Smart5Grid

Demonstration of **5G** solutions for
SMART energy **GRID**s of the future

5G PPP
The 5G Infrastructure Public Private Partnership

SUSTAINABLE PLACES 2021
Sep. 28 - Oct. 1, 2021 | Rome, Italy

This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement n° 101016912

Consortium Composition

24 partners, 2 Linked Third-parties, 13 SMEs

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Coordinator

enel

TELCOs

WINDTRE

OTE GROUP OF COMPANIES

VIVACOM

NETISSAT

Tech Companies

ENGINEERING

Atos

Universities/Research institutions

i2cat

HELLENIC REPUBLIC
National and Kapodistrian University of Athens
EST. 1837

University of Cyprus
KIOS

DSOs

e-distribuzione
e-distribución

TSOs

ECO ЕАД

ադμηε

SMEs

EIGHTBELLS
Independent Research & Consultancy

INFOLYSIS

SC

NBYCOMP
NearbyComputing

axon logic

ubiwhere
SUITING THE FUTURE

ATHONET

SETECHCO

SIDROCO

ENTRA ENERGY

UBITECH
digitizing energy

nosia
- SEÑALIZACIÓN INDUSTRIAL
- EQUIPAMIENTO PARA LA INDUSTRIA

STAM
MASTERING EXCELLENCE

(Linked third-parties of Enel GI&N)

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GENERAL INFORMATION

THE CONSORTIUM

24 EUROPEAN PARTNERS COVERING 7 EU STATES

DURATION

3 YEARS

TOTAL BUDGET

8M€

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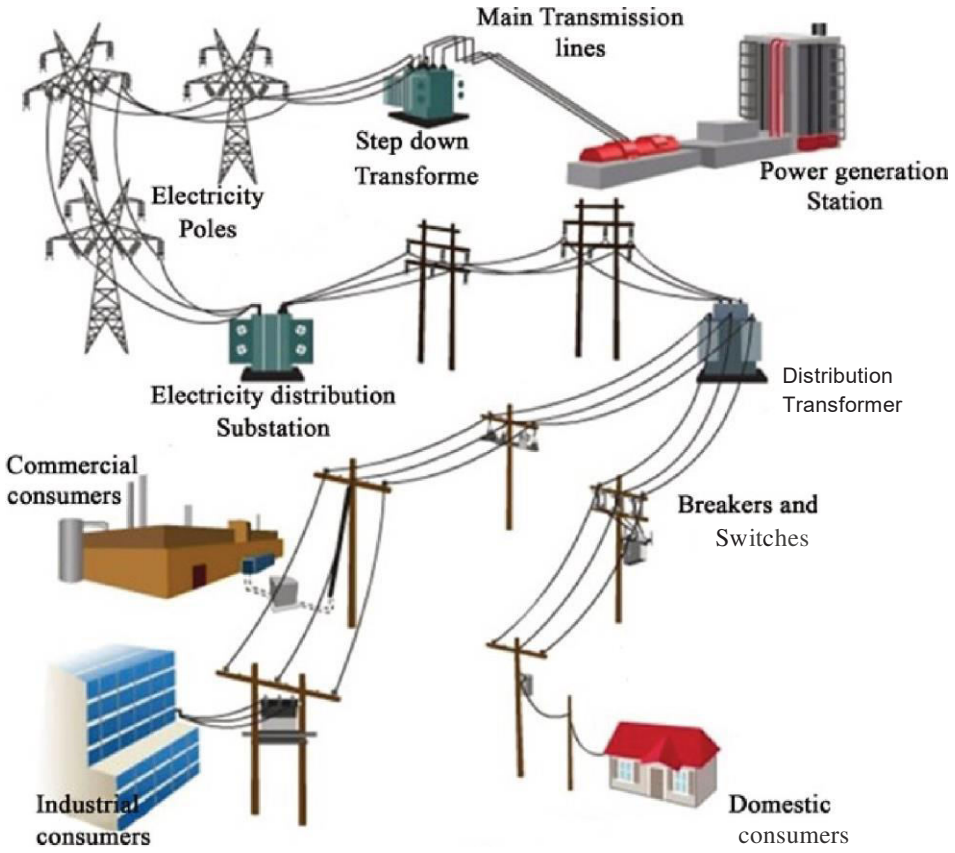
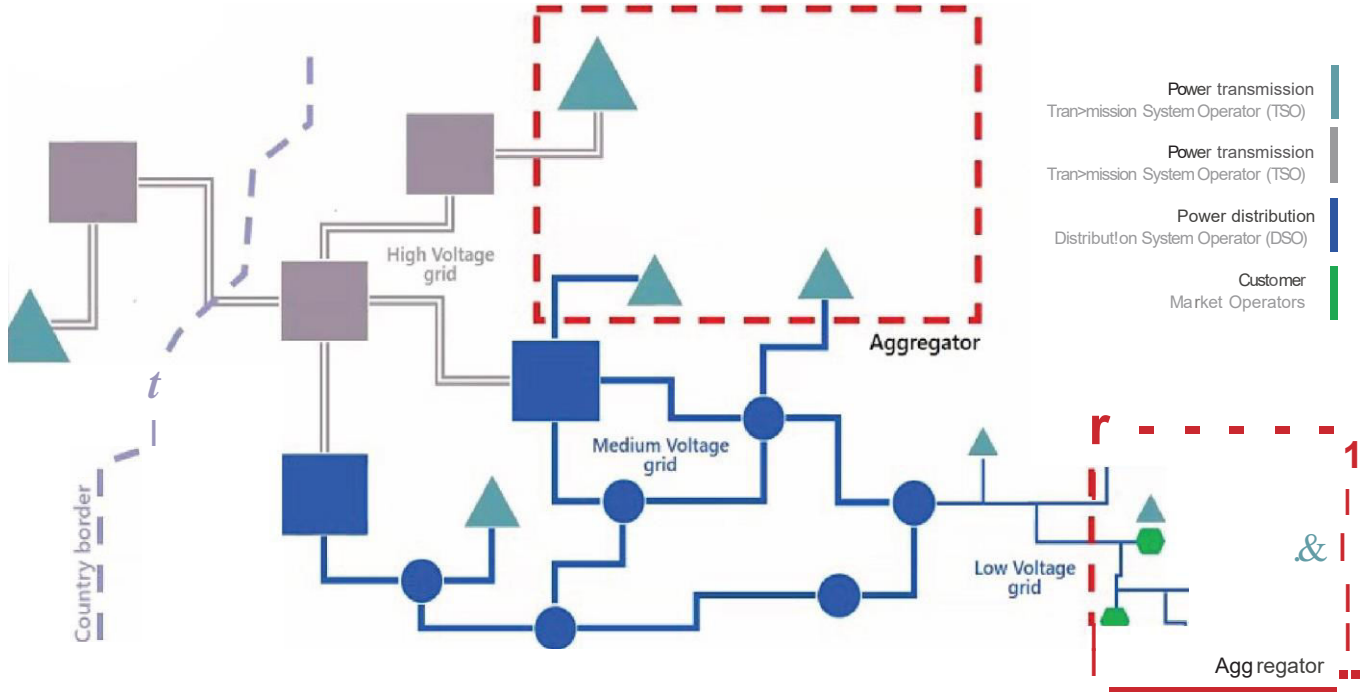
ENERGY VERTICAL



Traditional Power Grid



Smart Grid

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ENERGY VERTICAL – SGAM VS Smart5Grid Architecture

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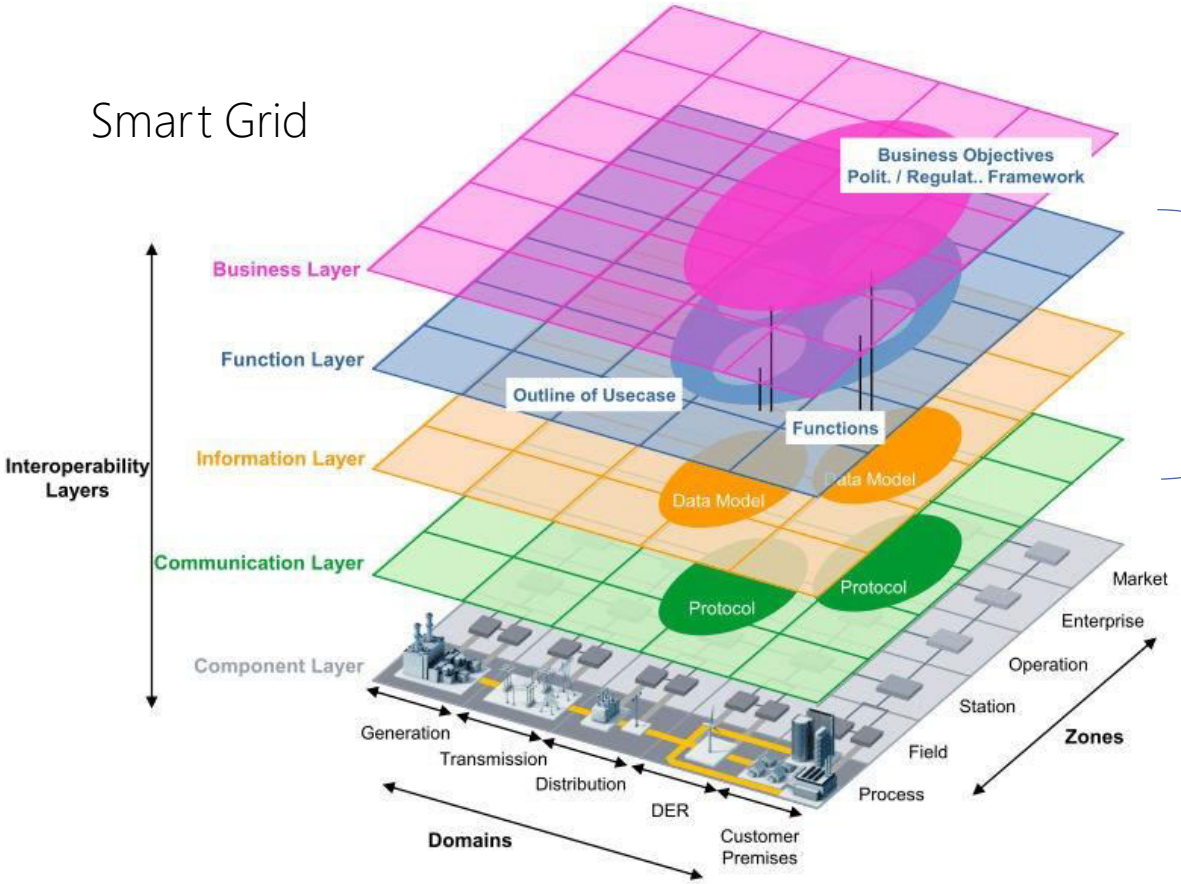
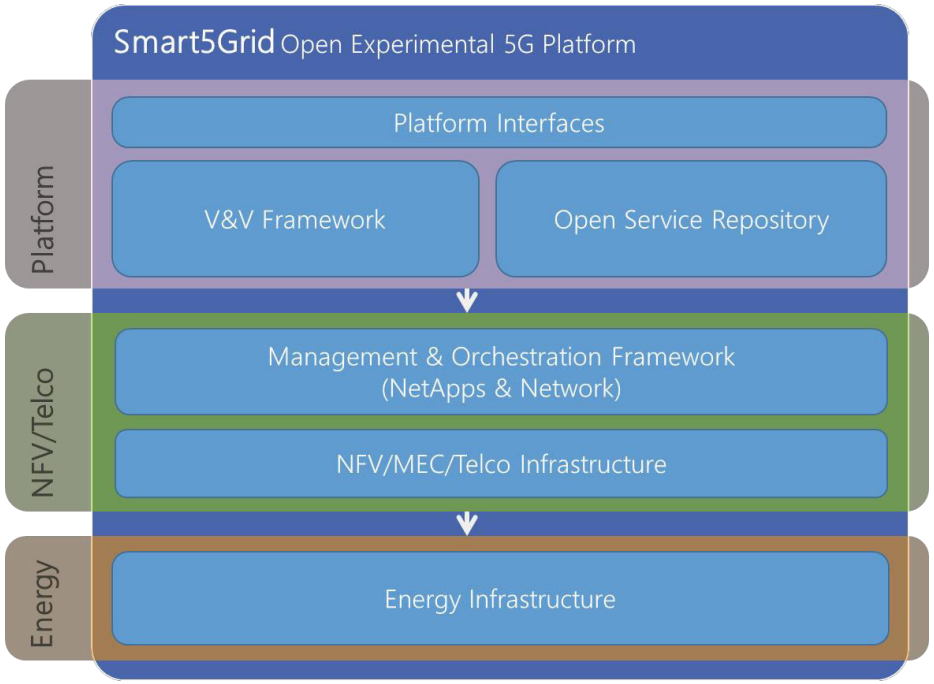
Smart Grid





Smart5Grid High-level Architecture

Source: , CEN-CENELEC-ETSI, Smart Grid Coordination Group, *Smart Grid Reference Architecture*, Tech. Rep., 2012

Key Objectives

Through deployment of **5G networks** and respective **NetApps** that will be developed and validated on real power grid facilities, **Smart5Grid** will facilitate the current energy sector stakeholders (DSOs, TSOs) as well as future smart grid shareholders (i.e. SG operators, Independent System Operators, Energy Aggregators, Regional Distribution Organizations, Energy Service Providers (ESPs), etc.) to:

i) easily and effectively create advanced energy services,

ii) interact in a dynamic and efficient way with their environment, and

iii) automate and optimize the planning and operation of their power and energy services

Objective #1

To specify the critical architectural and technological enhancements from previous 5G PPP Phases needed to fully enable an **open experimental platform** for the **Energy vertical**

Objective #2

To design, deploy, operate, and evaluate in real world conditions the **baseline system architecture** and **interfaces** for the provisioning of an integrated, open, cooperative, and **fully featured 5G network platform**, **customised for smart energy distribution grids**

Objective #3

To develop an **open NetApp repository**. In conjunction with the 5G network facility, the **Open Service Repository** will have access to network resources and it will be used to develop and accommodate NetApps, providing rapid access and execution environment to developers, third parties, and **SMEs** from the energy vertical sector

Objective #4

To develop **high-performance NetApps** that will support the ambitious Smart5Grid energy-oriented use cases

Objective #5

To provide a Validation and Verification (V&V) experimentation framework for NetApp **automatic testing**, **certification**, and **integration**

Objective #6

To realise **four advanced 5G real-life demonstrations** over a wide set of energy related use cases. To exhibit that performance has been conforming to 5G PPP KPIs

Objective #7

To conduct a **market analysis** and to establish new business models. Detailed techno-economic analysis and road mapping towards exploitation and commercialisation by industry partners and SMEs are also of high priority for the project

Objective #8

To ensure **maximisation** of **Smart5Grid impact** to the **realisation** of the **5G vision** by establishing close liaison and synergies with 5G PPP Phase-2 and 3 projects and the 5G PPP. To pursue extensive dissemination and communication activities, as well to assess the perceived impact from the stakeholders and the wider community

Use Case Highlights

- ✓ **Smart5Grid** intended to boost innovation for the highly critical and challenging energy vertical by **providing an open 5G enabled experimentation platform** customized to support the smart grid vision.

- ✓ The Open Smart5Grid Experimental platform is meant to be **a marketplace where stakeholders** in the energy vertical, ICT integrators, Network Applications developers, telecom industry actors, SMEs, and/or network service providers in general **will be able to test and validate their NetApp solutions in the context of four specific vertical use cases and to create 5G open-source repositories for wide use and towards standards development**.

- ✓ **Four use-cases to capture a wide range of power system operation scenarios**:

  UC1: Automated fault detection and self-healing in distribution grids (IT demo)

  UC2: Improving safety for maintenance workers in high voltage power substations by use of intelligent cameras and wearable sensors (ES demo)

  UC3: Millisecond level monitoring of distributed, renewable-based power generation resources (BG demo)

  UC4: Wide Area Monitoring (WAM) of large interconnected and cross-border power grids (BG-GR demo)


Italian Demo | Olbia


Smart5Grid
Spanish Demo | Barcelona


Bulgarian Demo | Southern region


Bulgarian-Greek Demo | Cross-border

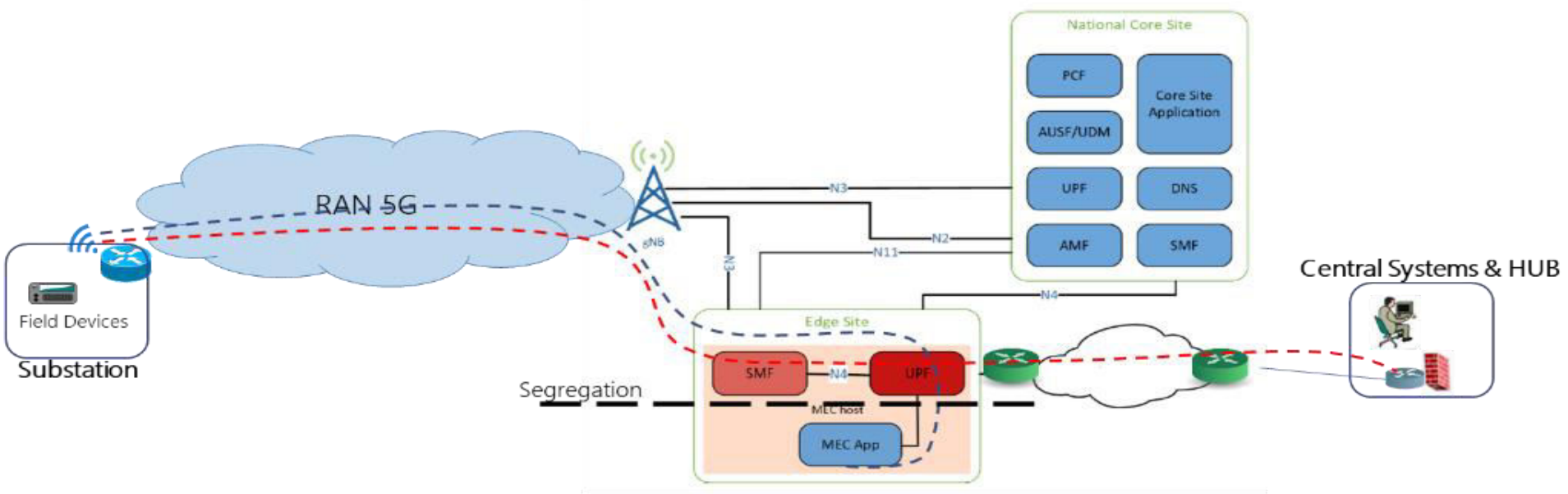
Use Case 1

Automatic Power Distribution Grid Fault Detection (e-Distribuzione, IT)

Pilot demo of **real-time identification and insulation of faults in the backbone distribution network (self-healing)** and **automatic recovery in less than 1 sec** using an array (thousands) IEDs and an experimental Smart5Grid MEC platform where specific NetApps will provide flexible and interactive self-healing functions:

- Ultra-fast fault detection and isolation and rapid recovery of regional power supply (ultimate goal of less than 5 msec vs 500 msec of typical controller self-healing time after fault isolation)
- URLL and mMTC 5G network services by NetApps running on the Smart5Grid platform to enable effective and quasi-instantaneous operation of grid control and protection devices
- Extracting valuable data for end-users by leveraging on automatic selection of distribution of network failures based on the communication between protection and fault detection devices on real power distribution infrastructures over a public 5G network
- Minimizing SAIDI (System Average Interruption Duration Index) and CAIDI (Customer Average Interruption Duration Index) of the smart energy grid at DSO level

UC1 Layout



LEGENDA

- Remote Control traffic in end to end tunnel
- Monitoring Traffic by NetApp

Use Case 2

Remote Inspection of Automatically Delimited Working Areas at Distribution Level (ENEL, ES)

Pilot to demonstrate how the developed 5G platform and NetApp capabilities for **remote inspection of automatically delimited working areas at distribution level through the deployment of a private 5G network** can improve personnel safety and efficiency and reduce the costs of inspections of energy distribution grid assets:

- Prevent the exposure of maintenance personnel to dangerous working conditions (high climbing for tower/pylon inspections, difficult ground patrols, electric arc hazards, etc.)

- Enable high-safety remote inspection and maintenance of delimited working areas at distribution level form central offices to support risk prevention and achieve efficient and short-duration inspection and maintenance procedures without compromising quality

- 5G eMBB will permit high-bandwidth data exchange between grid monitoring devices (sensors and HD cameras) and the cloud-based inspection platform in order to be processed with AI and ML based algorithms and interface modules for automated evaluation of equipment condition and automated delamination of working areas for remote inspection

UC2 Layout

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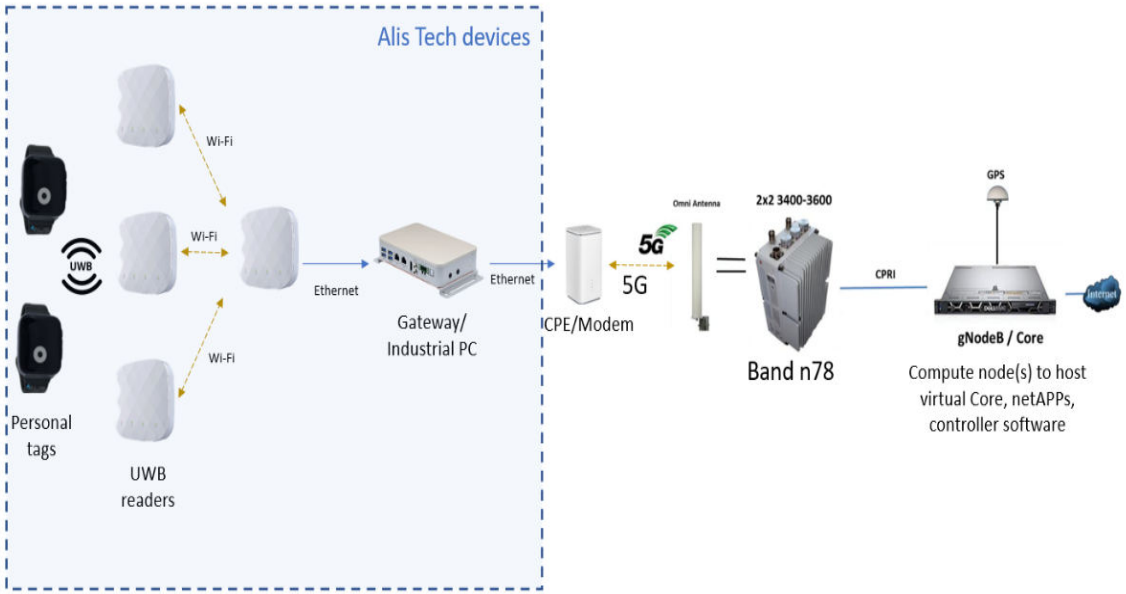
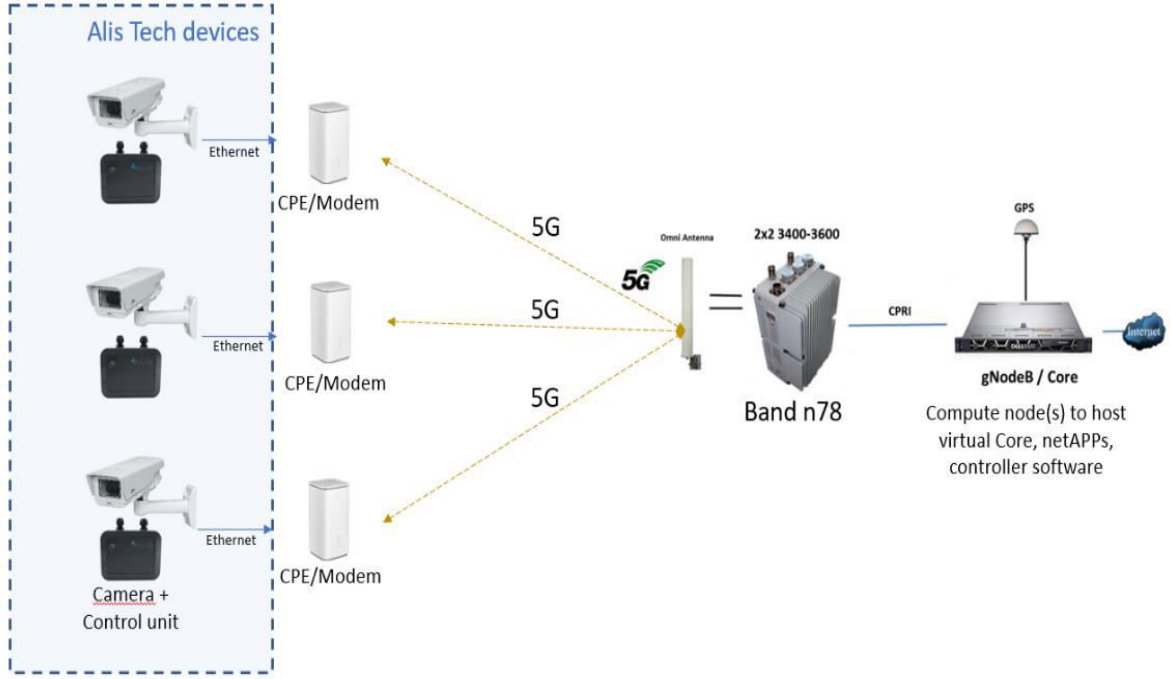
Spanish Pilot

Example of private 5G network + UWB

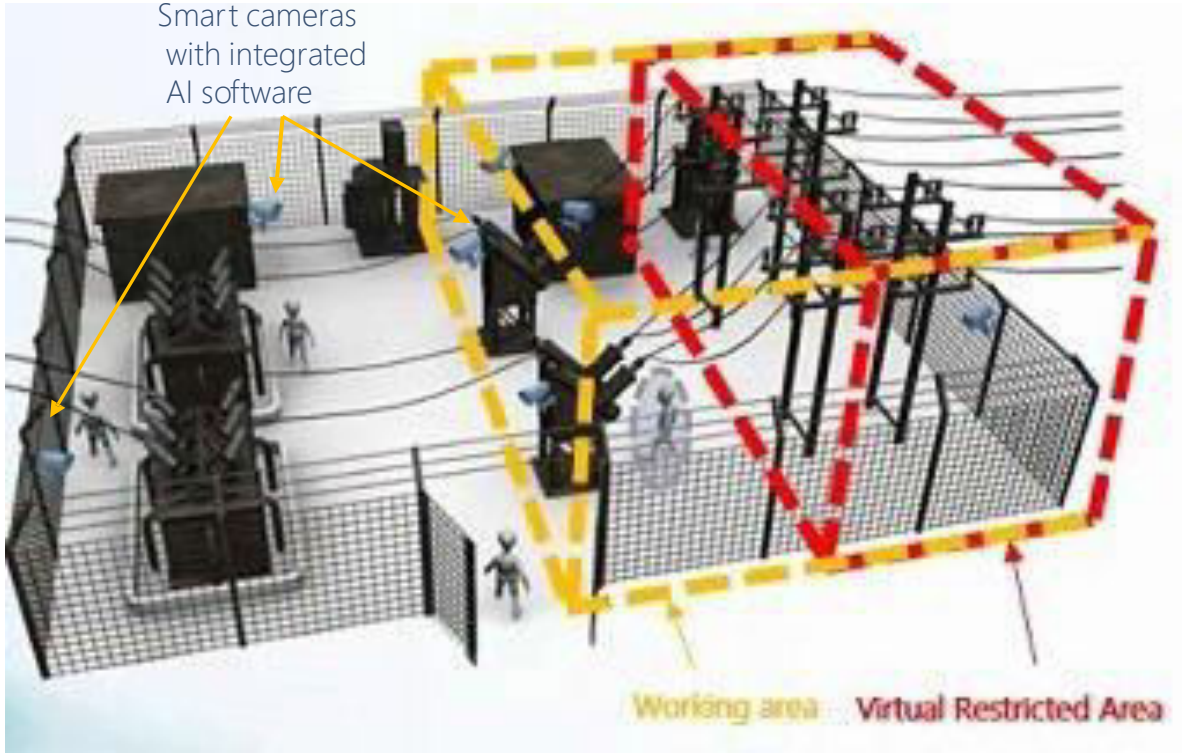


Spanish Pilot

Example of private 5G network + cameras



UC2 – Spatial Demo



(UC#2) (DSO- Safety)

Remote Inspection of Automatically Delimited Working Areas at Distribution Level, Garraf Natural Park, Barcelona, Spain.

A system for monitoring the safety of workers performing maintenance tasks in HV power substations, using a private 5G facility. High resolution 3D cameras with integrated AI software will assist workers during their maintenance, avoiding them to reach energized power equipment, which could endanger their lives.

Use Case 3

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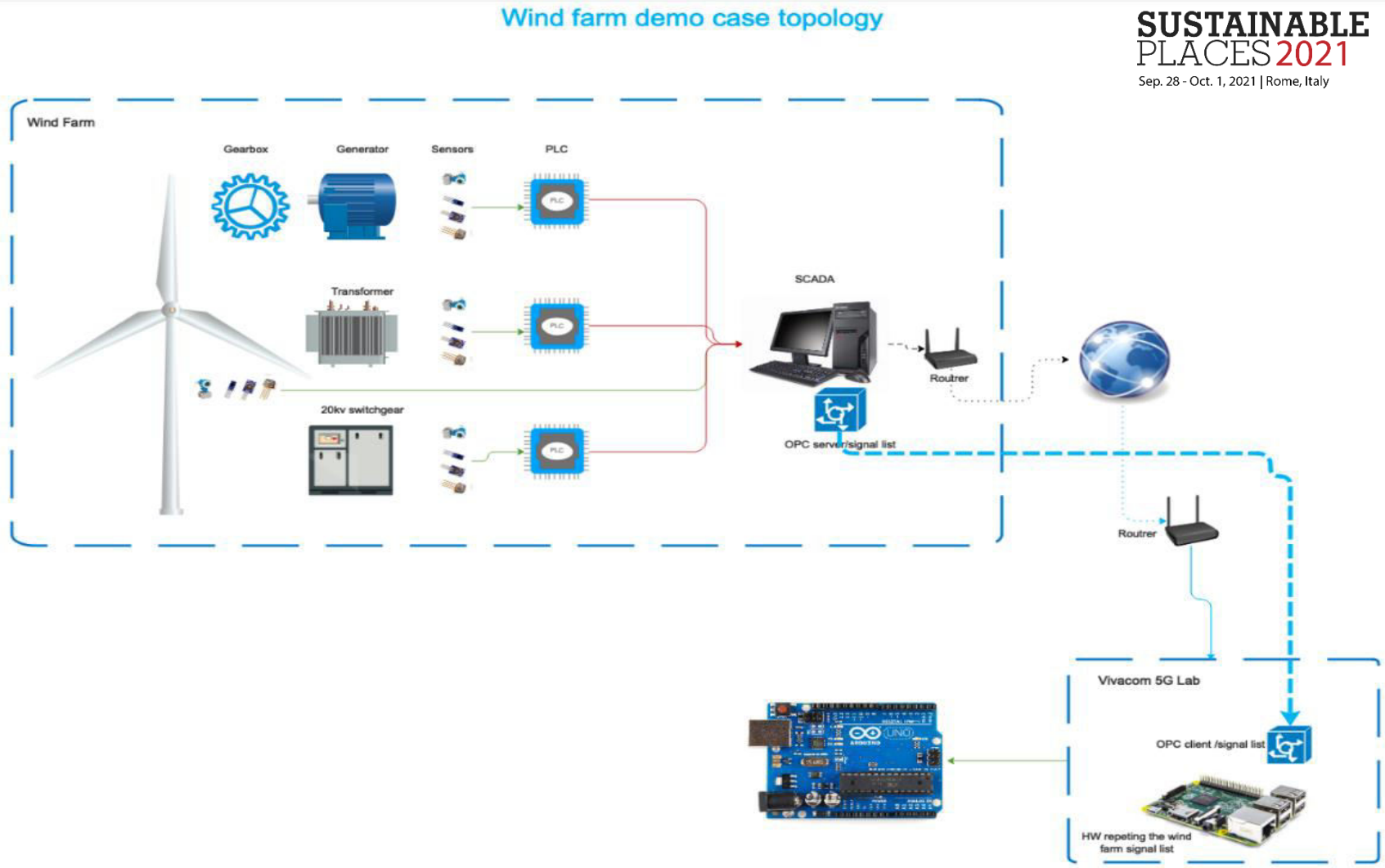
Millisecond Level Precise Distribution Generation Control (EE Windfarm, DSO/TSO, BG)

With most of the worldwide electricity expected to originate from RES by 2050, this pilot will **demonstrate the connection of thousands of MV and HV decentralized RES units and their inverters to a platform with installed 5G communication protocols that will allow their aggregation and control by the DSO/TSO in millisecond rates** enabling renewable asset owners to:

- Use fast real-time cloud-based tools for optimized scheduling to best fit power system needs
- Monitor and rebalance the network by managing distributed flexibilities provided by their decentralized energy resources like windfarms, hydro plants, storage, and dispatchable loads, according to the grid service market incentives and business models, i.e. aggregators, suppliers, storage owners
- Capitalize on the Smart5Grid platform and related NetApps and protocols to meet demanding requirements of industrial applications, especially related to end-to-end latency, service availability, jitter, and reliability
- Tap the potential of next generation HW and SW solutions with ultra-fast communication ensuring seamless integration of high RES penetration to smart grids

UC3 Layout


Wind farm demo case topology
Wind Farm
Gearbox
Generator
Sensors
PLC
Transformer
20kv switchgear
SCADA
Routrer
OPC server/signal list
Routrer
Vivacom 5G Lab
OPC client /signal list
HW repeting the wind farm signal list

Use Case 4

Real-time Wide Area Monitoring (ESO, IPTO, BG-GR)

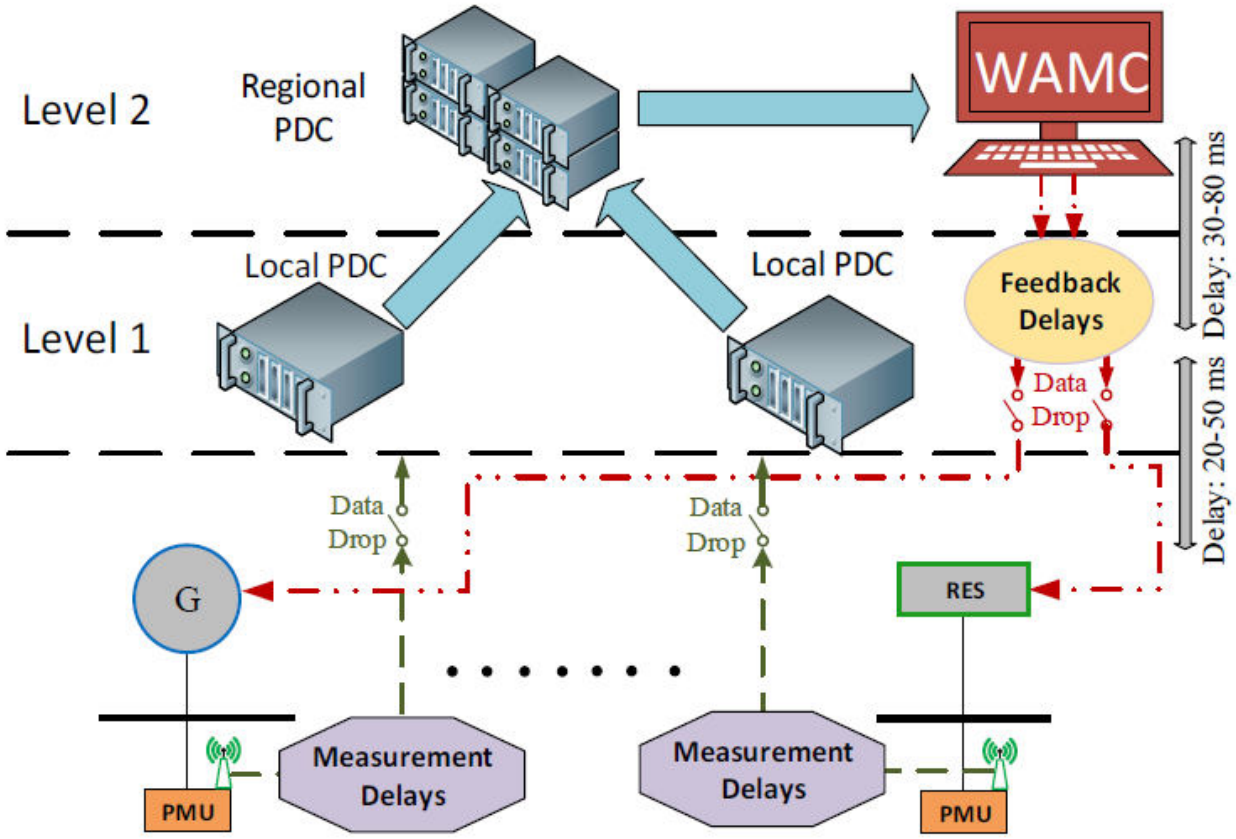
A **Smart5Grid pilot demonstrator of the 5G virtual PDC capabilities for WAM of end-to-end electricity grids**: from MV DER operated by DSOs to HV level operated by TSO, as well as inter-TSO cross-border Regional Security Coordination

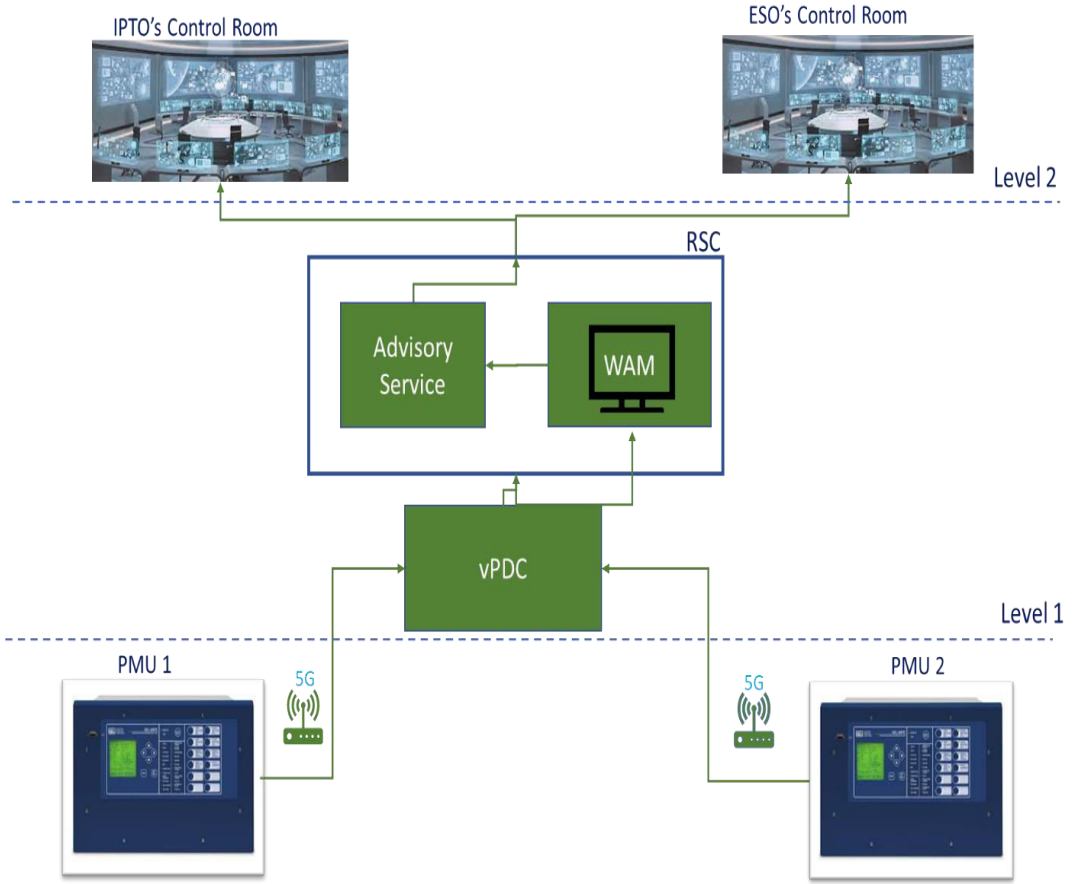
- Leveraging URLL data exchange via the Smart5Grid platform for precise real-time WAMS measurements to counter inter-area *frequency oscillations and power swings,* boosting effective maintenance of TSO, TSO-TSO, and TSO-DSO grid stability and reliability

- Real-time (RT) 5G infrastructure to significantly minimize WAMS data transfer delays from time-stamped PMUs located on both sides of the BG-GR border to a cloud-based vPDC, avoiding conventional two-layer infrastructure with inherent delays of 50-130 msec and ensuring minimum possible data loss, corruption and interference

- Virtual 5G PDC NetApp to enable comparison of different measured variables from various PMUs for both RT and historical data; RT monitor of triggered events detected by PMUs; shapshots of such events in various levels of detail; RT displacement of the ROCOF across the entire monitoring network; configuration of voltage magnitude and angle difference state measurements across distribution and transmission grid segments in real time; vPDC also serving for TSO-DSO PMU configurations to maintain national power grid stability

UC4 Layout


Level 2
Regional PDC
WAMC
Local PDC
Local PDC
Level 1
Feedback Delays
Delay: 30-80 ms
Data Drop
Data Drop
Data Drop
Delay: 20-50 ms
G
RES
Measurement Delays
Measurement Delays
PMU
PMU


IPTO's Control Room
ESO's Control Room
Level 2
RSC
Advisory Service
WAM
vPDC
Level 1
PMU 1
5G
5G
PMU 2

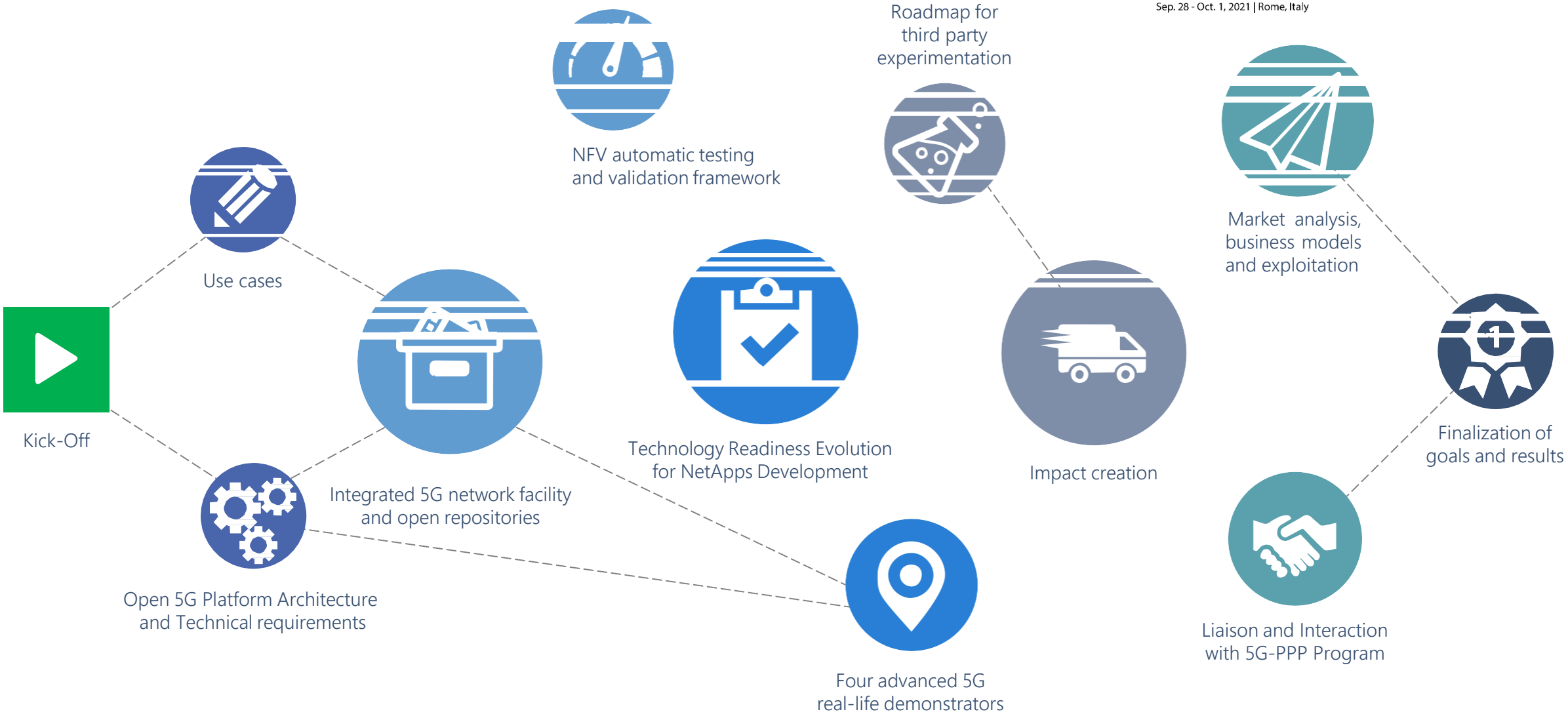
Innovation Aspects

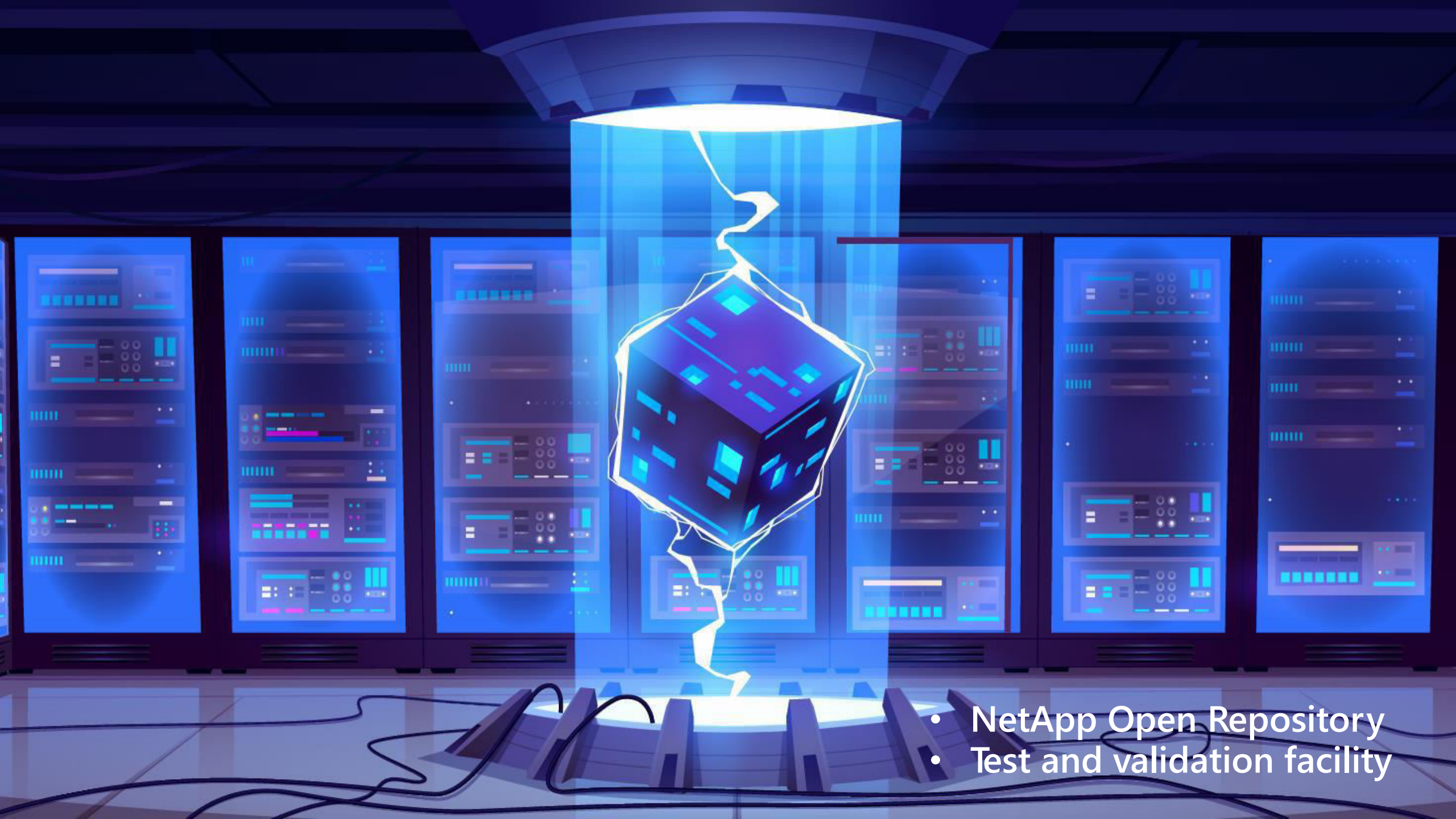
Smart5Grid to **substantially improve network end-to-end latency and data rate (throughput)** in addition to **providing reliability and availability, guaranteed Quality of Service (QoS), and unprecedented flexibility**. Furthermore, Smart5Grid aims to capitalize on several architectural features enabled by the network softwarization principles, such as:

- ✓ Deployment of **service-based architecture** (**SBA**),
- ✓ **Functional split in Radio Access Network (RAN),**
- ✓ **Multiaccess Edge Computing (MEC)** on top of **network slicing** (i.e. separation of multiple virtual networks operating on the same infrastructure for different NetApps) or distributed orchestration of network resources (both hardware and software).
- ✓ Orchestration of eMMB, URLLC and mMTC services plus slicing configurations tailored for energy vertical use cases running on the same network infrastructure

Structure of the project

Overall project plot




• NetApp Open Repository
• Test and validation facility

Conclusions

Main project elements and expected results

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Open NetApp repository

NFV automatic testing and validation framework

Four advanced 5G real-life demonstrators

Roadmap for third party experimentation

Liaison and Interaction with 5G-PPP Program

Impact creation and exploitation

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Thank you!

ESO EAD Smart5Grid Team
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Eng. Daniel Shangov