



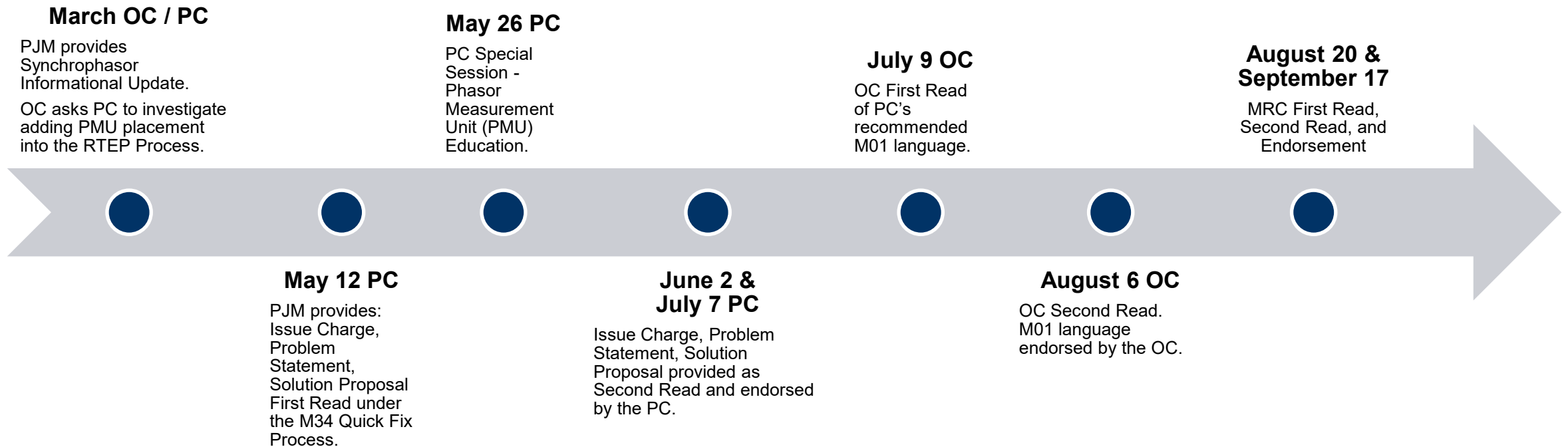
# PMU Placement Plan in the Transmission Planning Process

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- Application R&D over the past 8+ years have identified several key applications for PJM:
  - Linear State Estimator
  - Oscillation Detection
  - Dynamic Model Validation
  - Building backup EMS monitoring: Redundant IROL Monitoring
- DOE grant-funded PMUs are aging and seeing retirements
- Open issue of TO / ISO CIP classification of PMU equipment

- To maintain a structured growth-cycle of Synchrophasor devices and keep deployment costs as low as possible, we need a prospective placement requirement.
- Generator interconnection requirement has been very successful.
- To balance PMU observability between generators and the transmission system, and ensure a minimum coverage across the PJM footprint, a transmission-level PMU requirement would be valuable.
- Provide new guidance on PJM's anticipated decision-making posture in the future.

- PJM is a stakeholder driven organization with committee governance.
- The PJM Synchrophasor team provides annual project updates to the Operating Committee.



**Vision:** Full Synchrophasor observability of all EHV equipment 100 kV and above

## Benefits:

- Ability to detect high-speed grid disturbances (oscillations, equipment failures)
- Expanded Linear State Estimation
- Assist PJM in meeting its NERC reliability obligations:
  - BAL-003-1.1
  - IRO-008-2
  - TOP-001-4
  - MOD-032-1/033-1

## Risk of unobservable grid events:

- Widespread installation of Synchrophasors was a recommendation following the 2003 blackout, which lasted 4 days, affected 50 Million people, with an estimated cost of \$6 billion.

Identified benefits and enhanced observability outweigh incremental costs.

# Endorsed PMU Placement Language

The Operating Committee endorsed the following additional language to M01 Section 3.6:

For substations with three or more non-radial transmission lines at 200 kV or above, and four or more non-radial transmission lines between 100 kV and 200 kV. Synchrophasor measurements are required for the following equipment types (see the applicability of requirements below). All measurement points must be in the form of positive sequence values.

- Voltages for busses at 100 kV and above
- Line-terminal voltages and currents (both ends) for transmission lines at 100 kV and above
- High-side/low-side voltage and current values for transformers with a rated low side voltage of 100 kV or greater
- Dynamic reactive device power output (SVCs, STATCOMs, Synchronous condensers, etc.)

Note: These Synchrophasor data requirements shall only apply to new **Regional Transmission Expansion Plan (RTEP) baseline and supplemental projects, other than network upgrades for the purpose of interconnecting a new generator,** presented to the Transmission Expansion Advisory Committee (TEAC) and/or the Sub Regional RTEP Committees (SRRTEP) for inclusion **or integration** in the ~~Regional Transmission Expansion Plan (RTEP)~~ on or after June 1, 2021. **PMUs will increase the level of observability allowing PJM to better perform its reliability obligations, and facilitate compliance with the applicable NERC reliability standards as the grid continues to evolve.** In situations where the installation of a Synchrophasor device causes technical challenges resulting in unusually high installation costs, PJM may, on a case-by-case basis, **waive the requirement or** approve an alternative Synchrophasor device installation plan proposed by the Transmission Owner or Designated Entity. Supporting equipment (PDC, GPS clock, etc.) installed per this requirement shall include necessary design and configuration to make the device 'CIP ready'. **PJM will evaluate the effectiveness of the Synchrophasor measurement requirements on a periodic basis and work with PJM stakeholders to modify such requirements as necessary.**

The Operating Committee endorsed the following additional language to M01 Section 3.6:

For substations with three or more non-radial transmission lines at 200 kV or above, and four or more non-radial transmission lines between 100 kV and 200 kV. Synchrophasor measurements are required for the following equipment types (see the applicability of requirements below). All measurement points must be in the form of positive sequence values.

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✓ Keep costs as low as possible

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The Operating Committee endorsed the following additional language to M01 Section 3.6:

For substations with three or more non-radial transmission lines at 200 kv or above, and four or more non-radial transmission lines between 100 kv and 200 kv. Synchrophasor measurements are required for the following equipment types (see the applicability of requirements below). All measurement points must be in the form of positive sequence values.

- Voltages for busses at 100 kv and above
- Line-terminal voltages and currents (both ends) for transmission lines at 100 kv and above
- High-side/low-side voltage and current values for transformers with a rated low side voltage of 100 kv or greater
- Dynamic reactive device power output (SVCs, STATCOMs, Synchronous condensers, etc.)

✓ New PMUs must be CIP-ready

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# Lessons Learned

- Stating the obvious: plurality of stakeholder views and interests. Varying levels of familiarity and buy-in.
- Answering the hard questions:
  - *“What are the monetary benefits of installing PMUs?”*
    - Emerging grid technologies generally focus on either **reliability** or reducing congestion.
    - Detecting dynamic grid events are difficult enough. What’s the probability of a dynamic event occurring?
    - What are the potential costs of an unmitigated dynamic grid event?
    - How could this issue evolve as distributed and inverter-based resources grow in the future?
  - *“What’s the minimum coverage of PMUs needed for oscillation detection?”*
    - In some cases, comparing PMUs to RTUs is easy. In others, we need to find an in between solution.
  - *“How do you install a PMU to guarantee good data quality?”*
- Cutting to the chase: PMU observability impact on reliability (NERC compliance)



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