

# LBMP: Three Components Summary

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**LBMP In-Depth Course**

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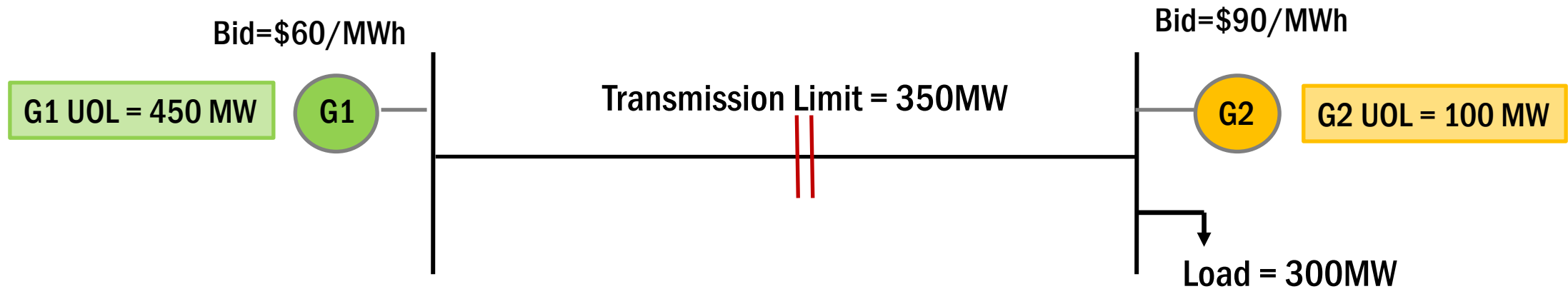
# Session Objectives

- **Upon completion of this module, trainees will be able to:**
  - Explain how the marginal costs of Energy, Loss and Congestion are calculated in an unconstrained/constrained system using a two-bus model
  - Describe the role of shift factors in determining LBMP in an unconstrained system using a three-bus model
  - Determine how LBMP is established through co-optimization of Energy, Operating Reserves, and Regulation Service using a two-bus model
  - State how gen parameters ( Ramp UP/DOWN rate) are factored into determining LBMP

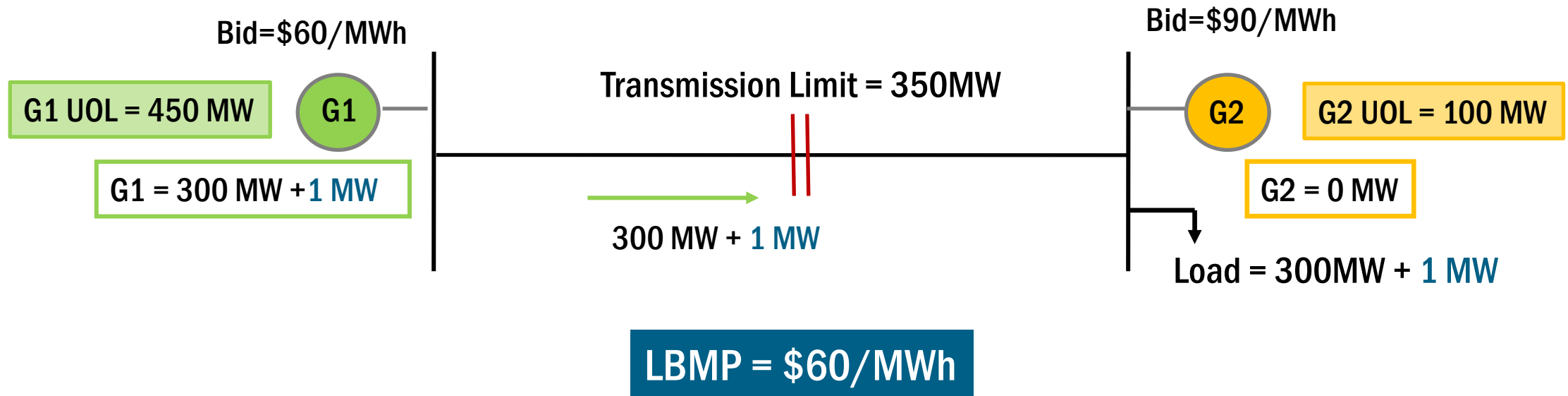
# Outline

- **Example 1: Unconstrained system**
  - No losses and no congestion
- **Example 2: Unconstrained system**
  - With losses and no congestion
- **Example 3: Constrained system**
  - No losses and with congestion
- **Examples 4 & 5: 3-bus model, Unconstrained system**
  - No losses and no congestion
- **Example 6: Co-optimization of Energy and Ancillary Services**
  - No losses and no congestion
- **Example 7: Understanding Ramp UP/DOWN rate; Unconstrained system**
  - No losses and no congestion

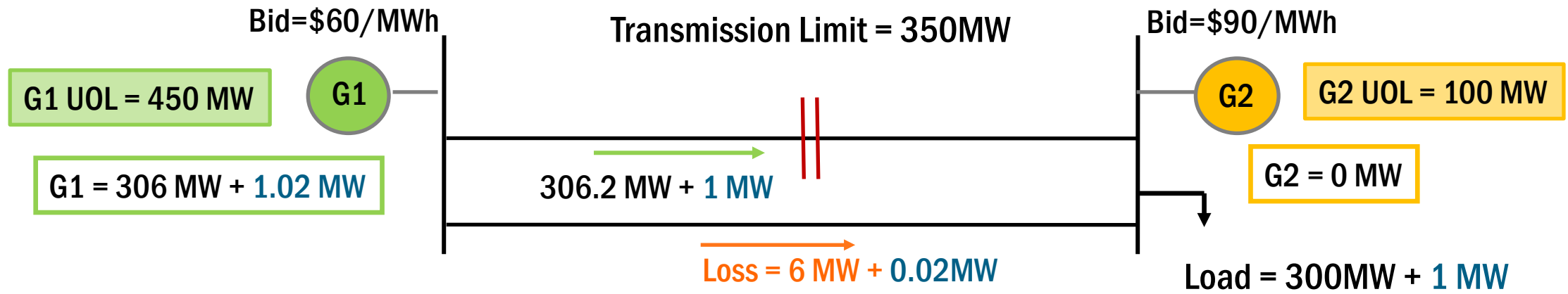
# Example 1: Unconstrained System (No Loss & No Congestion)



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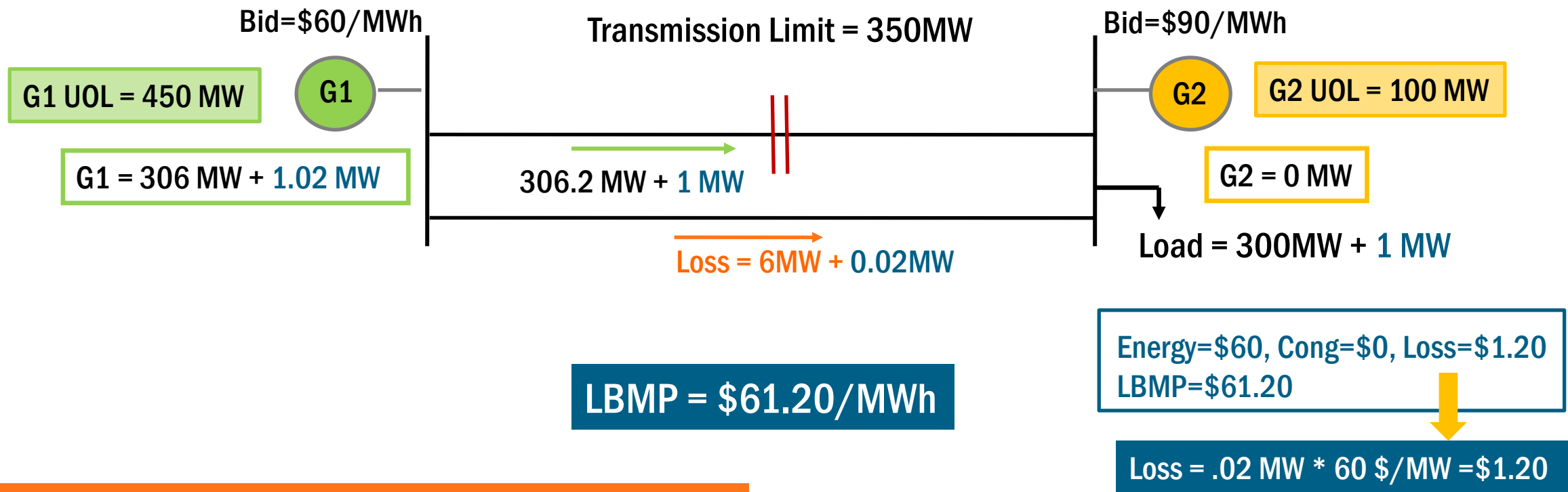


# Example 2: Unconstrained System (With Loss & No Congestion)



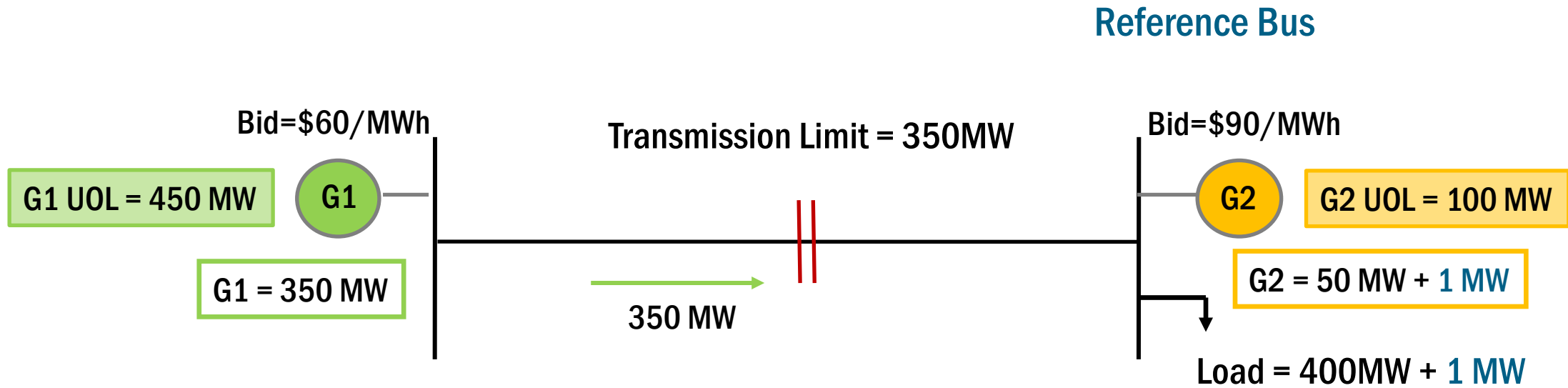
Here Physical loss associated with transmission of 300 MW is 6MW

# Example 2: Unconstrained System (With Loss & No Congestion)



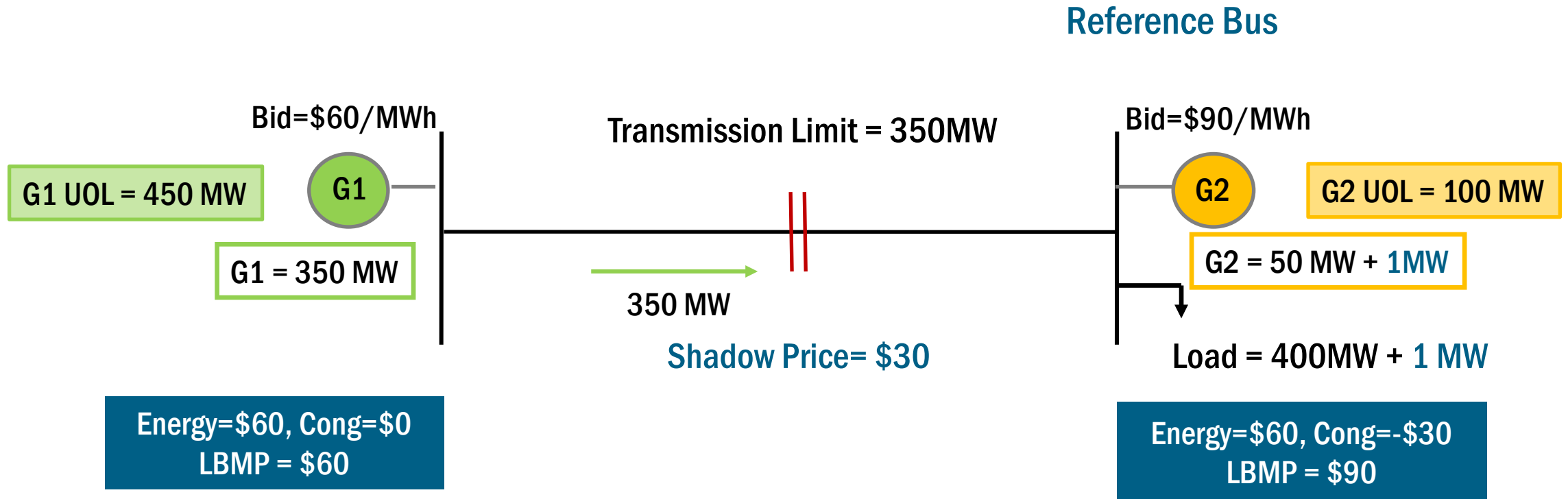
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# Example 3: Constrained System (No Loss & With Congestion)



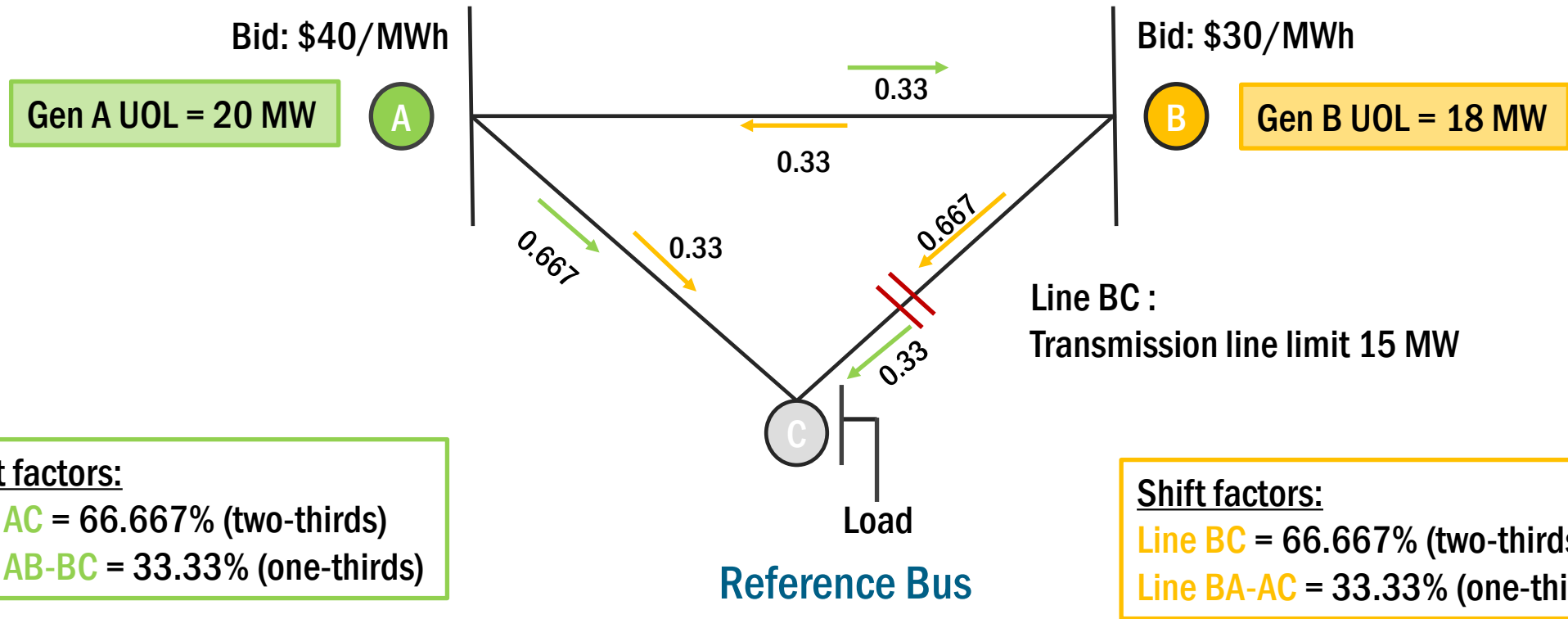


# Example 3: Constrained System (No Loss & With Congestion)

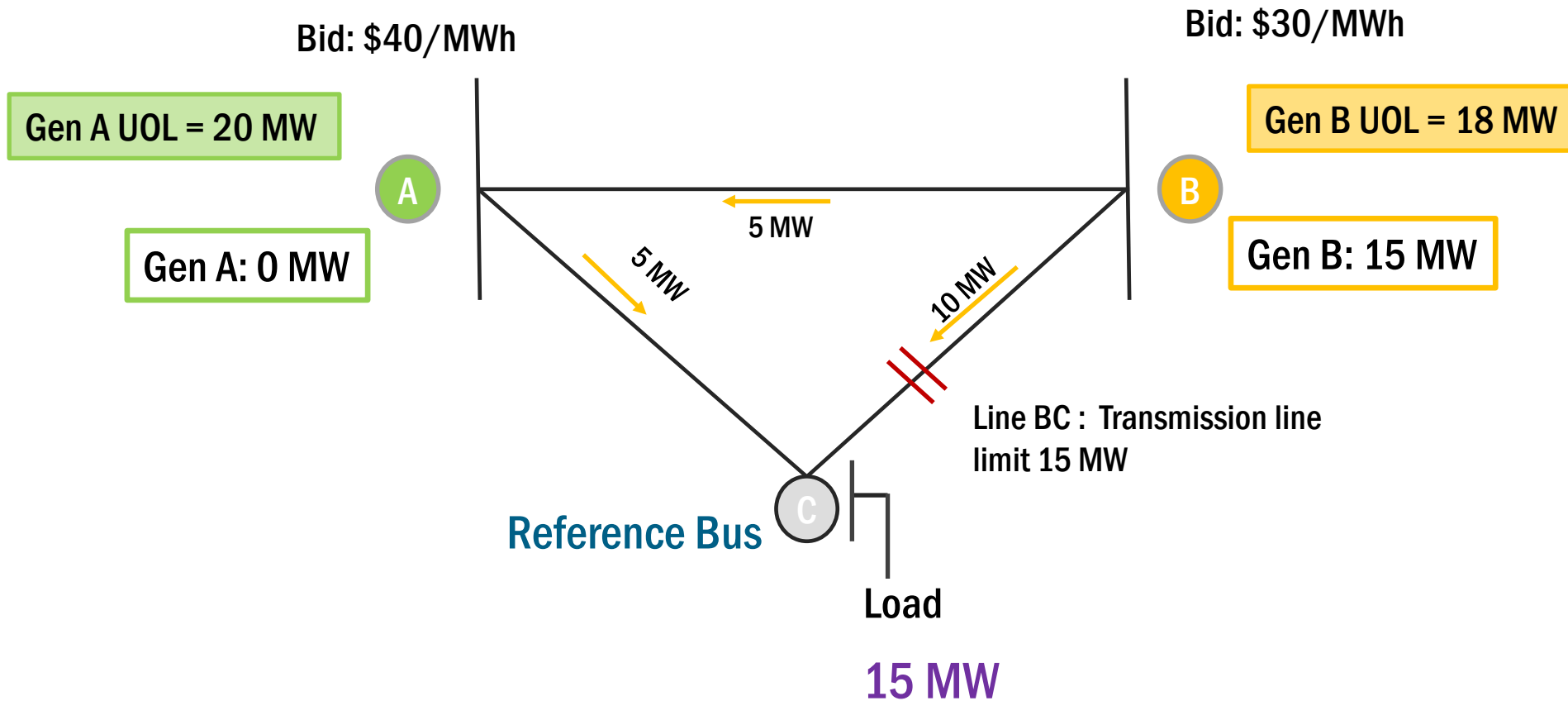


# Example 4: Unconstrained System (No Loss & No Congestion), 3-bus system

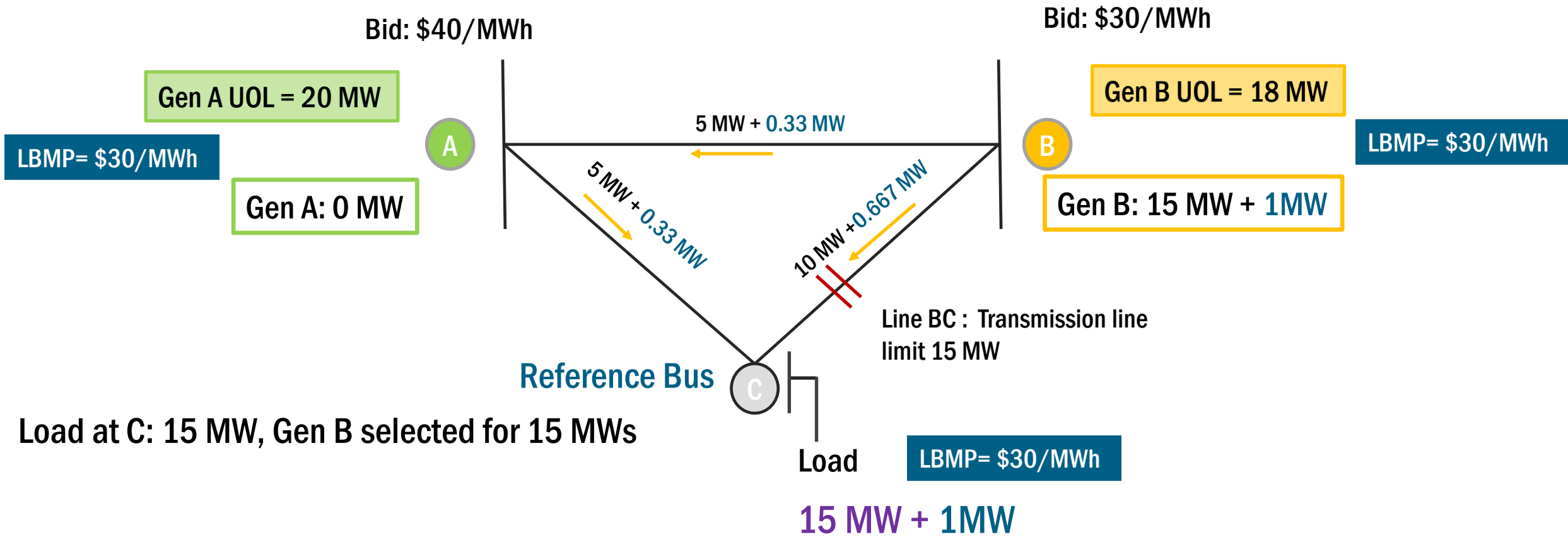
## System



# Example 4: Unconstrained System (No Loss & No Congestion), 3-bus system

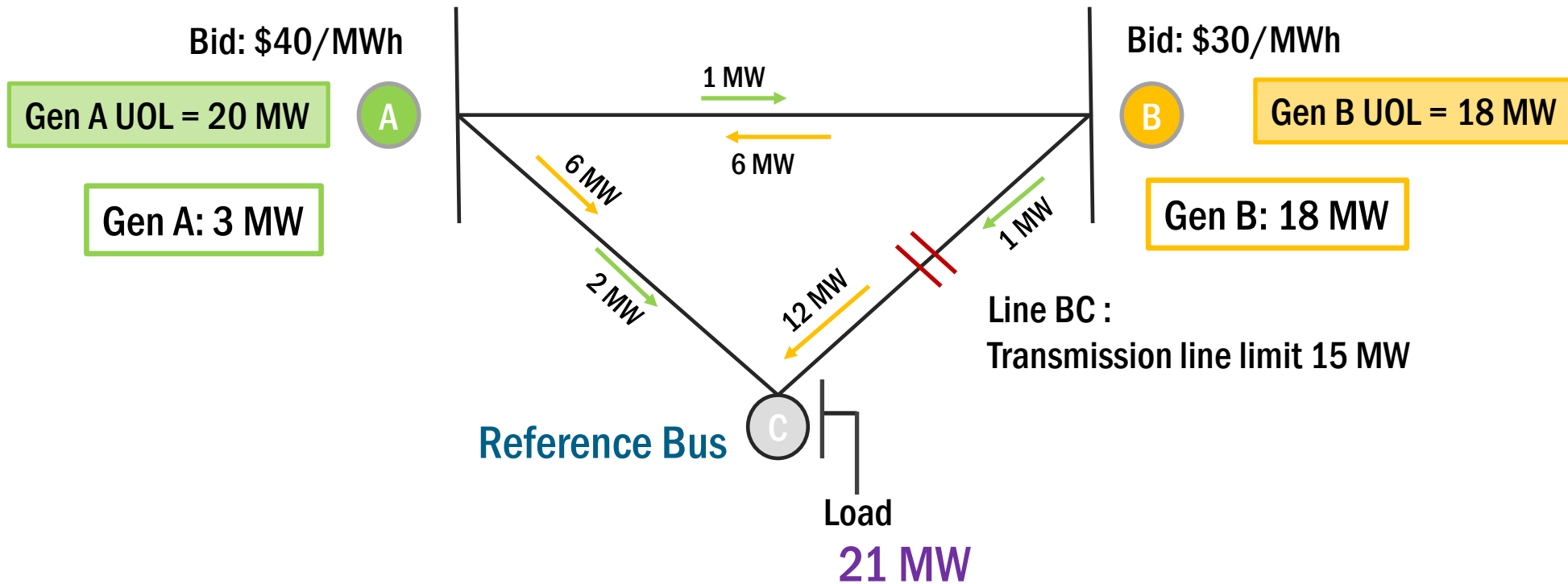


# Example 4: Unconstrained System (No Loss & No Congestion), 3-bus system



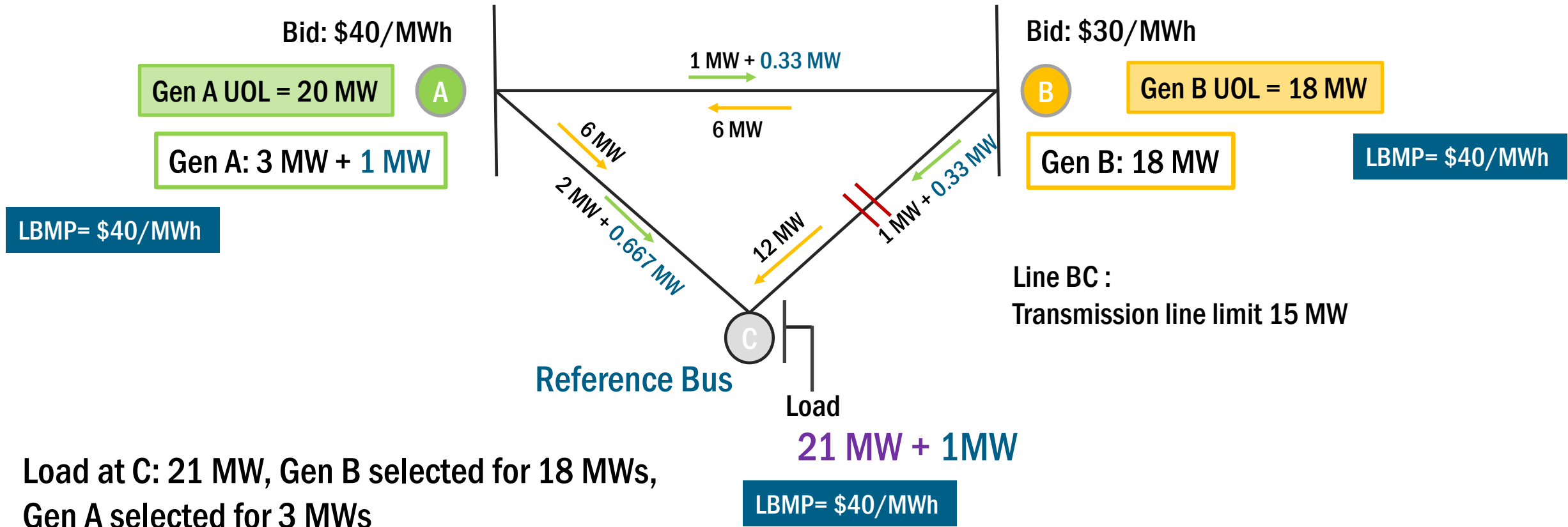
# Example 5: Unconstrained System (No Loss & No Congestion)

LOAD INCREASES TO 21 MW



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LOAD INCREASES TO 21 MW



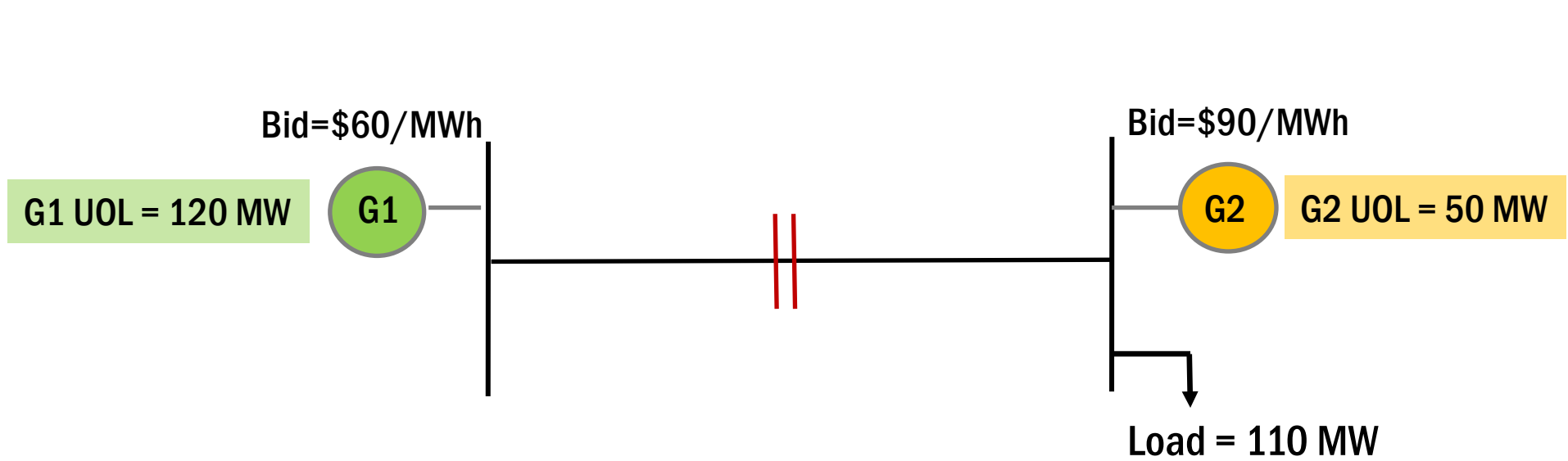
Load at C: 21 MW, Gen B selected for 18 MWs,  
Gen A selected for 3 MWs

LBMP= \$40/MWh

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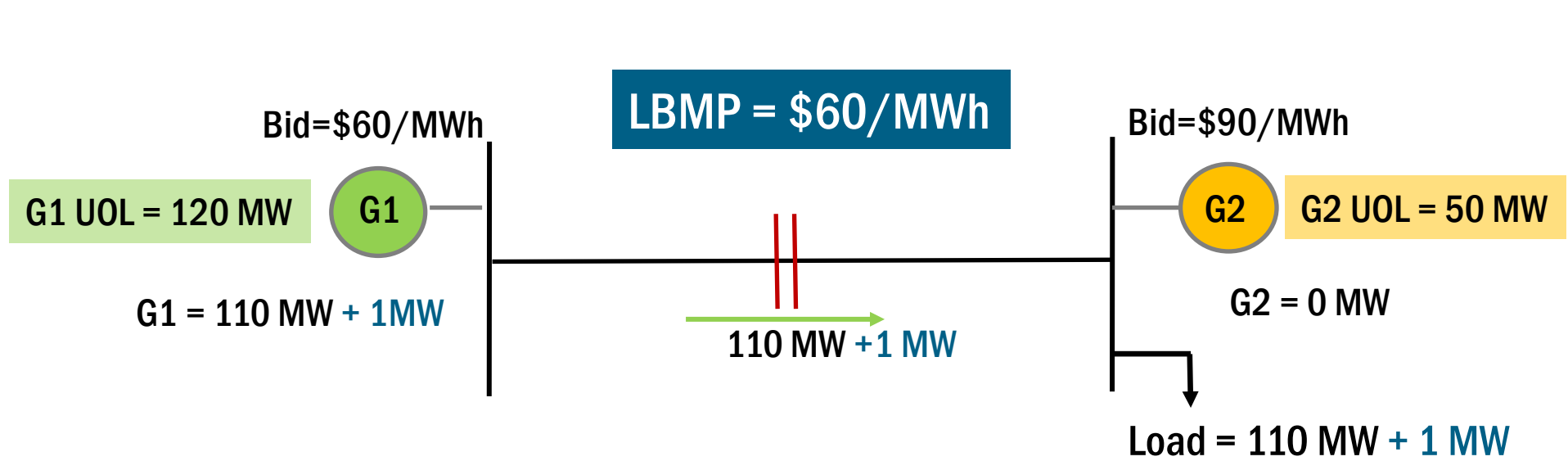
Line BC :  
Transmission line limit 15 MW

# Example 6: Co-optimization Energy & Spinning Reserve (No Loss & No Congestion)



Solution with only Energy, no Spinning Reserves

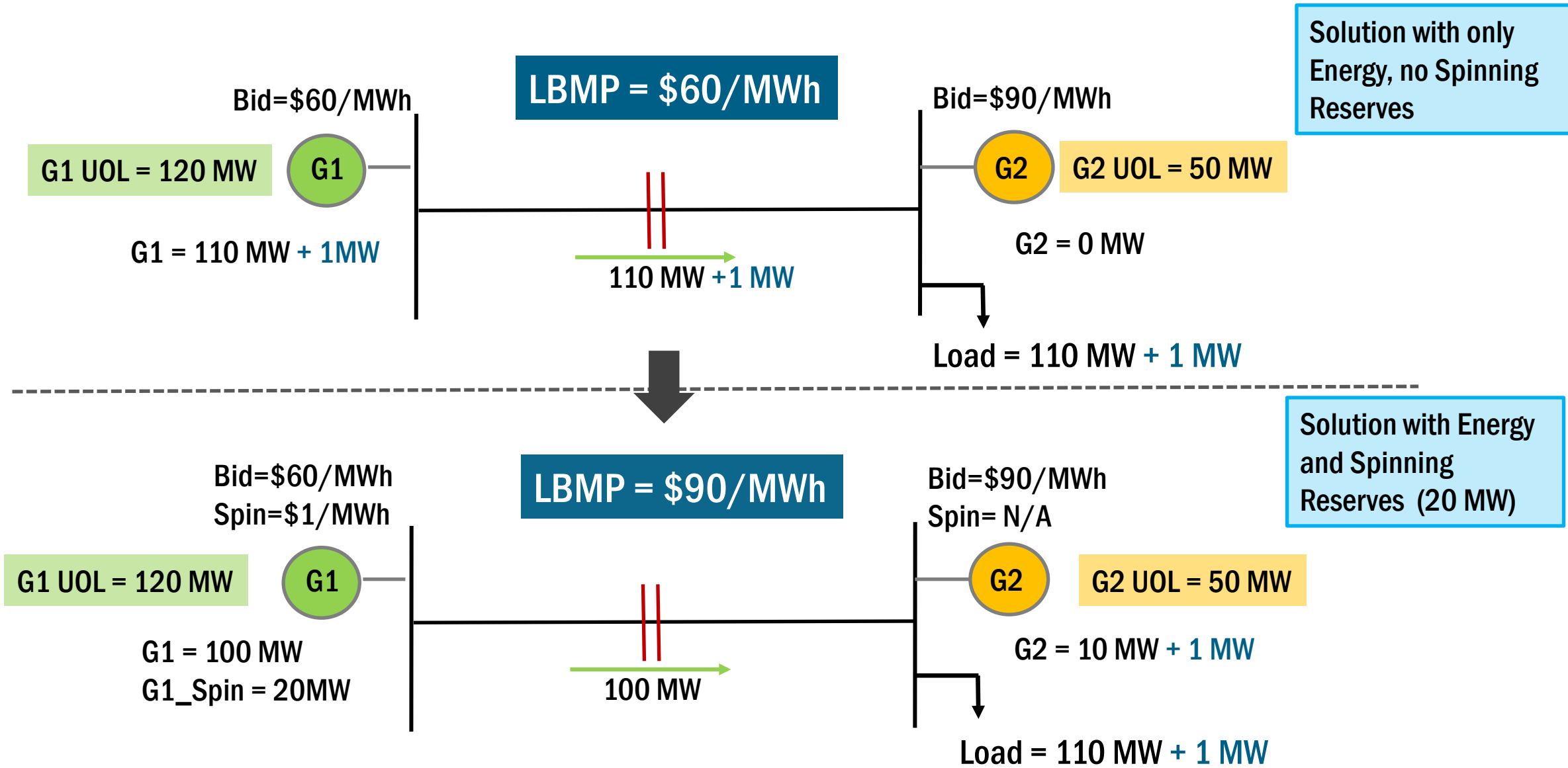
# Example 6: Co-optimization Energy & Spinning Reserve (No Loss & No Congestion)



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# Example 6: Co-optimization Energy and Spinning Reserve

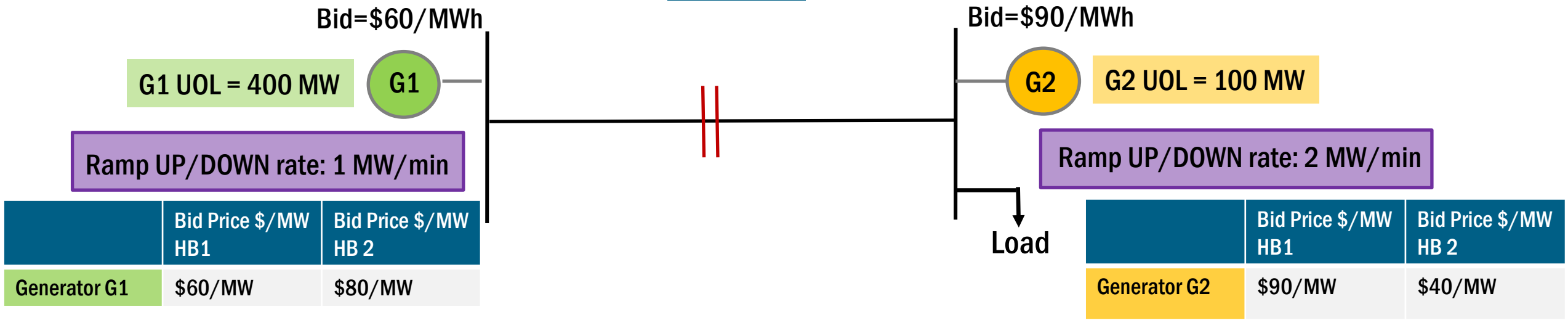


Solution with only Energy, no Spinning Reserves

Solution with Energy and Spinning Reserves (20 MW)

# Example 7: Understanding Ramp UP/DOWN Rate; Unconstrained System (No Loss & No Congestion)

**System**



**Load:**  
 t = 312 MW  
 t+15 = 354 MW

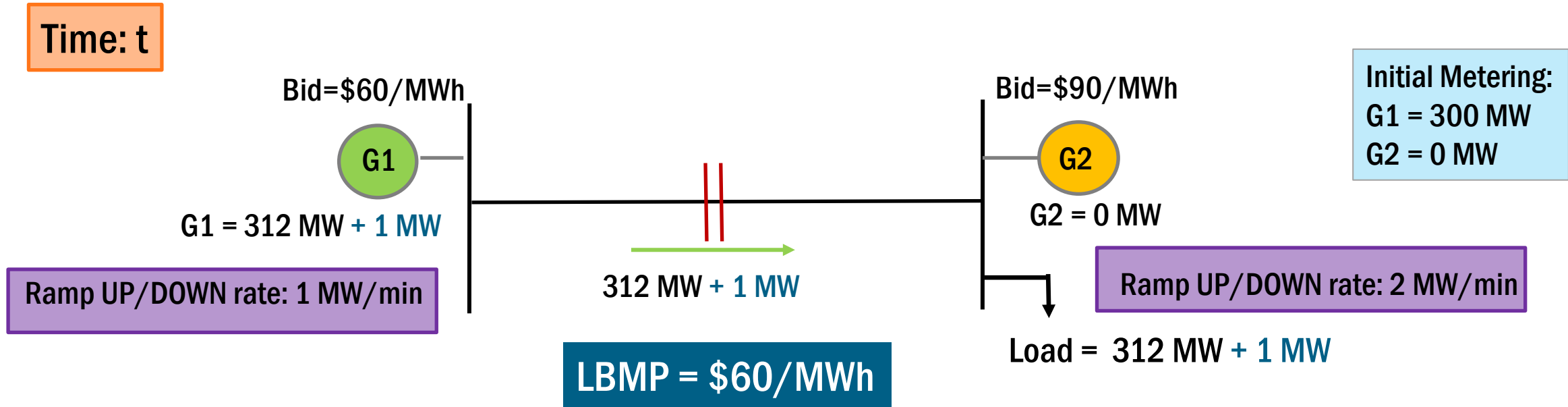
**Initial Metering:**  
 G1 = 300 MW  
 G2 = 0 MW

Dispatch solution for timesteps t and t+15:  
 Solution for timestep t uses the Bid prices from HB 1  
 Solution from timestep t+15 uses the Bid prices from HB 2

Initial metering is the MW level the generators are at time of software execution to determine the dispatch solution

# Example 7: Single-Period Dispatch (No Loss & No Congestion)

Time: t



Cont...

# Example 7: Single-Period Dispatch (No Loss & No Congestion)

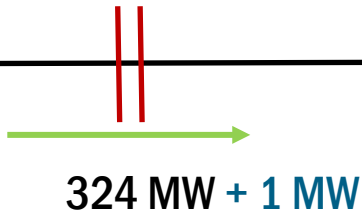
Time: t+15min

Initial Metering:  
G1 = 312 MW  
G2 = 0 MW

Bid=\$80/MWh  
G1  
G1 = 324 MW + 1 MW

Ramp UP/DOWN rate: 1 MW/min

LBMP = \$80/MWh



Bid=\$40/MWh  
G2  
G2 = 30 MW

Ramp UP/DOWN rate: 2 MW/min

Load = 354 MW + 1 MW

- For timestep t+15, G2 is the cheaper generator, and therefore chosen first
- G2 will be dispatched for 30 MW (2 MW/min x 15 min), because Ramp UP/DOWN rate for G2 = 2 MW/min

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