The key answer according to STER's ten years of experience and working with multiple clients is: it depends on the application that uses the PMU device data. The following few examples illustrate this point.

Example 1: H2020 project FARCROSS, WAMS demo in IPTO

WP6 in H2020 FARCROSS project through several demonstration applications like

a) Voltage stability,
b) Submarine cable monitoring,
c) ZoneIIA protection,
d) LFO (low frequency oscillation) detection

for the first time introduces the WAMS/WAMPAC technology into the Greek transmission system operator IPTO. 15 PMU deployed in key locations: cross-border lines, key internal 400 kV lines, and on 150 kV submarine cables Crete-Peloponnese (s/s Chania - s/s Sklavouna) and Cyclades (Syros)-Mainland (s/s Syros - s /s Lavrio).

Example 2: WAMS in HOPS d.d. - Croatian TSO

The first WAMS pilot in HOPS consisting of two PMUs was created in 2003 for monitoring of resynchronisation of the first and the second UCTE zones on 10th October 2004. Today, 70+ PMU units are installed on

- all 400 kV lines,
- important internal and all cross-border 220 kV lines,
- all 110 kV cross-border lines,
- selected 110 kV lines (congested lines, WPP evacuation, …)
- selected generation units.

Such WAMS topology follows the target applications:

- integration with AGC controller: fast PMU data complements SCADA measurements
- WAMS-based fault locator:
    - Single PMU method – comparable to distance protection relays,
    - PMUs on both terminals – location of SLGF works significantly better than distance protection locator,
    - includes a set of neighbouring TSO's PMU data delivered via electronic highway (EH)
- monitoring of synthetic inertial responses and activation of primary frequency regulation
- several other protection and optimisation algorithms

Example 3: ELIA – asset monitoring in Belgium TSO.

ELIA has been used WAMSTER, a web-based PDC service since 2016. At the moment, there is a pool of 10 portable PMUs for near real time monitoring of key assets with portable WAMS technology in ELIA. PMUs are repositioned on a project basis or as needed for asset management purposes. The key advantage of portable PMUs comparing to stationary PMUs for ELIA is the ability to use the mobile telephone network to connect the PMU to the web-based PDC service. This feature simplifies the extension of WAMS to any node of the ELIA network, onshore and offshore. Few past campaigns:

a) Monitoring of nuclear plant interaction with the grid (LFO monitoring)
b) Commissioning of the ALEGRO line - HVDC link Germany-Belgium

c) Monitoring of the MOG (Modular offshore grid) project in order to precisely determine the causes of low-frequency oscillations detected in wind power plants connected to the North Sea energy hub.

Example 4: 50Hertz – dedicated WAMS for black start tests
50Herz had formed dedicated WAMS to support monitoring of black start testing. In the 2021 black start test conducted on October 23, 2021, the WAMS consisted of 3 PMUs that were installed in s/s Markersbach, s/s Streumen and s/s Graustein. The 2022 black start test conducted on July 23,2022 was monitored with PMUs installed in s/s Altenfeld and s/s Remptendorf.