FTR Market Fundamentals

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This presentation is intended to provide an overview of the PJM FTR/ARR Market:

- **Overview**
  - Brief history and definitions

- **Market Structure**
  - ARR/FTR timing, products

- **Market Rules**
  - FTR clearing overview

- **Market Settlements**
  - Billing timing, charges and credits
Overview
Enhance forward price discovery, transparency and market liquidity in order to provide efficient hedging mechanisms against future, unknown congestion costs associated with delivering energy in a Locational Marginal Pricing market.
Why do we need FTRs?

- **Challenge:**
  - LMP exposes PJM Market Participants to price uncertainty for congestion cost charges
  - During constrained conditions, PJM Market collects more from loads than it pays generators

- **Solution:**
  - Provides ability to have price certainty
  - Provides load a priority right to the transmission system and congestion revenues
  - FTRs provide hedging mechanism that can be traded separately from transmission service
PJM FTR Policy Background

Financial Transmission Rights have evolved over time

Mar. 12
FERC accepts revisions for the creation of an annual FTR auction and Annual Revenue Right (ARR) allocation process

Apr. 1
FTRs introduced after the introduction of LMP markets via a direct allocation to load serving entities in order to offset congestion costs associated with load delivery (1999 – Monthly Auctions)

Jul. 25
FERC accepts revisions for the creation of a Long-term (3-year forward) FTR auction

Dec. 14
FERC accepts a Balance of Planning Period (BOPP) Auction process, created to allow for additional congestion hedging opportunities in order to better meet the business needs of market participants
What are Financial Transmission Rights?

Financial instruments awarded to bidders in the FTR Auctions

+/- Cost determined by auction clearing results

Point-to-point hedging mechanism to offset future unknown costs (1 mo. – 3 yrs. in future)

+/- Value determined by day-ahead congestion price differences
What are Auction Revenue Rights?

Financial Equivalent to Physical Transmission Service

Nomination Process (no cost) to Firm Transmission Service Customers

Point-to-point hedging mechanism to offset future unknown costs (Stage 1A ARR 10 years)

+/- Value determined by FTR auction clearing prices
ARRs provide a revenue stream to the firm transmission customer to offset purchase price of FTRs.

**Annual Allocation**
- ARRs Allocated (MWs)

**Annual FTR Auction**
- FTRs Awarded to Bidders (MWs & price)

**Hourly**
- Day-Ahead Congestion Charges (price)

**Model PJM System Capability**

**Auction Revenue Rights**

**Day-Ahead Congestion Charges**

**Residential**
FTR/ARR Market Timeline

Annual Allocation Stage 1A

Annual Allocation Stage 1B

Annual Allocation Stage 2 (3 Rounds)

Participants may relinquish Stage 1 ARRs (subject to feasibility)

Annual FTR Auction (4 Rounds)

March 4, 2019
March 8, 2019
March 18, 2019
April 5, 2019
April 8, 2019
April 9, 2019
May 6, 2019
Auction Revenue Rights
- Provides LSEs priority rights to the transmission system and the congestion revenues.
- Allows non LSEs to participate to add liquidity and price discovery.

- Protects native load utilization of the transmission system while providing long-term certainty.
- Point-to-point hedging for self-supply and bilateral transactions.

- Flexibility to adjust hedging paths annually.
- Choice to collect a fixed revenue stream by holding on to the ARR or a refund of congestion revenues (via FTR) on either historical paths or alternate path.
Participation in the ARR Allocation

- Allocated to Firm Transmission Service Customers annually in a two-stage allocation process
  - First stage protects native load utilization of the transmission system providing long-term certainty
  - Second stage provides flexibility to adjust hedging paths annually
- PJM coordinates with each Transmission Owner to determine the load ratio share of each LSE within their zone to determine ARR MW cap for each LSE
  - Stage 1 paths: Historical/QRR Resource -> Load
  - Stage 2 paths: Gen/Zone/Hub/Interface -> Load
• Economic value based on LMPs from the Annual FTR Auction
  – Defined from source to sink
  – Only available as an obligation
    • obligation can be benefit or liability
  – Financial entitlement, *not* physical right
  – Must be simultaneously feasible
ARR Target Allocation = (ARR MW) * (LMP_{ARR Sink} - LMP_{ARR Source})

- ARR Target Allocation is equal to the ARR MW amount times the average price difference from the ARR sink point to the ARR source point over the 4 rounds.
- ARRs can be a benefit or a liability.
Participants with ARRs

- **Convert ARR into FTR** by “self-scheduling” FTR into Annual Auction on exact same path as ARR
- **Reconfigure ARR** by bidding into Annual Auction to acquire FTR on alternative path or for alternative product
- **Retain allocated ARR** and receive associated allocation of revenues from the auction
ARRs are acquired in the following mechanisms …

1. Annual Allocation
   - Auction Revenue Rights (ARRs) requested by Firm Transmission Customers are allocated on an annual basis
   - Previously pro-rated Stage 1B ARRs, or Residual ARRs, are available monthly based on updated models and simultaneous feasibility

2. Daily ARR Reassignment
   - ARRs allocated for the planning period will be reassigned on a proportional basis within a zone as load switches between LSEs within the planning period
ARRs allocated for the planning period will be reassigned daily on a proportional basis within a zone as load switches between LSEs within the planning period

- An LSE that loses load in a zone will lose ARRs if the LSE has a *net positive economic* ARR position for that zone

- An LSE that loses load in a zone will not lose ARRs if the LSE has a *net negative economic* ARR position for that zone

- An LSE that opted for a direct allocation of FTRs and that loses load will lose a proportional share of each FTR
Daily ARR Reassignment Process

**STEP 1**
How Does Load Shift?

- Compare each LSE’s daily deviation of Network Peak Load in zone

**STEP 2**
Who Loses ARR?

- Analyze each LSE’s net economic position
  - For each LSE losing load AND have a net positive position for that zone
    - Determine load lost %
    - Reduce each ARR owned by that percentage

**STEP 3**
Who Gains ARR?

- Assign total set of forfeited ARRs to LSEs that gain load in zone
  - Determine percentage of ARRs to be assigned to each LSE gaining load
    - Assign LSE gaining load % of each ARR in this set of forfeited ARRs
ARRs are allocated in **March** for the next planning period using an **estimate** of peak load contributions for June 1.

A reassignment will occur on **June 1** by comparing the actual June 1 load contribution to the estimated June 1 load contribution.

An ARR reassignment for **January 1** will not be conducted because new zonal loads are uploaded and allocated on January 1.
Residual ARRs

• ARRs prorated in Stage 1 of the Annual ARR Allocation may be allocated Residual ARRs for the following:
  – Increased transmission capability made available by certain transmission upgrades made during the planning year that were not modeled in the Annual ARR Allocation
  – Increased transmission capability made available for periods when ARR modeled transmission outages are not out of service

• Residual ARR MWs plus previously awarded Stage 1 and Stage 2 MWs cannot exceed the Network Service Peak Load value for a particular participant

• Residual ARRs are effective the first month the increased transmission capability is modeled in the Monthly FTR Auction. Residual ARRs cannot be negative.

• Economic value of Residual ARRs are based on the MW amount and the nodal clearing price difference between the source and sink nodes for FTR Obligations resulting from each monthly FTR Auction the Residual ARR is effective
• ARRs entitle the holder to receive allocation of Annual FTR Auction revenues

• ARRs are allocated to Firm Transmission Service Customers

• ARRs may be self-scheduled to an FTR before the first round of the Annual FTR Auction

• ARRs are reassigned on a proportional basis within a zone as load switches between LSEs within the planning period

• ARRs are only available as an obligation
  – Obligation can be benefit or liability

• ARRs must be simultaneously feasible

• Residual ARRs may be available within a planning period for increased transmission capability
Financial Transmission Rights
Characteristics of FTRs

- Economic value based on Day-Ahead Congestion Prices
- Defined from source to sink
- Can be in form of obligation or option
  - obligation can be benefit or liability
  - option can be benefit but never liability
- Financial entitlement, *not* physical right
- Independent of energy delivery
- Must be simultaneously feasible
**Economic Value of FTRs**

| FTR Target Allocation | = (FTR MW) * (Congestion Price \textsubscript{FTR Sink} – Congestion Price \textsubscript{FTR Source}) |

- FTR Target Allocation is equal to the FTR MW amount times the congestion price difference from the FTR sink point to the FTR source point.
- Congestion Price based on the clearing prices from Day-Ahead Market.
- If Congestion Price \textsubscript{FTR Sink} < Congestion Price \textsubscript{FTR Source}:
  - The FTR is a liability if FTR defined as Obligation.
  - The FTR has zero value if defined as Option.
FTRs are acquired in several market mechanisms . . .

- **Annual FTR Auction**
  - Multi-round
  - Entire system capability minus approved Long-Term FTRs

- **Long-Term FTR Auction**
  - Multi-round
  - Purchase residual system capability assuming the self-scheduling of ARRs

- **Monthly FTR Auction**
  - Single-round
  - Purchase “left over” capability

- **FTR Secondary Market**
  - Bilateral trading
FTRs can be acquired in two forms ...
What Are FTR Obligations Worth?

**Benefit**
- The hourly congestion value is positive
- FTR same direction as congested flow

**Liability**
- The hourly congestion value is negative
- FTR opposite direction as congested flow
What Are FTR Options Worth?

**Benefit**
- The hourly congestion value is positive
- FTR same direction as the congested flow

**Neither a Benefit or a Liability**
- The hourly congestion value is zero
- FTR opposite direction to the congested flow

*FTR Option cannot have negative value*
FTR Credits and Congestion Charges

Congestion Charge =
\[ \text{MWh} \times (\text{Day-ahead Sink Congestion Price} - \text{Day-ahead Source Congestion Price}) \]

FTR Credit =
\[ \text{MW} \times (\text{Day-ahead Sink Congestion Price} - \text{Day-ahead Source Congestion Price}) \]
FTR Obligation is a Benefit

**Thermal Limit**

**FTR Obligation = 100 MW**

**Energy Delivery = 100 MWh**

**Congestion Price = $30**

**Congestion Price = $15**

Bus A: Source (Sending End)

Congestion Price = $15

Bus B: Sink (Receiving End)

Congestion Price = $30

Congestion Charge = 100 MWh * ($30-$15) = $1500

FTR Obligation Credit = 100 MW * ($30-$15) = $1500
FTR Obligation is a Liability

Thermal Limit

FTR Obligation = 100 MW

Energy Delivery = 100 MWh

Congestion Price = $30

Source
(Sending End)

Bus A

Congestion Price = $15

Bus B
Sink
(Receiving End)

Congestion Price = $30

Congestion Charge = 100 MWh * ($30-$15) = $1500

FTR Obligation Credit = 100 MW * ($15-$30) = $-1500
FTR Option is a Benefit

**Thermal Limit**

**FTR Option = 100 MW**

**Energy Delivery = 100 MWh**

**Bus A**
Source (Sending End)
Congestion Price = $15

**Bus B**
Sink (Receiving End)
Congestion Price = $30

**Congestion Charge** = 100 MWh * ($30-$15) = $1500

**FTR Option Credit** = 100 MW * ($30-$15) = $1500
FTR Option is Neither a Benefit/Liability

Congestion Charge = 100 MWh * ($30-$15) = $1500
FTR Option Credit = 100 MW * ($15-$30) = $-1500 = $0

***When calculated, the FTR Option Credit is negative, therefore the economic value will equal zero.*****
• FTRs are financial instruments used to hedge congestion costs

• FTRs can be acquired in the Annual FTR Auction, Long Term FTR Auction, Monthly FTR Auction, or Secondary Market

• FTRs can be Obligations or Options
  – obligation can be benefit or liability
  – option can be benefit but never liability

• FTRs must be simultaneously feasible
Overview of Simultaneous Feasibility Test (SFT)
Clearing the FTR Market

• Fundamentally an optimization problem
  • Objective function: Maximize bid-based revenue (i.e., revenue to ARR holders)
  • Subject to: Transmission constraints (N-1)

• Solution Mechanism
  – FTR Optimizer
    • Input: Set of transmission constraints to respect
    • Figure out the optimal set of FTRs to clear by calculating “cost effectiveness ratios” of each FTR to each constraint
    • Output: Cleared FTRs (i.e., a set of generators and loads)
  – SFT – “Simultaneous Feasibility Test”
    • Input: Set of generators and loads
    • Figure out which constraints are violated (do N-1 contingency analysis)
    • Output: Updated set of transmission constraints to respect
What is a Simultaneous Feasibility Test?

Test to ensure that all subscribed transmission entitlements are within the capability of the existing transmission system

Test to ensure the PJM Energy Market is revenue adequate under normal system conditions

*NOT* a system reliability test

*NOT* intended to model actual system conditions
ARRs must be simultaneously feasible to ensure that Annual FTR Auction revenues are sufficient to cover ARR Target Allocations.

FTRs must be simultaneously feasible to ensure that total congestion charges collected from Day Ahead are sufficient to cover FTR Target Allocations.
• FTRs or ARR are modeled as generation at source point and load at sink point

• Single contingency test criteria

• Perform DC powerflow analysis to
  – Evaluate ability of all system facilities to remain within normal thermal ratings
  – Evaluate ability to sustain the loss of any single contingency event with all system facilities remaining within applicable short-term, emergency ratings
• Uncompensated Parallel Flow Injections
• Transmission Outages
• Existing FTRs or ARRs
• Facility Ratings
• PJM Network Model
• List of Contingencies
• Interface Ratings
A constrained transmission system with nodal prices

LMP prices are quoted as $/MW-period (contrast with $/MWh in DA)

If you take the cleared nodal prices from FTR and divide them by the number of hours in the period, you are getting what the speculators believe the average congestion price will be in DA per hour over that period at that node

\[
\text{Cost} = \text{FTR}_{LMP,\text{sink}} - \text{FTR}_{LMP,\text{source}}
\]
ARR / FTR Settlements
• The Annual FTR Auction and corresponding ARRs will be settled for on a weekly basis over the course of the planning period for which the Annual FTRs are in effect.

• Since ARR ownership can change daily through ARR reassignment, PJM Settlements calculates:
  – daily Annual FTR Auction revenues by dividing annual auction revenues by the number of days in the planning period.
  – daily ARR credits by dividing ARR Target Allocation by the number of days in the planning period.
ARR Target Allocation = \((\text{ARR MW}) \times (\text{LMP}_{\text{ARR Sink}} - \text{LMP}_{\text{ARR Source}})\)

• ARR Target Allocation is equal to the ARR MW amount times the average price difference from the ARR sink point to the ARR source point over the 4 rounds

• LMPs based on the average nodal clearing prices over the 4 rounds of the Annual FTR Auction

• ARRs can be a benefit or a liability
ARR Settlements (cont.)

• If sufficient revenues are collected from the Annual and Monthly FTR Auctions to satisfy ARR Target Allocations then:
  – ARR Credits = ARR Target Allocation

• Excess auction revenues are used to fund any deficiencies in FTR Target Allocation payments

• If insufficient revenues are collected from the Annual, Long-Term, and Monthly FTR Auctions to satisfy ARR Target Allocations then:
  – ARR Credits are prorated proportionately
  – ARR deficiencies are funded from:
    1) Any annual excess congestion charges remaining at the end of a planning period after fully funding all FTR target allocations for the planning period, then
    2) An uplift charge assessed to FTR holders on pro-rata basis according to total Target Allocations for all FTRs held at any time during the planning period
The Long-Term FTR auction credits appear on the weekly billing statement.

Revenues from the Long-Term FTR auctions are used to first fund any shortfall in ARR Target Allocations then FTR target allocations for the planning period in which the Long-Term FTR is in effect.
The monthly auction credits appear on the weekly billing statement.

Revenues from the monthly auctions are used to first fund ARR Target Allocations then FTR Target Allocations.
FTR Target Allocation = (FTR MW) * (Congestion Price FTR Sink – Congestion Price FTR Source)

- FTR Target Allocation is equal to the FTR MW amount times the congestion price difference from the FTR sink point to the FTR source point.
- Congestion Price based on the clearing prices from Day Ahead Market.
- If Congestion Price FTR Sink < Congestion Price FTR Source
  - the FTR is a liability if FTR defined as Obligation
  - the FTR has zero value if defined as Option.
FTR Settlements (cont.)

• If sufficient congestion charges are collected from the Day Ahead market to satisfy FTR Target Allocations then:
  – FTR Credits = FTR Target Allocation

• Excess congestion charges are used to
  – cover any deficiencies in FTR Target Allocations within month
  – cover any deficiencies in FTR Target Allocations within planning period
  – any remaining year-end excess covers any deficiencies in ARR Target Allocation from previous months within planning period
  – any remaining year-end excess distributed to ARR participants pro-rata to total positive ARR Target Allocations
• If insufficient revenues are collected from the Day Ahead Market to satisfy FTR Target Allocations then:
  – FTR Credits are prorated proportionately pro-rata to FTR Target Allocations
  – FTR Target Allocation deficiencies are funded from:
    1) Excess congestion charges from current month and subsequent months, then
    2) An uplift charge assessed to FTR holders on pro-rata basis according to total Target Allocations for all FTRs held at any time during the planning period
Historical FTR Target Credits vs. Congestion Revenues

Revenue Adequacy 100% since 14/15
ARR/FTR-to-Congestion Load Payout Ratios

*Represents the percentage of total congestion dollars returned to Load*

<table>
<thead>
<tr>
<th>Planning Period</th>
<th>ARR Credits</th>
<th>FTR Credits</th>
<th>Total Congestion</th>
<th>Offset</th>
<th>Total Surplus</th>
<th>Adjusted Offset</th>
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</thead>
<tbody>
<tr>
<td>2014/2015</td>
<td>$482.4</td>
<td>$384.2</td>
<td>$1,388.5</td>
<td>62.4%</td>
<td>$130.40</td>
<td>71.8%</td>
</tr>
<tr>
<td>2015/2016</td>
<td>$772.1</td>
<td>$125.9</td>
<td>$982.7</td>
<td>91.4%</td>
<td>$42.60</td>
<td>95.7%</td>
</tr>
<tr>
<td>2016/2017</td>
<td>$632.9</td>
<td>$169.8</td>
<td>$810.2</td>
<td>99.1%</td>
<td>$74.60</td>
<td>108.3%</td>
</tr>
<tr>
<td>2017/2018</td>
<td>$266.5</td>
<td>$522.4</td>
<td>$1,198.1</td>
<td>65.8%</td>
<td>$368.70</td>
<td>96.6%</td>
</tr>
</tbody>
</table>

- All dollars in millions
- ARR Credit: ARR Target Credits – FTR Self-Scheduling Costs
- FTR Credits: FTR Target Credits Purchased by Load (self-scheduled and directly-allocated for new zones)
- Total Congestion: DA Congestion + Bal Congestion + M2M
- Filed with FERC in 2018 to return congestion surplus to ARR holders, changed from FTR holders
• OA Schedule 1, sections 5 and 7
• Manuals 6 and 28
• RTO FTR/CRR/TCC Business Rule Matrix will be posted in May
• Questions to FTRGroup@pjm.com