



Phasor Measurement Unit (PMU) Placement Plan in RTEP Planning Process

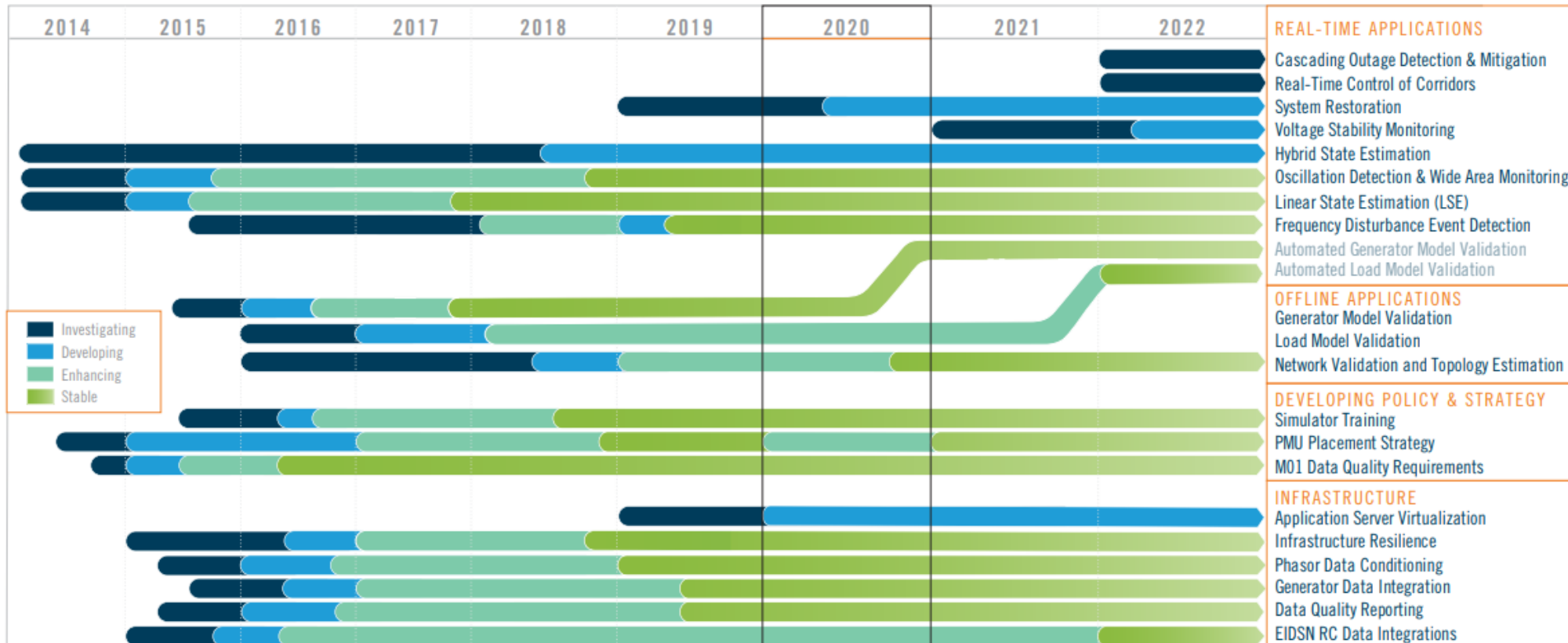
Planning Committee
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Shaun Murphy

- Background
 - History of PMU Project at PJM
 - Lesson's Learned
- Problem Statement: PMU Placement in RTEP Planning Process
- Solution Proposal
- Stakeholder Process Plan
- Q & A

PJM SYNCHROPHASOR TECHNOLOGY ROADMAP

USED & USEFUL	Year Started	Year Stable
Phasor Data Concentrator	2013	2015
TO DOE Project Data Integration	2013	2016
Post-Event Analysis	2014	2016



Benefits

- Oscillation Detection
- Post Event Analysis
- Dynamic Model Validation
- Linear State Estimation
- Use of PMUs to support / replicate existing applications (Hybrid SE)

Challenges

- Data Quality
- CIP Compliance
- Operator Training
- RTO-Wide PMU Placement Strategy

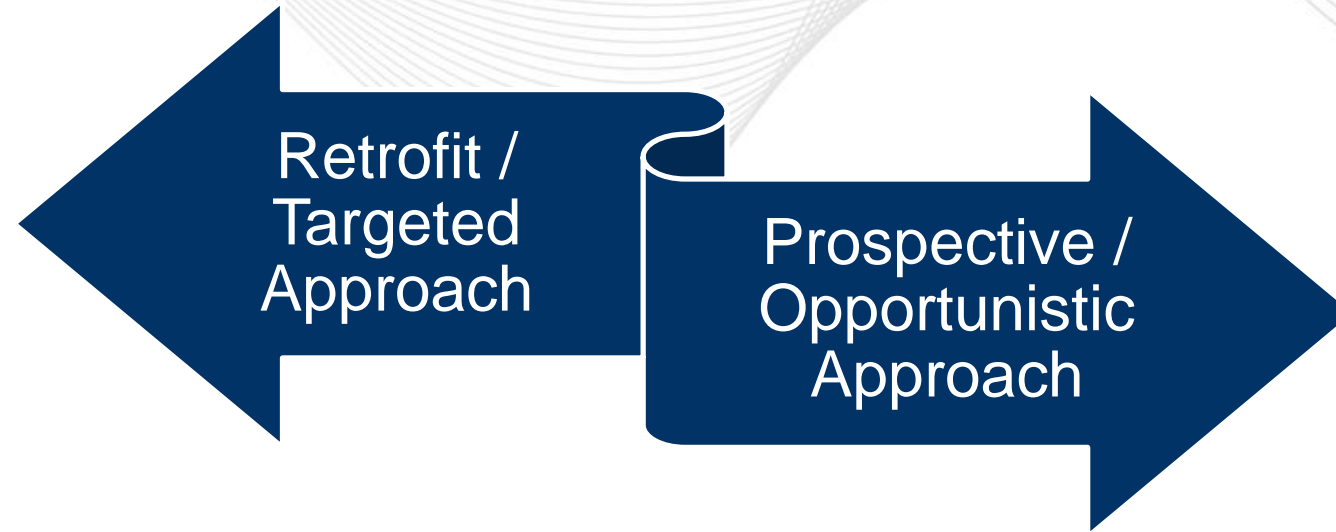
Type	Quantity
SGIG – Active	372
SGIG – Retired	23
ISA Requirement	35
TO Sponsored Installation	62
External RTO	398

Benefits

- Redundancy in measurement collection system
- Dynamic Model Validation
- Asset health
- Linear State Estimation

Challenges

- Relay vs Digital Fault Recorder
- Networking: LAN & Serial
- PDC Configuration (substation & data center)
- Latency Settings



- Retrofit requirement - standalone installation in surgical list of substations.
- Ensures near-term usability.

- Prospective/Opportunistic planning requirement – install PMUs in certain projects meeting a voltage / equipment criteria.
- Minimizes cost.

Recognizing the history and lessons learned from the Department of Energy's 2009 Smart Grid Investment Grant (SGIG) PMU deployment project, a formalized process is needed to expand deployment beyond the existing research-grade PMU devices on the PJM transmission system. This placement process is needed to:

1. Ensure that PJM's real-time, post-event, and planning applications have the proper quantity and quality of PMU measurements required by these applications.
2. Expand the coverage of high-speed Synchrophasor devices in the PJM footprint to meet the dynamic monitoring needs of the future grid.

This plan would establish a minimum standard of PMU placement and would target the backbone transmission system in PJM.

- PJM has identified the [reliability and resilience benefits](#) of PMU data observability across the PJM footprint. To achieve and maintain these benefits, a minimum coverage of Synchrophasor devices are needed.
- A PMU placement provision is needed in the RTEP planning process to ‘opportunistically’ install Synchrophasor devices at minimal cost. Targeted (retrofit) PMU placement projects may be needed to ensure near-term PMU coverage needed by key Synchrophasor applications.
- PJM sees an opportunity to incorporate PMU Placement as a prospective requirement in the RTEP planning process to establish a growth-cycle of new and replacement PMU devices. Adding such a requirement for an identified category of RTEP projects will be a low-cost, high-benefit implementation.
- Such a requirement would require a long-lead notice for newly approved projects to include PMU devices in project costs and design documents.

Substation Costs

- Costs to make a substation “PMU Ready”
 - Updating drawings
 - Cabinet / rack space
 - Substation PDC
 - GPS Clock
 - Network infrastructure

Estimated total: ~120k

Project Costs

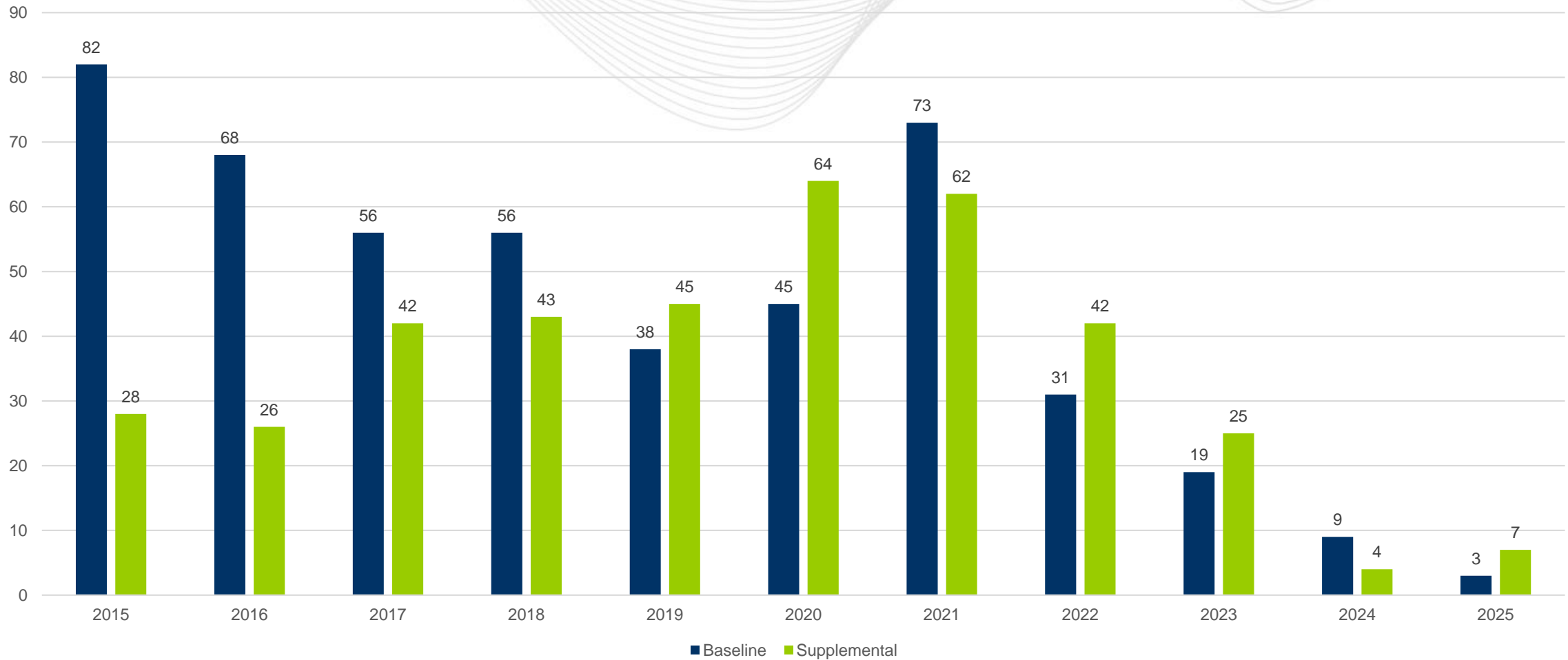
- Costs to install a single PMU
 - Updating drawings
 - PMU device (relay) configuration

Estimated total: ~10k

- Equipment type
- Voltage level

Voltage Threshold	New dynamic reactive device	New Line	Line rebuild / reconductor	Line rebuild / reconductor (partial)	New Transformer	New Substation	Substation Rebuild	Total
115	17	161	272	81	137	106	115	889
138	16	135	225	59	103	84	82	704
161	8	51	78	19	41	29	30	256
230	8	50	77	19	41	29	30	254
345	2	14	20	7	18	4	9	74
500	2	4	11	3	4	1	4	29
765	1	0	0	1	1	0	1	4

Solution Options Affected Projects 2015-2027: 100 kV+



The Planning Committee (PC) will **approve** the following modifications to M14B:

- **Additional language to M14B Appendix B as follows:**

The 5-year plan will specify the level of budget commitments which must be made in order to meet scheduled in-service dates. The commitment may include facility engineering and design, siting and permitting of facilities, **installation or modification of metering system(s) required by Manual 01**, or arrangements to construct transmission enhancements or expansions.

- **Additional language to M14B Section 1.4.1.3:**

Maintaining a safe and reliable Transmission System also requires keeping the transmission system equipment in safe, reliable operating condition as well as addressing actual operational needs. On an ongoing basis, PJM operating and planning personnel assess the PJM transmission development needs based on recent actual operations. This may lead to special studies or programs to address actual system conditions that may not be evident through projections and system modeling.

To ensure that system facilities are maintained and operated to acceptable reliability performance levels, PJM has implemented an Aging Infrastructure Initiative to evaluate appropriate spare transformer levels and optimum equipment replacement or upgrade requirements. This initiative, based on a Probability Risk Assessment (PRA) process, is intended to result in a proactive, PJM-wide approach to assess the risk of facility failures and to mitigate operational and market impacts. Section 2 of this manual provides further discussion of the PRA process.

Additionally, ensuring adequate Synchrophasor device coverage is needed to support PJM's real-time applications. The PMU Placement Strategy (PPS) identifies the Synchrophasor device coverage needed to support PJM's real-time Synchrophasor applications. The PPS will include placement targets and required operational dates to guide installation plans. The PPS will be periodically reviewed and updated by PJM Operations and will be included in the Operational Performance assessment process.

Refer **recommended** M01 language to Operating Committee to set placement requirements.

1. Prospective requirement
2. Integrate PMU Placement Strategy into M01 and Operational Performance process

1. Additional language to M01 Section 3.6:

Required Synchrophasor Data*:

Synchrophasor measurement signals are required for the following equipment locations:

- Bus voltages at 100 kV and above
- Line-terminal voltage and current values for transmission lines at 100 kV and above
- High-side / low-side voltage and current values for transformers at 100kV and above
- Dynamic reactive device power output (SVC, STATCOM, Synchronous Condenser, etc.)

*These requirements do not apply to existing transmission facilities placed in service prior to June 1, 2021. In situations where the installation of a Synchrophasor device would incur an usually high installation cost, PJM may approve an alternative Synchrophasor device installation plan proposed by the Transmission Owner.

2. Review the [PMU Placement Strategy](#) & Incorporate into M01 as Attachment F

- Continue to close the gap between research & real-time control room use
- Phase-in conversion of research-grade synchrophasor field devices to CIP-ready performance
- Improved data reliability & availability for primary applications
 - Oscillation detection
 - Post event analysis
 - Dynamic model validation
- Expanded observability and redundancy for PJM's Linear State Estimator

RTEP PMU Placement Issue: Stakeholder Process Plan

- Informational update in March OC/PC
- March OC – PJM proposes to bring issue to PC
- May PC – First Read: Problem Statement & Solution
- June PC – Endorsement: M14B Language
- July OC – First Read: M01 Language
- August OC – Endorsement: M01 Language

Supplemental information: [ISO New England Operating Procedure No. 22 – Disturbance Monitoring Requirements \(OP-22\)](#)