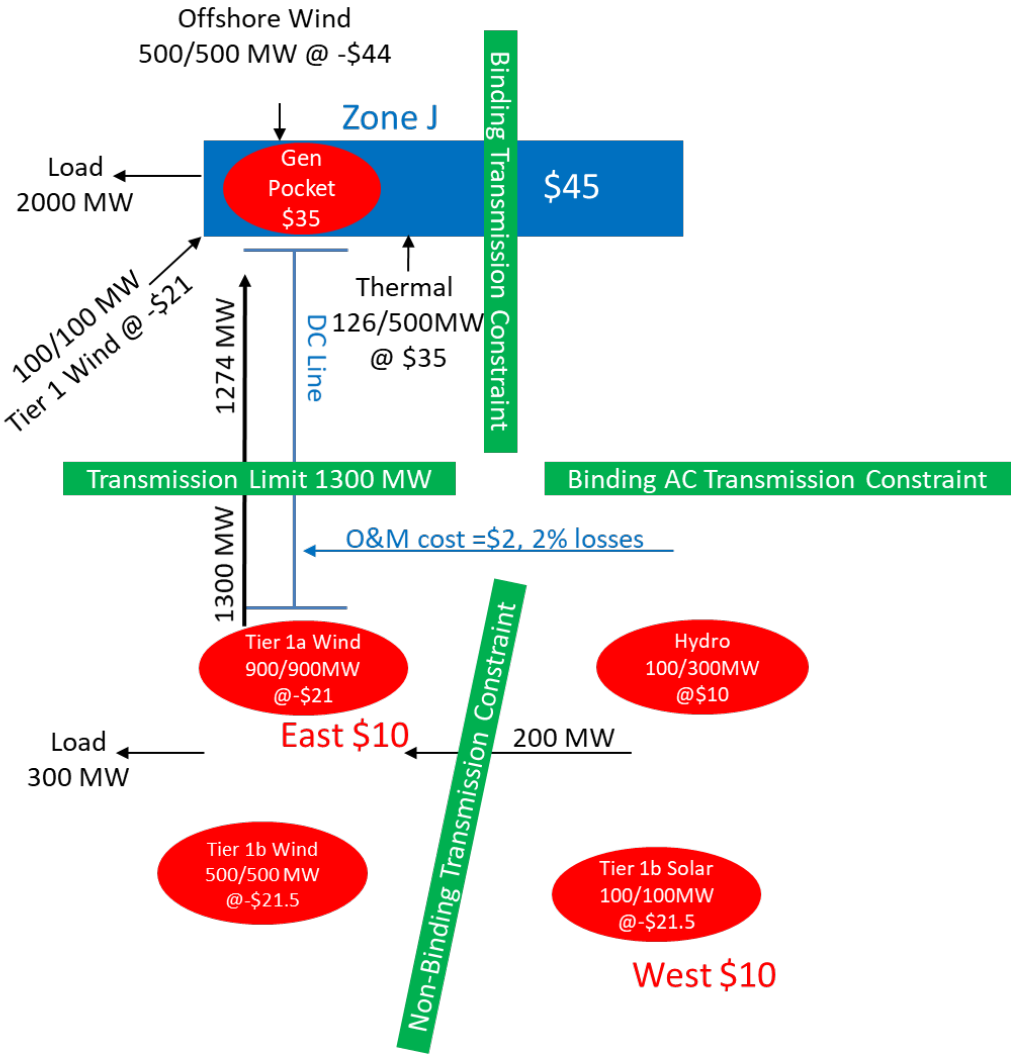
Case 1, the DC line is fully utilized with hydro generation on the margin in Zone E.

- The New York ISO would be revenue adequate with payments from load and payments by the DC line owner to purchase power exactly covering payments to generation and for deliveries by the DC line.
- The DC line owner would earn congestion rents attributable to meeting load in Zone J with the lower cost generation in Zone E.

| | DC line net revenues | | | |
|---|---|---|---|---|
| MW | | | Prices | Payments |
| 1,300 | purchases | | $10 | -$13,000 |
| 1,274 | sales | | $35 | $44,590 |
| 1,274 | O&M costs | | $2 | -$2,548 |
| | | | margin | $29,042 |

# Constrained DC Line

# Case 1



# Constrained DC Line

## Case 2

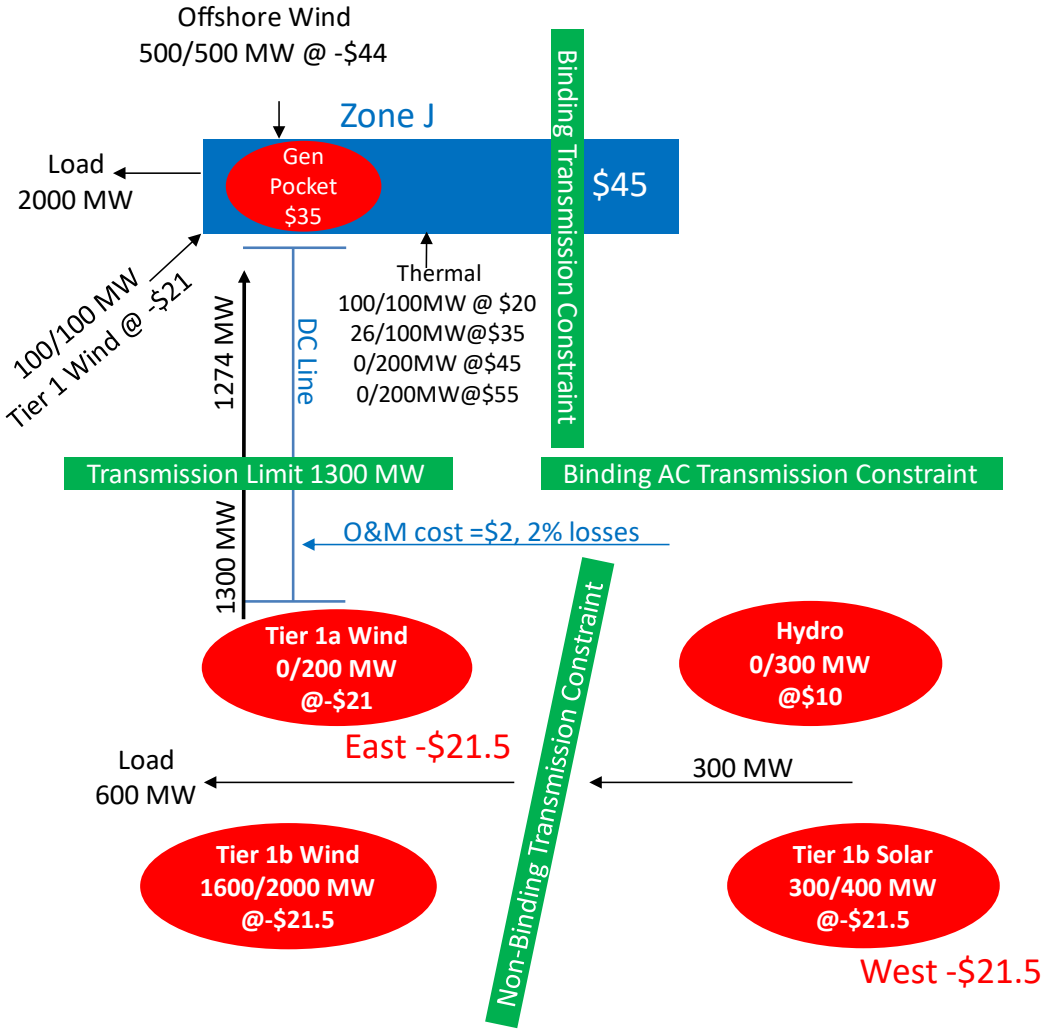
Case 2, the DC line is again fully utilized so prices in Zone J are set by the offer prices of Zone J generation. However, in this example, Tier 1b wind and solar generation is on the margin in Zone E, setting prices.

- The New York ISO would be revenue adequate with payments from load and payments for purchases by the DC line owner exactly covering payments to generation and payments for deliveries by the DC line.
- Output of Tier 1b generation exceeds the load plus flows on the DC line so Tier 1b generator offer prices would set prices in Zone E at -$21.5, slightly below the value of Tier 1a subsidies, displacing Tier 1a generation output offered at -$21.
- The DC line owner would earn congestion rents on the difference between Zone J and Zone E prices.

| | DC line net revenues | | | |
|---|---|---|---|---|
| MW | | | Prices | Payments |
| 1,300 | purchases | | -$21.50 | $27,950 |
| 1,274 | sales | | $35.00 | $44,590 |
| 1,274 | O&M Costs | | $2.00 | -$2,548 |
| | | | margin | $69,992 |

# Constrained DC Line

# Case 2-corrected



# Unconstrained DC Line Example

# Unconstrained DC Line — Case 3

Case 3: In this case the DC line is not fully utilized so Zone E production is on the margin in Zone J, displacing all thermal generation in Zone J.

- The New York ISO would be revenue adequate with payments from load and payments for purchases by the DC line owner exactly covering payments to generation and payments for deliveries by the DC line.
- The DC line owner would basically break even in NYISO markets if the DC line were scheduled based on its O&M costs by the NYISO.

| | DC line net revenues | | | |
|---|---|---|---|---|
| MW | | | Prices | Payments |
| 1,020.41 | purchases | | $10 | -$10,204.10 |
| 1,000 | sales | | $12.21 | $12,210 |
| 1,000 | O&M Costs | | $2 | -$2,000 |
| | | | | $6 |
| | | | margin/MWh | $0.01 |

# Unconstrained DC Line

# Case 3