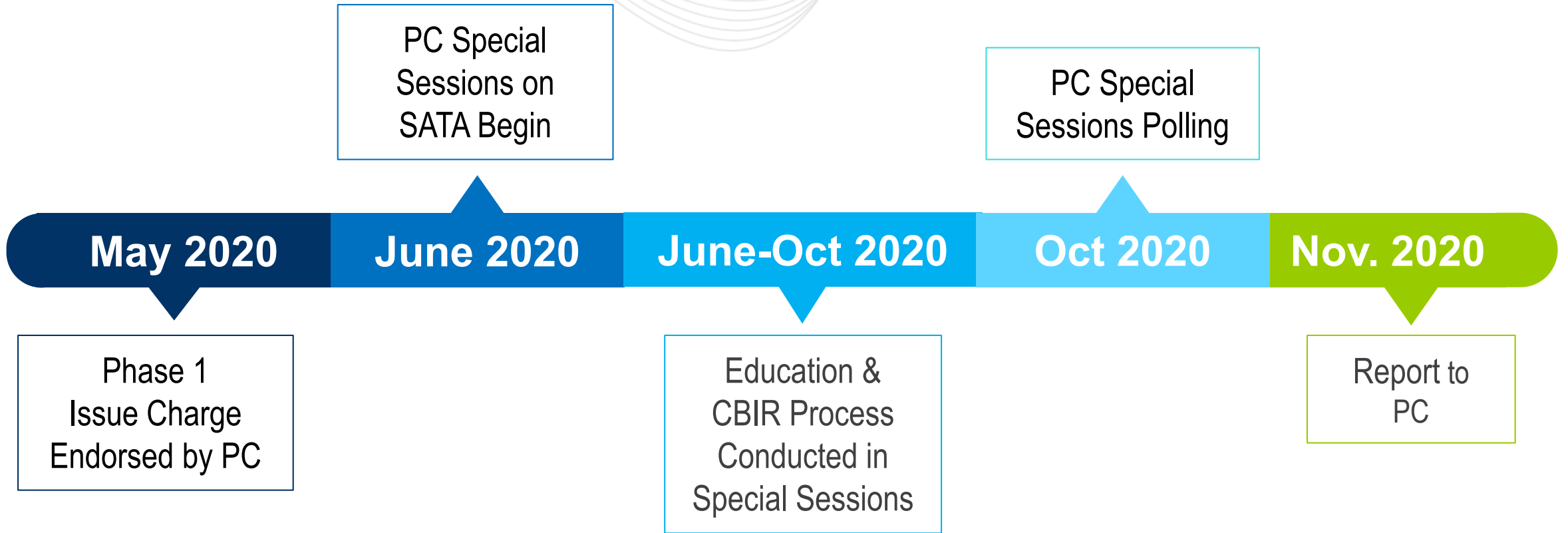


Storage as a Transmission Asset

Michele Greening, Stakeholder Affairs
Knowledge Management Center

Markets & Reliability Committee
January 27, 2021



Storage as a Transmission Asset Work Plan	MEETING									
	PC 5/12/2020	PC: SATA 6/5/2020	PC: SATA 7/6/2020	PC: SATA 8/6/2020	PC: SATA 8/24/2020	PC: SATA 9/25/2020	PC: SATA 10/9/2020	PC: SATA 10/22/2020	PC 11/4/2020	PC 12/1/2020
Issue Charge Approval	X									
Develop Work Plan		X								
Education & Joint Fact-Finding		X	X			X				
Interest Identification			X	X						
Develop Design Components			X	X						
Document Relative Importance of each Component			X	X						
Develop Options for each Component				X	X	X				
Narrow Options				X	X	X				
Develop Packages					X	X	X			
Narrow Packages <i>(Compare Packages to Interests & Importance Ratings)</i>					X	X	X	X		
Consensus Testing						X	X	X		
Tier 1/Tier 2 Decision Making									X (first read)	X (endorsement)
Reporting to Parent Committee			X	X	X	X	X	X		

- The effort explored existing transmission planning criteria, including performance measurement methodology, and where there were gaps, developed additional criteria to be used in evaluating storage as a transmission asset to address elements in the RTEP associated with Reliability, Market Efficiency, Operational Performance, and Public Policy to allow PJM to plan the RTEP effectively.

- Focused on reliability aspects and establishing clear and transparent criteria to measure against.
- Education on current business rules, regulatory background and FERC precedent
- Considerations of both Reliability and Market Efficiency
 - Status Quo business rules
 - Identification of potential business rule gaps
- Development of criteria for modeling SATA and evaluating SATA proposals in relation to traditional transmission reinforcement
- One Solution Package Proposed by PJM



Storage as a Transmission Asset (SATA) Phase 1 First Read of the PJM Package Proposal

Jeffrey Goldberg, Sr. Engineer II

Markets & Reliability Committee

January 27, 2021

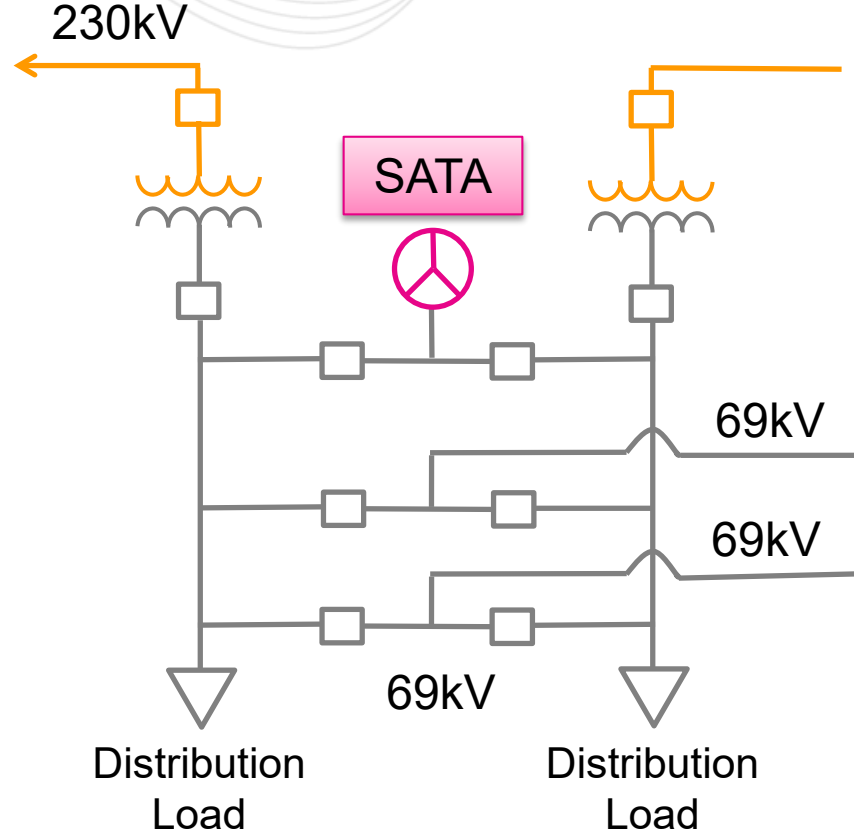
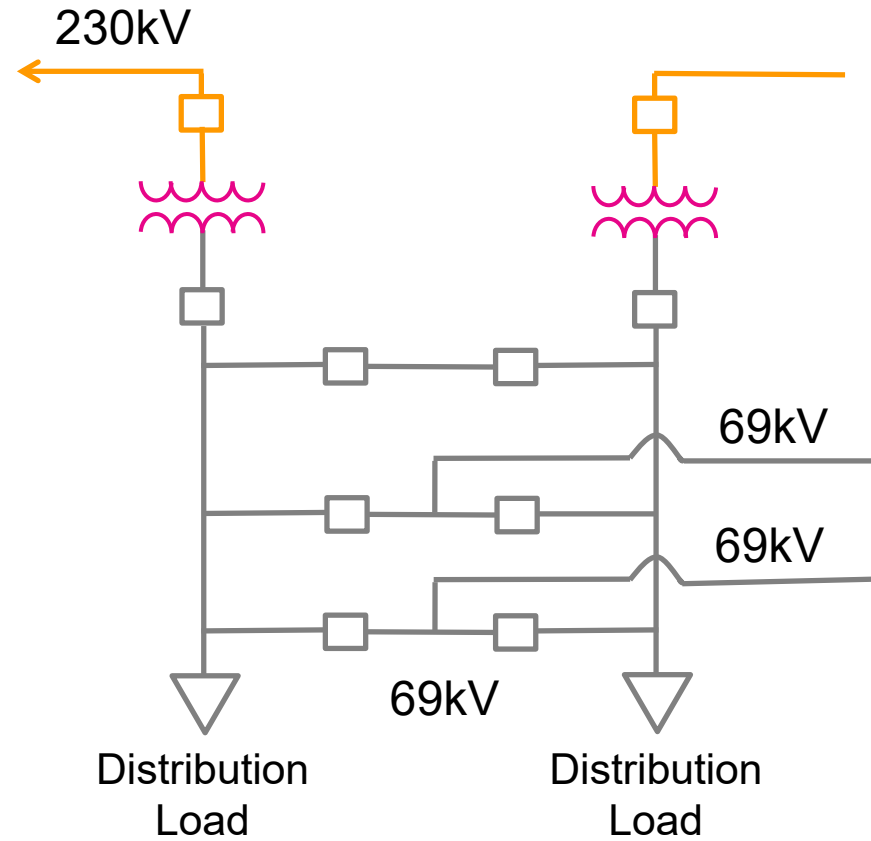
- Phase 1 is limited to Storage as Transmission Asset only
 - SATA is not allowed to participate in the PJM Markets
- Phase 1 goal is to provide transparent evaluation rules:
 - to establish a review of SATA to provide a comparison to typical “wires solution”
 - to establish SATA RTEP requirements to ensure implementation maintains system reliability consistent with NERC standards
- PJM’s SATA evaluation approach ensures there are no adverse impacts to the PJM Interconnection Queue
- SATA must provide automatically and instantaneous post-contingency response to mitigate the identified local system need.

- SATA must remain connected to the Transmission System while operating to address the system needs for which SATA was planned
- A SATA receiving cost-based rate recovery that also receives compensation for market-based rate services during asset charging/discharging will be subject to appropriate market revenue crediting for any potential double recovery of costs.
- Phase 1 reliability requirements must be established in order to ensure any Phase 2 dual use does not adversely impact reliability requirements.

Evaluation of Reinforcement Projects – Practical Example

Traditional Solution

SATA Solution



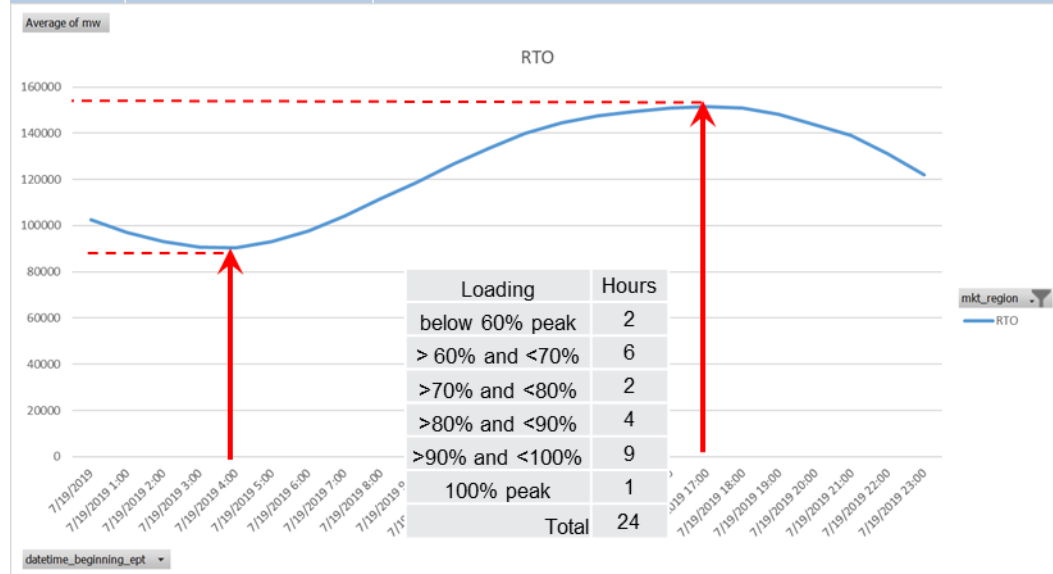
1. Traditional Solution upsizes two 230/69kV transformers
2. SATA Solution interconnects SATA at the 69kV bus

#	Category	Design Components	A
1	Reliability	Sensitivity cases to ensure compliance with Planning criteria	SATA sensitivity with it charging and discharging in the study case

- SATA model considerations
 - Appears in the Base Case – SATA in standby
 - Appears in Sensitivity cases – SATA as a generator and as a load

- These sensitivity cases would apply to:
 - M14B, Section 2.3.6 Baseline Thermal Analysis
 - M14B, Section 2.3.7 Baseline Voltage Analysis
 - M14B, Section 2.3.8 N-1-1 Reliability Analysis
 - M14B, Attachment C.2 Load Deliverability
 - M14B, Attachment C.3 Generator Deliverability
 - M14B, Attachment C.4 Long Term Deliverability Analysis
 - M14B, Attachment D.2 Light Load Reliability Analysis
 - M14B, Attachment D.3 Winter Peak Reliability Analysis

#	Category	Design Components	A
2	Reliability	Forecast mechanism to model daily load curves to within an acceptable margin of error, in relation to 5-year planning studies	<p>SATA must be sized appropriately to mitigate the reliability violation for a minimum duration based upon sensitivity analysis using granular load curves, as available.</p> <p>If granular load curves are not available, SATA must be sized to mitigate the reliability violation for a minimum of 4-hours, based on Long-term Emergency Rating.</p>



In the absence of a granular load curve

- The seasonal Emergency Rating Limit is typically defined as a 4-hour continuous rating.
- The SATA solution, at a minimum, must maintain post-contingency flows and voltage magnitudes within the seasonal emergency rating limits for the most aggravated system condition

#	Category	Design Components	A
3	Reliability	Generator Interconnection Study criteria - special cases to consider	<p>SATA sensitivity with it charging and discharging in the study case. The sensitivity case charge/discharge rates to be consistent with worst case violation studied rates.</p> <p>Charge and discharge will not be studied at the same peak/valley case.</p>

- To ensure that system conditions do not constrain SATA operations, the SATA must be studied with sensitivity cases to ensure reliability for all SATA modes of operation.
- For all PJM reliability analysis in which SATA is present in the study case, the SATA should be modeled in its standby mode. However, additional sensitivity cases must be studied for Do No Harm analysis; one sensitivity case with SATA injecting power pre-contingency, and another sensitivity case with SATA consuming power pre-contingency.

#	Category	Design Components	A
4	Reliability	Design for violation and identify its role as a harmer or a helper on other criteria tests	<p>PJM will complete do-no-harm testing utilizing the capability of the controls as specified by the proposing entity</p> <p>Proposing entity identifies any additional violation mitigation or help</p>

- PJM performs Do-No-Harm analysis for all RTEP projects; whether a traditional wires solution or a SATA solution
- SATA will be modeled in the study case for its full charge / discharge capability as specified by the proposing entity
- Identification of additional benefits beyond the intended violation mitigation should be identified by the proposing entity

#	Category	Design Components	A
5	Reliability	Performance expectations requirements	Ensure SATA capability is able to meet performance requirements for the life of the facility, while recognizing the unavailability of asset while charging

- SATA state of charge and readiness must be maintained to ensure reliable violation mitigation.
- SATA unavailability during charging must be considered for suitability in violation mitigation.
 - SATA would be unsuitable to mitigate Normal violations.
- Lifespan of SATA major components (i.e. batteries, inverters, GSU transformers, etc.) must be considered such that the SATA system as a whole can meet performance requirements for the life of the facility.
 - Proposing entity must provide the details regarding asset renewal as required to meet nominal lifespan

#	Category	Design Components	A
6	Reliability	Allowable modes of operation	<p>SATA must be at the desired state of charge and available to mitigate the violation as intended.</p> <p>SATA operating types may include:</p> <ol style="list-style-type: none"> 1) Pre-contingency response (automatic) 2) Post-contingency response (automatic) 3) Local load security (automatic)

- All SATA facilities shall be configured for local automatic operation, and capable of responding to contingencies instantaneously.
- The facilities should also provide for local manual operational control.
- Instantaneous automatic operation must occur with facility connected to the Transmission System under PJM’s control at the time of the contingency event

#	Category	Design Components	A
7	Reliability	Charge and discharge schedules and responsibilities	<p>PJM establishes timeframes when charge and discharge schedules can be accommodated and will be documented in operating procedures.</p> <p>Asset owners responsible for maintaining state of charge and submitting schedules to PJM. Submitted schedules would accommodate single peak and multi-peak days with allowance for off peak recharging.</p>

- In consideration of RTO independence, PJM cannot directly control the SATA charge and discharge functions.
- PJM will provide the timeframes for charge and/or discharge functions for restoring state of charge.
 - Guideline for timeframes will be documented in operating procedures
- Asset owners are responsible for maintaining state of charge
 - Submit charge / discharge schedules to PJM for approval
 - SATA capacity and schedules must accommodate single or multiple daily peaks as necessary and allowing for recharging at off peak periods.

#	Category	Design Components	A
8	Reliability	<i>Benefit measurements of SATA vs. traditional resources in reliability studies (subcomponents listed below)</i>	
8a	Reliability	Cost elements	<p>SATA estimated life should be a composite of all the major components (i.e. battery cells, inverters, GSU, auxiliary equipment).</p> <p>SATA will not participate in its markets but will use the appropriate settlement mechanisms to settle the charging and discharging functions to offset the rate of recovery</p>
8b	Reliability	Additional benefits	Proposing entity identifies additional benefits

- For the anticipated lifespan of the entire SATA system, costs for replacing degraded major components during the SATA lifetime must be provided by the proposing entity at the time of project proposal.
- Costs associated with charging and discharging will use market settlement mechanisms to offset transmission asset cost recovery.
- Proposing entity shall communicate additional benefits for consideration

#	Category	Design Components	A
9	Reliability	Lifespan and retirement considerations	<p>Components of SATA can be replaced as needed.</p> <p>At PJM's direction, SATA can be relocated to a different area of the system when system needs change. This would be driven by a baseline reliability study.</p>

- Consistent with Design Component 5, degraded SATA major components (i.e. batteries, inverters, GSU transformers, etc.) must be replaced as needed such that the SATA system as a whole can meet performance requirements for the life of the facility.
- Retirement of a SATA asset or relocation to another area of the grid must be supported by a PJM baseline reliability study.

#	Category	Design Components	A
10	Market Efficiency	Generator Interconnection Study Process - special cases to consider (IARRs)	Status Quo
11	Market Efficiency	Allowable modes of operation	Status Quo
12	Market Efficiency	Charge and discharge schedules and responsibilities	Status Quo

- The current PJM rules, study procedures, and tools have been reviewed for adequacy in assessing SATA for Market Efficiency.
- The findings are that there are no gaps in the status quo for Market Efficiency analysis as the current tools and analysis techniques are already sufficient to study and assess SATA.
- The recommendation is that no SATA specific rule changes are required

- January 27, 2021 MRC – First read of Proposed Solution Package and supporting OA language
- February 24, 2021 MRC – Endorsement of Proposed Solution Package and supporting OA language
- TBD - Present corresponding manual language revisions for the endorsed package and provide opportunity for PC review and endorsement upon FERC approval of OA language

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Storage as a Transmission Asset



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Appendix – PC Voting Results

Sector Results **Total Results**

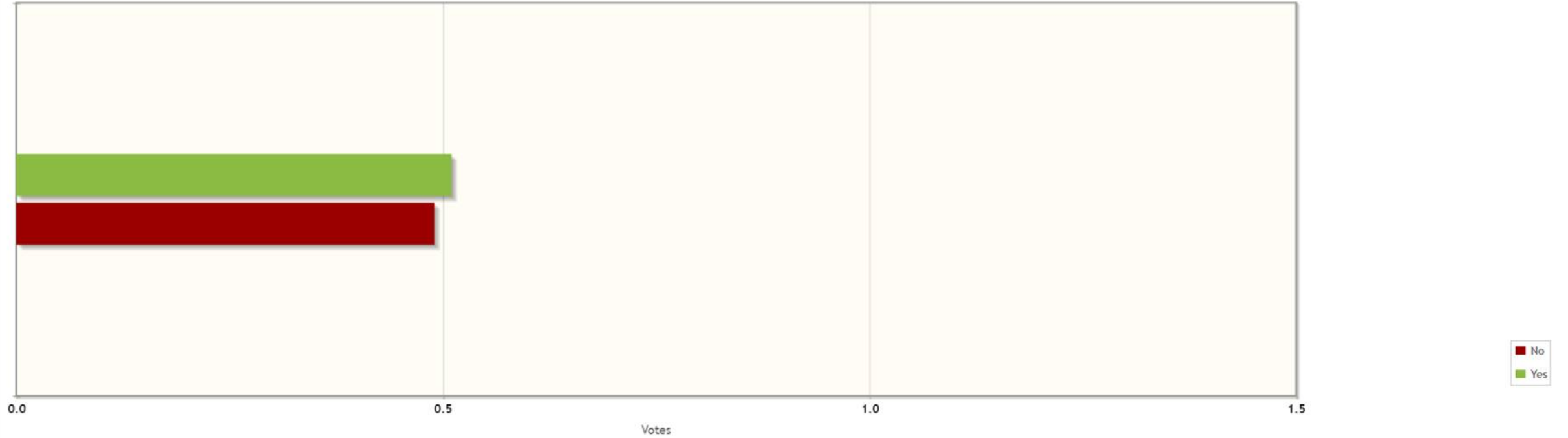
6: Do you support the PJM package for Storage as a Transmission Asset?



	Count	Tally	Threshold	Pass/Fail
Yes	91	0.58	0.5	PASSED
No	65	0.42		
Abstain	62	0		

Sector Results **Total Results**

6a: Non-Binding Poll: Do you support the PJM package over the Status Quo?



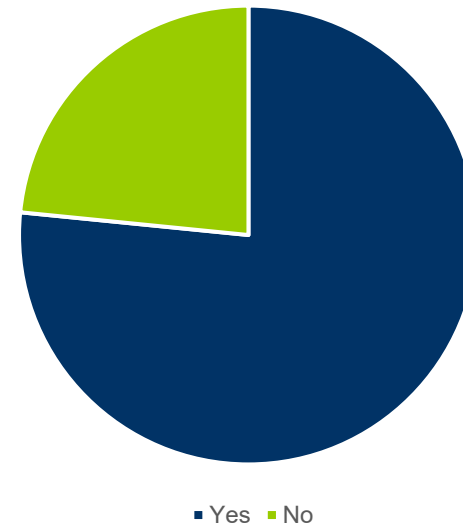
	Count	Tally	Threshold	Pass/Fail
Yes	90	0.51	0.5	PASSED
No	86	0.49		
Abstain	42	0		

Appendix - Special PC Polling Results

- Poll Open: 10/09/2020 – 10/16/2020
- 184 Total Responses
 - Voting Members - 36
 - Affiliate Members - 145
 - Non-Members - 3

1. Do you support the PJM package proposal to ensure existing planning rules provide sufficient clarity regarding how SATA should be evaluated and incorporated into the RTEP process?

	Count	% of Total
Yes	121	77%
No	37	23%
Abstain	26	n/a



We are not necessarily opposed to the idea of SATA. However, we do believe it is important that the markets and operations implications of deploying ratebase transmission assets that act as generation and load are discussed and resolved prior to approving such assets as solutions to RTEP violations. These facilities will impact gen/load balance and so will impact LMPs by their fundamental nature. Understanding how these impacts, as well as potential dual uses of the facilities in other PJM's markets (e.g. ancillary service markets), will be addressed and managed is important to companies whose asset prices and valuations will be impacted by the presence of the SATA resources. We also believe it is critical that market participants have a concrete expectation about how the SATA resources will be deployed in response to transmission constraints in operations. Such knowledge is critical to understanding how SATA will impact transmission congestion patterns, market prices and the dispatch of other generation resources.

The proposal is a good start to determine how PJM will evaluate and select SATA for baseline needs. As a broad guideline, SATA is a technology similar to capacitors and should be seen as an analog to how SATA should be treated in the planning analysis. There are however some confusing aspects in the proposal as to what is a planning consideration versus operational. For instance, the design component "Allowable modes of operation" imply an operational consideration but PJM staff have indicated the design component is only to determine how SATA is treated in the reliability case. Additionally, the design component "Charge and discharge schedules and responsibilities" are an operational consideration and has no impact on the planning analysis. If PJM intends to setup a future phase focused on the operational aspects of SATA, these operational considerations should be restated and extracted from the current phase and pulled into future discussions. The planning aspects around SATA for reliability purposes should be fully developed or future phases of SATA (e.g. dual use) will lack a useful model to build off of.

[Our] main concerns regarding Storage as a Transmission Asset pertain to issues that are out of scope of the Phase I discussion (e.g. dual-use treatment, ownership requirements, interconnection process). These issues must be addressed before we can feel comfortable with any aspect of the proposal.

The PJM proposal requires the update suggested by multiple stakeholders at the October task force meeting. It needs an explicit statement that, "PJM analysis protocols are based on storage being out of the energy and ancillary service markets so that it is 100% available when needed for reliability."

- mitigation of impacts on queued generation are insufficiently addressed
- must include explicit procedures to test reasonableness of SATA duration proposed
- needs explicit statement of which entities can propose SATA on which facilities and explain any existing TO rights of refusal.
- "costs of charging would be attributed to system losses" is not specific enough. There also may be misaligned incentives because owner is submitting schedule (which may affect RTE and operating costs) without being accountable for operating costs
- treatment of discharged energy is not specified. Is this netted from system losses or provided to SATA owner?

Our YES response is contingent upon the understanding that this is only a start to defining how to evaluate and select SATA for baseline needs. Much needs to be done to determine what is a planning consideration vs an operational one.

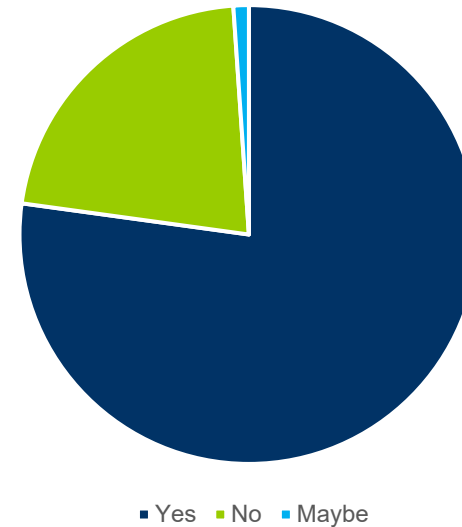
[We] believe this poll is premature. The first phase of this effort as outlined in the Issue Charge is to determine “If” Energy Storage Resources should be evaluated as Transmission Facilities (“SATF”) and incorporated into the PJM Regional Transmission Expansion Plan (“RTEP”) process. This poll is premised on the conclusion that ESR should be evaluated as Transmission Facilities and incorporated into the RTEP. However, assuming it has been determined that ESR should be evaluated as Transmission Facilities and incorporated into the RTEP, then [we] advocate that ESR should compete directly with the Immediate Need transmission designations. Today, if a reliability violation pops up and it is needed within 3 years, PJM often says it is “an Immediate Need transmission project”. Under the OA provision Section 1.5.8(m), PJM is required to review non-transmission alternatives before declaring a transmission improvement is “Immediate Need”. That is, PJM is to determine if there are non-transmission alternatives that could push off the immediate need until “year 4”. Implementing the OA in this manner would allow competitive transmission windows to occur for year 4 forward while creating a new 3 year market-based product (e.g., “3 year generation”, “3 year DER”, “3 year storage”, “3 year DR”, etc.) to defer “Immediate Need” determinations.

PJM proposal is a good starting point to address the baseline needs. [We] recognize that SATA will have wide variety of applications and the design package will further need to be updated to address those needs. However, there is room to improve the proposed package. For instance, clear guidelines needed regarding how the SATA’s charging and discharging credit should be handled. One of the ways to address the charging/discharging credit is to allocate them based on the cost allocation associated with respective SATA’s project. Simply allocating the SATA charging cost to system losses may not be the best long-term approach. Specially in market efficiency type applications where SATA may be charged/discharged on frequent basis to provide congestion relief, allocating charging cost to the system losses may not be a good idea.

PJM’s proposal seems to properly recognize (1) concerns about SATA having the wide-ranging ability to mitigate broader reliability issues; and (2) the belief that, for now, SATA is likely best invoked on a targeted local basis. It should hopefully further the interest expressed by FERC and others in promoting experience with Grid Enhancing Technologies (GETs). It also seems reasonable for PJM and TOs to consider SATA as a baseline or supplemental project solution where it would be both cost-effective and reliable. That said, PJM should provide additional guidance and there needs to be further discussion on the reference to cost elements in the PJM options matrix, including what PJM exactly means by (1) “SATA estimated life should be a composite of all the major components (i.e. battery cells, inverters, GSU, auxilliary equipment); and (2) “Costs associated with SATA charging would be attributed to system losses.”

2. Do you support continued discussions, following the conclusion of this phase, to explore the potential for dual use (use of storage as transmission reinforcement as well as allowing market participation) and resulting market process and tool changes?

	Count	% of Total
Yes	142	72%
No	40	27%
Maybe	2	1%



Given the newness of this topic, we think the conversation would benefit from first finalizing within PJM and getting FERC approval of the storage as transmission rules by themselves. Once that effort is totally complete and we have a common understanding and approved set of rules for how that will work and what the limits of that are, only then do we think it is ripe and a good use of time to embark on the further discussion of dual use.

inappropriate to allow ratebase assets

The dual use of SATA may follow the use of SATA for reliability needs but cannot be rushed given 1) the complex nature of separating costs associated with dual use and the bidding requirements of these assets, 2) the novel concept of a limited duration asset serving both reliability and market needs, and 3) the potential for market participants to exercise control of the transmission system. A thorough stakeholder discussion that allows for more time than PJM's Phase 1 process for SATA should be considered. While SATA for reliability needs is a complicated concept, the considerations for market participation of SATA are even more complex. CAISO has tried to tackle the issue but has temporarily suspended the effort for almost two years now. MISO has also suggested developing the market participation rules for SATOA but has yet to begin those discussions.

I do NOT support dual use (use of storage as transmission reinforcement as well as allowing market participation). But I do support continued discussion to ensure that storage is not depleted in markets when it has been built for transmission reliability purposes.

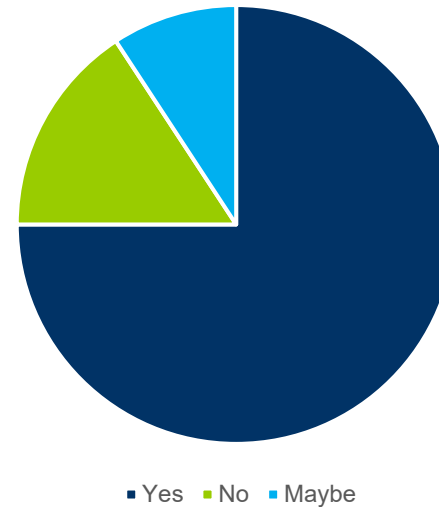
Our YES response is contingent upon significant further investigation into what constitutes dual use especially given the primary reliability considerations for use as a transmission asset.

Transmission assets are recovered through transmission rates. The market for storage as full-fledged market participants would be diminished if certain storage had the economic advantage of having their cost recovered through transmission rates.

It is probably a good idea to continue discussions. However, energy storage probably should not be sanctioned for dual use (i.e. not serving reliability and market services at the same time). It should either be used as a transmission reinforcement or as a market participation mechanism. Recognizing that there is only a narrow band for storage to assist as transmission and that stakeholder discussion thus far has seemed to indicate that most stakeholders are eager to discuss storage's market participation capabilities, the dual use concept should hopefully be a less controversial discussion.

3. Do you support continued discussions, following the conclusion of this phase, to include exploring operational process inputs as well as reviewing the need for potential operations process and tool changes?

	Count	% of Total
Yes	138	75%
No	29	16%
Maybe	17	9%



As it relates to storage operating just as transmission, possibly. It depends on whether we anticipate operational needs to be part of the FERC filing for approval. If yes, then we need to do that. If no, then it might be a better use of time to wait and get approval first before making operational determinations.

Yes. As PJM staff have said, the Phase 1 package proposed by PJM only considers the planning analysis aspects of SATA. There remains a considerable amount of questions around the operational aspects of SATA including: communication requirements and coordination of SATA operation between PJM, TOs and asset owners, whether development of operating guides and/or asset operation agreements that outline responsibilities of all parties associated with SATA are needed and how will costs and revenues associated with charge and discharge of SATA will be treated. Finally, under market efficiency solutions, how or will SATA need to be integrated into the PJM EMS to optimize both mitigating the constraint and the asset's state of charge (if not, which and how are those market signals integrated into the TO or asset owner's dispatch computer)? These are not insurmountable questions but need to be resolved in order to provide clarity around how SATA will be operated and treated.

pull these load profile assumptions into interconnection process for non-SATA storage projects.

Our YES response is contingent upon significant further consideration of what would constitute the operational aspects of SATA, particularly how costs will be treated.

We should put the discussion on hold and see if we can come back with broader issue statement/problem statement.

Storage as transmission should also be considered in the market efficiency context, as set out in the design components of the matrix. This would be a more fruitful phase 2 approach.

If PJM wants to move forward with SATA, how SATA will behave in real time from an Operations and Planning standpoint would be helpful to explore, including whether the computer systems/software/relays/processes are ready and capable of handling.