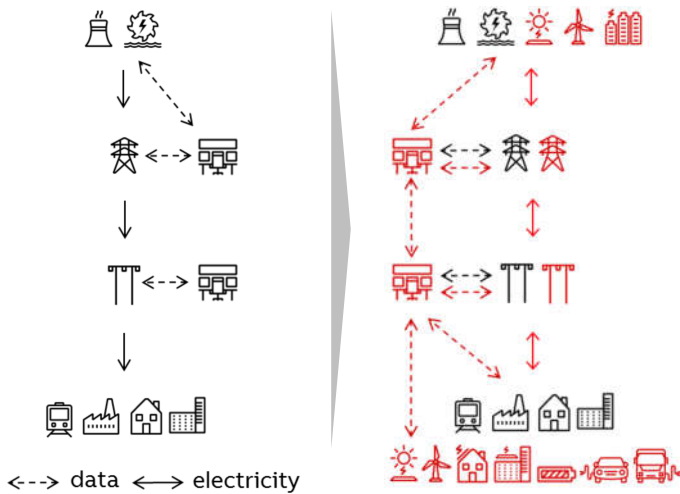


Digital Solutions for power system control and energy transition

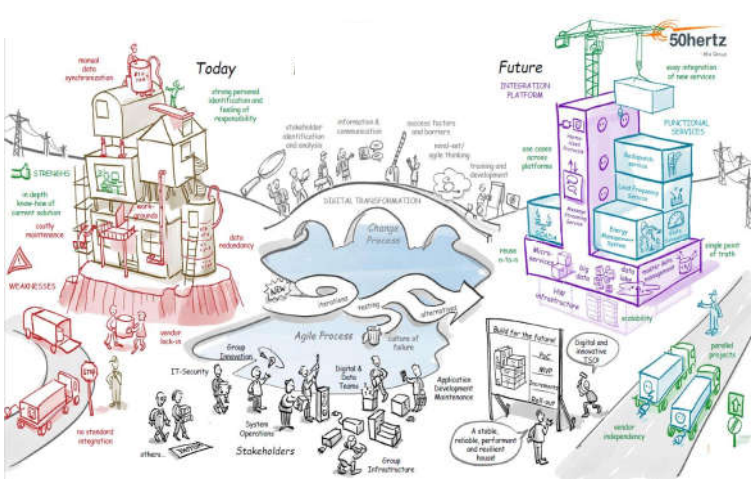
Lazar Bizumic

Drivers: Power Systems and the Systems that Control it are Evolving

Power Systems



Control Systems¹



Changing Grid demands a Flexible Platform that allows for faster Time to Value and improved Total Cost of Ownership

¹) Illustration from 50Hertz's Modular Control Center System: [50Hertz-MCCS-NextGen-SCADA-Conference](https://www.50hertz.com/en/press-releases/50hertz-mccs-nextgen-scada-conference) (hubspotusercontent30.net)

Further evolution of Architecture

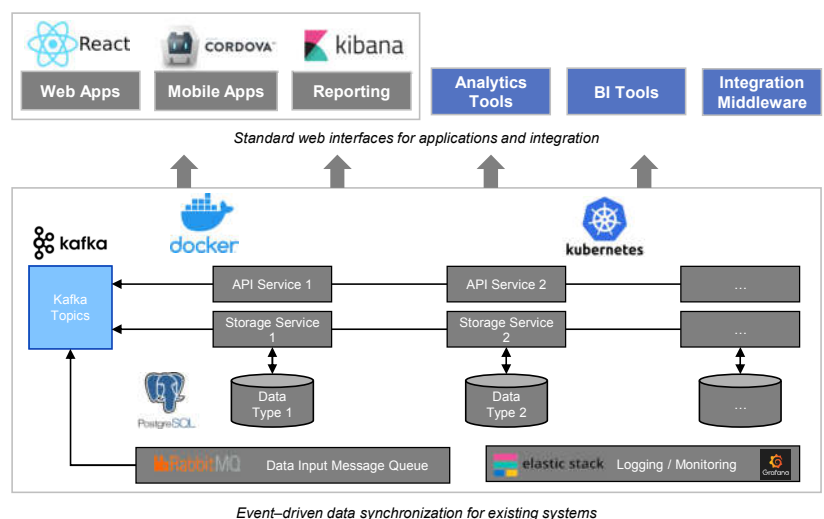
Leverage **modern, open-source technology** standards for all infrastructure, using familiar non-proprietary technology as much as possible according to **Lumada** guidelines

Data flows in and out use **standard interfaces**:

- Synchronous: REST, gRPC
- Asynchronous: Kafka, AMQP, MQTT
- Allows existing systems to be integrated with the platform rather than requiring rip-and-replace

Platform-neutral – can deploy on-premise, or on multiple types of cloud infrastructure (Azure, Amazon, etc.) or hybrid (on-prem and cloud).

Designed to be **managed automatically** with minimal IT admin effort, using **standardized monitoring**.

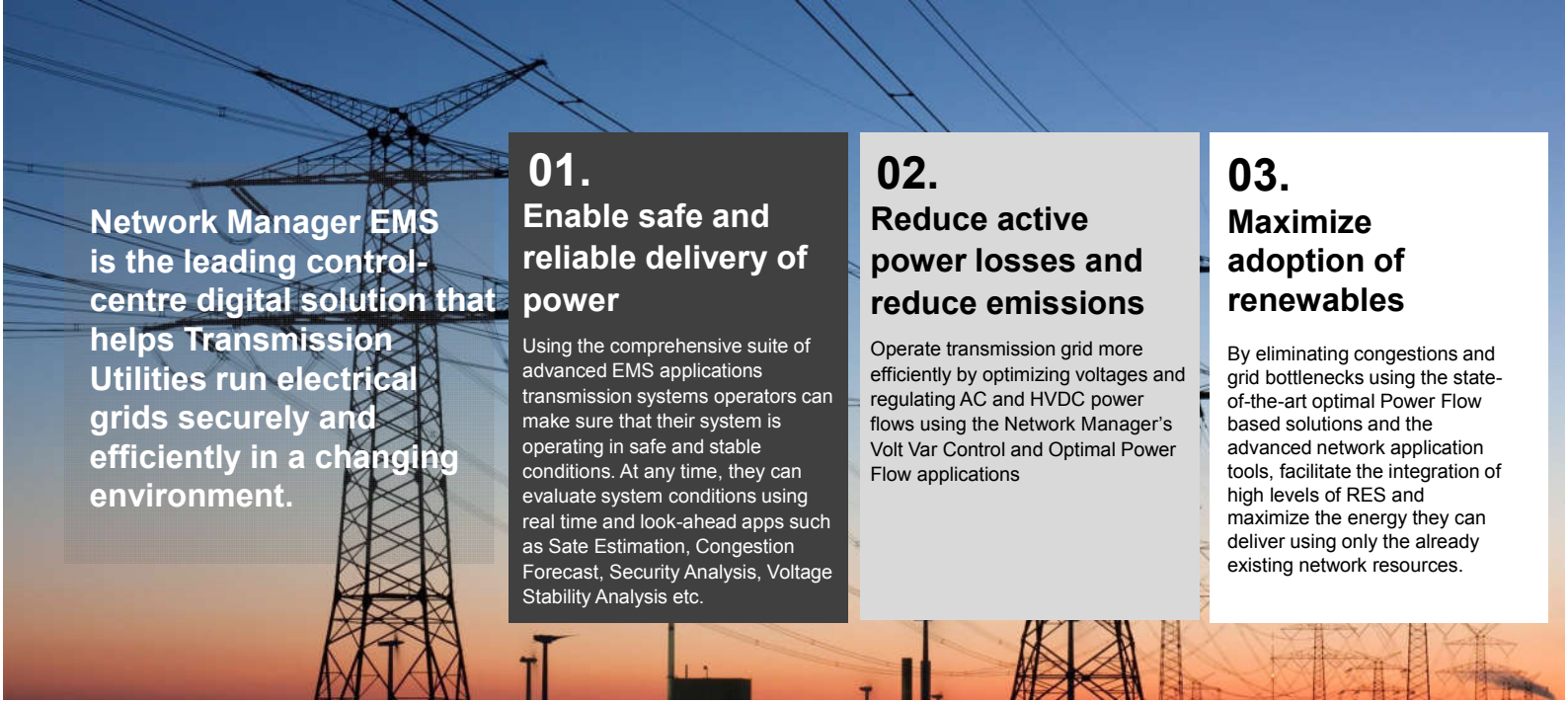


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Seamless navigation between
alarm list, geographic,
schematic, tabular views and
web views

Network Manager EMS for transmission utilities

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Network Manager EMS is the leading control-centre digital solution that helps Transmission Utilities run electrical grids securely and efficiently in a changing environment.

01. Enable safe and reliable delivery of power

Using the comprehensive suite of advanced EMS applications transmission systems operators can make sure that their system is operating in safe and stable conditions. At any time, they can evaluate system conditions using real time and look-ahead apps such as State Estimation, Congestion Forecast, Security Analysis, Voltage Stability Analysis etc.

02. Reduce active power losses and reduce emissions

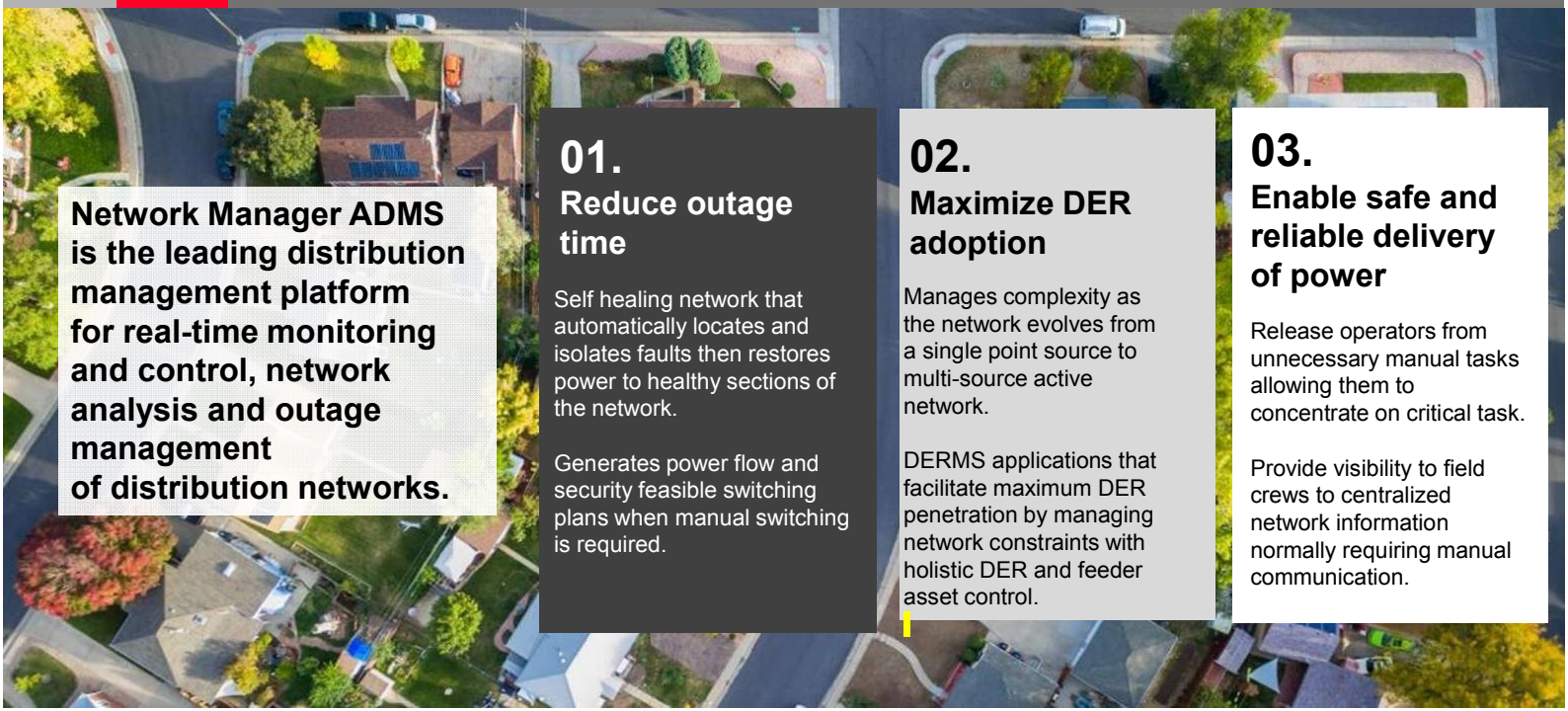
Operate transmission grid more efficiently by optimizing voltages and regulating AC and HVDC power flows using the Network Manager's Volt Var Control and Optimal Power Flow applications

03. Maximize adoption of renewables

By eliminating congestions and grid bottlenecks using the state-of-the-art optimal Power Flow based solutions and the advanced network application tools, facilitate the integration of high levels of RES and maximize the energy they can deliver using only the already existing network resources.

Network Manager ADMS for distribution segment

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Network Manager ADMS is the leading distribution management platform for real-time monitoring and control, network analysis and outage management of distribution networks.

01. Reduce outage time

Self healing network that automatically locates and isolates faults then restores power to healthy sections of the network.

Generates power flow and security feasible switching plans when manual switching is required.

02. Maximize DER adoption

Manages complexity as the network evolves from a single point source to multi-source active network.

DERMS applications that facilitate maximum DER penetration by managing network constraints with holistic DER and feeder asset control.

03. Enable safe and reliable delivery of power

Release operators from unnecessary manual tasks allowing them to concentrate on critical task.

Provide visibility to field crews to centralized network information normally requiring manual communication.

Advanced applications for secure power transmission

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Open systems integration

Ease of interaction between Network Manager and other software systems through APIs. Additionally interfacing with external entities such as Energy Market regulators (e.g. ENTSO-E) follows standardized information modeling and APIs

State estimation

Increases operator's situational awareness by providing accurate real time information about network conditions including information about power flows, voltages and voltage angles, power losses etc.



Enabled with a high-performance, scalable and cybersecure SCADA platform

Dynamic Line Ratings (DLR)

Use imported, forecasted DLR values in the real time and Look-ahead studies and optimizations in order to help in integrating maximum production of renewable energy and operating system and equipment closer to its actual limit in each conditions

Stability analysis

Checks if system is operating in a stable state by performing stability analysis calculations such as voltage stability, small signal stability and transient stability for the assessment of dynamic behavior of the system

Advanced applications for secure power transmission

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Wide-Area Management System (WAMS)

Operators can monitor fast developing power changes, which can threaten stability, even across an expansive area by unlocking all information from PMUs with WAMS

Optimal power flow

Incorporation of active grid elements such as HVDC, FACTS, On-Load Tap Changers and improved optimization needed for the future grid reduces losses and promotes sustainability of the electrical energy supply chain



Enabled with a high-performance, scalable and cybersecure SCADA platform

Security analysis

By performing series of Power Flow calculations, checks what happens in the network in case of contingencies and detects possible current or voltage violations.

Volt Var Control (VVC)

Help minimize active and reactive power losses by optimizing voltages across the grid and keeping them within the desired limits

Generation and demand forecasting

Advanced ML techniques are used to improve accuracy and granularity. Critical for balancing supply and demand during economic optimization

Advanced applications for secure power distribution

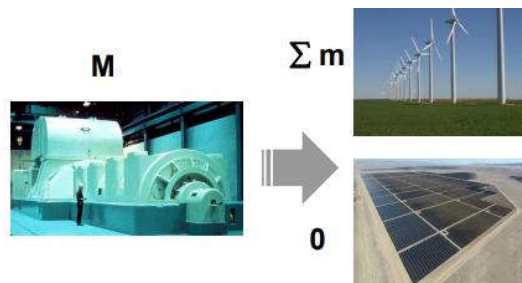
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Enabled by a high-performance, scalable and cybersecure SCADA platform	Outage	Outage prediction Field proven high performance and reliable outage prediction in the most catastrophic storms Reduces outage time and improves customer restoration notification time Configurable prediction rules accommodate individual utility requirements	Switch order management Electronic switching plans and safety documents increase efficiency and improve safety Configurable workflows and approval state accommodate utility specific requirements Fast simulation execution allows testing switch plans on current network conditions	Fault location isolation and service restoration Reduce outage time and in some case create momentary outage instead of a sustained outage Fully automatic and advisory modes to locate and isolate fault and restore power Manual execution of isolation
	Network Analysis	Real-time distribution state estimation Complete view of network operating state when only a minimal set of measurements is available Allows operation closer to the equipment limits Automatically computes pseudo measurements and accounts for the confidence of measurements	Active power DER Management Prevent or manage reverse power flows on feeders Fully aware of real-time network conditions including controllable DER, and operational security and safety constraints Controls PV, wind, and battery storage	Voltage Optimization Control Maintains voltage within regulatory limits in the presence of high penetration PV Holistically optimize regulators, capacitors and DER reactive power Accounts for autonomously regulating smart inverters

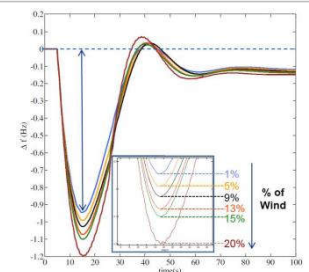
Changing grid and faster network dynamics

Evolving grids and PMU adoption

- With increasing RES penetration, power systems have less inertia associated with the new generation stack
 - Less inertia makes an interconnected power system more prone to increasingly pronounced dynamical excursions
 - This “tweaky” state makes real-time operation difficult using traditional approaches
-
- PMU adoption have steadily increased in the past decade ... Not just a niche technology anymore
 - Parts of the world have Power Systems with 100s-1,000s of PMUs installed
 - PMUs is the ideal technology to observe power system dynamics in real-time



... think ...



WAMS will be an integral part of Centralized Grid Control going forward

New HE WAMS solution built on the new system architecture

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Contracts and development

Hitachi Energy is delivering WAMS SCADA/EMS to a customer by March 2023.

Everything presented today is part of ongoing integration to Network Manager with a fixed time schedule or can be roadmap items (as noted)

The following standards are followed for WAMS and PMU:

- C37.118.1/2-2011 – Synchro phasor protocol and related PMU functions
- C37.240-2013 – Phasor Data Concentrator (PDC) requirements

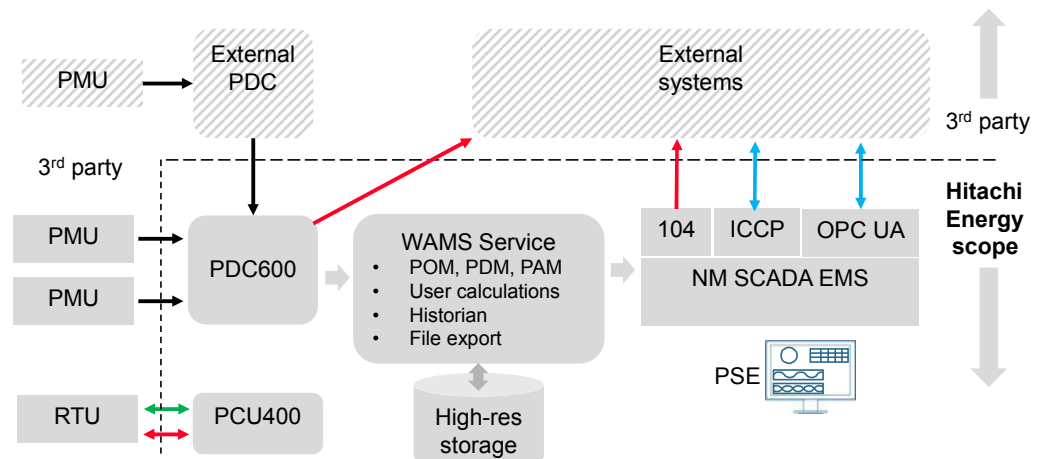
Hitachi Energy has been on the market for 15 years with WAMS!



NM WAMS Interfaces and Functions

Interfaces available:

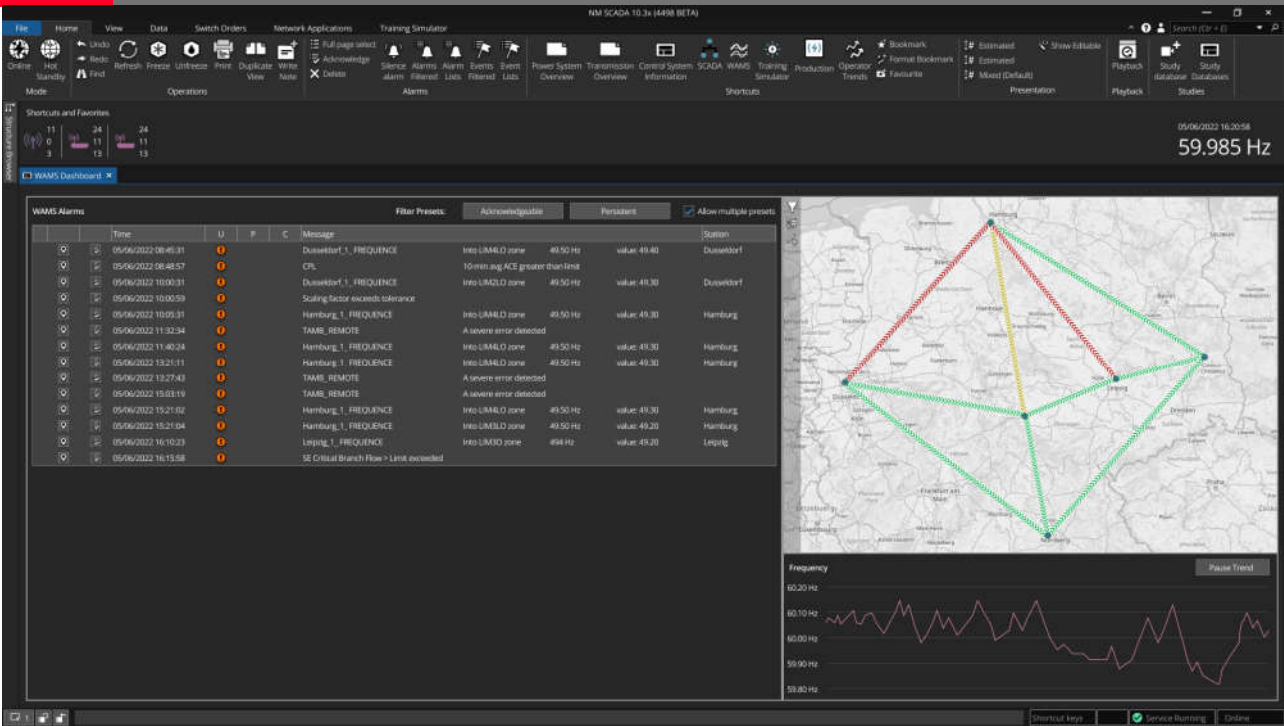
- C37.118-2005/2011 (black)
- IEC104 (red)
- ICCP Secure (blue)
- OPC UA server (blue)
- RTU protocols (PCU) (green)
- DNP3
- Modbus
- IEC101, IEC104,
- 61850
- ...and more

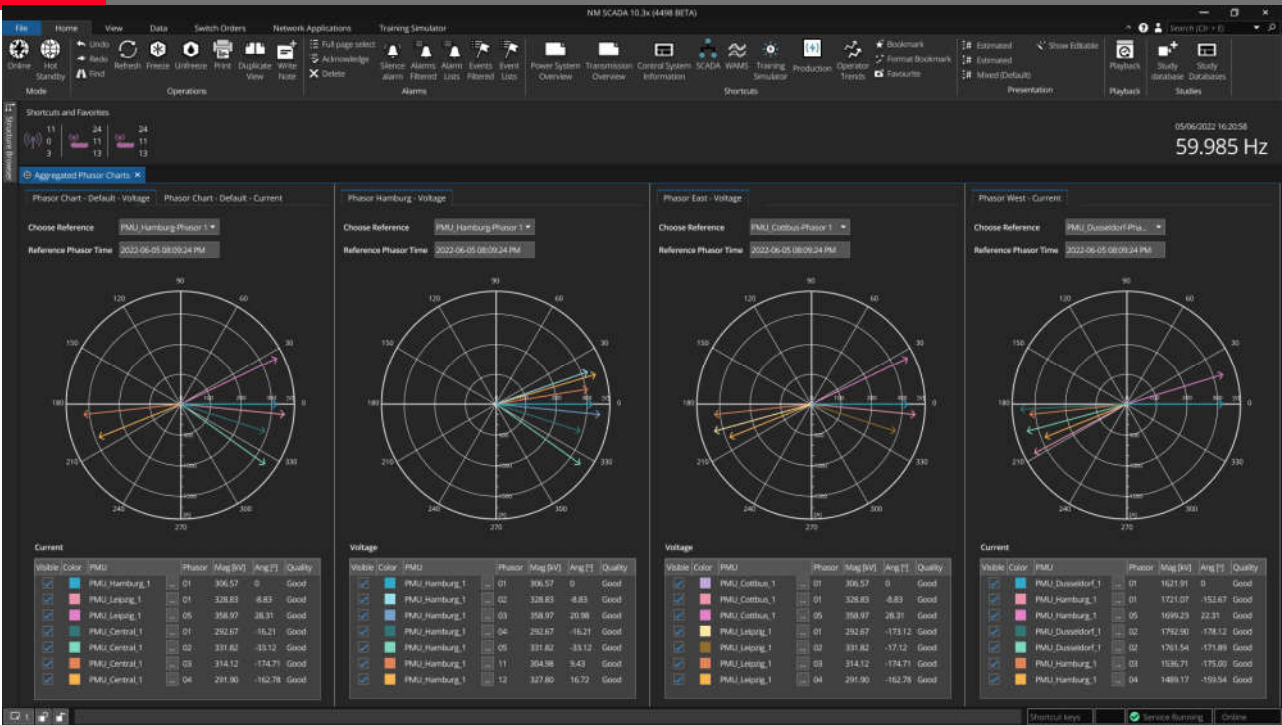


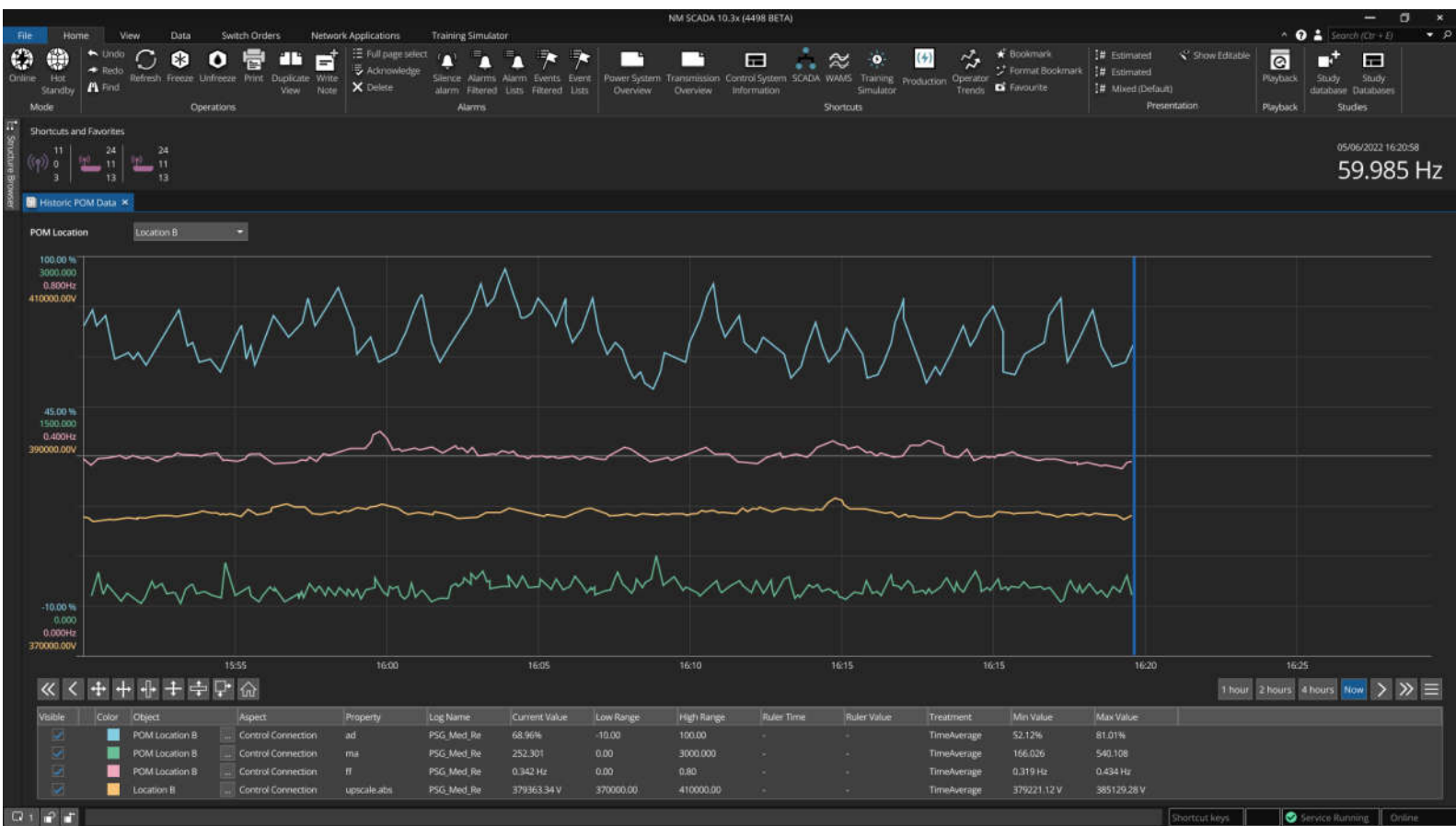
- WAMS applications is integrated as part of the Hitachi solution
- High resolution storage, data export, offline analysis, Historical trends
- WAMS is fully integrated with the User Interface of NM SCADA/EMS which gives advantage of one common Operator's Workplace

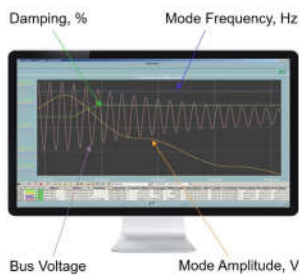
New WAMS Apps based on new system architecture

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Power Oscillation Monitoring (POM)



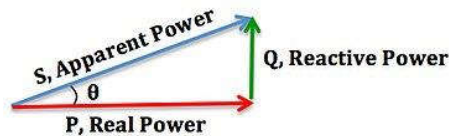
Power Damping Monitoring (PDM)



Phase Angle Monitoring (PAM)

- Algebraic
- Trigonometrical
- Complex and Real operations
- Any signal input
- Resulting objects

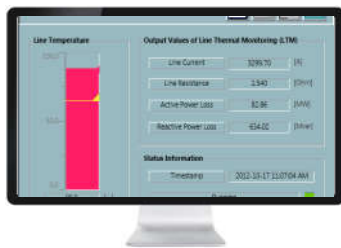
Used defined calculations



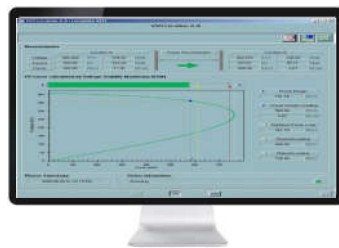
Power calculations

WAMS Applications - Roadmap

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Line Thermal Monitoring (LTM) (Road map)



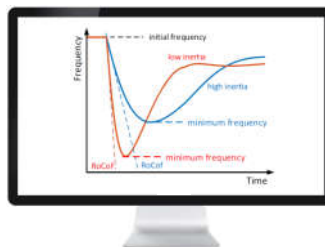
Voltage Stability Monitoring (VSM) (Road map)



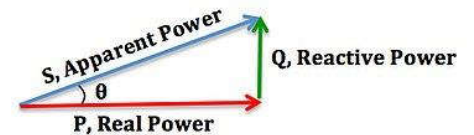
Islanding Detection (Road map)



Frequency Stability Monitoring (FSM) (Road map)



System Inertia Response Monitoring (Road map)



Linear State Estimation (LSE)

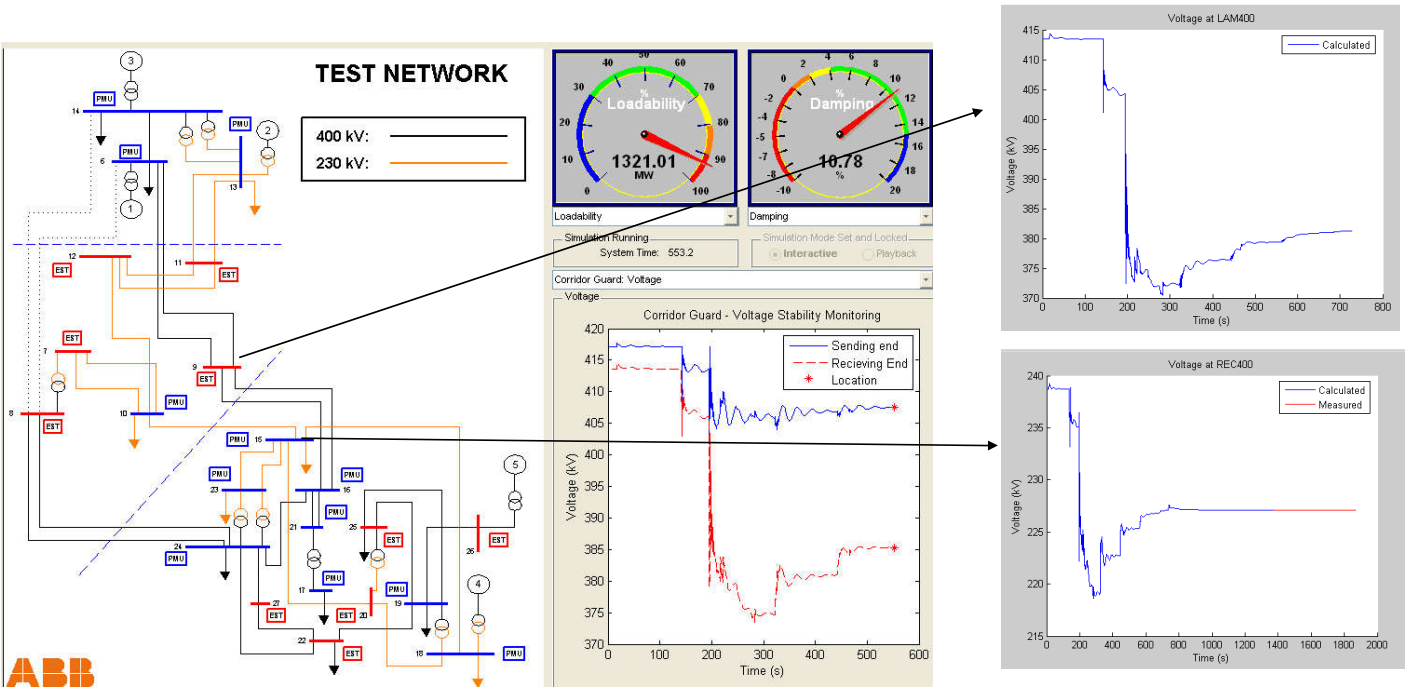
What is Linear State Estimation and how it can change the power system control in the future?

Linear State Estimation (LSE) is a calculation method which uses:

- PMU data (voltage and current measurements)
- Network equipment data (impedances, transformer ratios etc.)
- Network topology (status of the switches, tap positions etc.)

to quickly, accurately and reliably calculate the state of the electrical grid (voltages, voltage angles, line flows and injections).

Screenshot: Calculated vs Measured State





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