### Key Statistics

<table>
<thead>
<tr>
<th>Category</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Member companies</td>
<td>1,040+</td>
</tr>
<tr>
<td>Millions of people served</td>
<td>65</td>
</tr>
<tr>
<td>Peak load in megawatts</td>
<td>165,492</td>
</tr>
<tr>
<td>MW of generating capacity</td>
<td>178,563</td>
</tr>
<tr>
<td>Miles of transmission lines</td>
<td>84,042</td>
</tr>
<tr>
<td>2017 GWh of annual energy</td>
<td>773,522</td>
</tr>
<tr>
<td>Generation sources</td>
<td>1,379</td>
</tr>
<tr>
<td>Square miles of territory</td>
<td>243,417</td>
</tr>
<tr>
<td>States served</td>
<td>13 + DC</td>
</tr>
</tbody>
</table>

- 28% of load in Eastern Interconnection
- 20% of transmission assets in Eastern Interconnection

21% of U.S. GDP produced in PJM

As of 2/2018
Industry Paradigm Shift

Unprecedented number of changes in the power industry

- Storage technologies
- Distributed energy resources
- Intermittent renewables
- Alternative technologies
- Fuel Swap
- Changes in customer expectations
PMUs as part of the big picture

Resilience

Reliability

Risks / Dependencies:
- Extreme Weather
- Physical/Cyber Attacks
- Fuel Source/Security

Prepare
- Assess Risks
- Targeted risk management
- Strengthen Infrastructure
  - Make critical assets less vulnerable
- Increase Coordination
  - Cross-sector & public/private partnerships

Operate
- Strengthen Operations
  - Expand coordination and communications
- Enhance Continuity
  - Planned response exercises
- Apply Innovative Approaches
  - Microgrids & distributed energy resources

Recover
- Stabilize the System
  - Prioritize interdependent infrastructures for system survivability
- Regain Critical Functions
  - Balance industry and societal priorities
- Make Enhancements Based on Lessons Learned
2010
PJM and 12 Transmission Owners began the $27 M Synchrophasor Project with ~$14 M in DOE matching funds.

2013
Phasor Data Quality Task Force (PDQTF) stakeholder group established to improve Synchrophasor data quality performance and reporting.

2014
- Synchrophasor project implementation completed.
- New generators larger than 100 MW required to install PMUs.

<table>
<thead>
<tr>
<th>Initial Infrastructure</th>
<th>Today</th>
</tr>
</thead>
<tbody>
<tr>
<td>PMUs</td>
<td>301 (835 including external)</td>
</tr>
<tr>
<td>Transmission Substations with PMUs deployed</td>
<td>85</td>
</tr>
<tr>
<td>Data</td>
<td>21 Phasor Data Concentrators (TO-Level)</td>
</tr>
<tr>
<td></td>
<td>2 Super Data Concentrators (PJM)</td>
</tr>
<tr>
<td></td>
<td>42 GB stored per day</td>
</tr>
<tr>
<td></td>
<td>New applications developed and deployed</td>
</tr>
</tbody>
</table>

2018
PJM continues to use and expand our Synchrophasor infrastructure.
2018 Project Initiatives

- New version of RTDMS tested and installed—focus on oscillation detection
- Formalized PMU event analysis team
- Simulator-based operator training
- Interconnection – wide situational awareness tool
Visualization

- PMU location information in DIMA
- Data heat maps
How can Synchrophasor data improve PJM’s operational resilience?

PMU data can be used to replicate and reinforce existing operational functions:
- State Estimation
- IROL
- ACE
- Voltage monitoring
- Thermal monitoring

In-use applications unique to synchronized measurements:
- Detecting system islands
- Oscillation monitoring
• **Real-time tools:**
  – Oscillation Detection
  – GIS Visualization
• **Improve PMU Data Quality**
• **Strategic PMU Installations**
• PMUs improve real time dynamics monitoring
  – Oscillations
  – System Islands
• PMUs improve model validation
• Needs for System Resilience
  – Improve visibility
  – Backup essential functions

PMU System Expansion

PJM Benefits
• Wide area stability monitoring
• Model validation & alignment

TO Benefits
• Model Validation
• Asset Monitoring

System Evolution
• Generator Queue Projects
• New Transmission Projects
Model Validation using PMUs

- Generator model validation
- 2019 project to automate gen. model validation with event detection application
- Down the road: transmission and load model validation