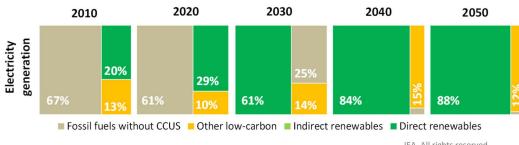


GE WAMS

Key Industry Drivers

Fast Renewable Integration

- Need for higher resolution visibility and faster agility to monitor and manage the grid
- ✓ Greater and regional variability in frequency (due to reduced/sparse inertia)
- ✓ Grid operating closer to its stability limits (frequency and voltage)



Source: Net Zero by 2050International Energy Agency

IEA. All rights reserved.

Future - Proof

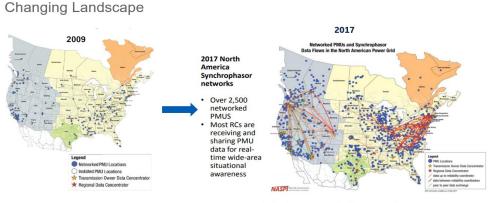
GE Digital

Scalable

- \checkmark Scale to manage the torrent of data
- Composable, bring together views, functions and data that may not be traditionally combined

Accelerated Adoption of WAMS sensors

- ✓ Customer field installations growing from 100s→ 1000s (e.g. ONS, Brazil 1000+; PowerGrid, India 2500+)
- ✓ Multifunctional IEDs (such as Relays & Fault Records) capable of providing WAMS data.



200 Sensors \rightarrow 2500+ Networked Capable Devices

Integrated

✓ Cloud-native, on-prem and hybrid

High Performance

 Ready to be integrated to Energy Management and Distribution Management Systems



Digital Energy

Smaller Total Cost of Ownership

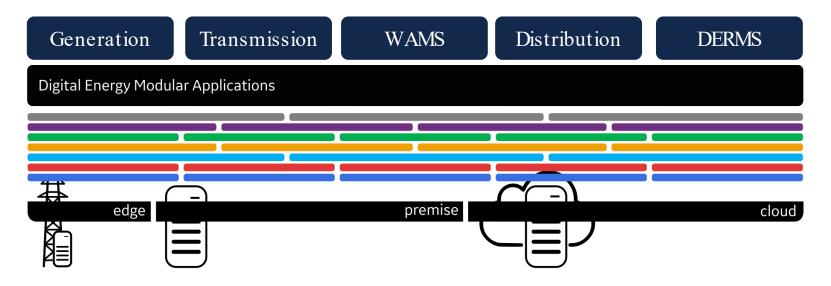
- Leverages Continuous Integration & Continuous Deployment
- Full Test Automation

Just the right bits

• Natively modular solution

Future proof

- Cluster based. Vertical and Horizontally scalable
- On-Prem; Hybrid or Cloud. Your choice





Digital Energy

Smaller Total Cost of Ownership

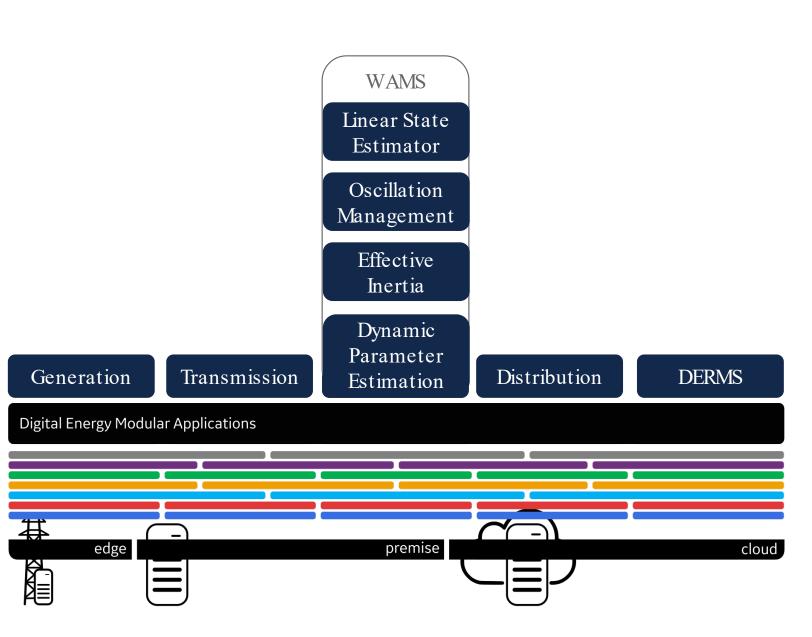
- Leverages Continuous Integration & Continuous Deployment
- Full Test Automation

Just the right bits

• Natively modular solution

Future proof

- Cluster based. Vertical and Horizontally scalable
- On-Prem; Hybrid or Cloud. Your choice





Digital Energy

User Interfaces and Experience

- Reusable components across use-cases
- Consistent and uniform experience
- Optimized workflows



Linear State Estimator

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Solution Highlights

Comply with NERC IRG008-2 R4 and TOP-001-4 R13as back-up to existing EMS State Estimation.

Tertiary realtime assessment solution Leveraging WAMS> Independent of data from EMS

Solves at incoming WAMS data rate; built error processing to ensure solution robustness

Extends WAMS observability beyond existing infrastructure

Detect and correct for erroneous/missing WAM data

Modular, IEC CIM based, state of the art UI/UX cybersecure, HA, interoperable

Oscillation Stability Management



Reducing system inertia

Area inertia effects

Reducing synchronous generator PSS

Reducing System Strength

Resonances: Series Capacitor–Shafts –VSC/HVDC

What's New in OSM:

- Extended Frequency Range for Oscillation monitoring (up to 46Hz/54Hz)
- Oscillatory Monitoring also extending to Voltage and MVAR measurements
- Oscillation Source Location to identify source of Oscillation.

| | 0.002112 | |
|----|----------|---|
| | | Governor Frequency Control |
| | 0.2Hz | |
| | | Rotor Angle Stability |
| | 4Hz | |
| | | |
| | | Control Modes |
| | | |
| | 12Hz | |
| | | Sub-Synchronous Oscillation |
| | | |
| | 50/60Hz | |
| | | ASPI Oscillation Source |
| LC | | est - GE 1st Place Winner! ontest! -60+ teams registered Q |

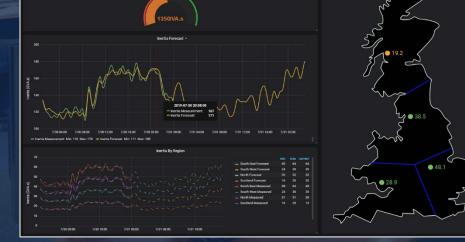
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Effective Inertia

Area Effective Inertia The Inertia Challenges

Measuring Area-Inertia with WAMS

Forecasting area-inertia



Inertia Measurement and Forecast

Solution Highlights

Outcome

Enable higher penetration of low inertia renewable generation

Reduce curtailment fees and penalties

Lower frequency response services

Increase network resilience; minimize risk of system separation

Effective Inertia

Nonintrusive metering of "effective" inertia

No expensive hardware required; leverages existing WAMS investment

Regional and global realme inertia measurements.

Inertia forecast from AI/ML analytics

EMS and PMU/PDC agnostic

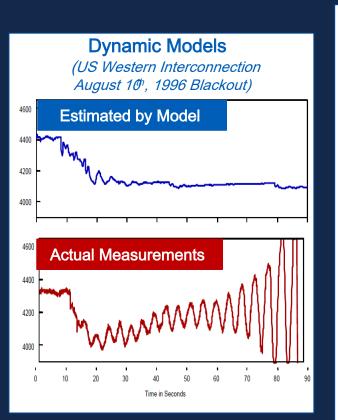
Meter and Forecast to Master High Renewable Integration



Dynamic Parameter Estimation

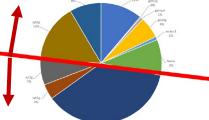
Challenges:

- Inaccurate Dynamic & IBR Models leading to inability to predict grid conditions.
- Small Disturbance Testing not Sufficient as this does not capture the large disturbance behavior.



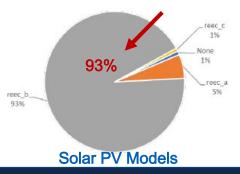
Inverter Based Resources (WECC Base Case Review, August 2

Everything above the line has incorrect, obsolete or no model...



Where using appropriate model default parameters widely used...

Wind Plant Models Everything in grey is "not acceptable" per WECC modeling list..



Solution Highlights

Non-Invasive & Data-Driven Approach that is:

- Cost-effective method for TOs and GOs to satisfy NERC Reliability Standards
- More accurate models for stability analysis => Improved Reliability
- More accurate calculation of system operating limits => Better Asset Utilization
- Works for Conventional/Renewable Gens, Composite Load, System External Equivalent Network

Compliance with NERC MO206/27 requiring transmission planners & operator to verify generator models (turbine & excitation controls) on a periodic basis







