Technical paper on "Situational Awareness of Grid using Wide Area Monitoring and Analytics based on WAMS-GETCO Project"

Gujarat Energy Transmission Corporation Limited

[An ISO 9001 : 2015 Company]

By

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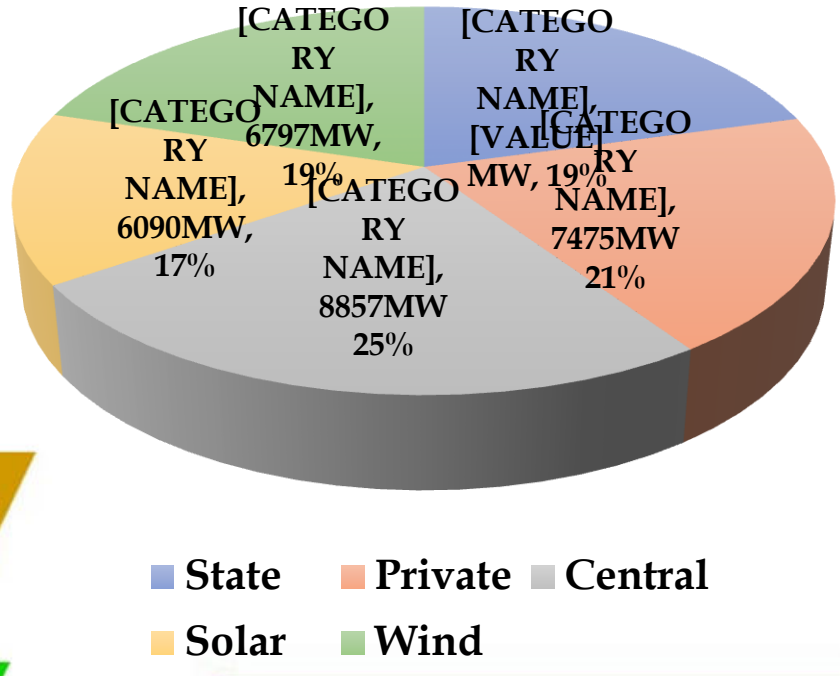
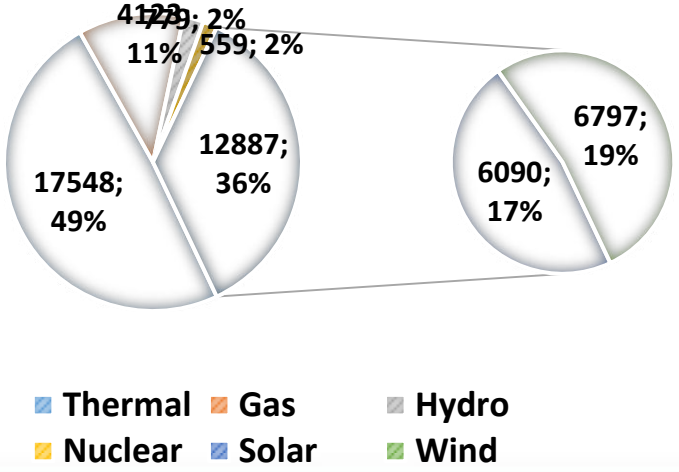
Mix of Generation of Gujarat at a Glance

- Installed capacity of wind is 19 % and solar 17 % with respect to total installed capacity as on July 2022
- Actual generation from wind and solar generation is 9 & 4 % during 2021 -22.





Wind Installed Cap	6525
Solar Installed Cap	5941
Includes CS (ISTS)	712
Excludes SKY	106
Excludes Roof top	1923
Total Solar Inst. Cap	8657
Hybrid Installed Cap	313

Challenges: Power Systems Operators

- Brisk pace of capacity addition; long distance power flows
- Multiple players
- Increasing competition in the electricity market
- Climate change
- large scale integration of renewable energy sources
- Increasing customer expectations.

" The ability of the system operators to take decisions in real-time is dependent *on their 'situational awareness' derived from the data/information available with them in real-time."*

Importance of the Project

- WAMS is advanced tool for power system monitoring by integrating PMU data using analytic software.
- SLDC - GETCO has taken pioneer steps for Wide Area Monitoring System (WAMS) using Phasor Measurement Unit (PMU) data & its Analytics for the power system of Gujarat.
- The data of WAMS based on Phasor Measurement Units (PMU) permits the operator to have a bird's eye view of the entire system dynamics.
- The data acquired are time synchronized with GPS, time stamped, and hence presents the snapshot of the system at any given point in time.
- CERC and CEA report on Grid Disturbance of 2012, recognizing the above importance of PMUs and associated visualizations and applications, has recommended installation of PMUs at all strategic locations to prevent system instabilities.

Wide Area Monitoring Systems (WAMS)

Total PMUs Location	**87 Location**	**At Strategic Location**
Total PMUs	**363 Nos**	Interface Point, Re Rich Pocket
400 kV Substation	**22 Nos**	All 400 kV Network of GETCO under PMU Observation.
220 kV Substation	**63 Nos**	Critical 220 kV Nodes (Interface Points, Wind & Solar station)
Generating Substation	**20 Nos**	Covered all Generating Station of Gujarat Grid
Tran. Elements / ICT under PMU	**1515 Nos**	400 kV, 220 kV lines & ICTs,GTs

Development of Synchro-phasor Analytics

Development of following Analytics from PMU data by IIT Mumbai.

1. On line oscillation mode identification (OscM)
2. State Estimator (SE)
3. Voltage Instability Early Warning Scheme (EWS) A Time Series Analysis Approach

To analyse the large quantum of high speed ms PMU data, WAMS analytics is at SLDC control center for real time grid monitoring, identify online oscillation mode identification & run state estimation of Gujarat grid.

WAMS System Utilization

Visualization

- Magnitude, angle of all three voltage/ current phasor
- Sequence components of voltage/ current phasor
- Rate of change of frequency
- Angular separation between pair of nodes
- Voltage recovery post fault clearance

Analysis

- Grid events within region
- Type of fault viz. LG, LL, LLG, LLLG
- Time of the fault and sequence of events
- Fault clearance time
- Summary of element on fault
- Protection operation / mal-operation
- 1-phase auto reclosing in EHV transmission line
- Performance of System Protection Scheme

Detection of

- Ambient and Automatic Event Detection
- Time, duration, amplitude, frequency of oscillations
- Type of oscillation
- Nature of oscillations viz. damped or un-damped
- Modes present, their amplitude and damping factor

Economic Rationale of the Project

Before WAMS Ph II project initiation:

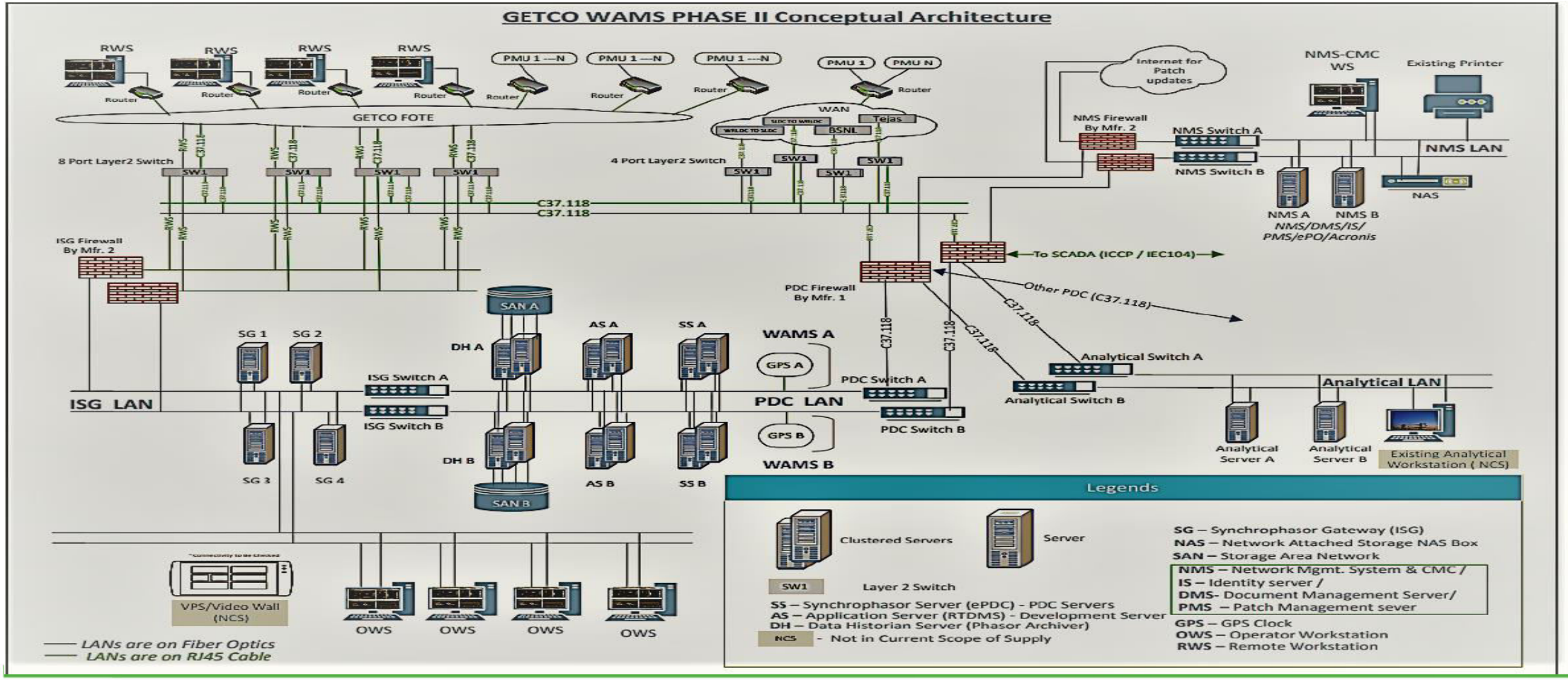
- The cumulative minimum savings in revenue from the from the events happen in GETCO grids is Rs. 84 Million for the condition considered in reports.
- Direct benefit from the use of PMU considering the pay back of Rs. 110 Million invested in Phase – 1, the savings for the minimum savings condition amounts to 70 % of cost invested and if we consider the case with maximum savings in revenue, then it would be more than the investment

"The intangible benefits include cost saved on account of improved situational awareness that resulted in preventing wrong operations or enabled quick decision making, prevention of mechanical damages to generators, damage to equipment, prevent network congestion, improved line loading factor, improved stability margin, Optimized Protection setting and also most importance human life"

WAMS in Gujarat Grid after Phase II Project.

- Total Substation Under PMU Observation: 87 No (Only GETCO & Generating Stationn.)
- Total Transmission Elements (Lines/BC/TBC/ICT/TR/GT): 1515 Nos
- Total Generating Station: 18 Nos
- In Phase II, PMU data sampling rate is 50 sample/Second.
- This reporting rate is first in Indian grid with one year data storage facility at Control Center with @1000 TB Data storage provision.
- Control Center Designing capacity having 1650 PMUs & 3300 Feeder Data monitoring capacity.
- 70 % Gujarat Grid under PMU Installation after phase II Project.

WAMS Phase 2 Architecture



WAMs / PMU - Technical Specification

PMU: (Phasor Measurement Unit):

- PMU have P class and compatible with IEEE C37.118-2005 & 2011 standard.

- PMU measures :
  - Bus Voltage, Line Current with angular Position
  - Frequency, DF/DT
  - Breaker & Isolator Digital ON/OFF status

- PMU have ability to observe low frequency swings in the phasor quantities.

- PMU reporting rate is selectable at 25 & 50 Sample/Second, presently it is selected 25 Hz (25 Sample/Second).

- All PMUs is with GPS time Stamped.

SYNCHROPHASOR ANALYTICS UNDER PLANNING

- Islanding detection and Resynchronization Application.
- Generation Trip and Load Trip Detection Application.
- Voltage/Angle Sensitivity, Voltage Stability Index Application
- Oscillation Source Location
- Real Time monitoring of System Inertia.
- Real time monitoring of Short Circuit Ratio (SCR) at various RE connected Buses
- Offline Advanced Study Tools / Report G

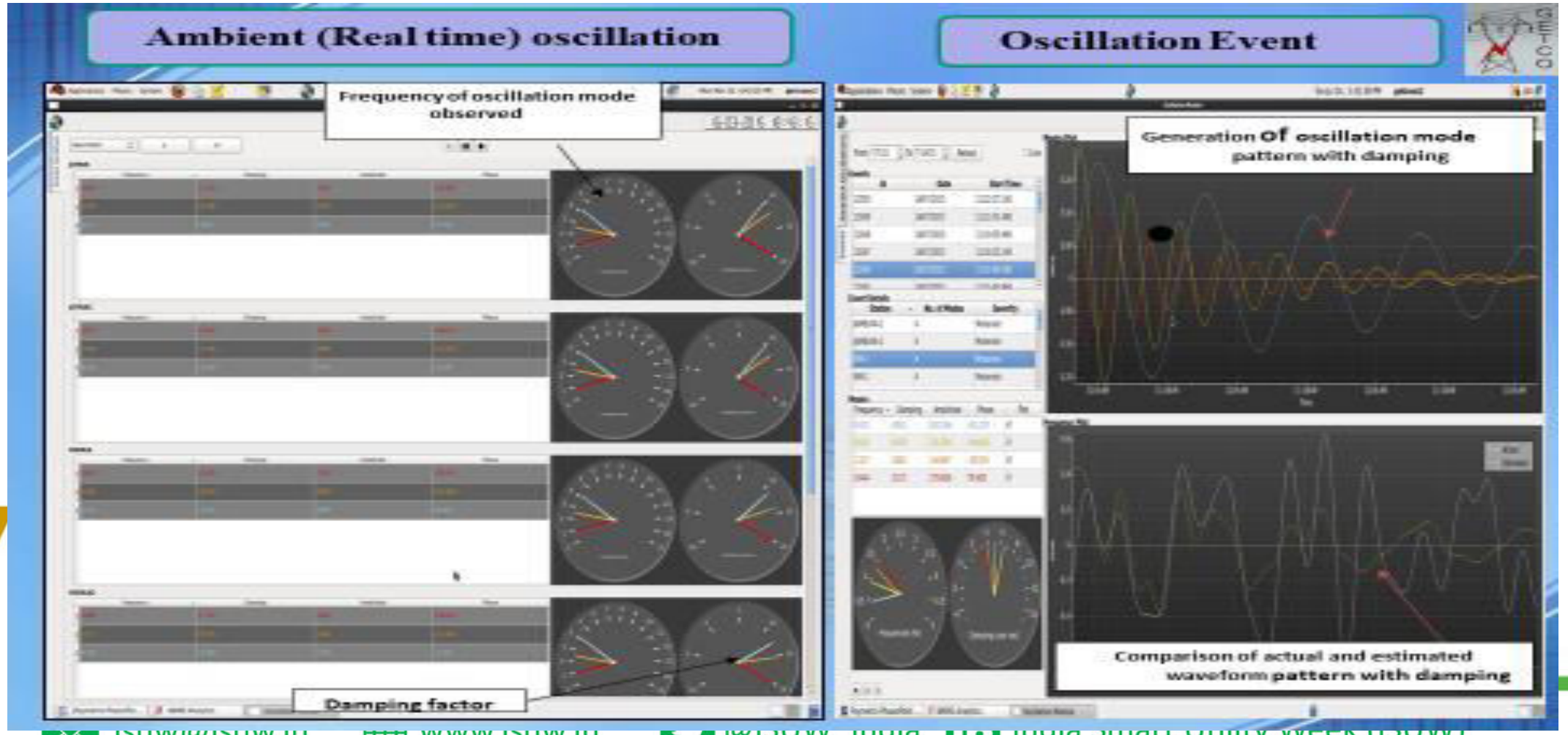
Key Benefits of Synchro phasor Analytics

- Fast and accurate detection of islands.
- Detect Multiple islanding conditions and assist in system resynchronization after islanding
- Fast and accurate detection of generation trip/load trip
- Identification of first responding PMU location closet to generation trip location.
- Assess severity of event and system response.

Key Benefits of Synchro phasor Analytics

- Accurate Estimation of ROCOF and under frequency performance due to increased penetration of renewables.
- Monitor and assess voltage stability of the system using voltage sensitivities and VSI index.
- Real time assessment of voltage/angle sensitivities to real power flows.
- Detect unknown forced oscillations in real time.
- Monitor inter area oscillations.
- Report on analytic results and alarm summary.
- System performance trends.

Screen Shot of Analytics



Thank you

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