Pricing and Aggregated Pricing Nodes

CRR Educational Class #7

CAISO Market Operations
Why are Pricing and Aggregate Pricing Nodes Important to CRR Allocation Process?

- The pricing and aggregated pricing nodes determine how certain Sources and Sinks are allocated to the underlying FNM.
- This in turn plays a role in the resulting flow on branches and interfaces in the allocation process.
- The APnodes for the standard Sinks are based on load distribution factors (LDFs).
Course Objectives

Upon completion of this course, you will be able to:

- Understand the basic concept of a Pricing Node and an Aggregated Pricing Node
- Understand the basics of a Trading Hub
- Understand the use of an APnode in the Integrated Forward Market and how they may differ from those used in the CRR Allocation
Agenda

- Definition of Pricing and Aggregate Pricing Nodes
- Simple Examples
- What Aggregate Pricing Nodes represent in the CRR Allocation
  - Generation (Source)
  - Load (Sink)
  - Trading Hubs (Source or Sink)
- Aggregate Pricing Nodes in the Forward Market
Important Notice

Please be advised: the terms “Pricing Node” and “Aggregate Pricing Node” used in these presentations are intended to be more generic than what might be found in the current draft version of the MRTU Tariff.
Definition

- Pricing node also referred to as
  - Pnode
  - Pricing Location

- Aggregated Pricing Node also referred to as
  - APnode
  - Aggregated Pricing Location
Definition

Two Attributes of Pricing Node or Aggregated Pricing Node

- A set of one or more nodes from the underlying network model
  - This set of one or more nodes provides a mapping back to the underlying network model
  - An LMP is calculated in the Forward Market at each node in this set

- A set of allocation factors, one for each of the nodes
  - Each allocation factors is greater than or equal to 0.0
  - Each allocation factors is less than or equal to 1.0
  - The allocation factors sum to 1.0
Definition

- **Pricing Node**
  - Maps back to just one node in the underlying network model
  - There is one allocation factor with a value of 1.0

- **Aggregated Pricing Node**
  - Maps back to more than one node in the underlying network model
  - The allocation factors are fixed relative to each other
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Pnode and APnode in the CRR Allocation

- Pnodes and APnodes are used as Sources and Sinks in CRR Allocation
- Each Source and Sink are defined with
  - Name of Pnode or APnode
    - Defines the location
  - Value of Source or Sink
    - Defines the amount (MW) of
      - Injection for the Source
      - Withdrawal for the Sink
APnode as a Source

- APnode as a Source
  - Source has an associated MW value
  - APnode has the set of underlying network nodes and allocation factors

- Source is a set of injections into the underlying network nodes
  - Injection at each of the underlying nodes within the APnode
  - Value of injection at each node is \((\text{Source MW}) \times (\text{allocation factor for that node})\)
APnode as a Sink

- APnode as a Sink
  - Sink has an associated MW value
  - APnode has the set of underlying network nodes and allocation factors

- Sink is a set of withdrawal out of the underlying network nodes
  - Withdrawal at each of the underlying nodes within the APnode
  - Value of withdrawal at each node is \((\text{Sink MW}) \times \text{(allocation factor for that node)}\)
APnode example with a grouping of 6 electrical nodes
Mappings from the Sink MW value to MW values placed on the underlying electrical nodes by allocation factors. These MW values are withdrawals for the Sink.

Note that the Allocation Factors sum to 100%.
APnode Sink Example

Use this APnode as a Sink with a MW value of 100 MW

100 MW

APnode maps to underlying electrical nodes

100 * 20% = 20 MW
100 * 40% = 40 MW
100 * 10% = 10 MW
100 * 5% = 5 MW
100 * 15% = 15 MW

100 MW maps to underlying electrical nodes.
What do the Pnodes Represent in the CRR Allocation

- Pnodes can present
  - Physical resource locations in the Full Network Model
    - Generation location
    - Import and Export scheduling tie points
    - Load points
  - Trading Hub points
  - Virtual points
    - No generation or load
What do the APnodes Represent in the CRR Allocation

- APnodes can present
  - Physical resource locations in the Full Network Model
    - Generation locations
    - Import or Export scheduling tie points
    - Load aggregations
  - Trading Hubs aggregations
  - Virtual points
    - No generation or load
Generators as Pnodes or APnodes

- Generally used as Source point only in the allocation
- Underlying network nodes are generation locations
- When are APnodes used for Generators?
  - Generator is composed of many units
  - Each unit is modeled at different but tightly coupled electrical nodes or in a Hydro/River system
  - Generally the Source is not scheduled at each electrical node
  - Scheduled under one resource name
  - APnode maps back to each unit’s node
  - Allocation factors may be based on Pmax of each unit
Generators as a APnode

- Generator station with 3 units
- Scheduled into the Forward Market under one resource name

Actual network connection

Gen Unit 1  Gen Unit 2  Gen Unit 3

Rest of Network
Generators as a APnode

- The resource name is an APnode that maps back to each unit.

\[
\text{AF}_1 \quad \text{AF}_2 \quad \text{AF}_3
\]

Injection at each Unit \((i)\) is \((\text{MW Value}) \times (\text{AF}_i)\)

AF = Allocation Factor
Loads as Pnodes or APnodes

- Generally used as Sink points only the allocation
- Underlying network nodes are load locations
- APnode modeling
  - Used to model Load Aggregation Points
  - The allocation factors may be based on load distribution factors (LDFs)
    - See Presentation on Load Distribution Factors
Any Questions?
Trading Hubs Used in the Settlements Process

- The concept of a Trading Hub will be used in the Settlements process
- Trading Hubs can be used for Inter-SC trades
  - This promotes commercial transactions
  - The price at the Trading Hub may delineate transmission congestion charges between the trading parties
- Inter-SC trades are used only in Settlements
  - Based on Day-ahead LMPs, a price for each Trading Hub may be calculated
  - The Inter-SC trades are not explicitly modeled in the Integrated Forward Market LMP calculation
Trading Hubs Used in the Settlements Process

- Trading Hubs in the Settlements process have the same look and feel as an APnode.
- A Trading Hub in the Settlements process has two attributes:
  - A set of network nodes
  - A set of allocation factors or more appropriately weighting factors
- The Trading Hub price is calculated from the weighted average of the nodal prices using the weighting factors:
  - This is an aggregated priced
Trading Hubs Used in the Settlement Process

- A stakeholder process was started in late 2004 to discuss how Trading Hubs will be defined.
- Currently Trading Hubs are to be comprised of generators within each currently defined congestion zone, NP15, ZP26 and SP15.
- Current thought is that the seasonal/TOU output of the generators will be used as the basis to calculate weighting factors for the Trading Hubs.
Trading Hubs Used in the Settlement Process

- The Trading Hub price is calculated from the weighted average of the nodal prices using the weighting factors.
- This is an aggregated priced.
- Trading Hub Price = \( \sum_i (\lambda_i \times WF_i) \)
  - The summation above is for all nodes defined in the Trading Hub set and WF is the corresponding weighting factors.
Trading Hubs Used in the Settlement Process

- A Trading Hub could be used when a Load Serving Entity (LSE) has a bilateral contract with a generation company
  - The Trading Hub price may delineate the congestion costs to deliver the power from generation companies’ generator(s) to the LSE’s load
- The generation company may have many generators and from this portfolio of generators they will serve the LSE’s load
- It may be the discretion of the generation company to determine which generator at any given hour is to be used to serve the LSE’s load
The generation company may state that they will trade (i.e., delivery) the power to serve this load at a Trading Hub.

The generation company may not know in advance what generators will be used to serve the load so they cannot specify an exact generator location in advance (or even an import location).
Trading Hubs Used in the Settlement Process

Example for a given hour in the Day-ahead (DA) Market

- Generation company will trade at TradingHub 1
- LSE tells generation company that it needs 100 MWh of energy for that hour
- LSE submits DA load schedule of 100 MW and a trade (with generation company) of 100 MWh at TradingHub1
- Generation company submits a generation schedule from a specific generator of 100 MWh and a trade (with LSE) of 100 MWh at TradingHub1
Trading Hubs Used in the Settlement Process

Settlement Process

- Assume neither the generation or load in question was curtailed, but there was congestion
- Payment to Gen from ISO: $\lambda_{gen} \times 100$ MW
- Payment to ISO from Gen: $\lambda_{TH1} \times 100$ MW
- Payment to Load from ISO: $\lambda_{TH1} \times 100$ MW
- Payment to ISO from Load: $\lambda_{LAP} \times 100$ MW
- LAP = Load Aggregation Point
  - Where the LSE scheduled its load
Trading Hubs Used in the Settlement Process

- **Settlement Process**
  - Effective congestion charges to the generator company
    - \((\lambda_{TH1} - \lambda_{gen}) \times 100\) MW
  - Effective congestion charges to the LSE
    - \((\lambda_{LAP} - \lambda_{TH1}) \times 100\) MW
The concept of a Trading Hub will also be used in the CRR Allocation.

Whereas Inter-SCs trades are not explicitly modeled in the Integrated Forward Market, they are explicitly modeled in the CRR Allocation.

In the CRR Allocation process the Trading Hub is modeled as either a Pnode or APnode.

The Trading Hubs (Pnodes or APnodes) may be used as a Source or Sink.
Trading Hubs in the CRR Allocation

- **Simple Example**
  - One party has a CRR from a Source to the Trading Hub
    - Trading Hub used as a Sink
  - The other party has a CRR from the Trading Hub to a Sink
    - Trading Hub used as a Source
Trading Hubs in the CRR Allocation

- The Trading Hubs used in the CRR Allocation should be consistent with the Trading Hubs in the Settlements Process
  - Same set of underlying network nodes
  - The set of weighting factors for determining the Trading Hub price need to be the set of allocation factors
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APnodes in the Integrated Forward Market

- APnodes are also used in the Integrated Forward Market
- In the Integrated Forward Market most Load is scheduled at a Standard Load Aggregation Point (LAP)
  - There are some exceptions
  - See Load Distribution Factor presentation
- This Standard LAP is a form of an APnode
The Load schedules/bids that are scheduled at a standard LAP are distributed to the nodes of the underlying network model using allocation factors:

- Similar to how the CRR APnodes map back to the underlying network.
- These allocation factors will generally be based on Load Distribution Factors and may change accordingly with time-of-use periods, seasons, etc.
In general the LAP price can be calculated as

\[ \lambda_{\text{LAP}} = \sum_i (\text{AF}_i \times \lambda_i) \text{ with } i \text{ over the nodes in the LAP} \]

This is identical to determining the total cost to load in the LAP, \( \sum_i (\text{Load}_i \times \lambda_i) \), and dividing this value by the total load, \( \sum_k (\text{Load}_k) \), with \( \text{Load}_i \) being the final load schedule at node \( i \) with \( i \) and \( k \) as indices over all nodes in the LAP.

\[ \left( \sum_i (\text{Load}_i \times \lambda_i) \right) / \left( \sum_k (\text{Load}_k) \right) \]

\[ = \sum_i \left( \left( \text{Load}_i / \sum_k (\text{Load}_k) \right) \times \lambda_i \right) \]

\[ \text{AF}_i = \left( \text{Load}_i / \sum_k (\text{Load}_k) \right) \]

Note the \( \text{AF}_i \) above are calculated based on the final Load Schedules.
APnodes in the Integrated Forward Market

- The difference between the APnodes used in the CRR Allocation and those used in the Integrated Forward Market is in the handling of the allocation factors.

- In the CRR Allocation the allocation factors are FIXED relative to each other over the term of the CRR that used the APnode, but in the Integrated Forward Market they may not stay fixed over the same period of time.

- For the Integrated Forward Market, the allocation factors will generally be based on Load Distribution Factors and may change accordingly with time-of-use periods, seasons, etc.
APnodes in the Integrated Forward Market

- There will generally be an inconsistency between the allocation factors used for APnodes in the CRR Allocation and the allocation factors used for the same APnodes in the Integrated Forward Market.

- Why is knowing this inconsistency important to understand?

- To help ensure revenue adequacy for the CRRs (see presentation on CRR Basics), the price used in the CRR revenue calculation should be calculated using the CRR APnode allocation factors.

- However, allocation factors from the Integrated Forward Market may be used in determining the prices used in the CRR revenue calculation.

- This does not imply revenue inadequacy will occur, it just does not guarantee revenue adequacy.
Any Questions?