MINSAIT

Edge Computing Unit

February, 2025

MINSAIT

01

EDGE COMPUTING FOR GRID MONITORING AND OPERATION

02

EDGE+ DESIGN AND CONSTRUCTION

03

EDGE+ TECHNICAL REQUIREMENTS

04

MANAGEMENT PLATFORM

05

REFERENCES AND SUCCES STORIES

MINSAIT

Our understanding of the Edge Computing Unit (ECU)

Supply of Edge Computing Unit (ECU) for Transformer Monitoring

- Specification document:
  - 57-SDMS-00 Specification for the Edge Computing Unit (ECU) for Transformer Monitoring
- Other relevant documents:
  - 57-SDMS-00A Specifications for ECU Application System (ECUAS)

Transformer Monitoring Unit (TMU)	DER Monitoring Unit	ECU Application System	Minsait's Contribution
Monitor the measurement data of the Transformer using a 3-phase 4-wire probe unit.	Monitor the measurement data of DER inverters	Management	Additional System features

- Voltage and current variations
- Active and reactive energy
- Power Quality
- Connection to ECUAS
	- Waveform distortion rate (THD)
	- Active Power and energy
	- Reactive power and energy
	- Apparent power and energy
	- Alarms etc.
		- Data collection
		- Device management
		- Fleet Management
		- App Store
		- Dashboarding
			- Losses detection
			- Flexibility
			- ADMS integration
			- Device virtualization
			  - vRTU
			  - vPAC
			  - vPMU

Edge Computing for Grid Monitoring and Operation

01

MINSAIT

IoT & Edge Computing at the core of the Digital Grid

Grid monitoring

Sensors, transducers, cameras, LiDAR, meters... provide valuable data to optimize grid operation and maintenance that is conveyed from the field to operational systems.

IIoT and Edge capture, process and communicate data

Device management

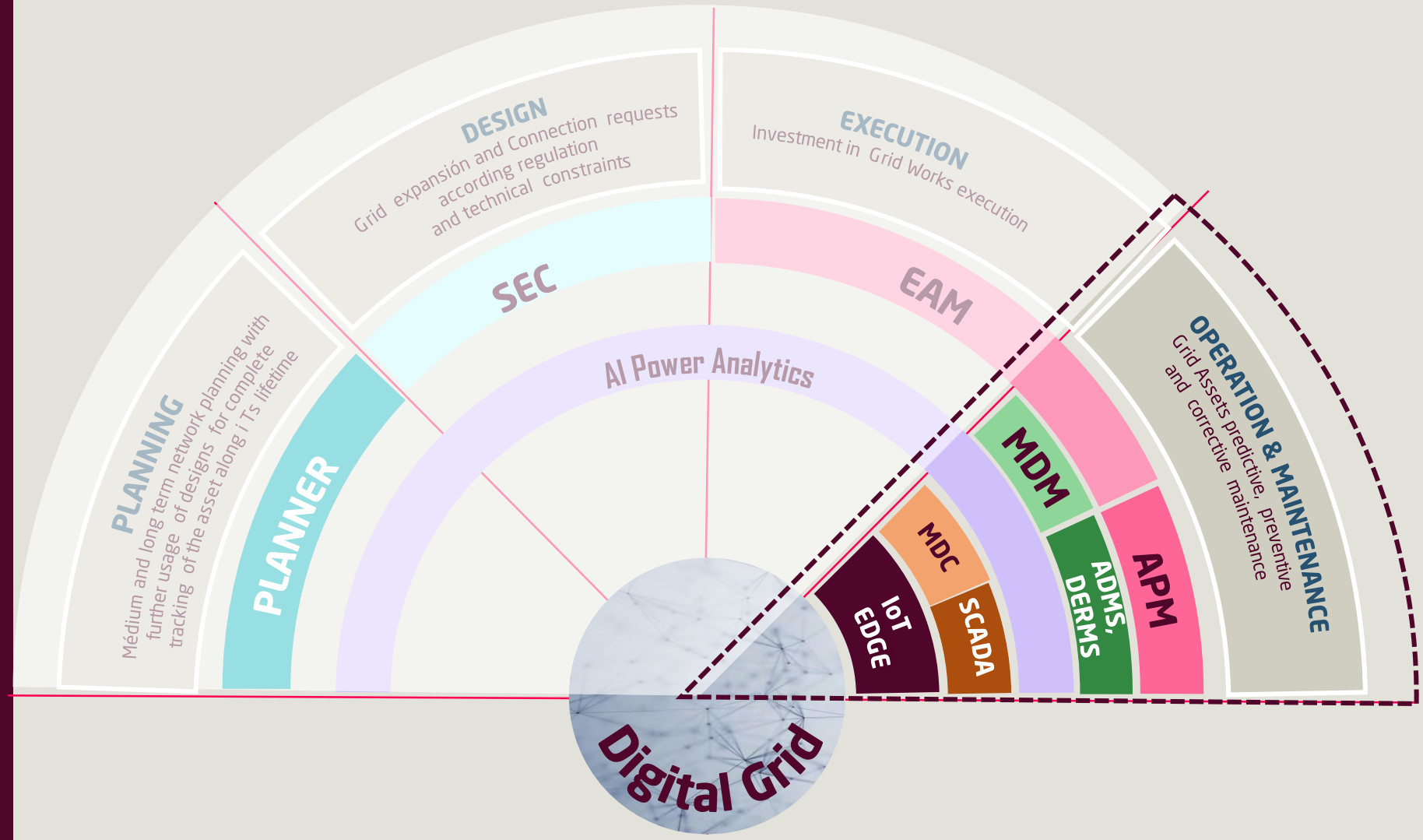
Edge computing platform is a toolbox to manage devices in the edge through remote connection to modify configurations and setting.

Allows individual and group management

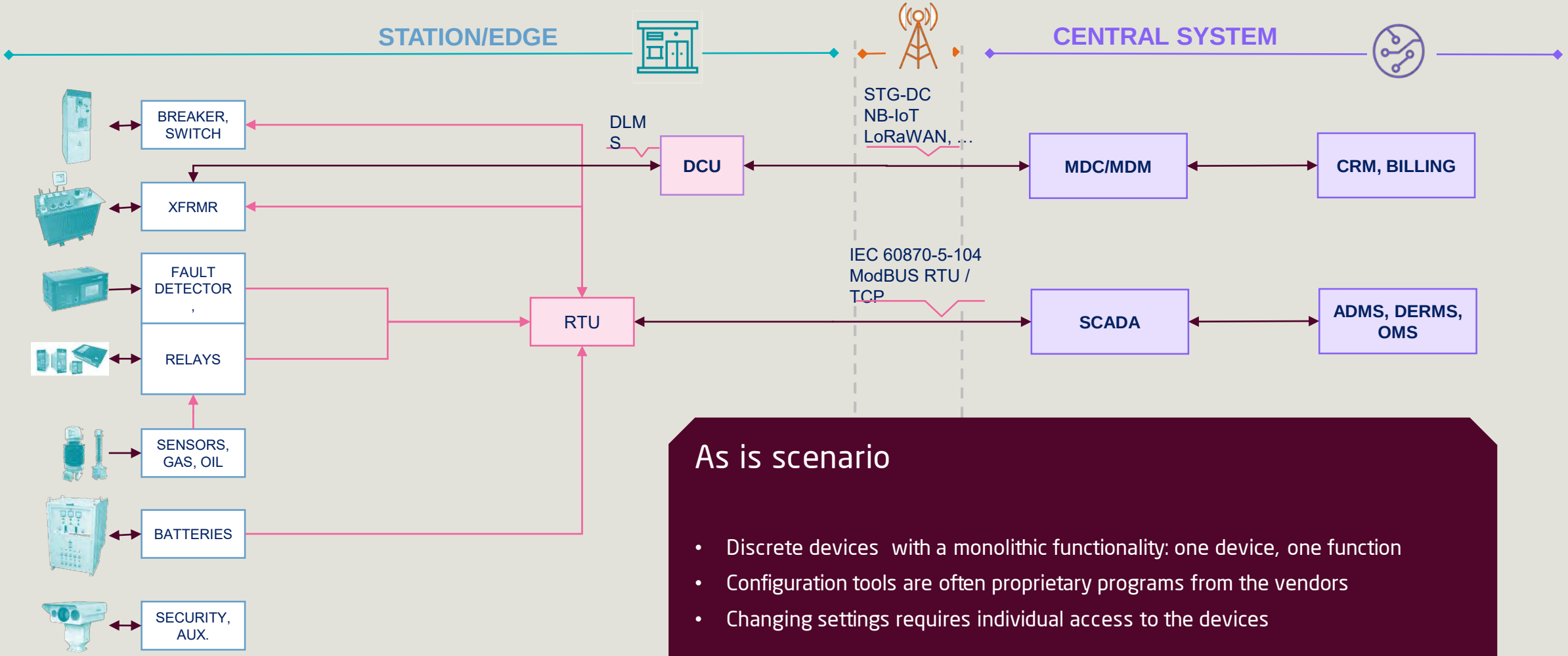
Grid management

Edge devices provide local interfaces to build the channel to remotely control grid assets.

DER management is one of the use cases



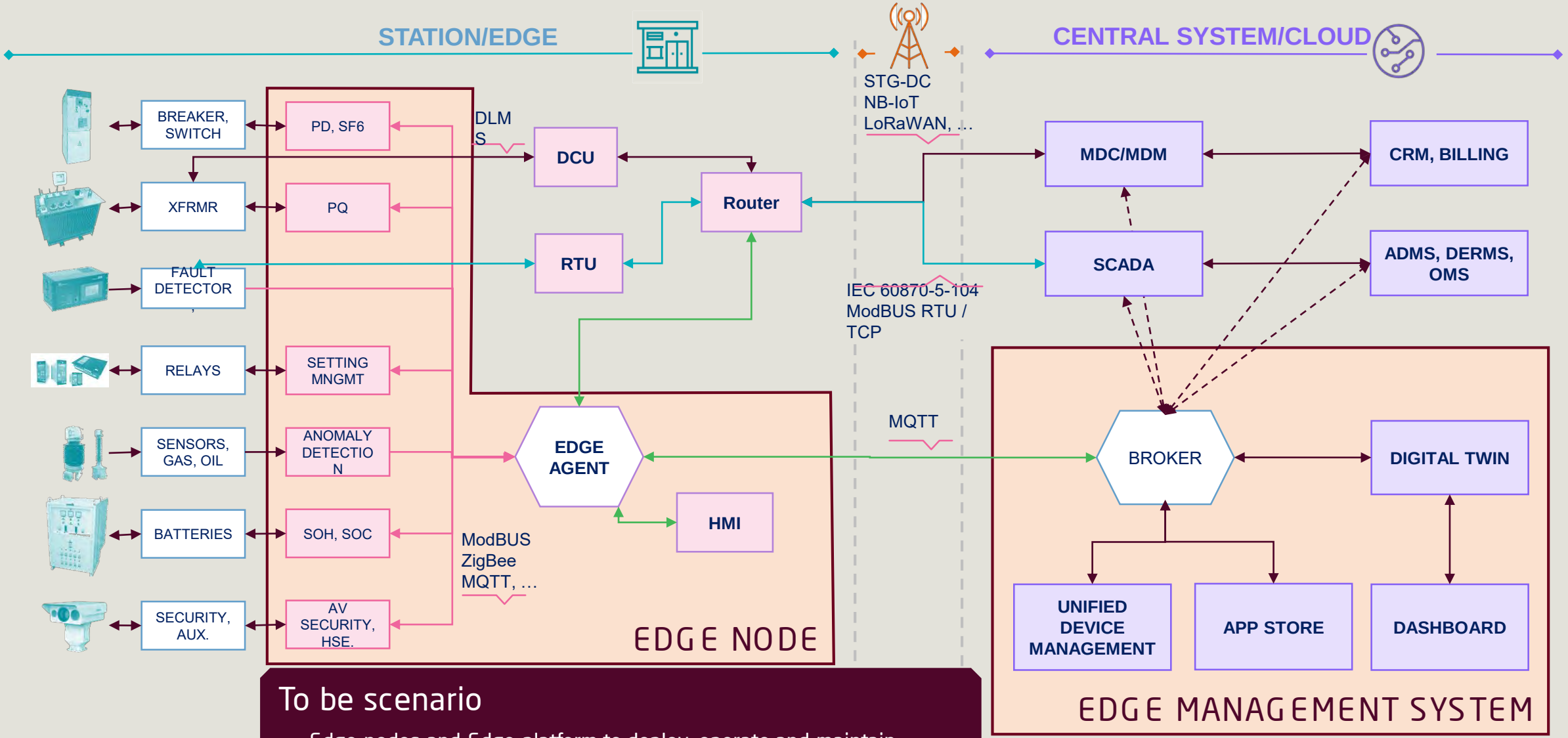
Transform secondary substations into Smart Grid Nodes...



As is scenario

- Discrete devices with a monolithic functionality: one device, one function
- Configuration tools are often proprietary programs from the vendors
- Changing settings requires individual access to the devices

… by implementing Edge WorkLoad Consolidation® …

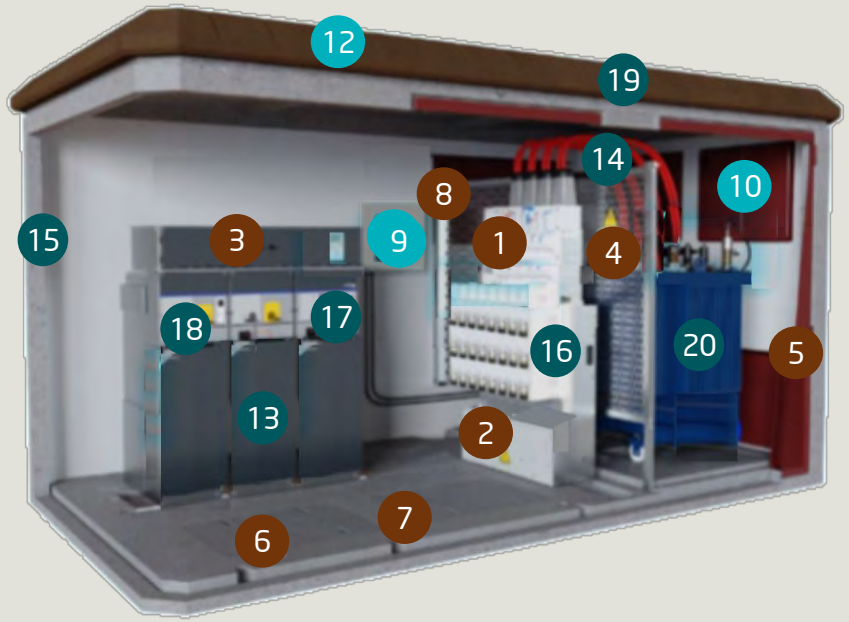


To be scenario

- Edge nodes and Edge platform to deploy, operate and maintain
- Support present and future Use Cases

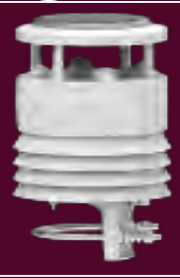
… and tackle new Use Cases in Secondary Substations

Fast and agile adoption of new operational scenarios



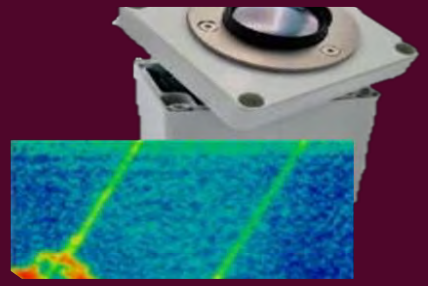
1. Transformer LV Monitoring
2. LV Feeder Monitoring
3. MV Monitoring
4. PQ monitoring IEC 61000-4-30
5. IoT Fire Sensors
6. IoT Flooding Sensors
7. IoT Open door sensor
8. IoT Temperature sensor
9. Virtual Router
10. Smart Lock
11. Smart Street Cabinet
12. IEC 62351 secure OT protocols
13. Gas SF6 Detection / Leakage
14. Partial Discharge
15. AI/AV/ML asset monitoring
16. Smart Flow: losses, fraud
17. Virtual Protection
18. Virtual PLC
19. Flexibility management
20. Virtual DCU
21. Device & Fleet Management
22. Modelling and Digital Twin
23. AppStore
24. Diagnostics

Evolving sensors and actuators



Weather Station

Ultrasonic anemometers with Modbus RTU interface for measuring wind speed and direction, solar radiation, temperature, humidity

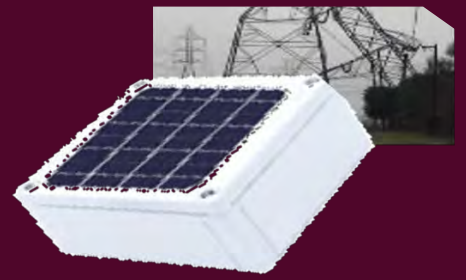


Thermal Sensor

Wireless IIoT Thermography device to monitor/detect elements of the electrical superstructure of power lines, overheating by means of AI

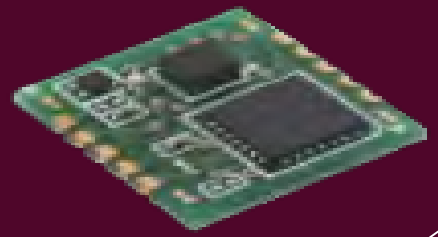
Dynamic Line Rating

System that determines the maximum ampacity of an overhead line (projecting it over a short-term time horizon)



Structural integrity

Solution capable of promptly detecting the incipient loss of verticality of the pylons that support the conductors



Seismic sensor

High-precision IoT seismic sensor.
Low electricity consumption thanks to 3-axis acceleration sensors and a unique SI (Spectral Intensity) value calculation algorithm.

Grid Eye

Computer Vision Processing is hardware dedicated to image processing through graphic filters and CNN (Convolutional Neural Networks) for early detection of events.

Air sensor

Direct detection of changes in air quality through the measurement of PM1.0, PM2.5, PM10 and CO2. Communication via Modbus RTU

Smart Lock

Mechatronic cylinders to ensure a high level of security and smart access management to critical areas such as substations, designed to replace traditional mechanical cylinders

EDGE+ Solution
Design and Construction

02

MINSAIT

Onesait EDGE+ Family

EDGE+

Processor and Comms unit

- 4 or 6 Core CPU
- Cellular, FTTH, Ethernet, serial

EDGE+

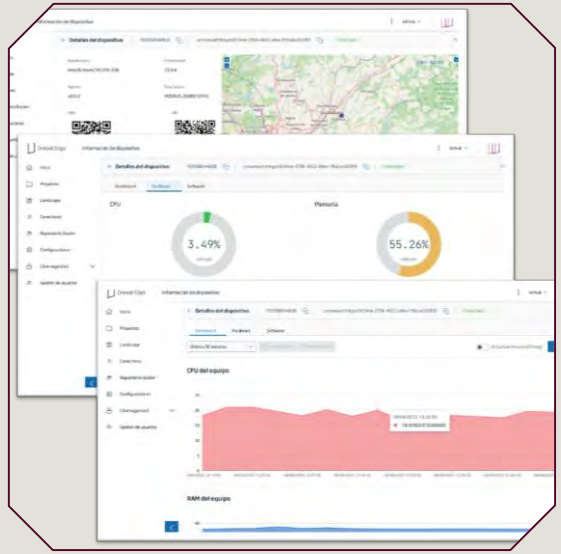
Port Expander module

- D I/O
- A I/O

EDGE+

PQ measurement module

- IEC 61000-4-30



Onesait Edge

Platform

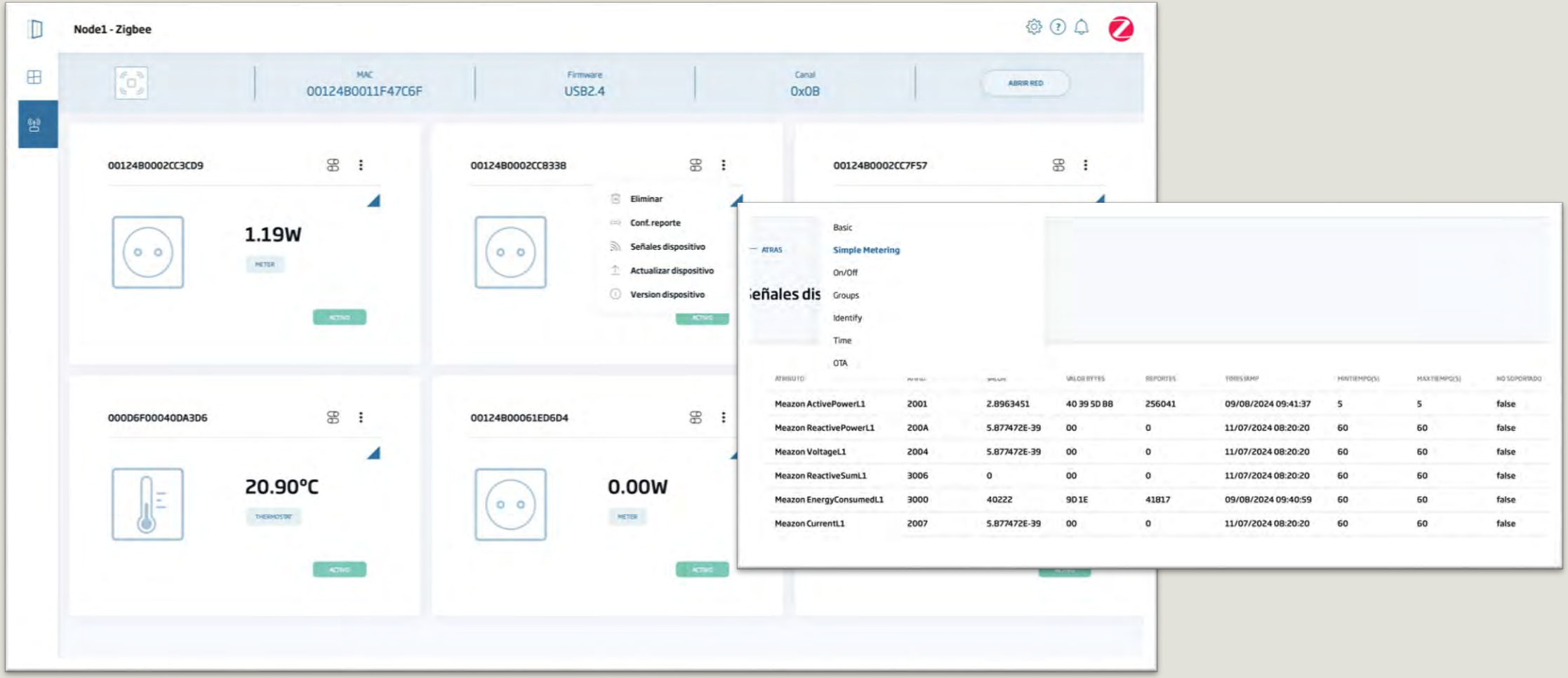
- Edge device management
- Workload management
- Data ingestión
- Remote command and control

EDGE+ Solution

03

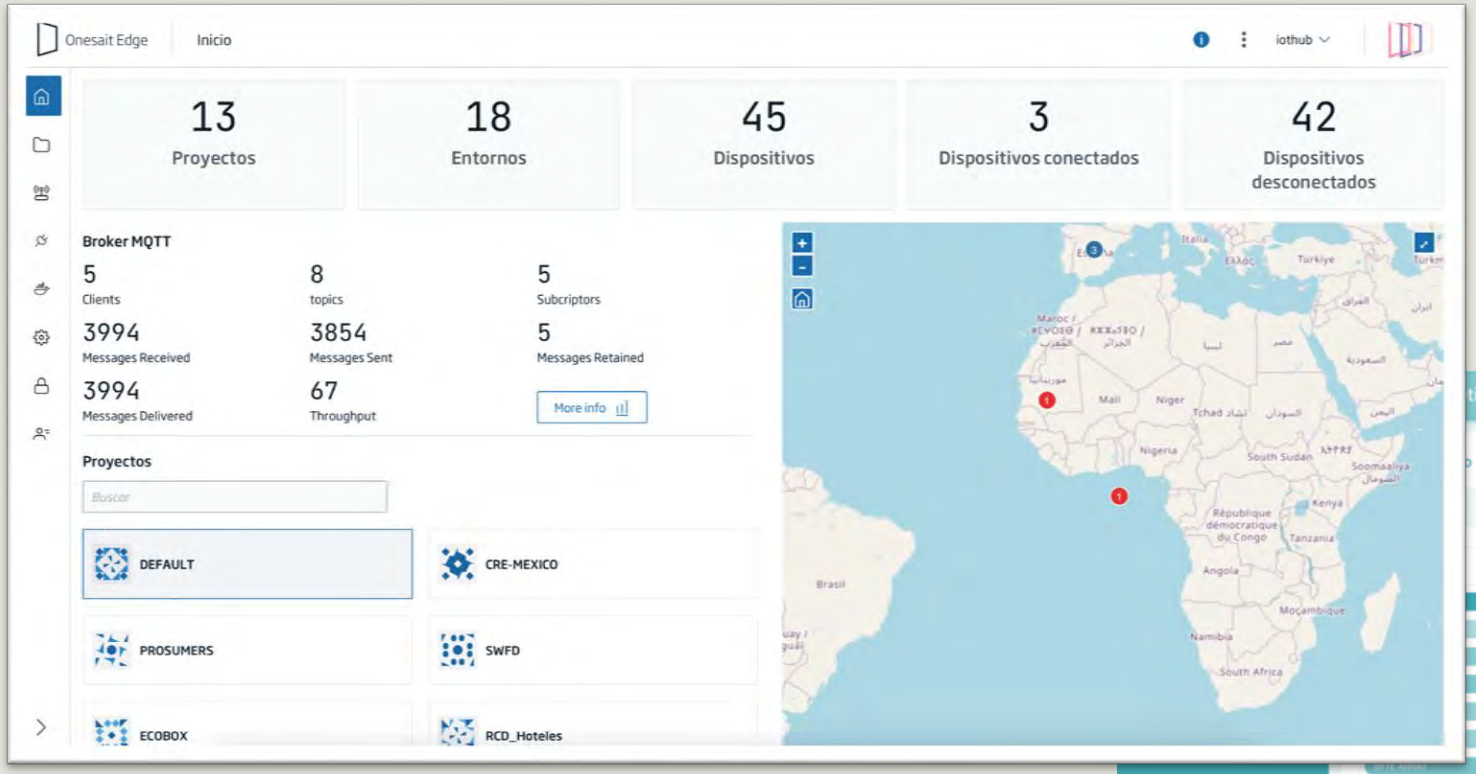
MINSAIT

Onesait Edge // Digital Twin



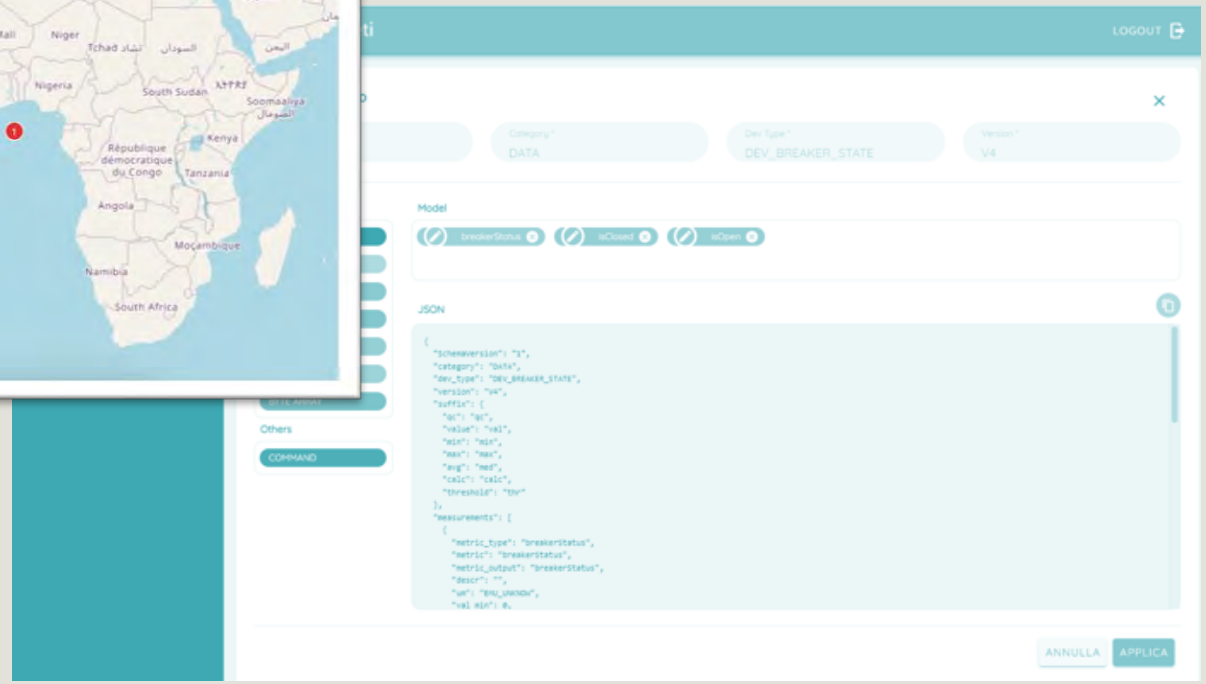
Edge+: Secondary Substation

Onesait Edge // GeoLocation & NoCode/LowCode User Interface



Geolocation

No-code / Low-code
User interface



EDGE+ Solution
Management platform

04

MINSAIT

Onesait Edge platform

DASHBOARDING

- System overview

DEVICE MANAGEMENT

- Device onboarding: zero-touch provisioning
- Performance monitoring
- Resource usage monitoring
- Software upgrade

WORKLOAD MANAGEMENT

- Application performance monitoring
- Remote Configuration
- Remote console and webUI access

USER MANAGEMENT

- User authentication
- Remote console and webUI access

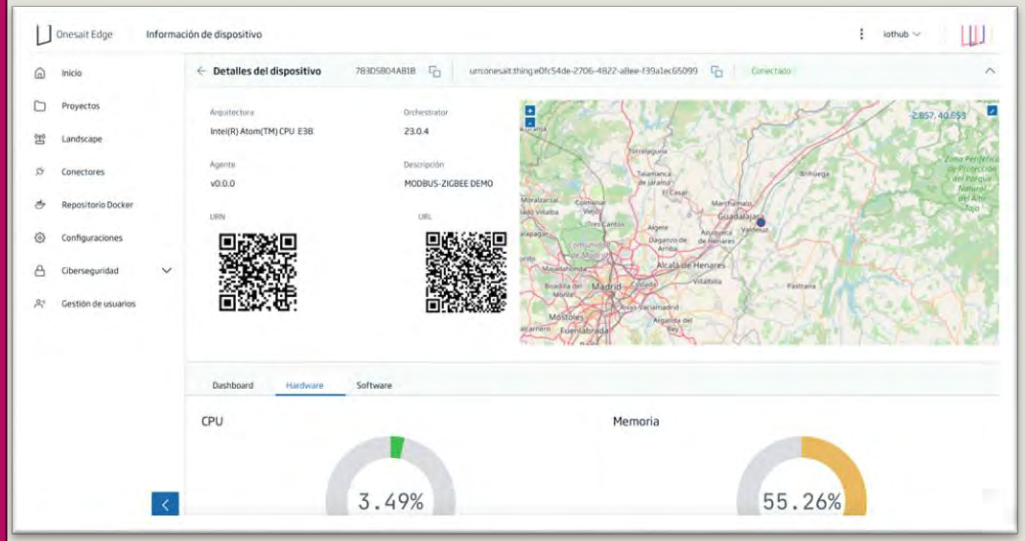
APP STORE

- Environmental sensors
- PQ
- vRTU
- vRouter
- vDCU
- vPAC
- vPMU
- ...

CYBERSECURITY

- Secure protocols
- TPM

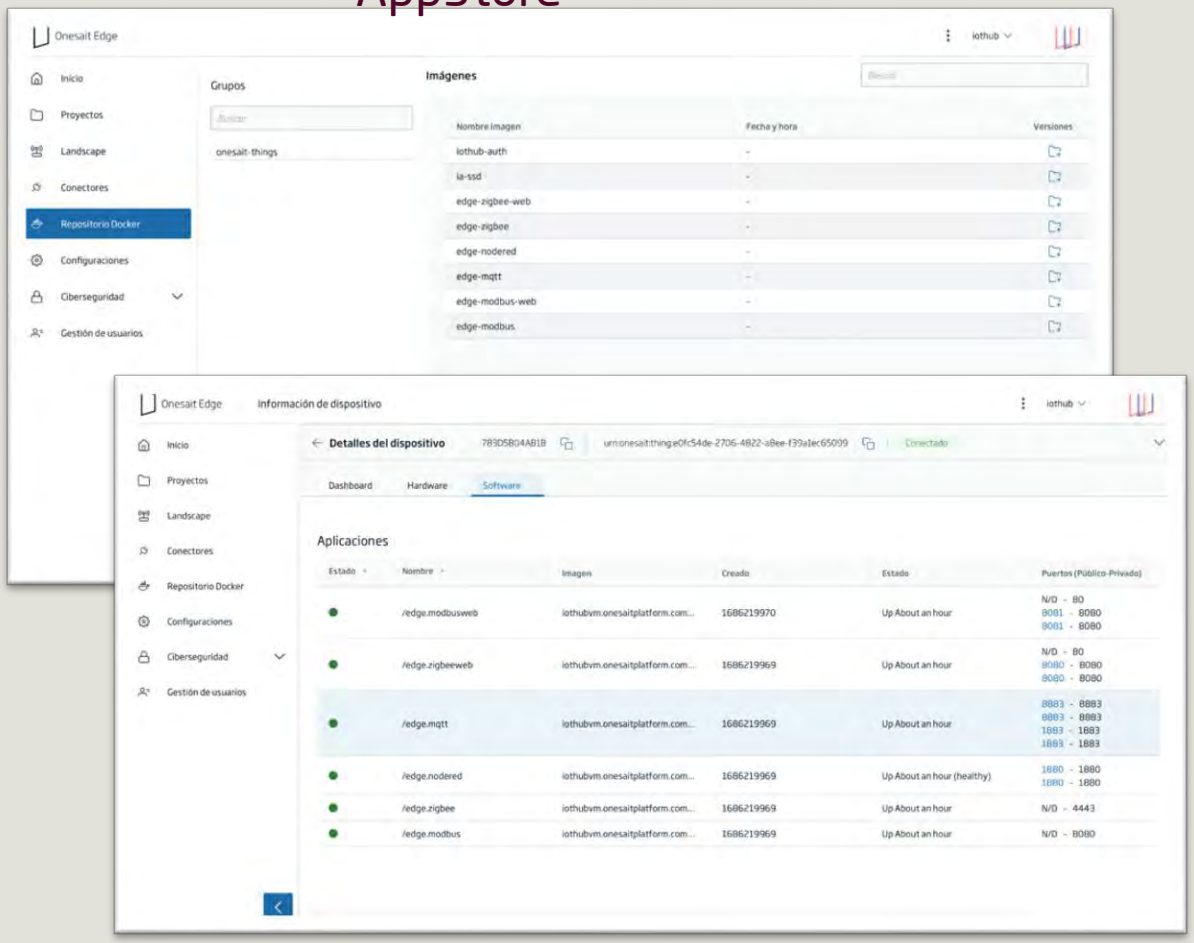
Landing page



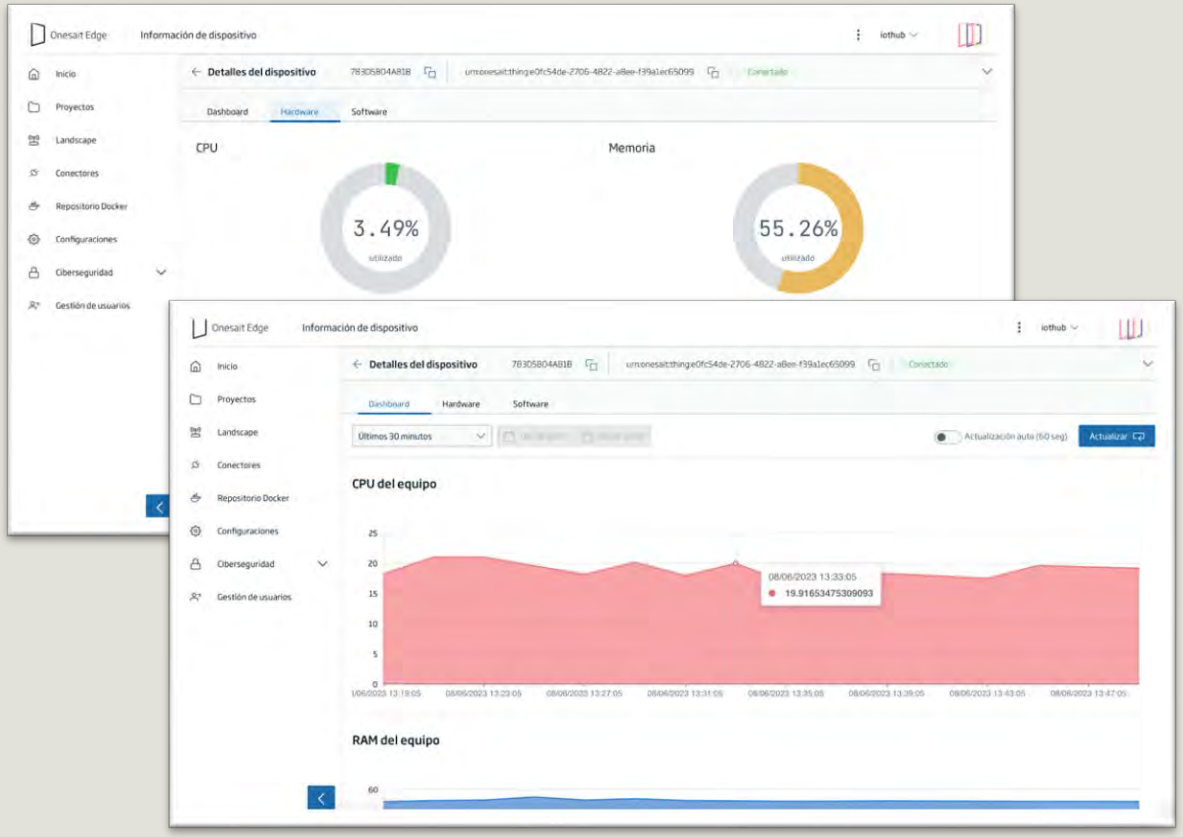
Onesait Edge // App Store & Workload Management

Technology - IoT & Edge Computing Platform

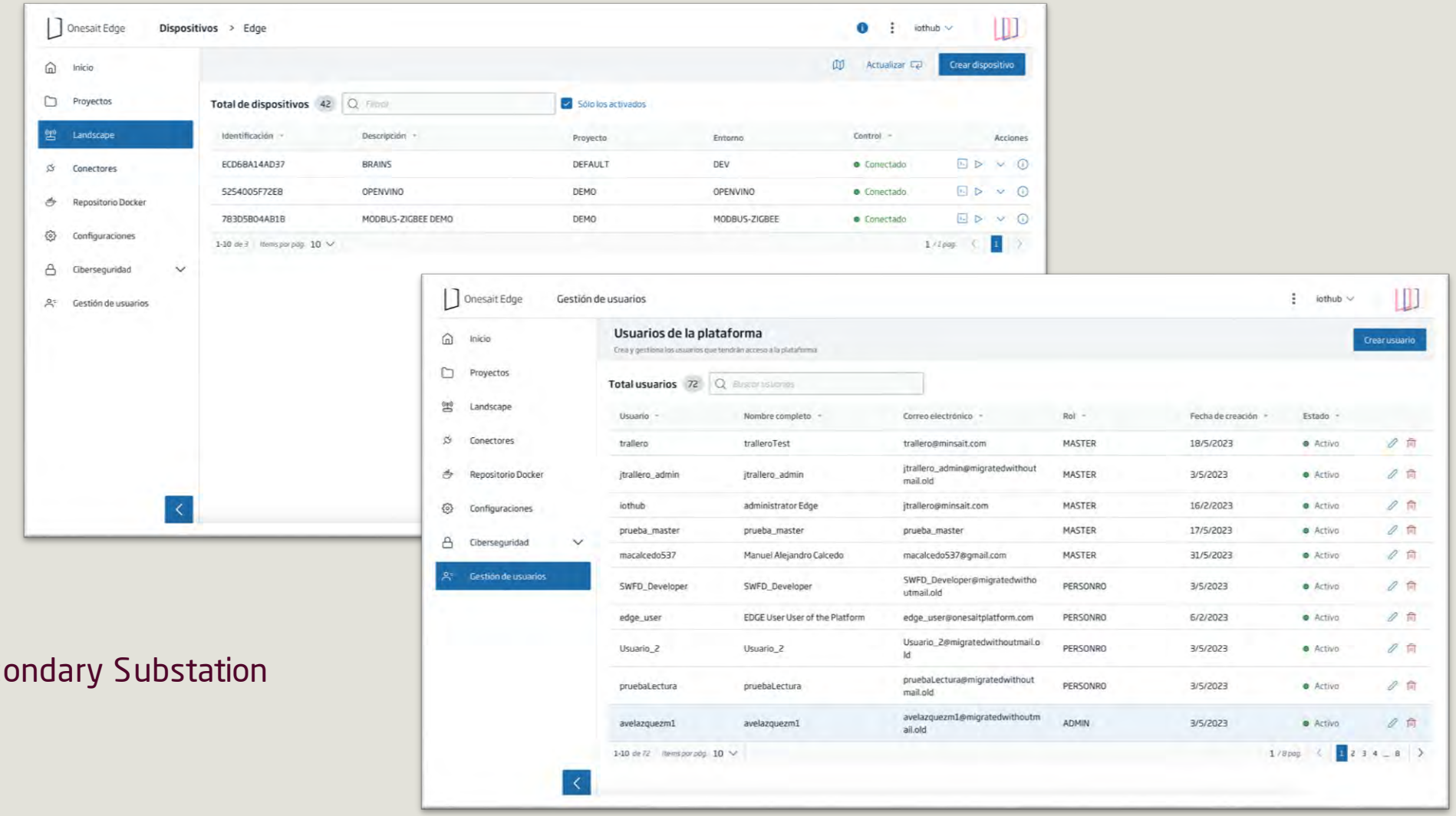
AppStore



Workload Management

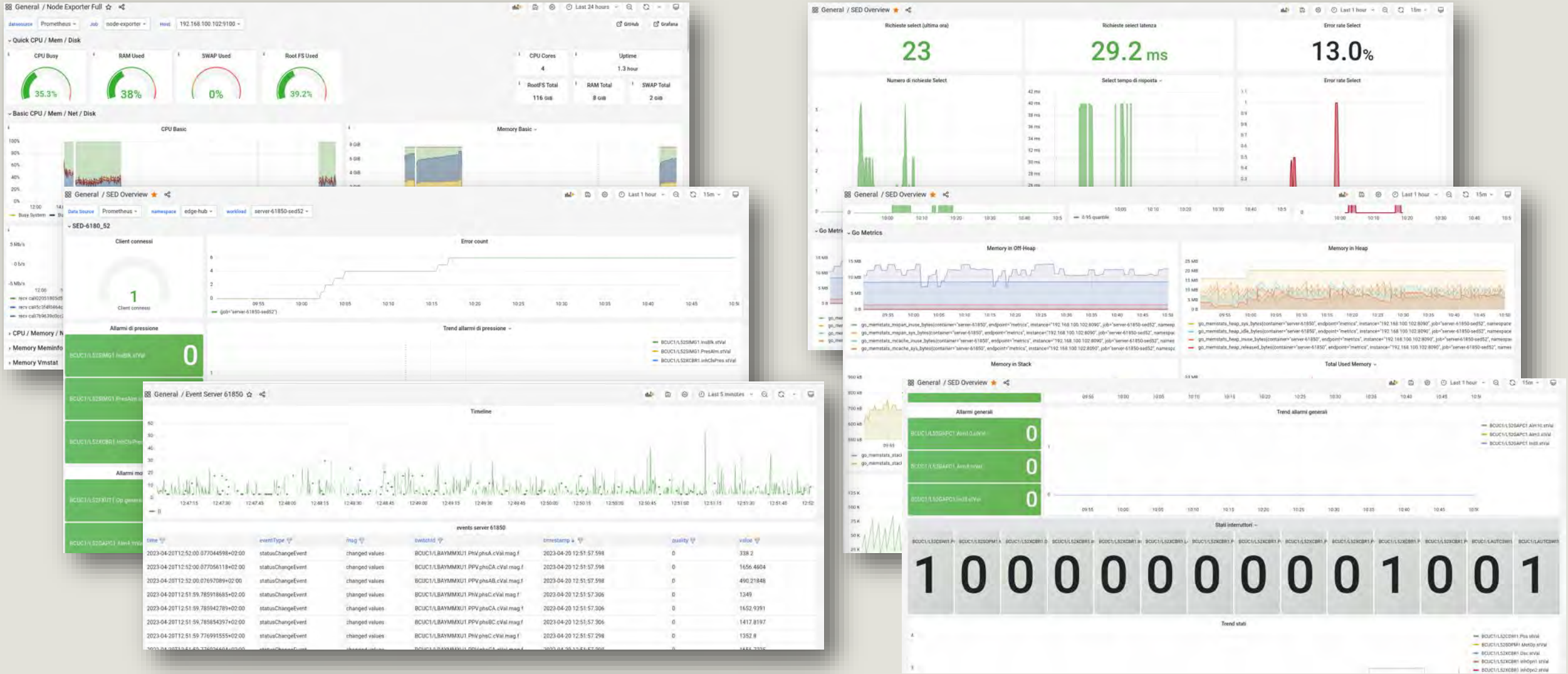


Onesait Edge // Device Management



Secondary Substation

Onesait Edge // Logging & Monitoring



References and succes stories

05

MINSAIT

From RTU to Managed Services

- Introduction of Edge devices in the MV/LV substations
- Virtualization of functions :
  - MV and LV RTU,
  - Virtual Router
  - other use cases.

Unified Device Management

- Manage RTUs from several vendors (Tesmec/ABB/schneider/COLGP)

Service Bus

- capable of interconnecting different systems, APM, SCADA, ADMS, WFM

LV Line Monitoring

Interface with Power Supply

- via RS485 and Modbus

Smart Lock

- for remote authorization to ccess MV/LV substatio

OC H24 with spare parts management

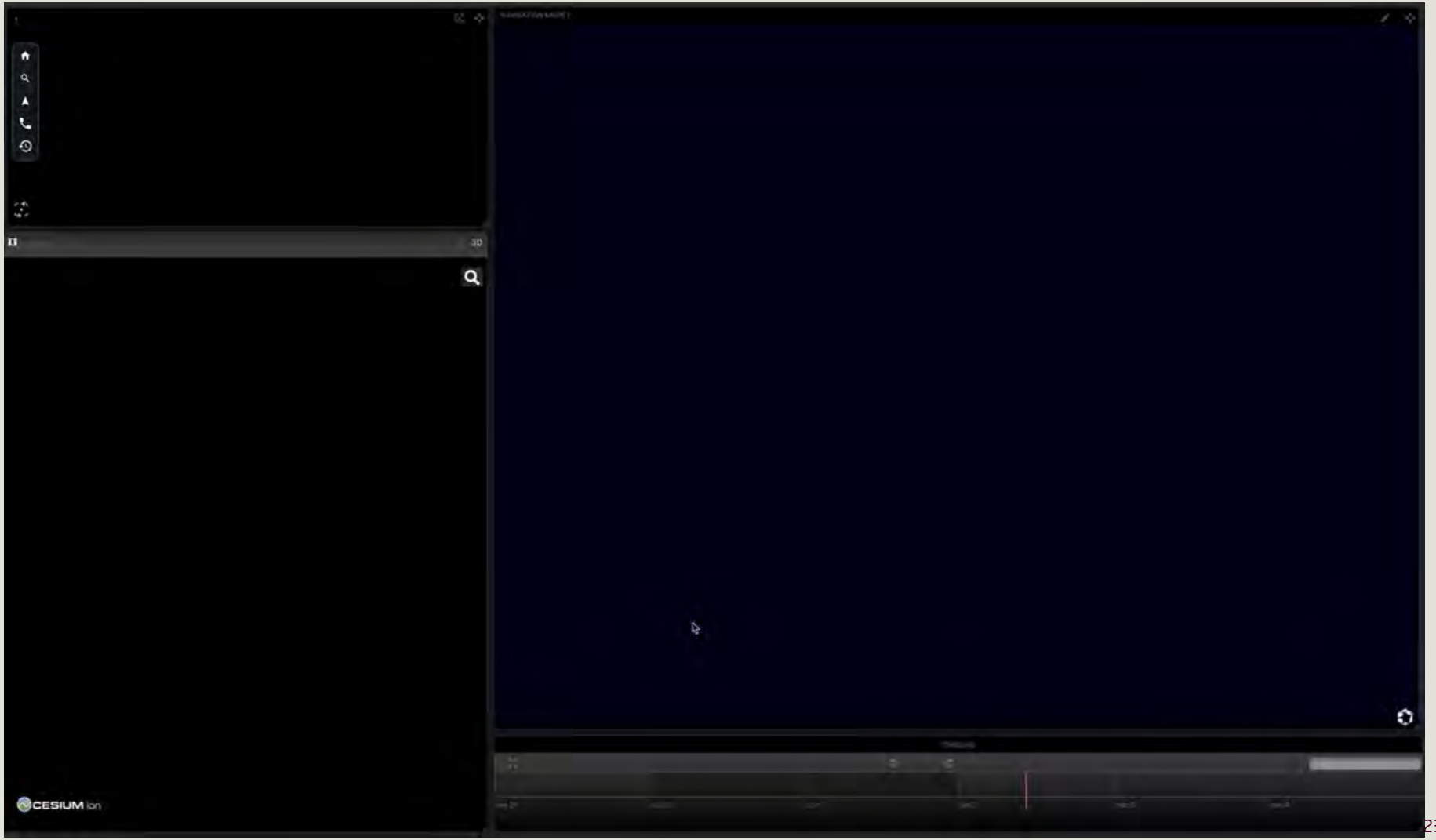
New sensors for predictive maintenance

Increased visibility of the substation

unareti

Design Challenges

- Connect and communicate with legacy OT devices
- Increase substation context data
- Introduce new monitoring logics at SCADA level
- Perform on-edge commands



Smart Secondary (MV/LV) Substation

Affected process

Deployment of new functionalities
Software updates
Device monitoring
O&M

HW/SW

Components of the substation
Edge computing node
Edge Management System
IoT Agent
Containerised applications
Virtualised devices

Edge Computing for Electricity Distribution

Deploy IoT and Edge Computing for decentralized management of the information gathered by the control systems from Iberdrola's distribution facilities

The system manages the deployment and operation of AMI, remote facilities using IEC 60870-5-104, integrating devices of different vendors using web services and avoiding on-site works

Functionalities

- Meter Data Concentrator
- Low Voltage Supervisor
- On-load tap changer control
- Energy balances
- LV network topology
- ...

SF6 GAS analysis in HV gas insulated substations (GIS) for renewable plants (Solar/Wind)

Considerations

Analyzers with focus on monitoring devices (fixed) rather than manual measurement devices

Measurement of density, humidity, temperature, pressure can provide important indications even without a chemical gas analysis that should be performed manually by specialized operators

Description

Sensor scouting for SF6 qualitative analysis.

Identifying methodologies for anomaly detection and possible predictive modeling

Approach

HW scouting with focus on fixed instruments, for example Gas Analyzers

Identification of installation methods and positioning

Parameter analysis (humidity, density, temperature, pressure etc.) according to IEC 60480

Identification of AI techniques for anomaly detection

Correlation of measurement parameters for predictive analysis (identification of early decomposition signals) inclusive of external (environmental and exogenous) parameters

Added value

- Early detection of potential faults in equipment
- Identification of deteriorated insulations
- Can provide additional information for PD analysis

Partial Discharge Detection on Bushing HV/MV in Renewable Plants (Solar/Wind)

Considerations

Analysis of unconventional detection modes may allow the identification of contactless solutions (e.g., antennas for detecting EM signals from PDs, ultrasonic acoustic detectors)

For conventional detection modes (capacitive, inductive) :

Ability to acquire PDs continuously.

Noise and noise elimination, as well as removing cross-coupling from other phases

Ability to discriminate whether the recorded PD activity is within the bushing

Measurement and annotation of arcing events

Description

Analysis of sensing methodologies

PoC E2E from Sensor to Phenomenon Predictive Model Development

Approach

Analysis of types of partial discharges in bushing (with focus on internal ones) and main failure modes

Sensor SWOT analysis (conventional - capacitive/inductive in the MHz range, acoustic, EM, optical)

Measurement analysis, for identification of parameters related to the phenomenon and annotation of main failure events

Definition of predictive algorithms on failure modes

Approach based not only on micro-current measurements, but rather on failure modes, correlating PD phenomena with changes in temperature, load, capacitance, power factor under operating conditions and with environmental and exogenous parameters.

Added value

In-line bushing monitoring, adding partial discharge analysis to relative changes in leakage current, can enable correlation patterns to identify failure modes and better plan offline testing and maintenance

Analysis of different detection modes can enable identification of the best trade-off for the specific EGP problem (e.g., conventional methods for pattern-recognition, EM methods for contactless detection)

Thermography HV Stations in Renewable Plants (Solar/Wind)

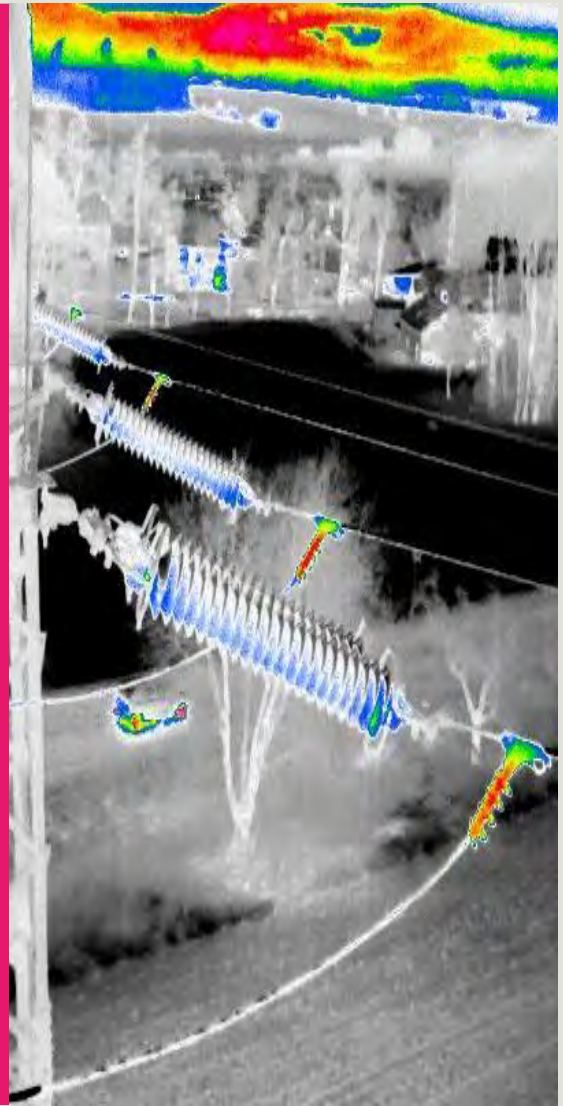
Considerations

Focus on priority anomalies (e.g., leakage, corrosion, damage, etc.)

RT Stream example: type, timestamp, integrity/anomaly, severity

Algorithmic approach:

1. Pre-processing, scaling and brightness correction
2. Object detection
3. Algorithm selection by anomaly type
4. Image reprocessing
5. Application of Machine Learning models to classify images



Description

Surveillance and monitoring to detect "hot spots" in major components and transformers, as well as to detect leakage or partial discharge

PoC E2E from Thermal Camera/Sensor to Predictive Model Development

Approach

HW scouting, focus on PTZ 360° cameras

Identifying positioning based on points of interest and defining anomalies in focus

Detection of changes in equipment conditions and in environmental parameters useful for correlation with respect to anomalies in focus

Application of AI techniques on images in pre-processing and post-processing

SWOT versus handheld and drone solutions

Added value

- contact and at a safe distance, without endangering operators and without shutting down the plant
- Identification of unbalances, poor connections, deteriorated insulation, possible gas leakage
- Utilization of thermal camera as general purpose sensor for a wide set of parameters (environmental and equipment temperature, presence of anomalies in operation, leakages, damages, etc.)

Anomaly Detection on Transmission Lines of Renewable Plants (Solar/Wind)

Considerations

Sensors on cables: pull, accelerometer, inclinometer, cameras

Malfunctions can be typically due to:

Unforeseen external situations, e.g., extreme weather conditions; impact with external objects; overcurrents or surges; human activities; degradation of components

Phenomena evolve according to different time scales, so attempts are made to address the phenomena both in the short term and in the medium to long term through different Data Science techniques

Description

Sensing methodologies analysis
Sensing methodologies analysis
Sensor scouting aimed at developing early detection failures models
Sensor scouting aimed at developing early detection failures models

Approach

Basic Asset Mapping - Detection of early signals of potential failure causes (by type of phenomena e.g. snow/ice, fire, lightning, hydrogeological phenomena, salinity and in general anomalies that may compromise structural stability)

Advanced - Detailed Asset Mapping and Maintenance Events Management: Statistical models, according to short/medium-term time horizons, thanks to sensor signals (local and in geographic proximity), compared to similar phenomena in the past

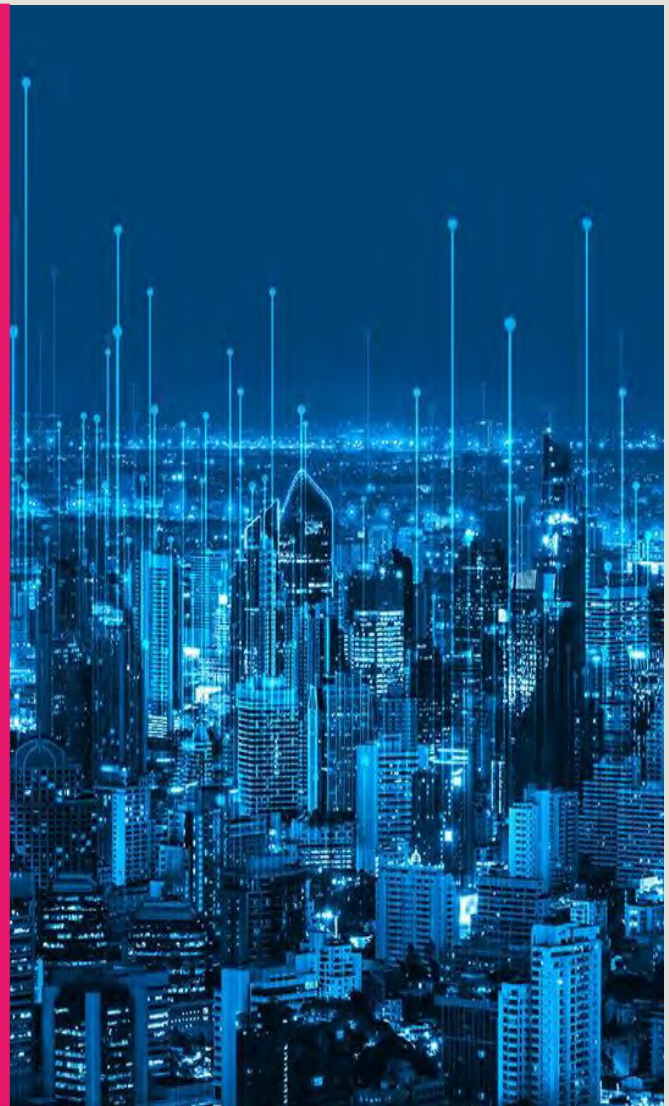
Implementation of predictive models over the medium/long term based on measurement patterns for a past time frame and transactional data from O&M processes, trained on real-time data

Added value

- Reduction of outages (disruptions);
- Reduction of network unavailability time;
- Increased useful life of assets;
- Optimization and efficiency of maintenance operations planning, scheduling, scheduling, execution, accounting and reporting

Infrastructure and applications for DERMS

UC San Diego



2

Hardware-in-the-Loop Simulators

2500

Edge Devices

>1 Million

Distributed Energy Resources

The project

DERConnect Project takes place in California, San Diego and it attempts to be the first-of-its-kind testbed aimed for utilities, academic institutions, researches and industry leaders to help them understand how to integrate DERs into the distribution power grid at utility scale.

The test-bed offers more than 2500 real and 1 million simulated DERs will be available to interact with the deployed solution.

DER Nodes: Edge device that will control and monitor one or several DERs

Key factors

- Key factors
  - o Size matters – simulations are made on utility scale networks directly importing utility network models.
  - o DERConnect CORE, blends simulated and real Hardware data with power electronics and a testbed for hardware testing
  - o Simulated DERs use real data.
  - o Communication topology among DER Nodes will be determined by users to create a variety of control algorithms and use cases
- Main Benefits:
  - o User will be able to deploy their proprietary control algorithms and compare them with the ones provided by the university and the Onesait DERMS platform
  - o The solution design has been oriented to reduce human interaction to the minimum in the process of setting up their tests.
  - o Test-bed customers will be able to design their tailored use cases and use either the provided DERMS functionalities or develop new ones.

Lesson learned

- A microservice-based architecture is key to guarantee the separation of functions and scalability, allowing the interaction of third-party solutions.
- DERMS has multiple use cases to cover, and the product can adapt to changes smoothly and with relative ease.

Artificial Intelligence (AI) for the operation of batteries based on price arbitrage strategies

1

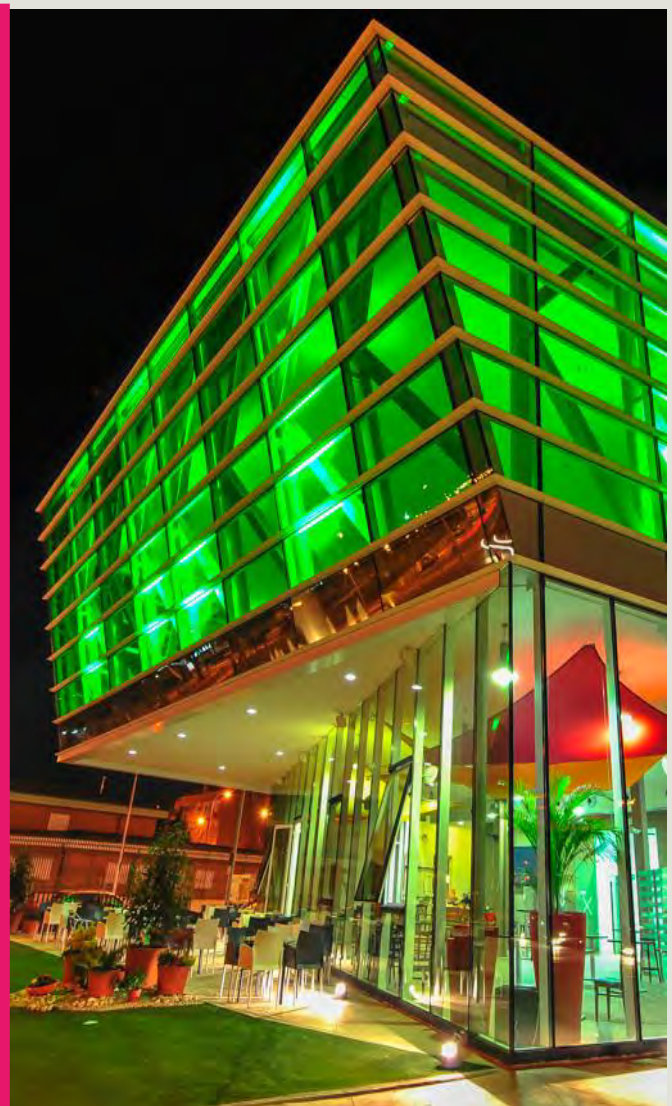
C&I building

250 kW

Contracted power

100 kWp

PV power and kWh Li-ion battery



Context

In a context of ever-increasing competitiveness in the provision of new energy services, Ferrovial is exploring new ways to maximize savings for their clients and create differential value propositions by taking advantage of new distributed energy resources, such as on site photovoltaic generation, batteries and electric vehicles. Ferrovial and Minsait have partnered to assess the viability of integrating **local storage optimization and demand management** processes into their routine operations, as a basis to develop a common **roadmap of new energy services.**

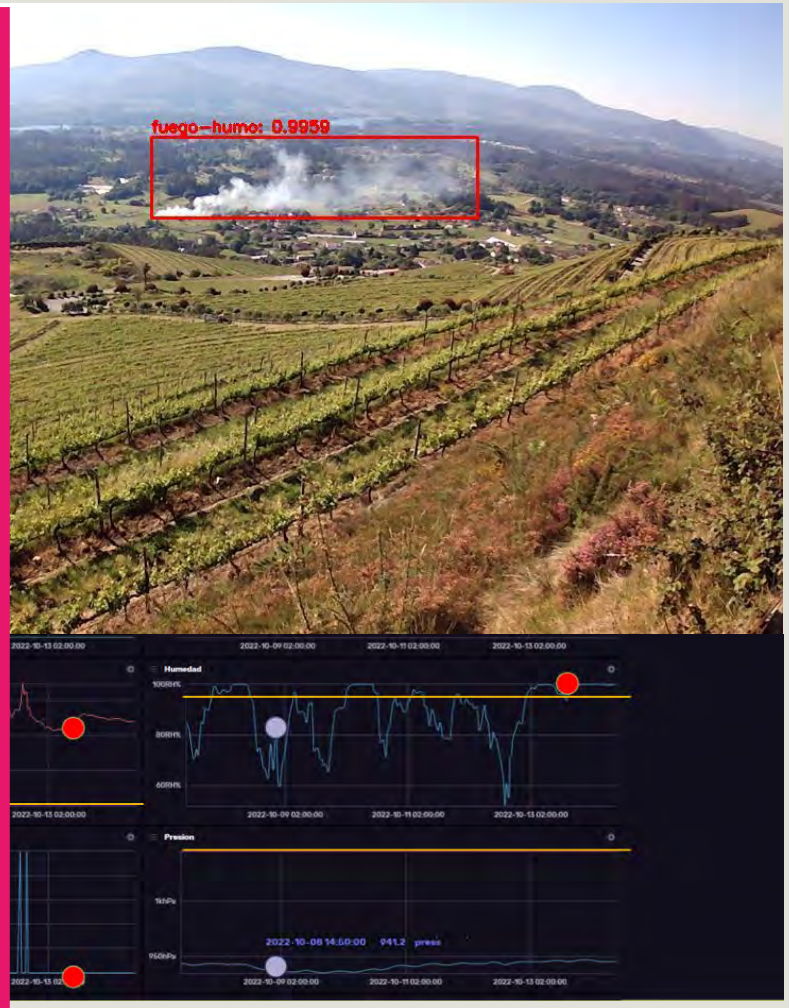
Key factors

- Key factors
  - Long-term service contracts and CAPEX-based business
  - Time-of-Use (ToU) tariffs
  - Onsite solar PV and storage capacity
  - Cultural building with variable usage conditions
  - Exploring the new business model and set a blueprint for future rollouts
  - Understanding cost drivers and analyzing the business case
- Main Benefits:
  - Integration of monitoring power meters, solar, battery and HVAC equipment under a single platform
  - Running an economic optimization model, based in historical demand, weather, occupation, working calendar and tariff, to calculate optimal operation schedules for battery
  - Running a second optimization model taking into account demand flexibility from HVAC, to calculate its optimal temperature set point schedule

Lesson learned

- There is value in the process since it helps understanding demand usage
- Leveraging existing monitoring equipment is key to make the business case
- Technology and AI are not plug-and-play and require adaptations to the specific site conditions
- Local flexibility services might reduce overall payback while preparing for the provision of services to the grid and the participation in markets

Grid Eye
Smart Wild Fire Detection



Edge Computing for Electricity Distribution

Grid Eye is a compact device that integrates Machine Vision algorithms, a set of sensors and IoT (Internet of Things) connectivity to offer a complete ecosystem for several services any company with distributed assets may take advantage

Its main scope of action is preventive maintenance, with the ability of identifying possible problems in advance or in real time as they occur in the case of spontaneous events.

Its design and construction integrates HW and SW optimized to guarantee self-sufficiency, reduce size, minimize consumption and maximize results.

Functionalities

- Fire alarm
- Object on line (e.g. branch)
- Twisted pole
- Faulty Insulator
- Nest on pole
- Object/vegetation close to danger zone
- J Worker safety
- Constructions underneath the line

Digitization of cables and lines

Considerations

Digitalization of underground cables and high-voltage overhead transmission lines

Integrate field systems for monitoring underground cables and overhead lines deployed throughout Italy with Terna's centralized IoT platform

Description

Enhancing Efficiency: Integrated IoT for Underground Cables & Overhead Lines with the Data Platform

Approach

Evaluation of cable and overhead line types, development and implementation of an IoT agent to collect underground cables and overhead line data.

The IoT Agent is designed to provide the following services/functions:

- Data acquisition from field sensors
- Data persistency
- Data processing
- Data collection via standard MQTTs 3.1.1 protocol;

Command & control: ability to receive command and control messages the standard MQTTs 3.1.1 protocol.

The field devices, through a LoRa modem, send the data collected from the field via the LoRaWAN protocol to the IoT Box. The IoT Box connects to Terna's central platform via Fiber or via LTE and sends the encoded and encrypted data to the central Network Server.

Added value

- Seamless integration with Terna's multi-vendor cable IoT platform
- Bundling and correlation of data generated by systems regardless of technology and vendor
- Streamlining of current data collection systems, leading to increased operational efficiency

IT/OT Substation Integration

Considerations

Introduction of a virtualization and automation model that allows:

- the reduction of hardware systems in the substation
- virtualization of assets
- device configuration management

Design and implementation of a system that allows real-time monitoring of the applications and the system itself.

Description

Full Digital Transformation of all Primary Substation components such as: high-voltage components (busbar systems, circuit breakers, etc); electrical station power supply systems; station automation system (SAS) for protection, command, control and monitoring system of the station; communication of Station Automation System with the Terna Control and Conduction System (SCCT).

Approach

Renewal project seeks cost-efficient, reliable substation of the future, incorporating existing solutions and exploring new use cases.

The project therefore contemplates the design of the Substation of the Future according to different stages:

- Understanding AS IS
- Market research and open source software solutions
- Definition of the guidelines and requirements of the Substation of the Future
- Design of a device/configuration management system
- Design and implementation of a distributed event flow bus through which the information can be accessed and published.
- Ensuring and improving the operability and resilience levels of the Substation of the Future.

Added value

Elimination of technological lock-in
Convergence of station services into a single IT/OT Data Driven infrastructure
Evolution of the resilience of substation systems
Remote operability of technological infrastructures
E2E Security By Design

IoT Platform

Considerations

Convergence of data streams from field edge devices onto a single platform

Streamlining how data is collected to enable advanced analytics

Technology Adaptation and Scale Up: Sizing and technology stack of new platform designed for volumes trending to future use cases

Description

Converged IIoT Platform: Advanced Analytics, Digital Twin, and Enhanced Asset Management for Terna's National Electrical Network

Approach

The new IIoT platform perform the following functions: Acquisition of information from field sensors; Information processing; Management of device master data; Management of commands and configurations to and from devices; Execution and management of applications deployed in the platform;

It allows to create a Digital Twin of installed assets through the integration and analysis of data collected in the field, and to manage applications through an AppStore

The dimensioning of the new solution is designed to be able to acquire data from the entire electrical network managed by Terna

The implementation technology involves the development of a microservices application, assisted by the integration of selected products on the market (database, LoRa network server, message broker)

Added value

Improved company information
Possibility to perform predictive maintenance
Improved KPIs for the management of national assets under Terna's responsibility
Improved service offered to the population
Digital Twin allowed the user to model the behavior and characteristics inherent to each class of device
AppStore allowing the management of the entire application lifecycle from a remote location

Optimized Grid Sensorization

Considerations

The IoT Sensing scale-up initiative will optimise and integrate monitoring systems, plant units and maintenance, gradually increasing the perimeter and level of control over Terna's grid.

It will enable optimized operations by means of the following main features:

- Real time anomaly detection
- Infrastructure RT monitoring
- Real time risk monitoring
- Conditioned based maintenance
- Preventive maintenance
- Predictive maintenance

Description

Risk Mapping Tool (SMR) aims to identify which pylons to equip with IoT devices, optimizing the IoT sensor scale-up on national scale, based on different types of risk. Certain risk factors are taken into account to determine the most vulnerable pylons and the existing installations are mapped.

Approach

- Data base validation and integration: Integration with Company Master Data and Systems; updating of cartographic data; dynamic spatial analysis
- Operational definition of the candidate sample: Integration of the Optimized Choice Algorithm into SMR (Scale up Sensors over the entire National Network)
- Shared sample validation: Development of a Custom Web Map; Integration of additional map layers into the Algorithm
- Creation of prioritization algorithms: Use the risk matrix, the network attributes and the geospatial constraints to rank the lines and pylons where to install new sensors according to predefined quantities and defining an optimized and uniform distribution over the territory for monitoring the different types of phenomena affecting the grid

Added value

- Real-time reporting of anomalies and faults to support decision-making for electrical load balancing modulation
- Support of personnel shift planning in the area for any events intercepted by the sensors
- Optimization of monitoring and maintenance activities
- Integrated governance in line with the different objectives of the Organizational Plans (Development, Safety, Renewal and Resilience)

Global Data platform for analytics/ML/AI

Considerations

Data platform services are necessary to **support a Data Driven organizational model** and to securely, efficiently and cost-effectively collect, store and leverage data for analytical purposes.

Digital solutions focus on:

- Collect and make information **assets** usable;
- Develop **tools** and **technologies**;
- Develop enabling **tools** and **technologies** from a data-driven perspective;
- **Data governance** (Iot & Data Platform), at the enterprise level

Description

Terna's Data Platform Services drive data-driven success with secure data collection, analytics, and governance, enabling enhanced processing and user experiences

Approach

The services in the Data Platform area include two types of services:

Application services: Design, development and maintenance of **new Data and analytics use cases**

Specialist support for the monitoring and evolution of the new applications: **Integration**; **Data management**; **Data protection**; **Application security**; **Feasibility** studies for development and evolution projects of the technology stack; **Advanced design** activities;

Technology Services: **Migration** from the transition solution to the target **Data Lake solution**

Data Lake Implementation

Specialist **support and AMS**

Added value

Converging to a Full Hybrid IT model in which data and applications are shared at the enterprise level, fully integrated through the Hybrid Ecosystem Integration framework, results in:

- New processing capabilities (more flexible and scalable);
- New modes of application integration;
- New simplified user, governance and management experiences

MINSAIT