# Qualitative Benefit Analysis of Deployment of Phasor Measurement Units (PMUs) in Ontario

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## Introduction and Background:

Over the last decade the Ontario electricity sector has evolved into a more dynamic power system with higher penetration of renewables and storage devices, and a decreasing quantity of large traditional generation sources. This evolving supply mix has resulted in less system inertia and greater challenges for system operators to continuously monitor the grid. Combined with the potential for climate change driven increases in severe weather events, tighter supply margins, and aging infrastructure, enhancing the IESO's situational awareness will be critical to maintaining reliability and resiliency.

Following the 2003 blackout that struck most of the north-east portion of North America, North American Electric Reliability Corporation (NERC) has placed increased emphasis on the need for system operators to have improved situational awareness. Recommendations to improve reliability included a broad deployment of Phasor Measurement Units (PMUs). NERC has already developed and published a reliability guideline for PMU placement and installation[1]. Given the growing use of PMUs by North American utilities and its application becoming increasingly established, it is anticipated to only be a matter of time until the use of PMUs is made mandatory by NERC via reliability standards. Independent System Operators (ISO's) and Reliability Coordinators in the United States (including PJM, NYISO, MISO, NE-ISO, CAISO, SPP, ERCOT) have already implemented PMU systems. The IESO needs to be prepared for a likely future where NERC reliability standards mandate the usage of PMUs.

During previous IESO stakeholder engagement activities[2,3], a number of stakeholders expressed a desire for the IESO to provide a cost-benefit analysis for the PMU initiative. The IESO believes that developing a robust cost-benefit analysis is impractical at this stage for the reasons noted below.

- On the cost side of the analysis, the costs for each Market Participant (MP) have the potential to vary significantly based on their specific situation and factors that the IESO does not have visibility into at this point. This includes factors such as the technology used for creation of phasor data, the vendors chosen to purchase the PMUs and associated devices, the IT infrastructure and communication method selected, labor costs, etc.
- Assessing the quantifiable benefits of PMUs is equally challenging for a number of reasons. Developing robust estimates of market efficiency would require assumptions around highly variable market and dispatch scenarios for a yet to be completed Market Renewal Program design and a changing supply mix. Additionally, there are significant challenges in establishing how to quantify many of the reliability and resiliency benefits PMUs provide associated with helping to avoid high impact, low frequency system events (e.g. major blackouts, damaged equipment, etc.).

[1] NERC guideline available here: https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Reliability%20Guideline%20-%20PMU%20Placement.pdf#search=PMU%20guideline

[2] Active Engagements. Retrieved from IESO: https://www.ieso.ca/-/media/Files/IESO/Document-Library/engage/pd/phasordata-20200624-presentation.ashx

[3] Active Engagements. Retrieved from https://www.ieso.ca/en/Sector-Participants/Engagement-Initiatives/Engagements/Updates-to-IESO-Monitoring-Requirements-Phasor-Data

However, to be responsive to this request from stakeholders, the IESO has taken the initiative to develop this report which seeks to clearly articulate the expected qualitative benefits associated with implementation of PMUs in Ontario[4].

The qualitative benefits are addressed in terms of (a) reliability and system resiliency, (b) efficiency and cost savings, and (c) social and environmental benefits under short- and long-term time frames based on research conducted by the IESO, neighbouring jurisdictions' experiences, and relevant working groups' reports[5,6].

## Expected Benefits Analysis

## Short-term Benefits

### 1. Reliability and System Resiliency Benefits

1.1 Inadequate monitoring and awareness has been a contributor to numerous major and minor system blackouts or forced outages. Due to its high resolution, the PMU data increases the granular visibility of the grid and provides enhanced situational awareness. This is useful as it gives the IESO's system operators the opportunity to take timely mitigation actions in response to warning signs in the network as well as to craft better responses to actual disturbances before those disturbances cascade into more significant events. Ultimately, this enhanced situational awareness provides significant cost savings associated with the avoidance of potential blackouts and outages.

1.2 PMU data facilitates post-event analysis to identify the root causes behind system disturbances to inform appropriate future remedial actions to be taken to avoid similar events. PMU data also aids in identifying malfunctioning equipment and potential sources of equipment failure before an event occurs, this facilitates early prevention/detection of future system issues or failures and avoids the costs associated with them.

1.3 Data mining, baseline analysis and pattern recognition based on historic synchrophasor data will equip system operators with informed decision tools and will provide insights into more accurate system operating limits accommodating more renewable generation by added economic value and maintained resiliency for the grid.

1.4 Higher situational awareness with a wider view of the interconnected grid for both Ontario and neighbouring jurisdictions can help system operators with identifying small signal stability issues as well as other unstable oscillatory modes. Such awareness is achievable through synchrophasor data and with associated supporting analytical tools allows for necessary mitigation measures to be taken in advance.

This improves grid reliability and therefore reduces frequency and duration of equipment outages, hence minimizing overall asset downtime with considerable economic benefits.

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[4] Refer to paper titled 'Estimated Quantitative Cost Range Analysis for Installation of PMUs in Ontario's Power System' for generic ranges of costs for deployment of PMUs

[5] Factors Affecting PMU Installation Costs. Retrieved from US Department of Energy: https://www.energy.gov/oe/downloads/factors-affecting-pmu-installation-costs-october-2014

[6] The Value Proposition for Synchrophasor Technology. Retrieved from NAPSI: https://www.naspi.org/node/356

1.5 PMU data includes a measure not otherwise visible to system operators, namely "phase angles". Lower angle differences assist efforts in successful restoration of equipment from outages and reduces power surges causing damage to assets. For generators and transmission lines, phase angle monitoring helps with the speed and accuracy of their synchronization and reclosing respectively. Faster system restoration and recovery with reduced damage to grid equipment enabled by PMUs will provide system wide cost savings.

### 2. Higher Efficiency and Cost Saving Benefits

2.1 Relying on PMU data, system operators benefit from more accurate models to develop line limits and to better manage energy throughput relative to thermal and voltage stability limits. This in turn reduces system congestion caused by inaccurate line limits. By facilitating more accurate limits, PMUs will allow low-cost energy to flow through the system without unnecessary congestions resulting in cost savings.

2.2 PMU data allows reduced need to take generation plants offline for the purpose of troubleshooting and validating models. Avoiding unnecessary downtime for plants and keeping them online for longer periods safely increases cost savings for asset owner as well as the overall energy market. Furthermore, PMU data helps power system operators with monitoring interconnections and balancing frequency to satisfy NERC standards, locating faults within shorter timeframes, forensic event analysis, and identifying mis-performing equipment before they cause system failures resulting in better asset utilization at lower costs.

2.3 Using higher-resolution PMU data enables grid operators to improve the accuracy of forecasting models used to manage the power grid securely. More accurate models that represent realistic behaviour of assets allows secure power system operation. Inaccurate models produce incorrect predictions leading to unsafe situations and under utilization of the power grid that results in lower efficiency and higher costs.

### 3. Environmental Benefits

3.1 Using PMU data also has positive environmental impacts by facilitating and accommodating higher levels of renewable generation through improved power plant models, fossil fuel offset through more effective management of energy congestion, and emissions offset with increased power flow capacity through transmission lines for renewable energy. This also avoids some fossil fuel consumption and associated pollution emissions.

## Long-term Benefits

### 1. Reliability and System Resiliency Benefits

1.1 PMU data enables amalgamation of real-time data from out-of-province entities to give wide-area visibility of the grid. Use of neighboring entities real-time synchropahsor data enables identifying larger issues and embracing long-term measures to avoid wide-spread blackouts resulting in benefits for Ontario.

1.2 Energy sources like renewables and storage are connected to the grid using complex electronic interfaces. They have fast switching that could potentially disturb the grid which could be identified only by high-resolution monitoring methods. In the long run, growth of such technologies are imminent and it is prudent to invest on a technology such as PMU to allow for their increased penetration in reliably.

## 2. Higher Efficiency and Cost Saving Benefits

2.1 The use of PMU data enhances the ability of IESO and industry peers to demonstrate their compliance to several NERC reliability standards where non-compliance entails severe financial penalties.

2.2. Granular PMU data supports the system operators with more accurate models to represent realistic behaviour of transmission infrastructure and set the operating limits accordingly. This will allow the IESO to accurately target its investments in transmission infrastructure beneficially by fully utilizing its existing grid. In absence of such awareness, under utilization of the power grid and wasteful investments will result in lower efficiency and higher costs.

## 3. Environmental Benefits

3.1 Application of PMU data enhances competition among market participants by avoiding barriers to entry for inverter-based resources and provides a more diversified portfolio of energy resources to the consumers.

**Independent Electricity System Operator**
1600-120 Adelaide Street West
Toronto, Ontario  M5H 1T1

Phone: 905.403.6900
Toll-free: 1.888.448.7777
E-mail: customer.relations@ieso.ca

**ieso.ca**

@IESO_Tweets
linkedin.com/company/IESO

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