Briefing on Western Energy Imbalance Market Price Formation

George Angelidis
Principal, Power Systems Technology Development

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Locational Marginal Price Definition

- The marginal cost of serving the next increment of demand at a network location
- Derived from sensitivity analysis at the optimal solution of the EIM
- Has four components:
  - System marginal energy cost (SMEC)
  - Marginal cost of congestion (MCC)
  - Marginal cost of losses (MCL)
  - Marginal cost of greenhouse gas regulation (MCG)
    - Only in EIM Balancing Authority Areas (BAAs)

System Marginal Energy Cost (SMEC)

- Same at all network locations
- Sensitivity cost (shadow price) of the EIM Area (CAISO and EIM BAAs) power balance constraint:
  - Σ(Generation) − Σ(Load) − Losses = 0

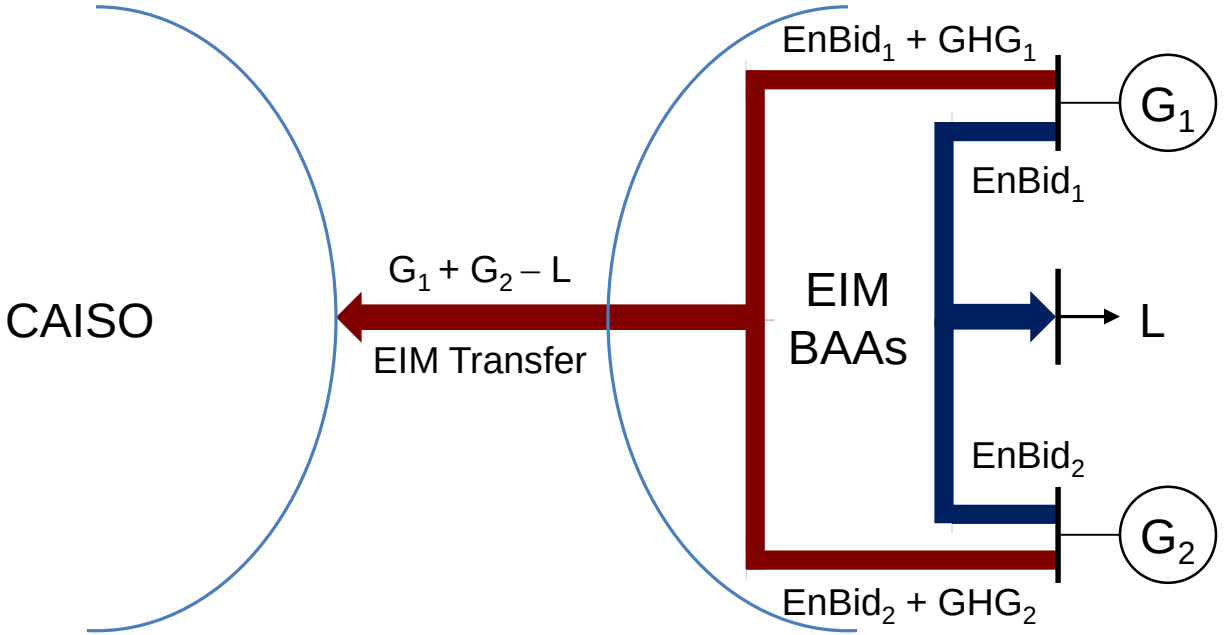
Marginal Cost of Congestion (MCC)

- Varies by location
- Sensitivity cost (shadow price) of the EIM BAA power balance constraint (PBC):
  - Σ(BAA_Generation) − Σ(BAA_Load) − BAA_Losses = BAA_Energy_Transfer
  - No power balance constraint for the CAISO BAA (redundant)
- Minus all binding constraint contributions:
  - Product of the sensitivity cost (shadow price) of binding constraint and the Power Transfer Distribution Factor (PTDF) for the location to the constraint
    - PTDF: percentage of power injection at the location that causes/relieves congestion on the constraint relative to a distributed load reference

Marginal Cost of Losses (MCL)

- Varies by location
- Marginal Loss Rate (MLR):
  - Nonlinear; calculated from an AC power flow solution
  - Loss sensitivity at a network location: reflects change in losses due to incremental power injection at the location
  - Distributed load reference for absorbing the incremental power injection
- EIM BAAs:
  - −(SMEC + BAA_PBC_Shadow_Price + MCG) * MLR
- CAISO BAA:
  - −(SMEC + BAA_PBC_Shadow_Price + MCG) * MLR

GHG Compliance Solution for EIM



Where:
$EnBid_i$: Energy Bid for Generator i ($/MWh)
GHG_i: GHG Bid Adder for Generator i ($/MWh)

Marginal Cost of GHG Regulation (MCG)

- Same at all EIM BAA locations
- Negative sensitivity cost (shadow price) of the GHG allocation constraint:
  - $-CAISO\_Energy\_Transfer \leq \Sigma(GHG\_Allocation)$
- Positive if CAISO Energy Transfer is import (serving CA load)
- Zero if CAISO Energy Transfer is export
- Does not exist in CAISO BAA
  - For CAISO resources, the GHG regulation cost is included in the energy bids and is reflected in the SMEC

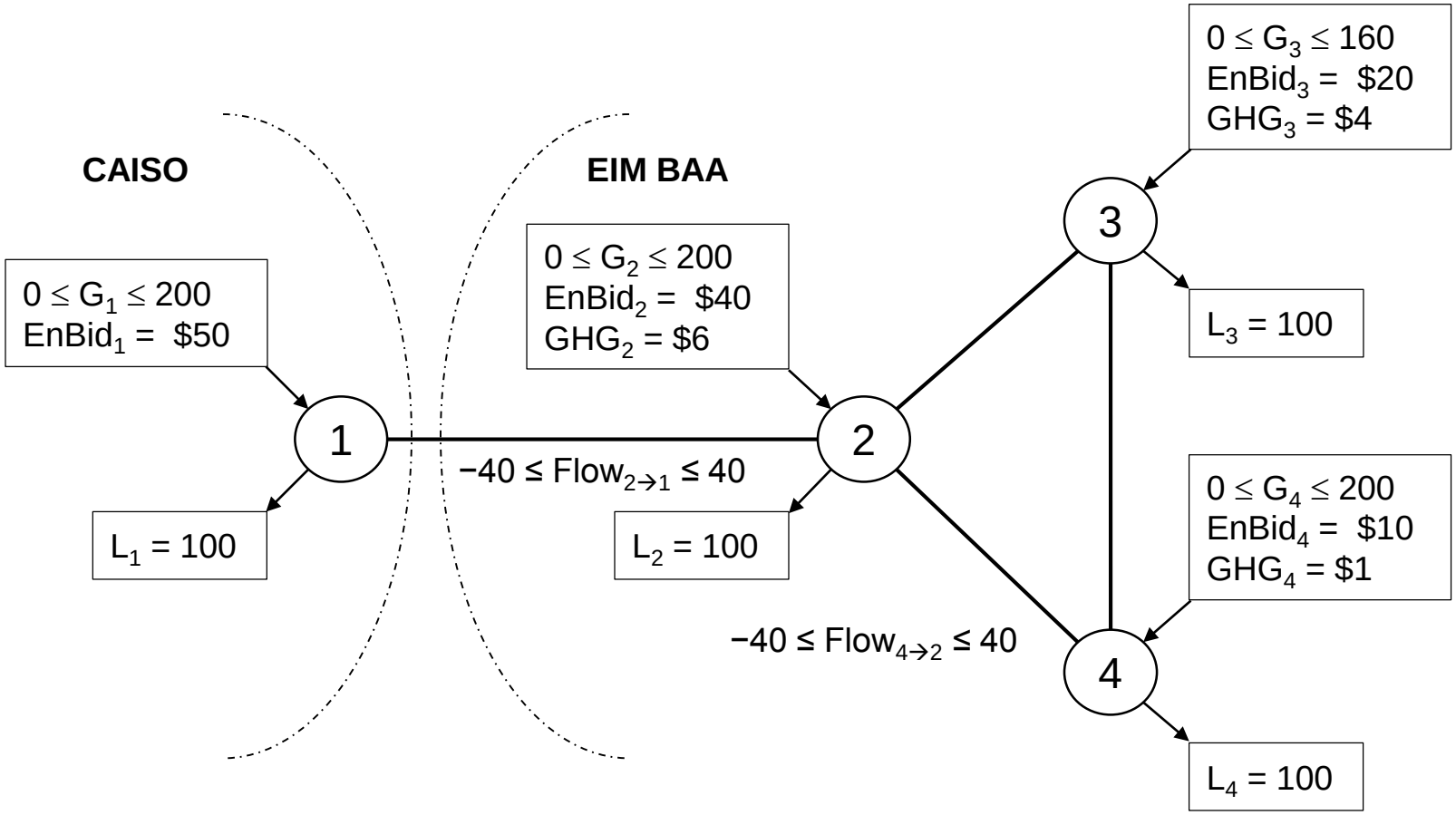
Locational Marginal Price Calculation

- The LMP is derived by adding all LMP components
  - EIM BAA location i:
    $LMP_i = SMEC + MCC_i + MCL_i + MCG$
    - $MCG \leq 0$
  - CAISO BAA location i:
    $LMP_i = SMEC + MCC_i + MCL_i$

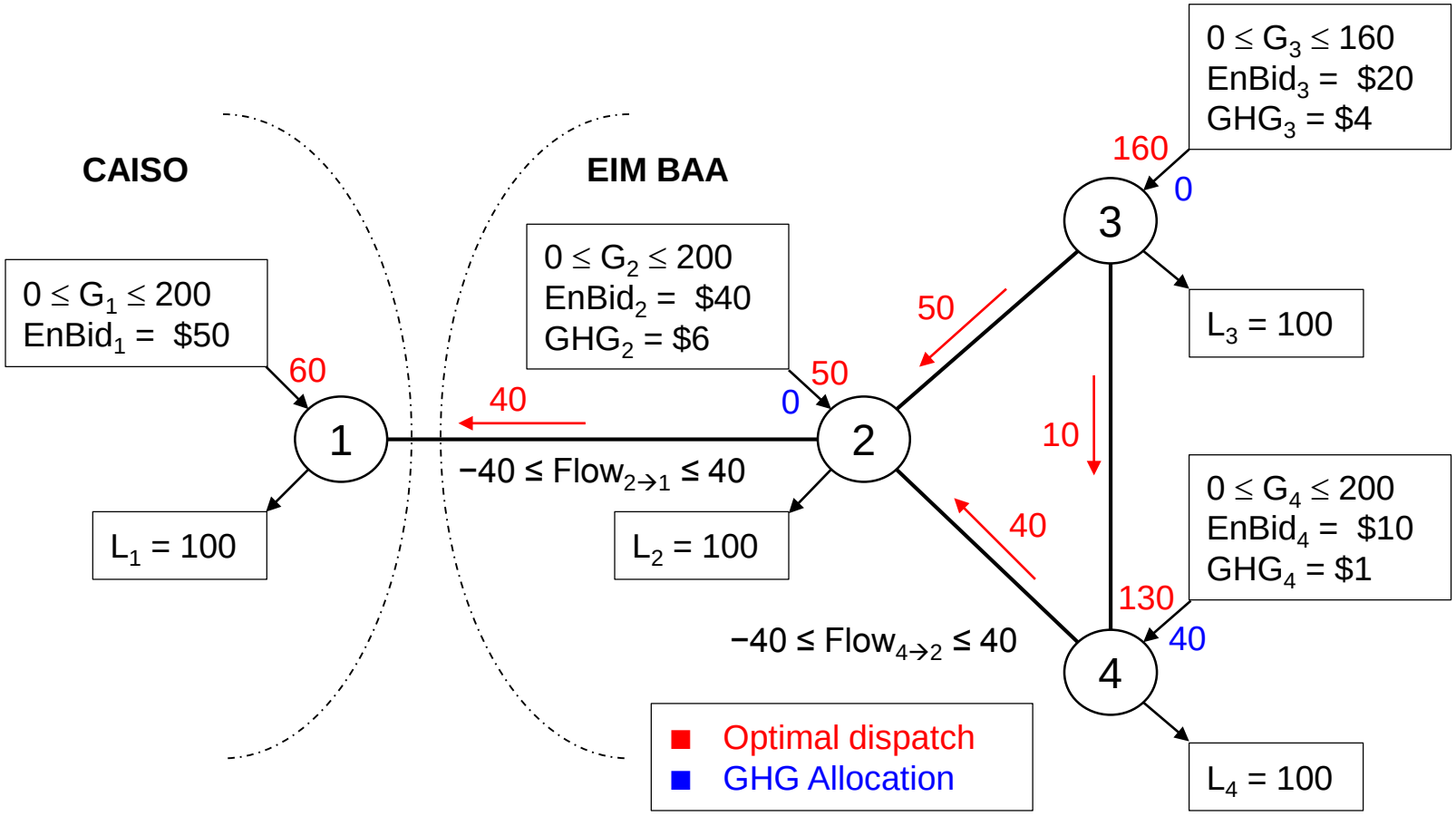
Locational Marginal Price Formation in the Energy Imbalance Market

Example

Example: Setup



Example: Optimal Solution



Example: LMPs