London Economics International LLC

PJM ARR/FTR Review: Summary of findings and recommendations *(Updated)*

prepared for the PJM ARR/FTR Task Force

January 22, 2021

Goal of today's session is to provide an overview of LEI's study and discuss our key findings

9:15 am – 10:30 am	· Overview of the project and summary of findings
10:30 am – 11:30 am	· Purposes of ARR/FTR
11:30 am – 1:00 pm	· Evaluating the existing ARR/FTR construct
1:00 pm – 1:45 pm	· Lunch break
1:45 pm – 2:00 pm	· Reviewing mechanisms in other power markets
2:00 pm – 3:15 pm	• Recommendations

Agenda

1	**Overview of the engagement and summary of findings**
2	Purposes of ARR/FTRs and criteria
3	Evaluating the current ARR/FTR mechanisms
4	Reviewing mechanisms in other markets
5	Recommendations
6	Appendix

Is the current ARR/FTR mechanism appropriate for ensuring that load receives the optimum value of the transmission system?

Key Questions

1) What is the original intent of ARR and FTR? Was it to address a problem?

2) Are they fulfilling, in the best way possible, their initial purpose and/or addressing the identified problem?

3) If not, why not? If so, how is this measured and verified?

4) Is this purpose still required, and if it is addressing a problem, are there alternative ways to eliminate the problem entirely?

5) Are there additional purposes and/or sources of value to the market that ARRs and FTRs are, or should be, fulfilling or delivering? If so, what are these purposes, how do they optimize value to load and other market participants; and how is this value optimization measured and verified?

6)? What other mechanisms can provide alternative ways to achieve some of these purposes

7) Are there changes in the market design, execution, etc. that would improve delivery of these instruments' purpose?

In order to methodically address the Key Questions, LEI employed a research and data-based approach spread over five tasks

Tasks

1. Identify the purposes of the ARR/FTR
2. Define measurable criteria for the evaluation of ARR/FTR mechanisms
3. Evaluate existing ARR/FTR construct and identify issues
4. Assess ARR/FTR construct in other US markets
5. Propose enhancements to the current ARR/FTR

Approach

Research and data collection

- FERC Orders, PJM filings to FERC
- PJM Manual, and other training materials
- Economic theory and academic research papers related to FTRs, property rights, auction design
- State of the Market reports, published metrics (PJM and other select US RTOs/ISOs)
- Presentations from stakeholders made in prior Task Force meetings
- Stakeholder input (interviews, survey questionnaire responses)
- ARR and FTR market data related to ARRs /FTRs (PJM and other select US markets)
- Data from IMM (Forfeiture data, congestion bus model, etc.)
- Data from outside PJM markets (bilateral trading data (EQRs), futures traded on exchanges)

Qualitative and quantitative analysis

- Consideration of purpose **(Task 1)**
- Selection of criteria **(Task 2)**
- Qualitative and quantitative evaluation of actual outcomes in PJM **(Task 3)**
- Identification of how rules changes over time impacted outcomes **(Task 3)**
- Comparative analysis of PJM and other markets **(Task 4)**

Formulation of findings and recommendations

- Should the current construct be retained **(Task 3)**
- Lessons learned from other US RTOs/ISOs **(Task 4)**
- Recommendations around potential enhancements **(Task 5)**

FTRs (and ARRs) serve two purposes, both of which create benefits for load

Purpose #1

Facilitate the return of overpayment in LMP (congestion charges) back to load

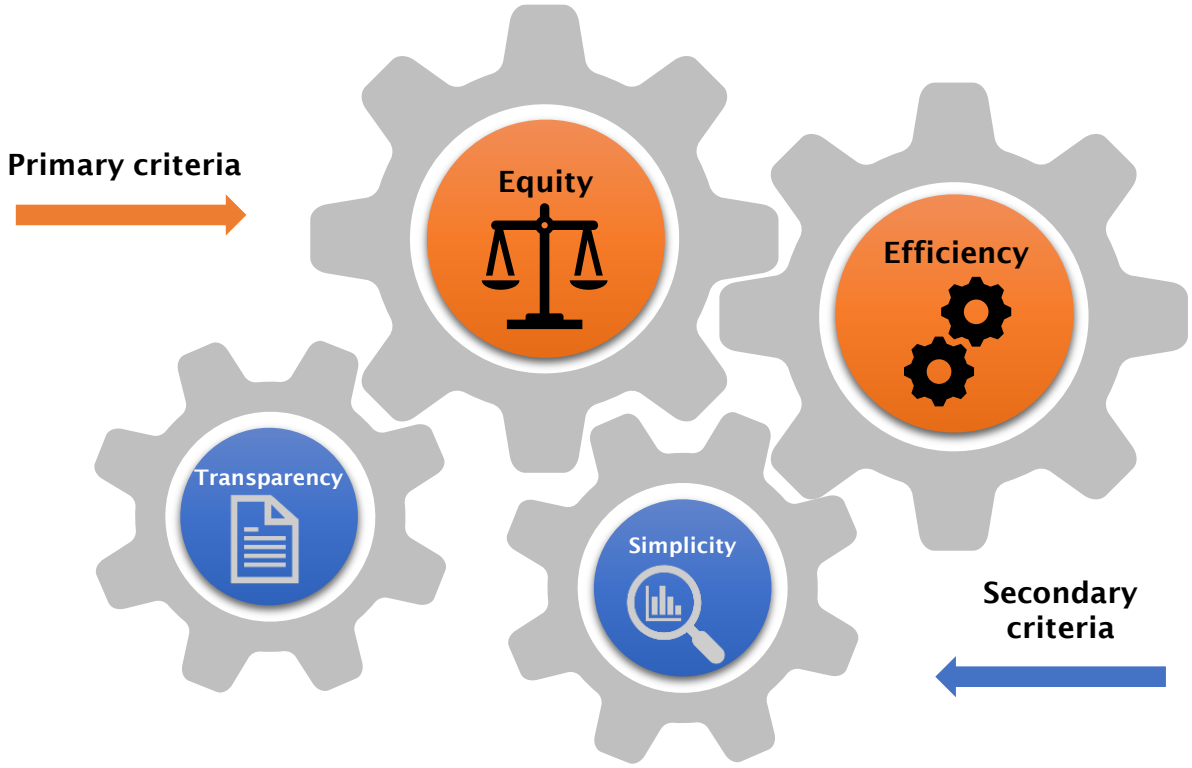
- Payments made by all **load serving entities exceed the payments to all generators** when there is congestion
- Overpayment should be **returned to load**, because load paid and continues to pay for the transmission system

Purpose #2

Enable hedging of the marginal cost of congestion in LMPs between different nodes and support forward market activity through the offering of FTRs

- FTR auction results provide a **granular understanding of expected network congestion**, which helps market participants hedge congestion risk more effectively
- Price discovery emanating from FTR auctions **supports liquidity in forward markets**, which **reduces the transaction costs** of hedging and bilateral contracting
- In the long run, load benefits from a **liquid and efficient forward market** through **lower transaction costs, lower financing costs and optimal reallocation of risk**

LEI identified four criteria drawn from best practices in regulatory economics and policy design



Equity	Efficiency	Transparency	Simplicity
Reflects the fair treatment of affected parties	Involves the optimal allocation of resources to those that value them the most	Timely access to relevant information for purposes of decision-making in an auction or regulatory context	Simpler theories should be preferred to more complex ones, so long as it does not compromise the mechanism's functionality

Current ARR/FTR mechanism produces reasonable outcomes for load in PJM

1. Majority of congestion charges collected in day-ahead energy market have been returned to load

   In last two years, enhancements have increased the aggregate payout to load

2. A path-based construct continues to be relevant in the present day due to the significant amount of load that is contracted bilaterally or self-supplied

3. FTR auctions are generally efficient and should be retained with mininmal changes

4. Dual system of property rights (encompassing ARRs and FTRs) creates value for load and should be preserved

5. Historical gen-to load ARR allocation process and rules-based surplus allocation may be creating equity issues between LSEs

Review of ARR/FTR constructs at three other US RTOs/ISOs identified some valuable "lessons learned"

Differences that would not be beneficial or relevant to PJM's construct:

1. Use of simple allocation rules (like pro rata to load) in combination with a single right system (like in ERCOT) would **reduce the flexibility and value** that PJM load gets from ARRs, and would **conflict with the zonal transmission rate design**
2. Reduction of FTR paths (like in CAISO) may **reduce the efficiency of the FTR auctions** and **undermine the value of the ARR property right** and **longer-term benefits** to load from liquid forward markets

Other differences that could be improvements and for further consideration by PJM and its stakeholders:

1. PJM should investigate the feasibility of **introducing more granular ARR products** (peak, off-peak, and seasonal)
2. PJM should also **revisit the FTR forfeiture** rule based on the experiences of other ISOs/RTOs

PJM and its stakeholders should focus on improving the equity-related features, while preserving the efficiency-related mechanics

Equity

- Develop an objective definition of equity; establish a more detailed understanding of zonal patterns of congestion
- Expand biddable points and time of use periods for ARRs
- Add flexibility to self-scheduling rules
- Explore alternatives to historical path assignment of ARRs
- Explore alternative allocation approaches for distributing surplus congestion

Efficiency

- Maintain PJM's annual, monthly and long-term FTR auctions
- Continue to allow non-load participation and the current set of biddable points
- Monitor competition and profitability trends over time
- Determine a minimum premium for options
- Evaluate changes to the current FTR forfeiture rule

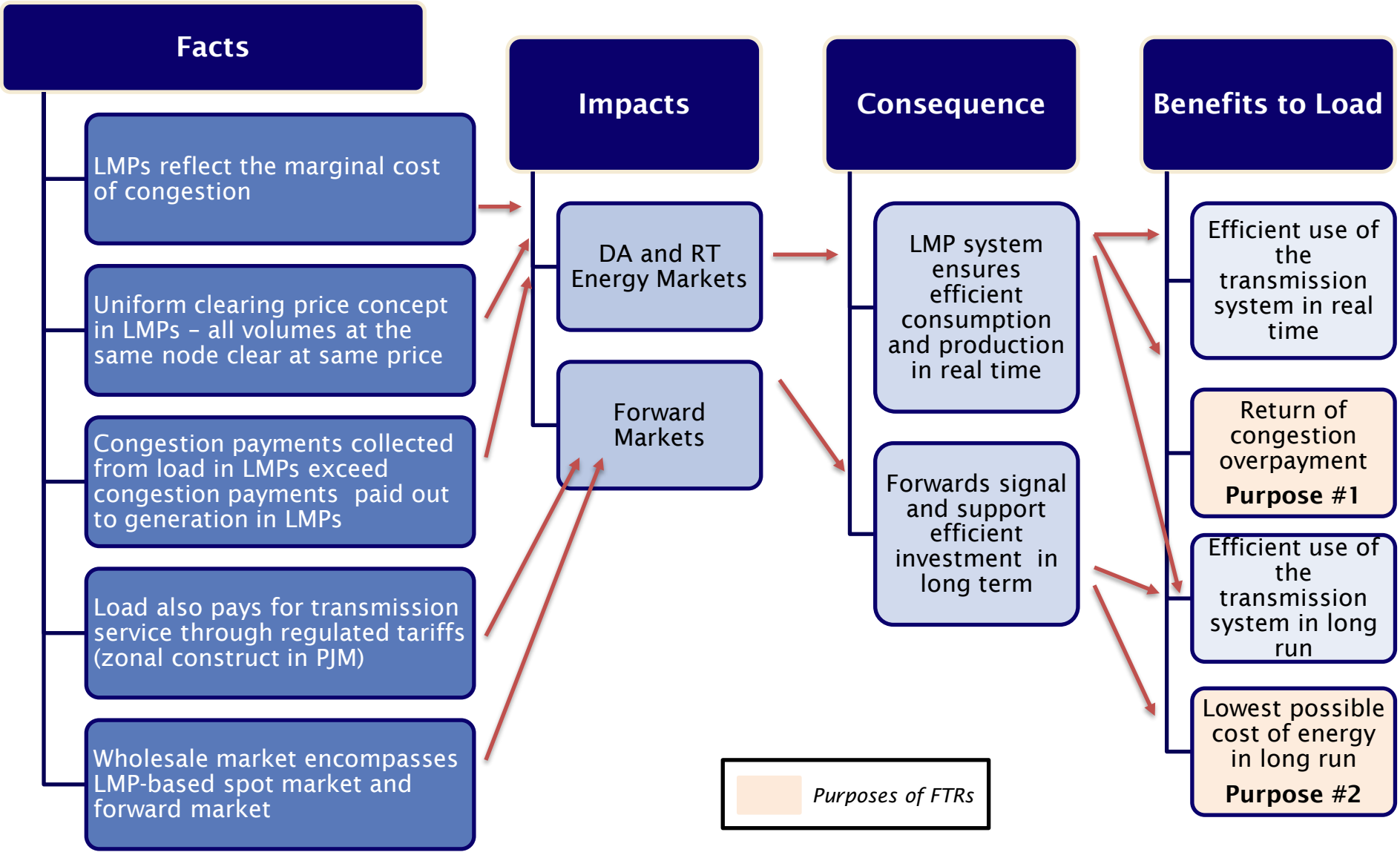
Transparency and simplicity

- Issue a network model manual
- Provide detailed documentation of network model changes over time
- Periodically retain transmission expert to independently review the network model

Questions?

Agenda

FTR/ARR mechanisms impact both the spot market and forward market, creating short term and long-term benefits for load



Purpose #1: ARRs/FTRs facilitate the return of LMP overpayment (congestion costs) to load

Purpose #1:

Facilitate the return of overpayment in LMPs (known as congestion charges)

Load paid for the construction of the transmission system and continues to pay for transmission service through a separate regulated rate

Physical rights to transmission would no longer be practicable with open access and wholesale competition

LMP system results in aggregate load payments that exceed aggregate generation payouts when there is congestion

Load pays for transmission congestion in LMPs, which is volatile and not hedgeable with power purchase agreements ("PPA")

FTRs/ARRs provide for pathway to return of congestion cost component of LMPs to load

Purpose #2: FTRs allow for hedging and support forward market activity

Purpose #2:

Enable hedging of the marginal cost of congestion in LMPs and support forward market activity

LMP-based spot markets were always intended to work with bilateral contracts and forward markets – ensuring a sustainable market design

Auctions results from the sale of FTRs support forward market – price discovery

Forward power sales and purchases provide a pathway for load to hedge the cost of supply and finance new investment, which ultimately benefits customers

FTR auctions support liquid forward markets, which benefit customers in the longer term

Equity and efficiency criteria relate directly to the identified purposes of FTRs (and ARRs), while transparency and simplicity criteria play a supporting but vital role

Primary Criteria

Efficiency	• Are FTR auction outcomes **efficient in allocating FTRs and pricing congestion**? • Does the FTR construct **support forward markets** (and what are the consequences)?
Equity	• Is load getting a return **of congestion payments collected in day ahead energy market**? • Is the **distribution of the returned congestion payments among load serving entities fair** and proportional to the underlying drivers/principles?

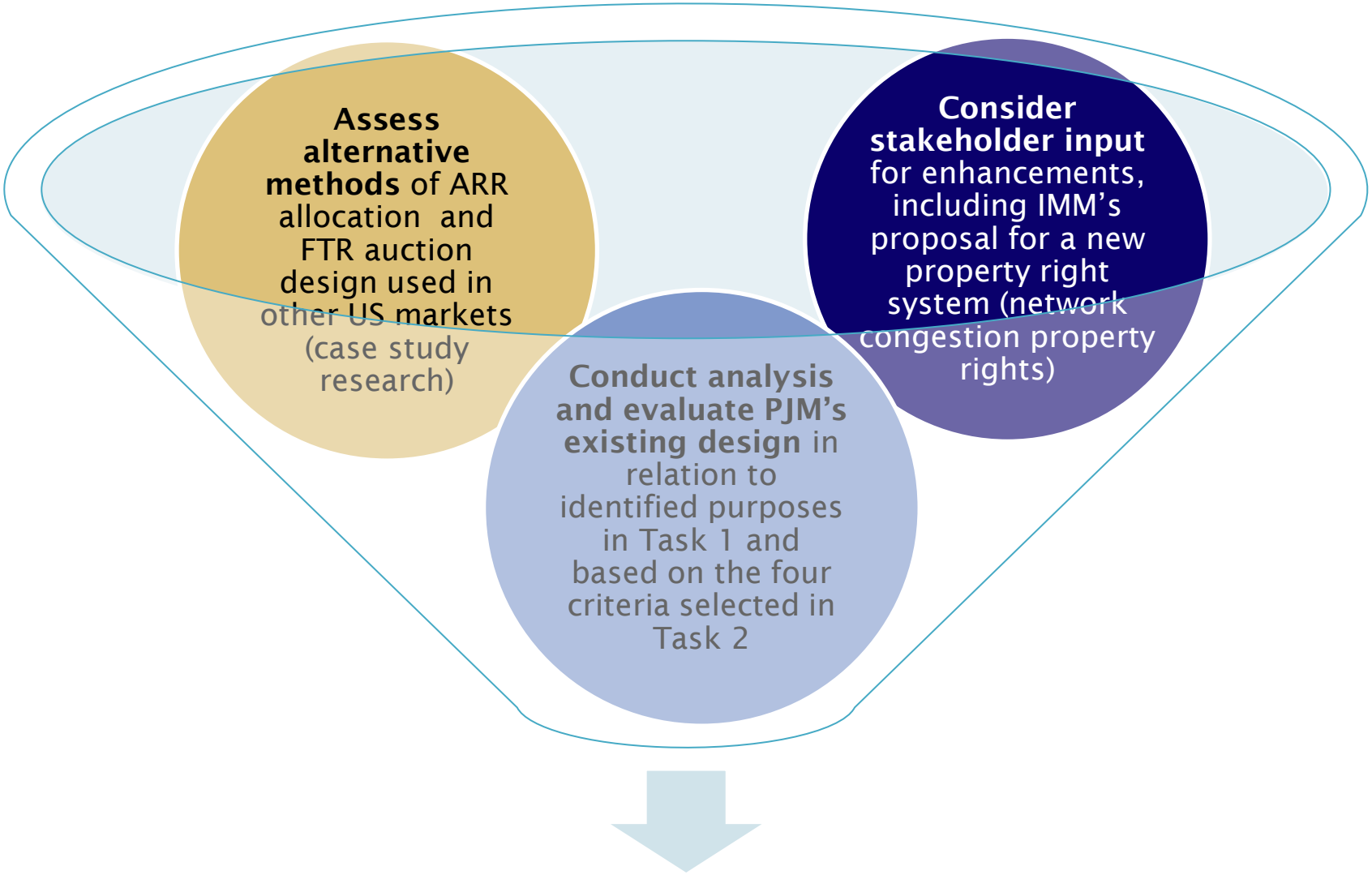
Secondary Criteria

Transparency	• allocation schemes and markets work best if **information is readily available** to support the decision-making of every market participant, leading to more efficient outcomes that are recognized as fair
Simplicity	• **simpler systems/markets** with **lower administrative** burdens are preferred, as long as simplicity **does not compromise functionality**

Questions?

Agenda

Findings for Task 3 are based on input from PJM stakeholders, assessment of alternatives used elsewhere, and systematic evaluation of the existing ARR/FTR construct



Past FTR/ARR mechanism changes have improved the functionality of the mechanism in PJM

Effective		Key Changes	Impact
2003	1	ARR mechanism included transmission capability created through merchant transmission investment	Refines the investment signal emanating from ARRs (Purpose #2)
2007	2	Revision of the allocation process to include Stage 1A and 1B	Provides more certainty (priority) to load regarding their long-term rights in network (Purpose #1)
2017	3	ARR allocation mechanism was adjusted to reflect the changing generation fleet	Allowed for more up-to-date ARR source points and improving investment signals (Purpose #2)
2006 & 2008	4	FTR auction design was modified (e.g., introducing balance of planning period and long-term auctions) and the universe of FTR products was expanded	Provides additional opportunities to reconfigure FTR portfolios and hedge (Purpose #1) Improves price discovery (Purpose #2)
2017	5	Allocation of balancing congestion costs was changed to solve the overpayment issue to FTR holders	Improves payout to load (Purpose #1) Pricing in FTR auctions no longer reflects risks of balancing congestion; more reflective of expected congestion in the day-ahead energy market (Purpose #2)
2018	6	Payment of surplus congestion was shifted from FTR holders to ARR holders	Improves payout to load (Purpose #1)

Many stakeholders offered suggestions for on potential enhancements to the ARR and FTR processes

- Majority of stakeholders support the current design and believe that the ARR/FTR mechanisms are generally working as intended
- Few stakeholders were open to the idea of a complete overhaul of the ARR/FTR design

Changes to ARR construct

- Frequency and flexibility of ARR allocation
- More granular ARR products

Changes to FTR construct

- Expand and provide more granular FTR products
- Introduce reservation price in FTR auctions
- Modify long-term auctions
- Consider number of biddable points
- Adjust tight timeline in FTR auctions

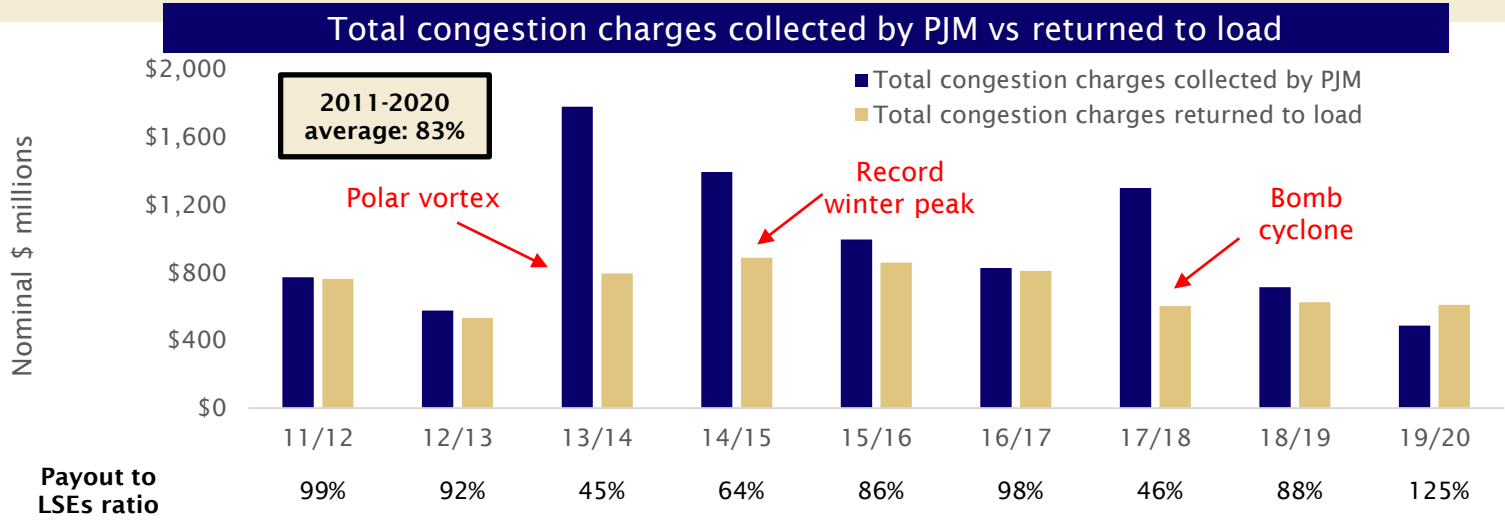
Other areas

- Improve network model accuracy (and transparency)
- Relax forfeiture rule

Analyzed quantitatively
Analyzed qualitatively
Explored further through case study analysis

In aggregate, load received on average, over 80% of the annual congestion payments in the past nine years

- **Rules have evolved to improve the amount of payout to load - in the past two planning periods, more than 100% of annual congestion payments collected in LMPs has been returned to load**
- **Years with low-payout ratios to load involve extreme weather conditions, resulting in low FTR auction prices relative to actual congestion charges collected**



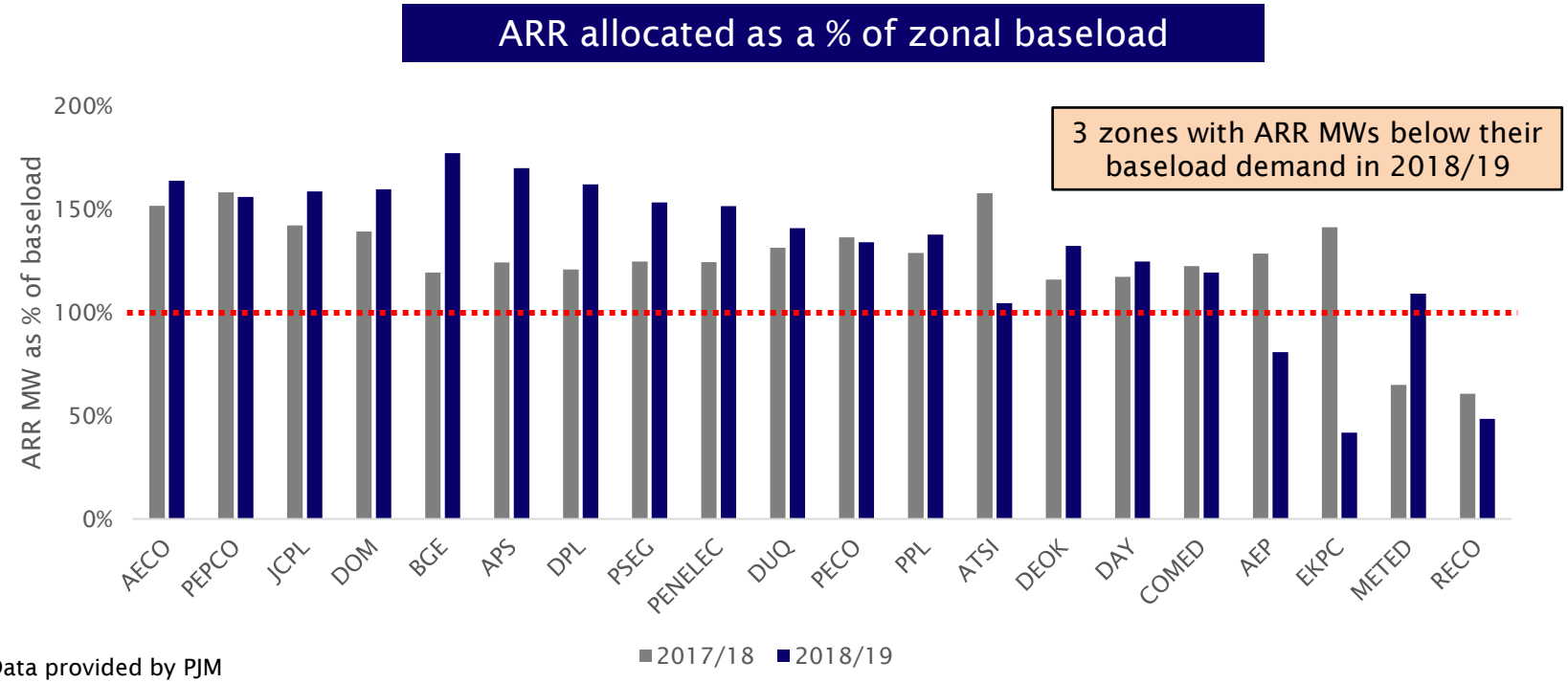
Source: Data provided by PJM

Congestion payout to load can be above or below 100% in any given year due to:

1. ***forecast error between auction results and DA outcomes,*** which means FTR prices (which sets ARR target allocation) can be above or below DA CLMP
2. ***Non-load participants in the FTR auctions need to be compensated*** for the risk they are taking, and that compensation reduces the "pie" left over for load
3. ***Ex-ante estimate of network capability may differ from actual network capability*** resulting in over- or under-funding of DA CLMP relative to FTR target allocation

Distribution of congestion payments between different LSEs may be inequitable due to current allocation rules

- **According to economic theory, initial allocation of property rights would not matter if the recipients of those rights can trade with minimal transaction costs**
  - ARRs are not tradable, but convertible to FTRs (and FTRs are tradable)
- **Current ARR allocation process leads to surplus congestion – not all paths traded in the FTR auction can be nominated as ARR paths, and FTR auction proceeds fund surplus**
  - Allocation of surplus congestion depends on the value of the initial ARR allocation and load cannot fully trade out their ARR positions, which means initial allocation of ARR does impact payout to load



Source: Data provided by PJM

Note: ARR allocated was 100% of baseload in some zones because LSEs may not have nominated ARRs. In RECO's case, it has no generation in the zone and therefore, had no path to nominate in Stage 1A

A path-based construct supports hedging and forward market liquidity; identified disadvantages can be further minimized by enhancing ARR processes

Advantages

- Provides "perfect hedge" to self-supply and sign a bilateral contract
- Allows for very granular price discovery – supporting forward market liquidity

Disadvantages

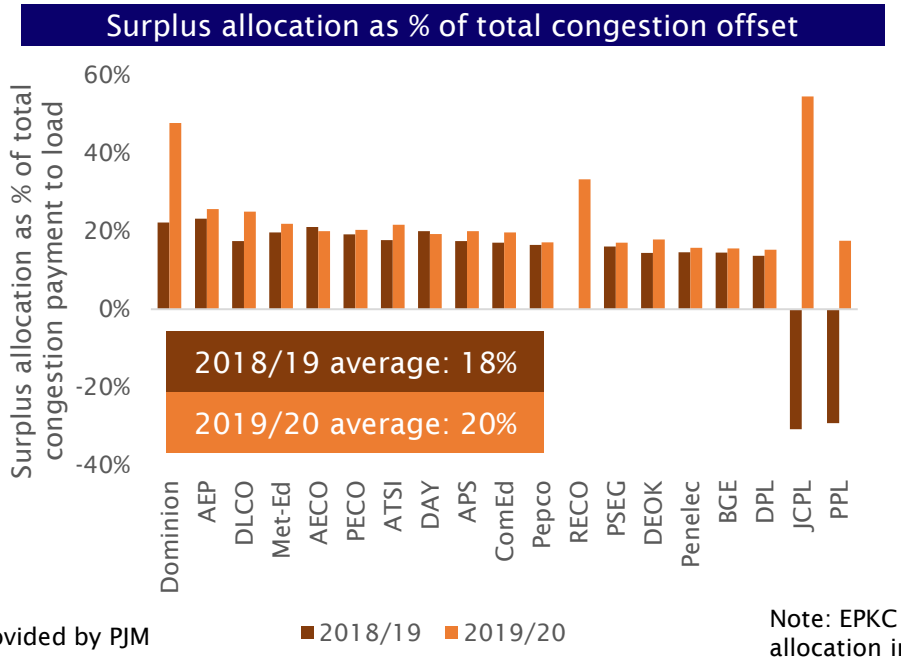
- Requires network model that relies on technical inputs and many assumptions to estimate network capacity for ex-ante allocation and auction
- Limitations on how much network capacity can be allocated/sold because of underfunding risk – which leads to surplus allocation

Dual system of property rights provides flexibility and value to load, but results in surplus or underfunding

Advantages

- Provides **flexibility** to load to choose to receive a fixed payment or variable payment (self-scheduling)
- Self-scheduling of ARRs can create a **perfect hedge** for bilateral contracts and self-supply
- Allows PJM to **prioritize allocation of congestion charges** to load by separating ARR holders from FTR holders

Disadvantages



- Network capability must be **"forecast"** and that creates complexity in the settlement process
- In the past 2 years, surplus represents over 18% of congestion charges returned to load in the aggregate, but the amount varies by zone and over time

Source: Data provided by PJM

Note: EPKC is not included in this figure because it did not receive any surplus allocation in 2018/19, and it had no total offset in 2019/20.

Conditions required for Coase Theorem to apply do not hold true for ARRs – initial ARR allocation does matter

The Coase Theorem states that the initial allocation of property rights does not matter from an efficiency perspective ***so long as they can be freely exchanged***.

J. Eatwell et al. (eds.), Allocation, Information and Markets, Palgrave Macmillan, 1989

Rights of ARR holder

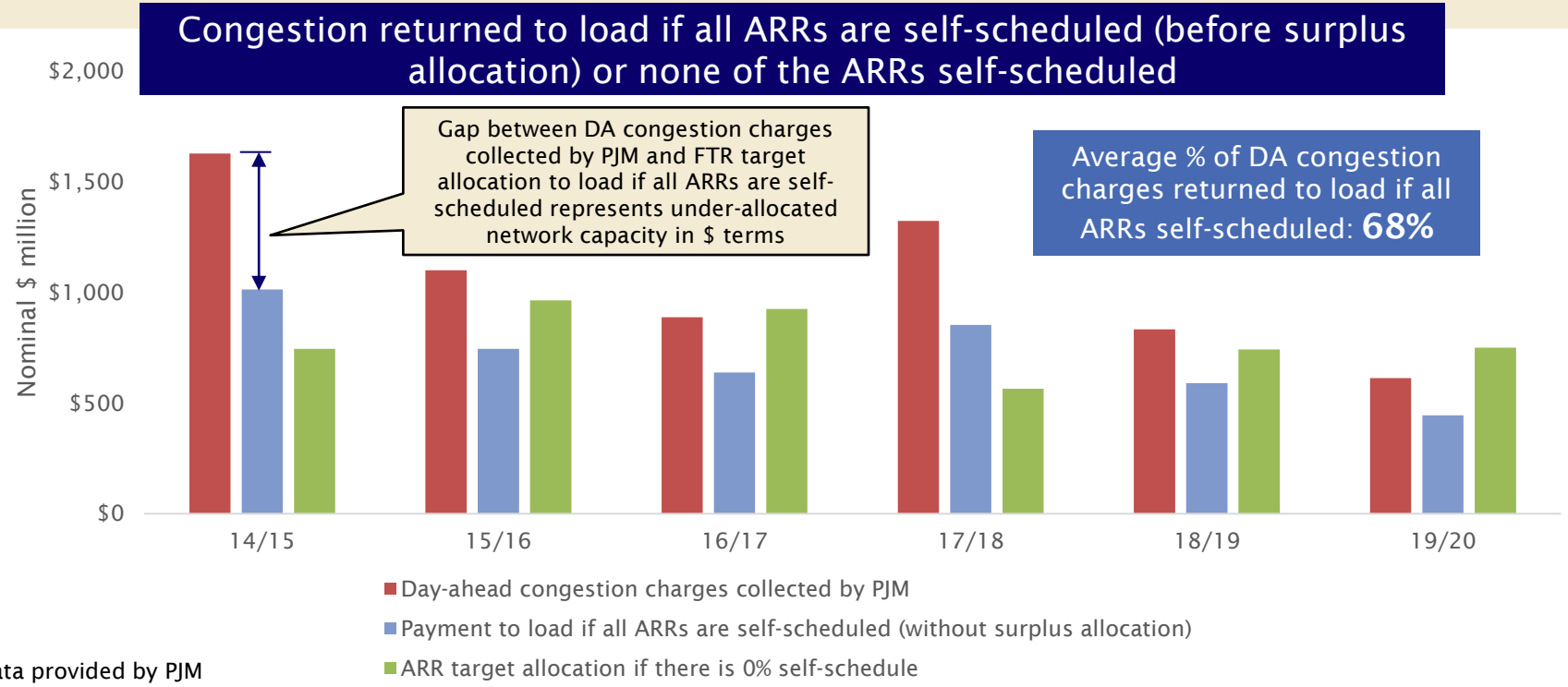
1. **Obligation to receive/pay FTR auction prices (i.e. ARR target allocation)**
2. **Right to receive surplus allocation (always positive) based on pro-rata share of positive ARR target allocations**
3. **Option to self-schedule the ARR path into FTR path, and receive a variable obligation based on DA congestion charges**

This part cannot be freely exchanged. Once the initial ARR allocation is completed, a load cannot obtain more or less surplus based on ARR target allocation value

This part can be freely exchanged (i.e., tradable) because once the ARR is self-scheduled, it can be sold in subsequent rounds of FTR auctions

What are the concerns with the initial ARR allocation? First, a significant amount of network capacity is not allocated to load

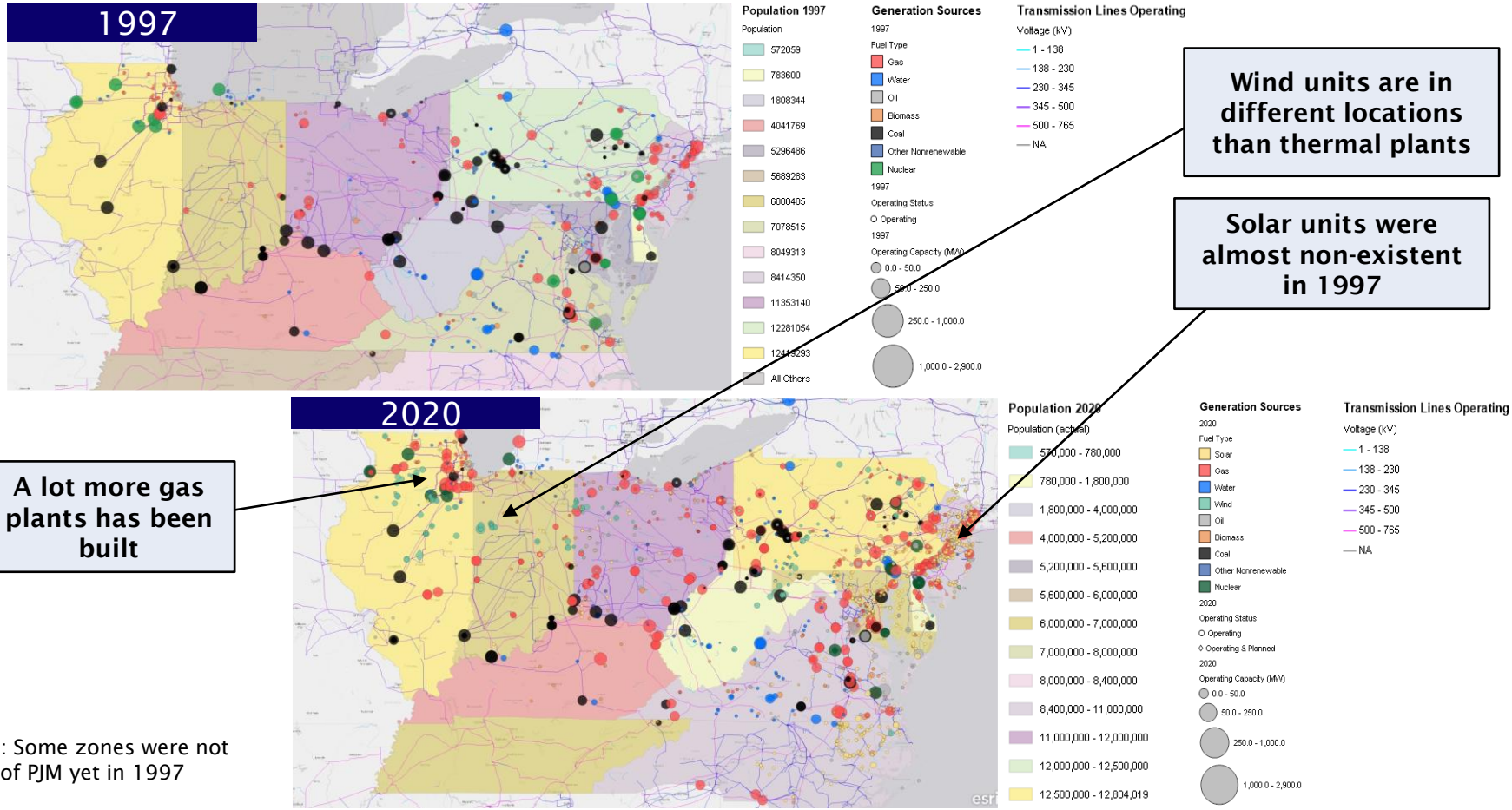
- **If all ARRs are self-scheduled to FTRs, congestion charges returned to load would purely be based on the % of network allocated to load during the ARR allocation process**
- **If all ARR were self-scheduled over the past 6 years, load would have received only 68% of day ahead charges before surplus**
  - The gap between this number (blue bar) and total DA congestion charges PJM collected (red bar) is the size of under-allocation measured in $ terms
  - Surplus is not included in this analysis because it is a "true up" mechanism to compensate for ARR under-allocation – the exact issue we want to analyze



Source: Data provided by PJM

What are the concerns with the initial ARR allocation? Second, ARR paths available to load are not representative of network use/value

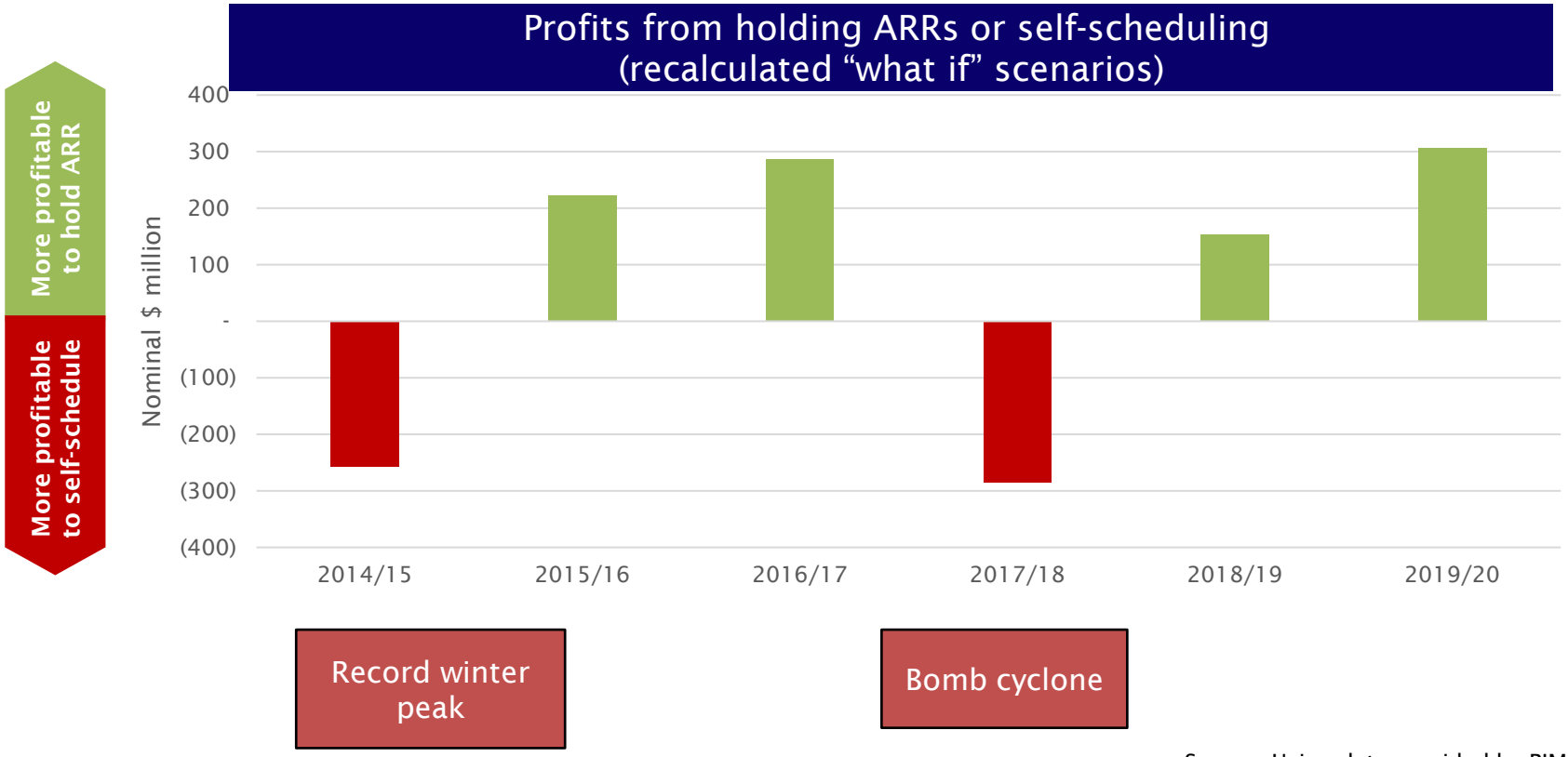
- Initial ARR target allocation is based on historical paths set many years ago
- Supply and demand conditions have changed; ARR paths may no longer reflect how load is being served
- Some load may not be able to effectively hedge congestion risk using current ARR paths



Note: Some zones were not part of PJM yet in 1997

FTR auctions has been generally efficient, benefitting ARR holders in the aggregate

- FTR auctions are relatively efficient, as shown in hypothetical below: load benefits more from holding ARRs
- Self-scheduling pays off only in years with abnormal weather – FTRs are more likely to be underpriced when the congestion charges are based on difficult to predict occurrences



Source: Using data provided by PJM

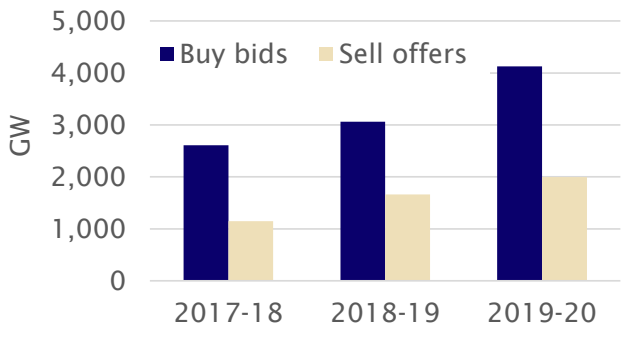
On average, net FTR auction revenues totaled over $800 million in the last 3 planning years

- FTR annual auctions represent the majority of net auction revenues – over 85%
- Monthly auctions produced the majority of cleared FTR products (in MW terms)

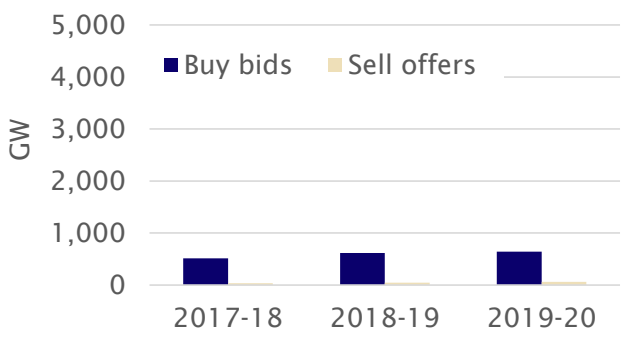
Net revenues

In nominal $ millions	Planning Period		
FTR Auction	2017-18	2018-19	2019-20
Monthly	$40	$60	$53
Annual	$542	$823	$845
LT	$19	$26	$86
TOTAL	**$602**	**$909**	**$983**

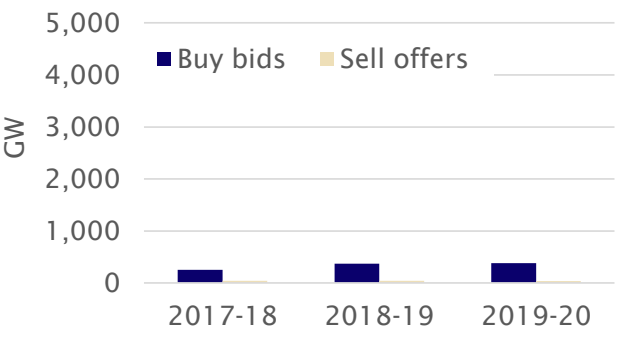
Cleared MW - Monthly



Cleared MW - Annual



Cleared MW - LT



Source: PJM

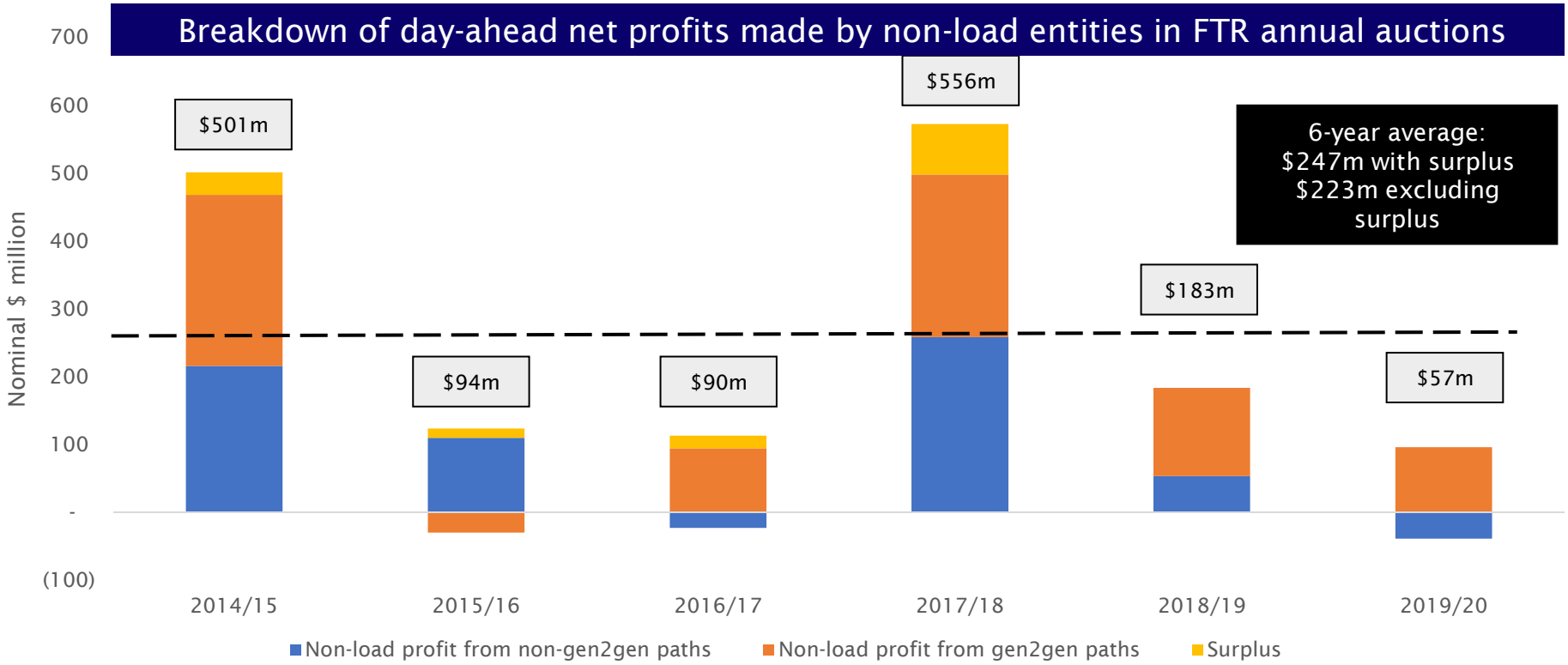
Statistical analysis shows FTR auctions are efficient and can predict day-ahead congestion

- Econometric analysis provides evidence that FTR auctions can provide price discovery; LEI tested relationship between CLMP and nodal prices from FTR auction clearing process
- Across various auctions, test results confirm statistically significant relationship between FTR auctions and day ahead CLMPs

Annual FTR Auctions	► Indicates overall efficiency of the FTR auctions, effectiveness of FTR auctions to set the value of ARRs held by load, and corroborates reasonableness of price discovery process
Simulated FTR Auctions	► Affirms that participation of non-load (financial) entities in the FTR auctions improves the predictive power of the FTR auctions
Monthly FTR Auctions	► Demonstrates efficiency of monthly auctions and ability to provide valuable information to the market about realized congestion in the day-ahead energy market, supporting price discovery
Long-term FTR Auctions	► Indicates long-term auction prices have some predictive power over CLMPs and positively impact price discovery process

Non-load participants have earned on average $223 million p.a. in net profit in the past years – this is commonly referred to as "leakage" vis-à-vis Purpose 1

- Net profits earned by non-load entities in total vary annually and is materially higher in abnormal weather years
- Net profits are expected – compensation for risk taken by non-load entities (akin to insurance premium)
- Net-profits from gen-to-gen paths account for 52% of annual average leakages



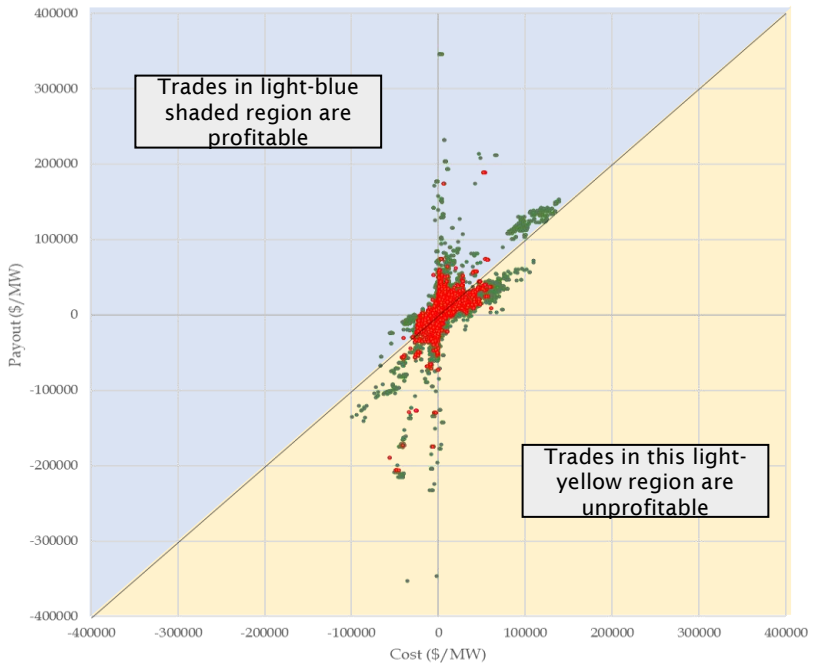
Note: These numbers include losses of GreenHat
Source: LEI analysis of data provided by PJM

Non-load participants trade on paths with higher "cost", providing additional liquidity in FTR auctions

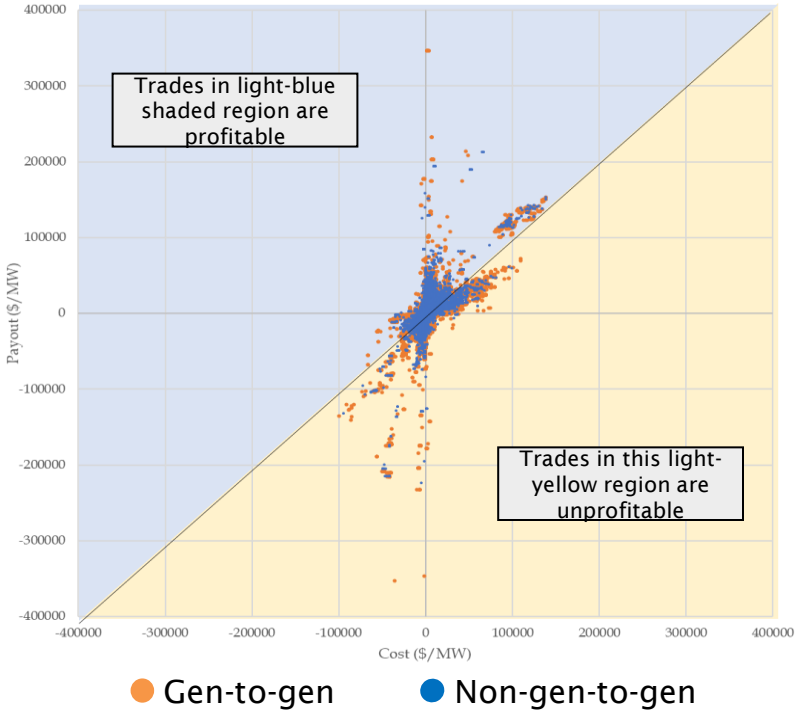
- Gen-to-gen paths bought by both non-load and load entities
- Although non-load participants make positive net profit from the FTR auctions, we observe a diversity of economic outcomes at the path level – there are profitable and unprofitable trades

Detail breakdown of 2017/18 annual FTR auction trades

Load vs non-load



Gen-to-gen vs non-gen-to-gen

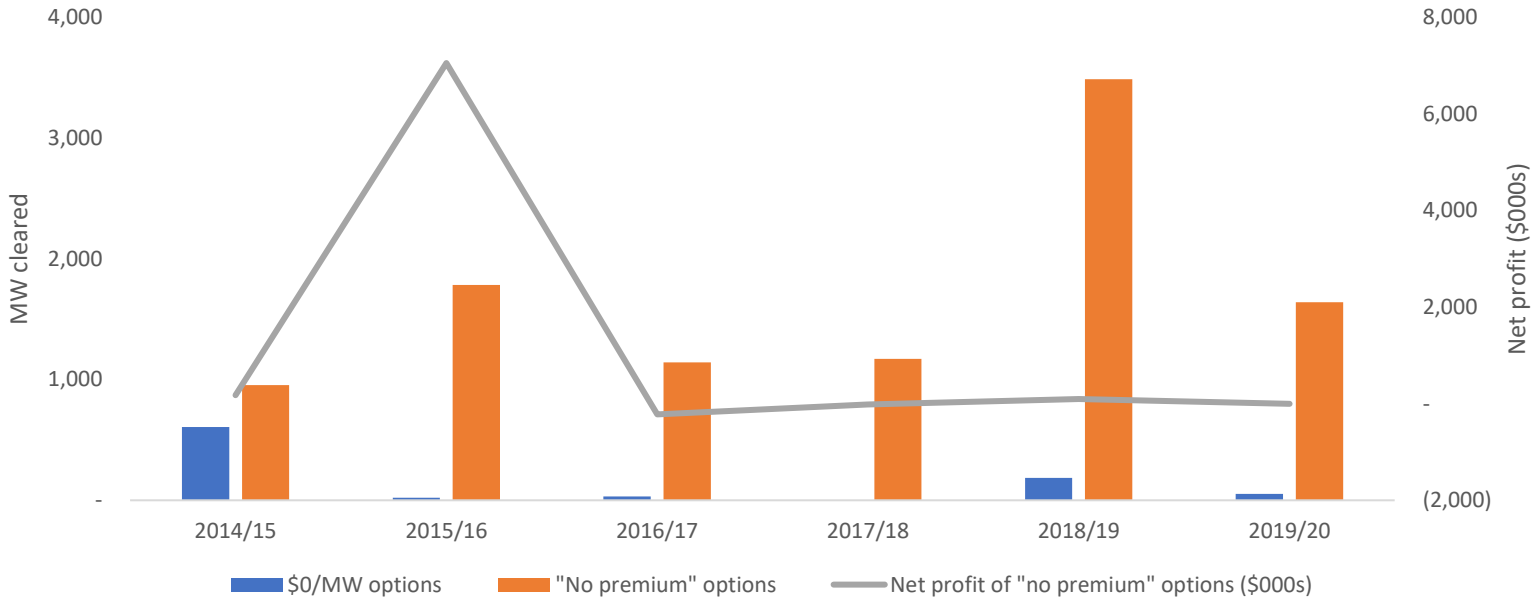


Source: LEI analysis of data provided by PJM

Some FTR options are sold at too low a price, which creates an arbitrage opportunity

- There were approx. 900 MW of FTR options that cleared at $0/MW from 2014/15 to 2019/20
- Approx. 10,000 MW of FTR options cleared at the same price as FTR obligations on the same path ("no premium" options)
- "No premium" options earned a net profit of approx. $7 million over the past 6 years
- PJM should enhance its auction clearing engine to mitigate these outcomes

FTR options cleared in the annual FTR auctions



Source: LEI analysis of data provided by PJM

LT FTR auctions provide multiple benefits to the load, including expanded hedging opportunity and price discovery for forwards

- FTR cleared volumes in PJM's long term FTR ("LT FTR") auctions have increased over the years
- Based on focus group discussions and survey, a majority of PJM stakeholders supported LT FTR auction process

Pathway for Hedging; Create Surplus for ARR holders

- FTR obligations for up to 4 years in the future
  - Can be used to hedge congestion risk for load
  - Can be used to lock in basis for multi-year PPAs
- LT FTR auctions produced 9% of total auction revenue that were returned to ARR holders in 2019/20 – small but a considerable number

Contribute to Price Discovery

- Based on Nodal Exchange, futures volumes increased over 40% on average in recent years after LT auction results are posted
- Based on LEI statistical analysis, relationship between LT FTR auction outcomes and realized CLMPs in day-ahead energy market is statistically significant
- According to the ICE and OTC Group Holdings data, PJM has the most liquid futures market amongst the US ISOs/RTOs (3.8 billion MWh futures traded) and lowest reported bid-ask spread

Current FTR auction design is reasonable and largely achieving the intended purposes

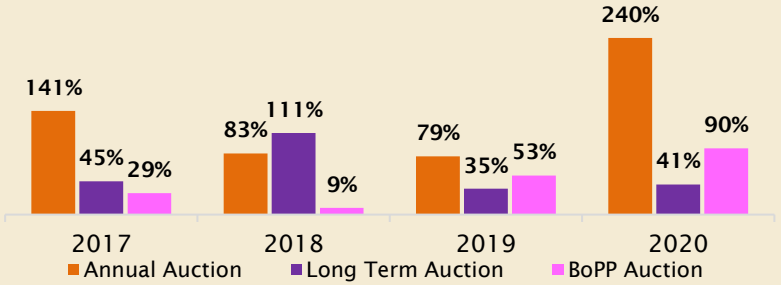
Annual FTR auction	▪ FTR prices are reasonably aligned with realized DA congestion (exceptions around unpredictable weather events) ▪ **Recommendation: retain status quo**
Monthly auctions	▪ Monthly auctions have very good price prediction power for on and off-peak DA CLMP – except during winter months with extreme weather ▪ **Recommendation: retain status quo, examine more granular FTR products (weekday versus weekend)**
Long-term FTR auction	▪ LT FTR auctions being acquired by LSEs and financial parties ▪ Provides hedging opportunity and a multi-year expectation of nodal prices to support price discovery ▪ **Recommendation: retain status quo**
Role of non-load participation	▪ Participation in FTR auctions by financial parties improve accuracy of price signal (price discovery) ▪ **Recommendation: retain status quo**
Profitability of non-ARR paths	▪ Gen-to-gen FTRs reduce amount of congestion returned to load, but increase liquidity and price discovery in the market ▪ **Recommendation: retain status quo, monitor competition and profitability trends over time**
Options	▪ Examination of auction results reveal presence of options with no premium over obligation price on the same path and some $0/MW cleared options ▪ **Recommendation: PJM should set threshold reserve price for options to avoid selling underpriced options**

Multiple indicators suggest a strong relationship between FTRs and forward markets

Link between FTR auctions and forward

- **Analysis of the Nodal Exchange data on the futures volumes in PJM across time shows a significant increase in activity after FTR auction results are posted**

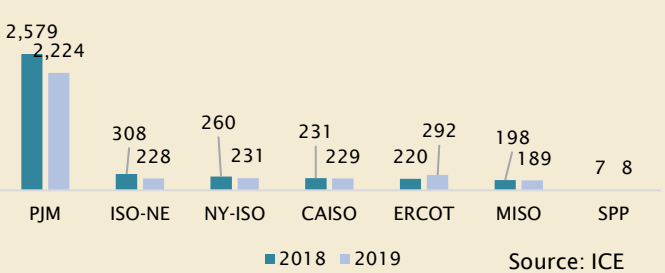
PJM exchange volume a week after FTR auction results



Source: Nodal Exchange

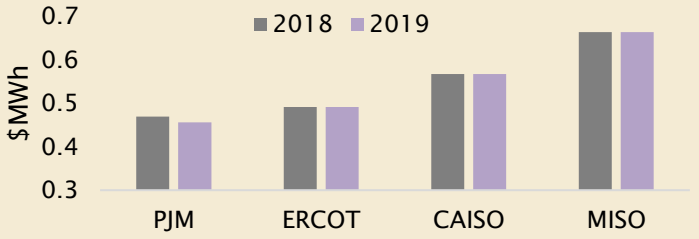
PJM has the largest volume of futures trade and the smallest reported bid-ask spreads across RTOs surveyed

Futures traded across US power markets (TWh)



Source: ICE

Futures bid-ask spreads across ISOs/RTOs



Source: OTC Group Holdings ("OTC GH")

Use of nodal delivery points; hedging

- **Over 50% PJM energy contracts reported to FERC EQR in 2018 and 2019 use a specific node (instead of hubs) as delivery point**
- **Twelve new CCGTs brought online between 2017 and 2020 have some form of financial hedge as part of it financing**

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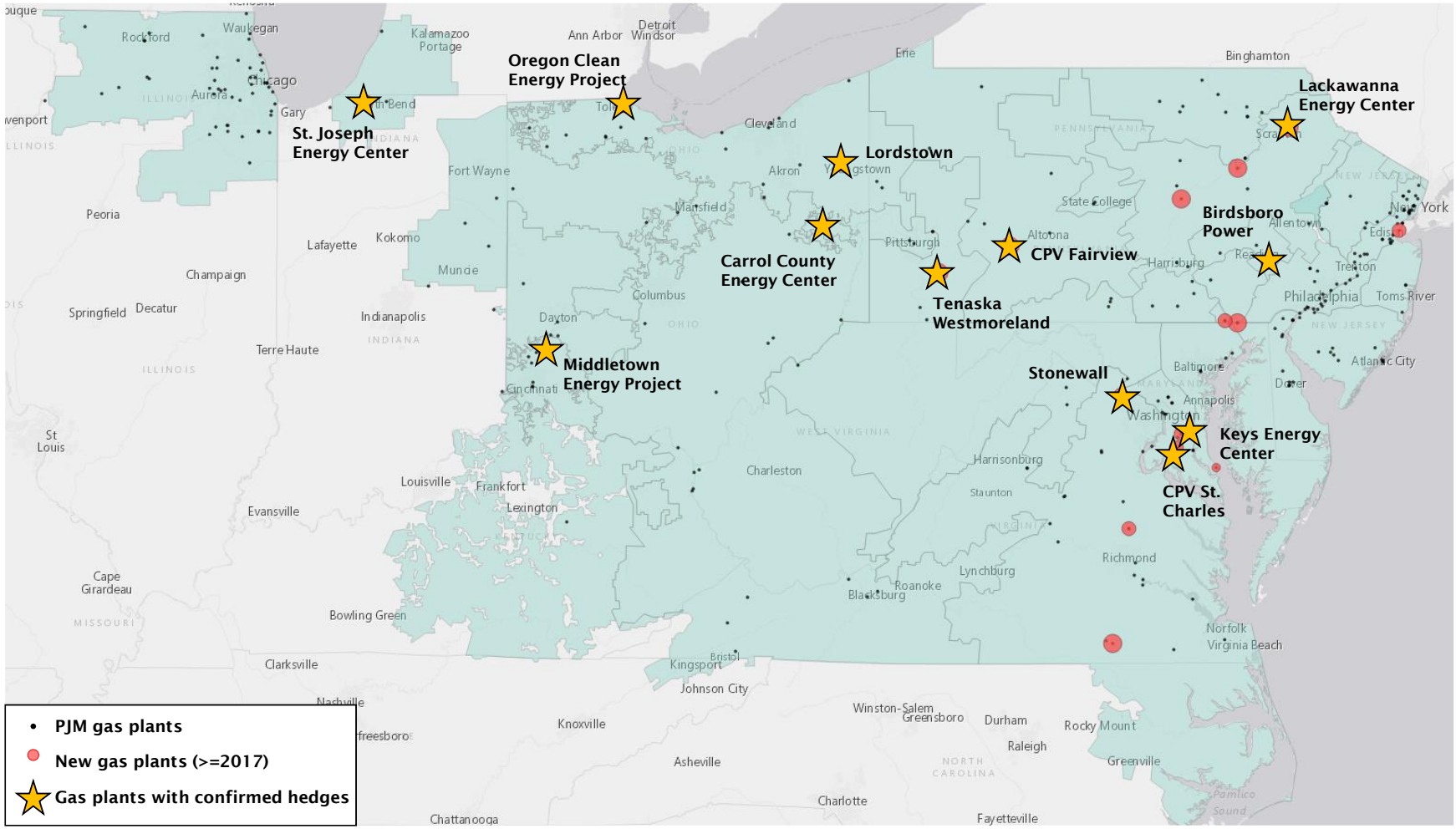
Nearly 9,500 MW of CCGT capacity that started commercial operation from 2017 to 2019 used financial hedges as part of its financing

- Market price risk associated with the financing of merchant CCGT investments was reduced with financial hedges
- Financial hedges were possible due to liquid forward markets in PJM



Longer term benefits to load associated with liquid forward markets likely outweigh the "leakage" in FTR auctions

Costs ("Leakage")

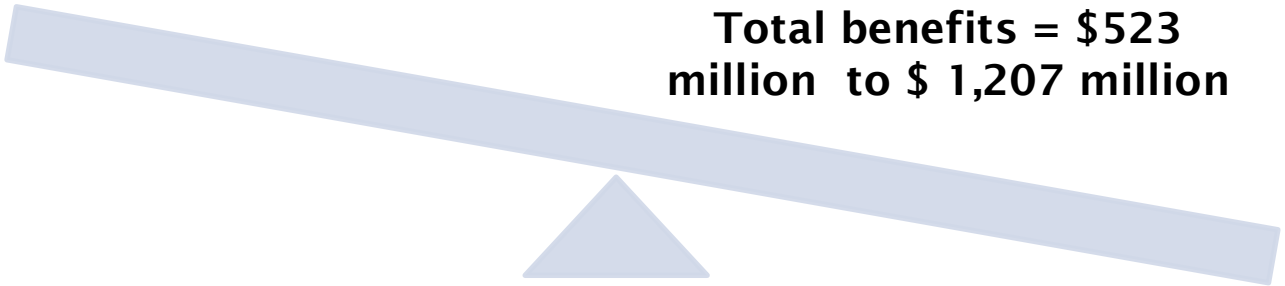
- Profits of non-load participants = annual average of **$223 million (2014/15 to 2019/20)**

Total costs = $223 million

Benefits

- Reduction in cost of capital of retailers = **????**
- Reduction in long-run marginal costs = **$99 million to $318 million a year**
- Lower transaction costs for hedging and contracting bilaterally = **$424 million to $889 million a year**

Total benefits = $523 million to $ 1,207 million



The long run benefits are additive in nature as they affect different segments of the industry and varying components of service from the perspective of load

LEI estimates long-run benefits as a result of cost of debt savings for new generation resources

LRMC savings associated with impact of hedging on cost of debt of new CCGTs ($ millions/yr)

		Frequency with which new CCGTs are directly or indirectly price setting in the long run	
		CCGTs have a 50% price setting share	CCGTs have an 80% price setting share
Change in the cost of debt for new CCGT due to hedging	0.39% change in cost of debt (quarter-notch improvement)	$99	$159
	0.78% change in the cost of debt (half-notch improvement)	$199	$318

Note: Spread change of 0.39% and 0.78% are based on ¼ and ½ of the average spread between a B and BB corporate bond yield in 2017-2019 based on Federal Reserve Economic Data.
The spread between B and BB rated bonds was used because PJM CONE for a new CCGT is based on the debt rates associated with B to BB-rated bonds. LEI surveyed credit rating agencies' assessment methodology and confirmed that the ability to hedge a project's revenue stream is a criterion in determining the project's credit rating.

Another long-term benefit of liquid forward market relates to lower transaction costs

- **Price discovery and liquidity achieved through FTR auctions help forwards markets avoid increase in transaction costs and benefit the load in the long run**
- **Bid-ask spread is an indicator of the magnitude of transaction costs incurred by engaging in forwards market activity**

Scale of financial Forwards Trade in PJM

- **PJM has one of the largest and most liquid forwards amongst the US ISOs (2.2 billion MWh futures traded in 2019) based on the ICE and OTC GH data**
  - PJM is over 9x larger than second placed ERCOT
  - PJM has churn rate* of 2.88x, the highest across ISOs

Lowest bid-ask spread

- **PJM futures have the least bid-ask spread amongst ISOs, reflecting – a high degree of liquidity based on the OTC GH data**
  - Between 2018-19, PJM's bid-ask spread contracted further in PJM, while it increased in other ISOs

Impact of forward market liquidity

- **Every $0.10/MWh in bid-ask spread raises transaction costs for physical and financial forward transactions by ~$424 million a year in PJM**

**Churn rate is defined as the ratio between volumes traded in the futures market relative to the throughput on the transmission system*

PJM's ARR/FTR market rules are naturally complex, but there are also areas where PJM's design is simpler than other US RTOs/ISOs

Simplicity advances the goals of efficiency by reducing administrative burden and transaction costs, which can serve as a barrier to efficient outcomes

PJM features	Relative to other ISOs	Description
ARR process done once a year	Better	PJM's once a year ARR allocation process may be less burdensome to market participants than in CAISO that allocates CRR on a monthly basis
Dual property system	Worse	PJM's dual system of property rights means additional process compared to RTOs with single property right like in CAISO and ERCOT
One ARR class	Better	More straightforward than MISO's 8-product ARR choice set
More FTR auctions	Worse	Might require participants to maneuver through more auctions and auction rounds
Fewer FTR classes but more biddable points	Worse	PJM has fewer FTR classes compared to other ISOs/RTOs but PJM's more biddable points make its ARR/FTR more complex

Simplicity should be preferred to more complex design as long as it does not compromise the market's functionality

LEI analyzed transparency based on comparative review of data release practices across RTOs

- **Similar documentation of FTR outcomes released to participants across RTOs but some stakeholders expressed concerned about network model complexity and transparency**

Data and information	Relative to other ISOs/RTOs	Description
Data is available to all participants and is issued at the same time	**Same**	All relevant information on ARRs/FTRs is ***publicly*** **available to all** market participants in all the RTOs/ISOs, including PJM
PJM releases data and information in a timely manner, and slightly faster relative to the other RTOs	**Better**	PJM posts auction results for each round **earlier** (within 2 business days) than the other RTOs (between 2 and 7 business days

Promoting greater transparency aligns with both purposes, as the availability of relevant information helps market participants understand the value of the product, which is vital for a well-functioning market

Key areas of concern from stakeholders related to the network model

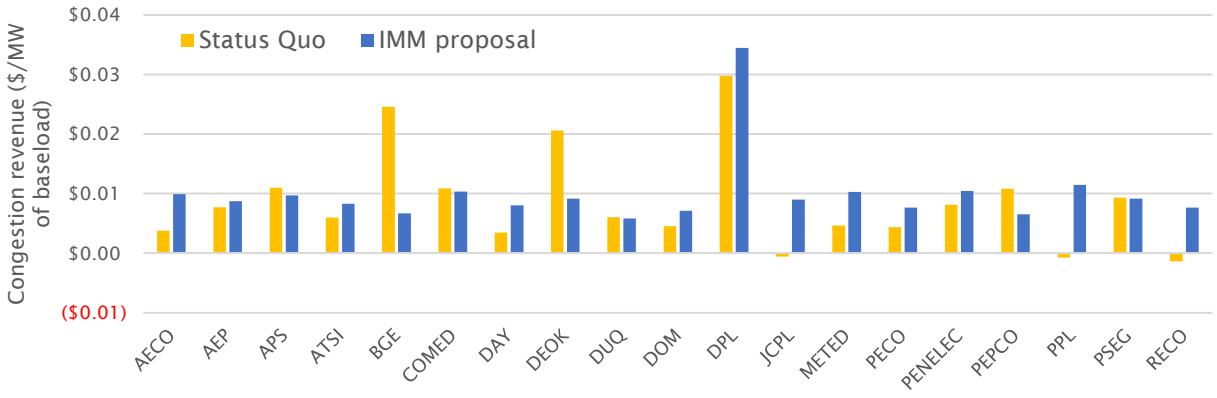
- updates to the network model need more explanation and documentation;
- concerns on software compatibility issues (for uploading ARR nominations and FTR path requests);
- timely release of network model

Transparency supports efficient outcomes, but also emphasizes the acceptability of the outcomes, a key condition for achieving an equitable effect

IMM is proposing to redefine the ARR/FTR construct – a novel yet untested proposal

- **IMM's approach is designed to get to *exactly* 100% of return of congestion collected in the LMP markets to load**
- **It would be difficult for LSEs to get an efficient price for their network congestion property rights under the IMM construct**
  - Value of network congestion property rights would not be known until after energy market settlement
  - Network congestion property rights will be more complicated to value since valuation is not based on having point to point path
- **IMM's approach focuses on the first purpose of FTRs and may impede price discovery for forward markets**
  - LSEs will not be required to sell their network congestion property rights in advance of the DA energy market
  - If only a subset of LSEs chooses to sell their network congestion property rights, there will not be a complete "picture" of expected congestion available for market participants to support forward market transactions

$/MW (baseload) congestion revenue to load (2018/19)



Allocation to LSEs (zones) creates winners and losers relative to status quo under the IMM's proposal

Source: LEI analysis of data provided by PJM

Questions?

Agenda

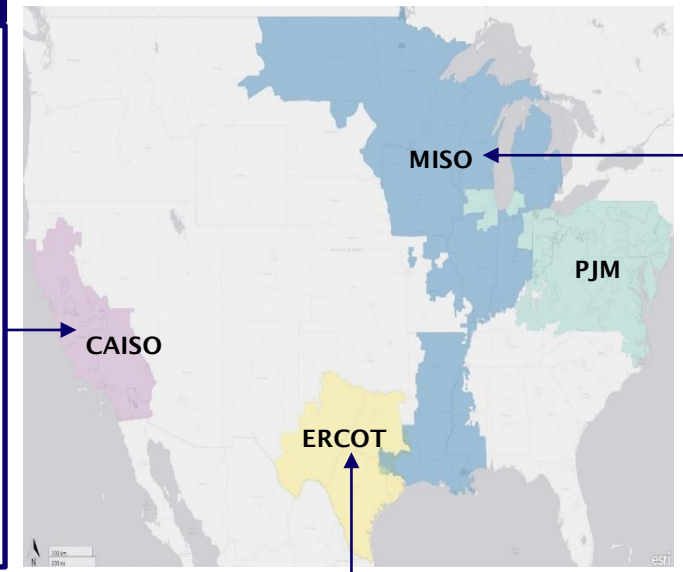
1	Overview of the engagement and summary of findings
2	Purposes of ARR/FTRs and criteria
3	Evaluating the current ARR/FTR mechanisms
4	**Reviewing mechanisms in other markets**
5	Recommendations
6	Appendix

Review of other RTOs/ISOs' ARR/FTR constructs identified several differences that LEI considered in its assessment of PJM's design

- All US RTOs/ISOs with LMP markets have some form of FTRs; however, not all have ARRs
- LEI selected three markets to study and compare against PJM's existing design
- In all markets, risk of FTR revenue deficiency is on the CRR/FTR holders while excess congestion rents are returned to load

CAISO

- **Has a single property right system**
  - Seasonal, peak and offpeak CRR product
  - CRRs are allocated to LSEs and then an auction is held
- **Annual and monthly CRR auctions**
- **CAISO has restricted paths sold in CRR auction**



MISO

- **Many similarities with PJM**
  - Multi-state RTO
  - Dual system of rights (ARRs and FTRs)
- **Annual and monthly FTR auctions**
- **Seasonal, peak, and offpeak ARRs (and FTRs)**

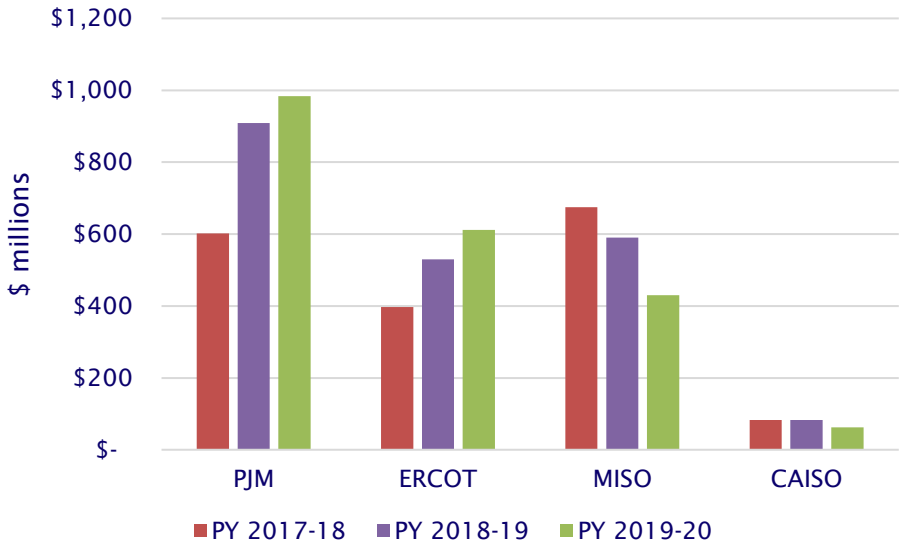
ERCOT

- **Has a single property right system - CRRs auctioned off**
  - Annual and monthly CRR auctions
  - 6-month and monthly products
- **ERCOT directly allocates CRR auction revenues to load**
  - Load can acquire specific CRR paths in auction

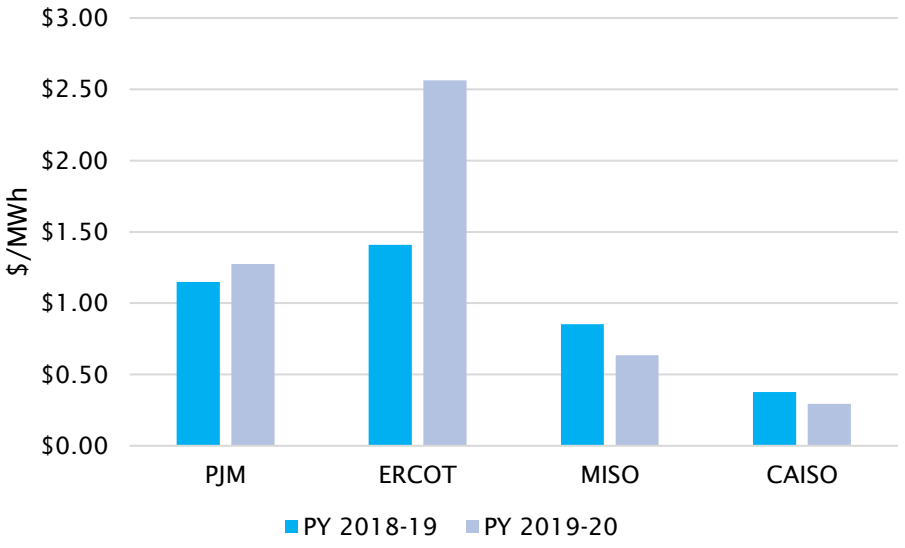
Of the three case study markets analyzed, PJM enjoyed the highest net auction revenues (particularly due to its size)

- PJM enjoyed the highest net FTR auction revenues in the most recent two planning years and experienced a significant increase between the PY 2017-18 and 2019-20
- However, ERCOT has the highest net FTR auction revenues per total energy consumption

Net auction revenues ($ millions, nominal)



Net auction revenues/total energy consumption ($/MWh, nominal)



Source: State of the Market Reports (PJM, ERCOT, MISO, and CAISO)

Comparative analysis of FTR/ARR mechanism and understanding of features from other power market design uncovered several differences

Not beneficial or relevant to PJM's construct

ercot

Use of simple allocation rules (like pro rata to load) in combination with a single right system

California ISO

Reduction of FTR paths

Enhancements for further consideration by PJM and its stakeholders

MISO

More granular ARR products (peak and off-peak and seasonal)

CAISO/MISO and stakeholders

Revisit the FTR forfeiture rule

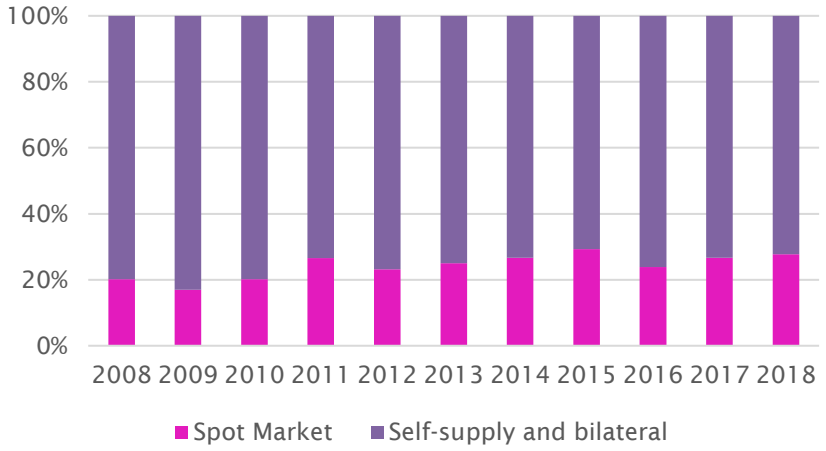
Questions?

Agenda

Path-based construct and dual system of property rights should be retained

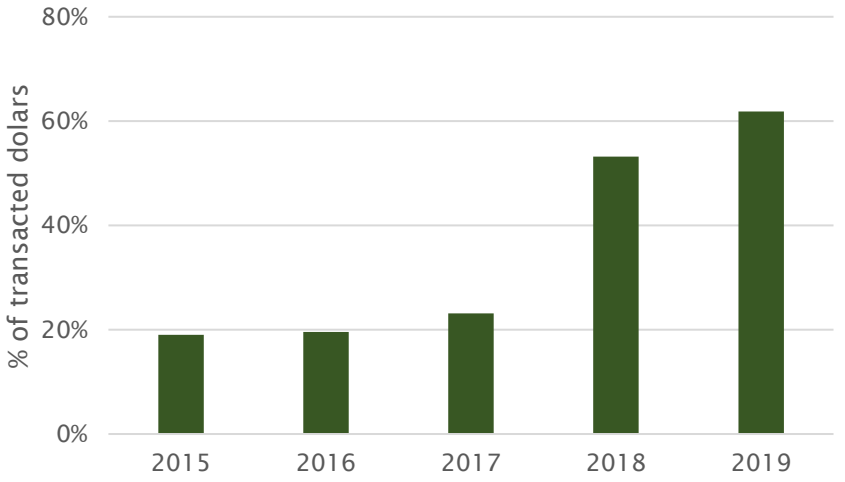
- **Point-to-point (or path-based) construct chosen originally because it aligned with existence of PPAs and other commercial arrangements used by utilities to serve load**
  - Most load continues to be served through bilaterals (and self-supply)
- **Bilateral transactions frequently deliver to nodes (as opposed to hubs and zones), reflecting continued trust in path-based construct in PJM**
  - Over last five years, approximately 35% of energy transactions (in terms of value) with physical delivery in PJM use a node as point of delivery
- **A non-path-based construct would obscure the expected impact of network congestion on CLMPs at specific nodes – undermining price discovery benefit of FTR auctions for the forward market**
- **Advantages of dual system of property rights benefits load and its disadvantages could be reduced through recommended changes to ARR process**

How load is supplied in the day-ahead market



Source: PJM. Financial Transmission Rights Market Review (p. 3)

How many energy contracts are settled at a node



Source: LEI analysis of FERC EQR database

ARR mechanism should be adjusted, including the assignment process and rules for what paths are eligible for ARR

- **LEI recommends a series of enhancements to address the main issues**
  - these enhancements are inter-related and should be considered as a "package" as much as possible

1	Consensus among stakeholders on what is an equitable allocation
2	Examine historical sources of congestion charges
3	Increase network capacity allocated in ARR process
	Allow load to nominate outside-its-zone nodes at earlier stages of the allocation process
	Permit load to nominate non-traditional ARR paths such as gen-to-gen paths or gen-to-hub paths
	Disaggregate 24-hour ARRs into on-peak /off-peak products that can be self-scheduled separately
4	Provide ARR holders with flexibility in self-scheduling
	Allow load to self-schedule in select months during the annual FTR auction
	Let ARR holders set "limit order" and only hold ARRs if the FTR auction price is above their target price

- **Net benefit to load could be improved by reducing leakages without limiting non-load's participation in the FTR auctions**

Step 1: stakeholders to agree on what is an equitable allocation

- **Changing ARR allocation methodology will result in winners and losers – the size of the pie for distribution (day-ahead congestion charges collected by PJM) does not change**
- **Stakeholders should find common ground on what is an equitable allocation**
- **Equity of different allocation methods can be measured if stakeholders can agree on what an "ideal allocation" should look like**
  - For example, a mean-squared-error from an "ideal" allocation can be calculated, and for each other allocation method and then compared

Illustrative example of using mean-squared error to compare two allocation methods

	Ideal allocation	Allocation A	Error squared	Allocation B	Error squared
LSE A	100	80	400	95	25
LSE B	50	60	100	70	400
LSE C	20	30	100	5	225
Average	**57**	**57**	**200**	**57**	**217**

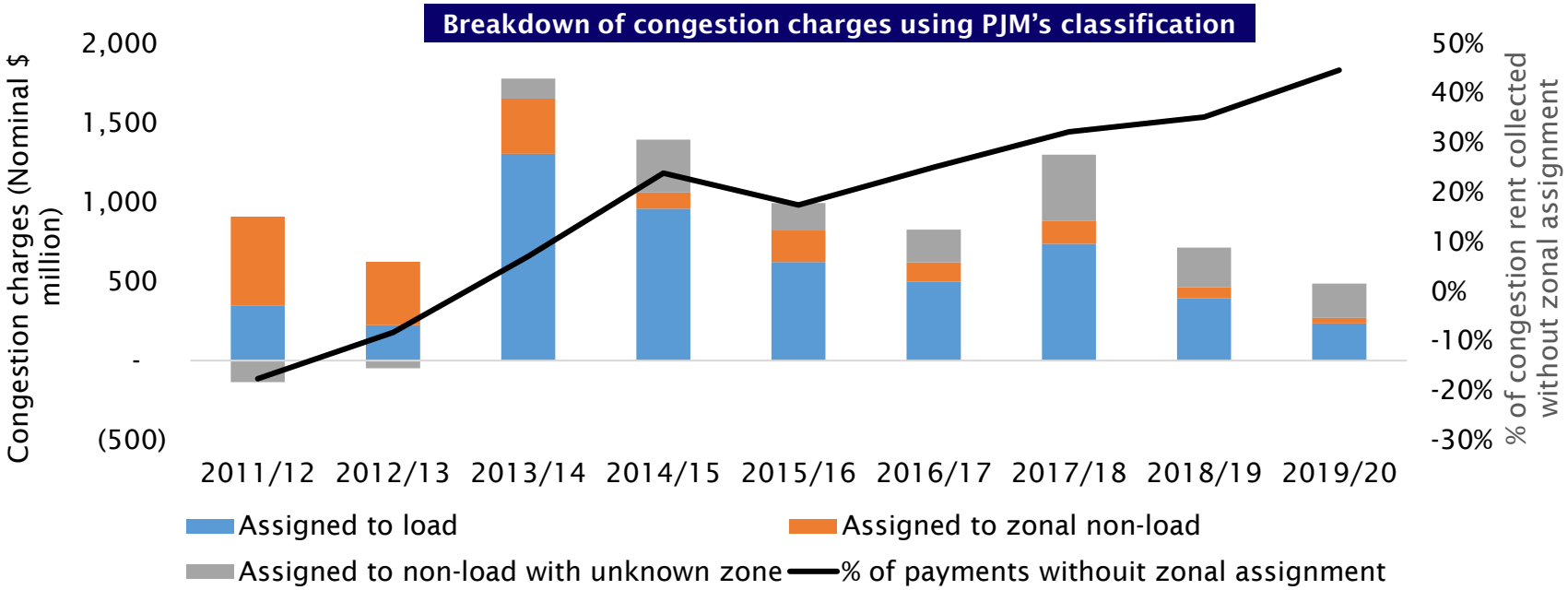
An "ideal allocation" is needed to establish the baseline before an "error" can be calculated

The three allocation methods have the same average (and total) payments in aggregate

The allocation method with lowest mean-squared error score is more equitable

Step 2: examine historical sources of congestion charges

- Both load and non-load customers have congestion credits or charges associated with their invoiced amounts
- Based on data provided by PJM, a large portion of congestion charges classified as "paid by non-load" does not have a zonal designation
- It is not easy to understand what an equitable allocation should look like if the location designation of congestion charges is not clear
- PJM should track down the locational characteristics of congestion payments



Source: LEI analysis of data provided by PJM

Step 3: increase network capacity allocated in ARR process

- **Benefits of allocating more network capacity to load in the ARR allocation process:**

1. Reduce the share of congestion charges returned to load through rule-based allocation (i.e., surplus allocation)

2. Potential in reducing "leakages" if load is more willing to self-schedule the ARR paths given to them for free, or ask for a higher price in the FTR auction

- **How to allocate more network capacity to load during ARR allocation process?**

1. Allow load to nominate outside-its-zone nodes at earlier stages of the allocation process

2. Allow load to nominate non-traditional ARR paths, such as gen-to-gen paths or gen-to-hub paths

3. Disaggregate 24h ARRs into on-peak / off-peak products that can be self-scheduled separately

PJM should conduct **periodic review of actual system usage** to identify meaningful and relevant ARR paths for load, and allow load to **voluntarily disclose bilateral arrangements** to gain access to source and sink nodes in earlier ARR stages

- **Why these changes would result in more network capacity allocated to load?**

Allowing load to nominate nodes outside-its-zone may better align with actual energy flow and bilateral arrangements, increasing willingness for load to self-schedule the ARR into the FTR auction to create a perfect hedge

If load can nominate non-traditional ARR paths and sell such paths with a "limit-order" in the FTR auction, it encourages load to actively evaluate hedging options and can reduce leakages

More granular ARRs may allow network model to allocate more ARRs to load during different time periods

ARR holders should have more flexibility in self-scheduling

	Recommendation #1	Recommendation #2
Observation	Monthly FTR auctions may have better predictive power on prompt month congestion than annual auctions	Load has no visibility of how much ARR target allocation they will get when they make a self-scheduling decision
Enhancement	Allow ARR holders more flexibility to choose to self-schedule in select months of the year during the annual ARR/FTR process	Allow ARR holders to set "limit order" and decide to hold ARR if the FTR auction price is above the target price
Potential benefits	Potential to reduce leakage if load can have more choice around self-scheduling in months with certain congestion profiles (less likely to receive underpriced ARR target allocations)	Allow better pricing of uncertainty, enables more active participation in ARR allocation process especially if non-traditional ARR paths are open for nomination

Current set of FTR auctions should be retained (including LT FTR auction), rules regarding participation and biddable points should remain unchanged

- Reducing FTR nodes increase surplus, as share of congestion charges returned to load – increasing reliance on rule-based allocation
- Increasing ARR flexibility solves the same problem using more market-based activities

→ When possible, increase ARR flexibility instead of restricting FTR activities

FTR auction clearing engine should be enhanced to prevent underpriced FTR options

PJM should revisit whether the FTR forfeiture rule is effective

PJM should continue to monitor trading activity in the FTR auction

PJM should enhance its network model transparency

1

Documentation of changes

Provide more detailed documentation of changes made to the model since last version/last auction

2

Business practices

Document in business practices the extent of manual adjustments that staff can make to network model

3

Network model manual

Provide network model manual that includes information on procedure description, definitions, software compatibility

4

Independent expert review

Retain a transmission expert to review independently the network model on a regular basis (e.g., every 3 or 5 years)

Questions?

Agenda

1	Overview of the engagement and summary of findings
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6	**Appendix**

Answers to key questions 1 - 2

1) What is the original intent of ARR and FTR? Was it to address a problem?

PJM Companies and FERC identified the need for FTRs to (1) return congestion payments in LMPs back to load and to (2) support hedging and integration of bilateral contracts with LMP spot markets and complement forward market activity

2) Are they fulfilling, in the best way possible, their initial purpose and/or addressing the identified problem?

The existing design is fulfilling Purpose #1 on an aggregate basis. But there may be equity issues between different LSEs. The path-based FTR product and the extensive trading opportunities presented by the various FTR auctions are providing price discovery for the forward market; bilateral transactions are frequently delivering to nodes, and new generation resources are taking advantage of financial hedges. Taken together, these observations suggest that the FTR auctions are also supporting longer term electricity market dynamics and fulfilling Purpose #2

Answers to key questions 3 - 4

3) If not, why not? If so, how is this measured and verified?

To confirm attainment of Purpose #1, LEI analyzed aggregate payout ("total offset") to load across PJM relative to the total congestion payments collected in LMPs. As part of the exercise, LEI also considered the initial allocation of ARRs and outcomes in the FTR auctions, and the decision of LSEs to hold onto ARRs versus self-schedule. LEI also analyzed the distribution of the payouts among load zones. For Purpose #2, LEI analyzed the predictive power of various FTR auctions. LEI also collected data on physical transactions, financing practices for new generation, and examined futures trading and hedging activities

4) Is this purpose still required, and if it is addressing a problem, are there alternative ways to eliminate the problem entirely?

The original purposes for having FTRs are still relevant today. LEI reviewed the ARR/FTR (or equivalent construct) in other US markets. LEI determined that the alternative approaches (such as direct allocation of FTR revenues or limitations on biddable points in FTRs) would not be preferable in the context of the PJM wholesale market. Therefore, a comprehensive alternative does not currently exist; however, the case study analysis suggested some areas for further consideration. For example, LEI observed MISO had more granular ARRs classes, which could improve the amount of feasible ARRs that could be allocated. LEI also observed that PJM was unique in application of its current FTR forfeiture rule. In combination with the concerns raised by stakeholders, this rule may need to be reviewed

Answers to key questions 5 - 6

5) Are there additional purposes and/or sources of value to the market that ARRs and FTRs are, or should be, fulfilling or delivering? If so, what are these purposes, how do they optimize value to load and other market participants; and how is this value optimization measured and verified?

Both purposes identified by LEI are important but not always complementary. Purpose #1 yields short term benefits to load while Purpose #2 provides longer-term benefits. Some portion of the value to load in the short term may need to be sacrificed to support the realization of the benefits in the longer term. The best way to examine whether this is yielding a net positive outcome is to consider the amount of short-term benefit that is foregone (e.g., FTR profits going to financial parties) versus the amount of long run benefits (e.g., liquid forward markets which help drive down the long run marginal costs of energy and transactions costs for hedging)

6) What other mechanisms can provide alternative ways to achieve some of these purposes?

An alternative way to achieve Purpose #1 has been proposed by the IMM. It would be a complete overhaul of the current system and therefore could cause some disruption with current bilateral trading and hedging activities. In general, the IMM's proposal is novel and untested. LEI has concerns that it may have shortcomings related to Purpose #2, given that the IMM designed it exclusively for Purpose #1. A more detailed specification of the IMM's proposal is required before a decision can be made on the overall merits of the IMM's proposal

Answers to key questions 7

7) Are there changes in the market design, execution, etc. that would improve delivery of these instruments' purpose?

Based on the findings compiled in this report, LEI concludes that the dual system of property rights remains valid and valuable to load, and that a path-based construct for ARRs and FTRs is consistent with bilateral arrangements and hedging. LEI has recommended several enhancements to the ARR mechanism (and allocation process) to improve the equity considerations under Purpose #1. LEI does not believe major changes are necessary to the FTR mechanism because the auctions appear to be functioning efficiently and supporting both Purpose #1 and #2. LEI has proposed several modest changes to the FTR construct which include changing the auction clearing rules to avoid selling underpriced FTR options, monitoring competition and profitability trends over time, and revisiting the FTR forfeiture rule

MISO is the only RTO in the case study list with a dual system of rights like PJM

	MISO	PJM
Options	• Hold on or self-schedule ARRs ("convert")	• Hold on or self-schedule ARRs
Basis of initial allocation	• Based on a reference year (depending on when the zone joined the RTO) taking into account annual adjustment to reserved source points	• Based on a reference year (depending on when the zone joined the RTO) taking into account some changes in generation status
Product definition	• Generation to load	• Generation to load

Allocation process	• 3 Stages with eligibility stage and restoration stage
	  • Stage 1A – can nominate up to 50% of **peak usage**
	  • **Restoration – Stage 1A curtailed ARR and long-term transmission rights candidates may be restored through counterflows**
	  • Stage 1B – can nominate up to 100% of peak usage less awards in prior stages
	  • **Stage 2 – determines unallocated ARR and assigns the right to receive excess FTR auction revenues**
		• 3 Stages
		  • Stage 1A- can cannot go beyond **baseload**; up to 50% of the qualifying transmission service reservation MW level for firm-point-to-point customers
		  • Stage 1B – up to the point not awarded in 1A and cannot go over peak load less awards in Stage 1A
		  • **Stage 2 – 3-round iterative approach and LSEs can ask for ARRs from any generation, bus, hub, zone or interface; 1/3 of remaining system capability allocated in each round**

Frequency	• Annual	• Annual
ARR products	• Obligation • **Peak and off-peak** • **Seasonal (summer, fall, winter, and spring)**	• Obligation • **24 hours**
Value (ARR Target Allocation)	Same as PJM's. However, the average price only considers the 3 rounds of the annual FTR auction rounds	ARR MW amount x Avg price difference from the ARR sink to the ARR source over the 4 rounds of the annual FTR auctions

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Differences in the FTR mechanisms include FTR products, number of rounds in the auctions, and presence of long-term FTR auction

	CAISO	ERCOT	MISO	PJM
Auctions	• Annual • Monthly	• Annual (also the long-term auction) • Monthly	• Annual • Monthly	• Annual • Monthly • **Long-term**
Annual auction # of rounds	• **1 round** per year after the annual allocation process	• **1 round**	• **3 rounds** of 8 independent auctions • Round 1: 1/3 of all capacity • Round 2: 50% of remaining • Round 3: All remaining	• **4 rounds** (25% awarded in each round) • Awarded FTRs may be sold in later rounds
Annual auction products	• **Seasonal (or quarterly) CRR** obligation, peak and off peak	• **Peak weekday (5x16), peak weekend**, off-peak	• FTR obligations–peak, off-peak and **seasonal**	• FTR obligations/**options**–peak, off-peak, and **24-hr**
Monthly auction # of rounds	• Residual CRRs • 1 round every month after **monthly allocation process**	• 1 round every month	• Residual FTRs after annual • 1 round	• Residual FTRs after long-term and annual auction • 1 round
Monthly auction products	• **Monthly** CRR obligation, peak, and off peak	• Obligations/options • **Peak weekday (5x16), peak weekend (2 x 16),** off-peak (7 x 8), 24-hour	• Offers the possibility of one or multiple **seasons**/months, each of them allowing FTRs obligations for peak and off-peak	• FTR obligations and options for peak, off-peak, and 24-hour
Long-term auction # of rounds	• None	• None	• None	• **Five rounds where 20% of available FTR is awarded in each round**
Long-term auction product	• N/A	• N/A	• N/A	• **FTR obligations for peak, off-peak, and 24hrs** • **1-year term**