Smart5Grid

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

# Smart5Grid Solutions for Enhanced TSO Grid Observability and Manageability in Massive RES Penetration Environment

5G PPP
The 5G Infrastructure Public Private Partnership

SUSTAINABLE PLACES

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

Smart5Grid

## Coordinator

enel

## TELCOs

WINDTRE

OTE GROUP OF COMPANIES

VIVACOM

## Tech Companies

ENGINEERING

AtoS

## Universities/Research institutions

i2cat

HELLENIC REPUBLIC National and Kapodistrian University of Athens

University of Cyprus

KOIOS

## DSOs

e-distribuzione

e-distribución

(Linked third-parties of Enel GI&N)

## TSOs

ECO ЕАД

αδμηε

## SMEs

EIGHTBELLS

INFOLYSiS

SC

NEARBY COMPUTING

axon logic

ubiwhere SUITING THE FUTURE

athonet

SETECHCO

SIDROCO

ENTRA ENERGY

UBITECH digitizing energy

nosia SEÑALIZACIÓN INDUSTRIAL EQUIPAMIENTO PARA LA INDUSTRIA

STAM MASTERING EXCELLENCE

# Smart5Grid

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

## GENERAL INFORMATION

### THE CONSORTIUM

24 EUROPEAN

PARTNERS

COVERING

7 EU STATES

### DURATION

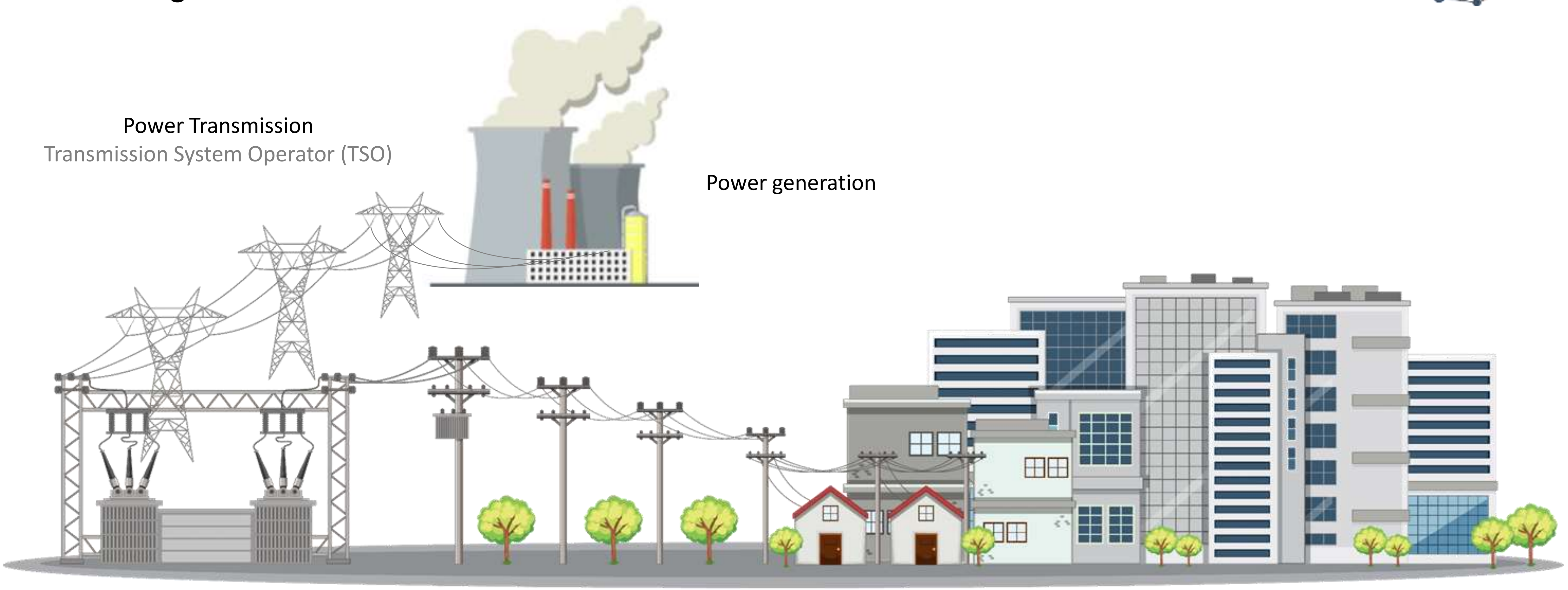
3 YEARS

### TOTAL BUDGET

8M€

# Energy Vertical

Traditional grid



# Energy Transition Scenario

Energy industry needs faster and more reliable communications

High penetration of Distributed Generation

New actors in the Energy Market (Aggregators, Flexibility Service Providers, etc.)

New generation of Smart Grids solutions

Stability issues

Safety for field operators

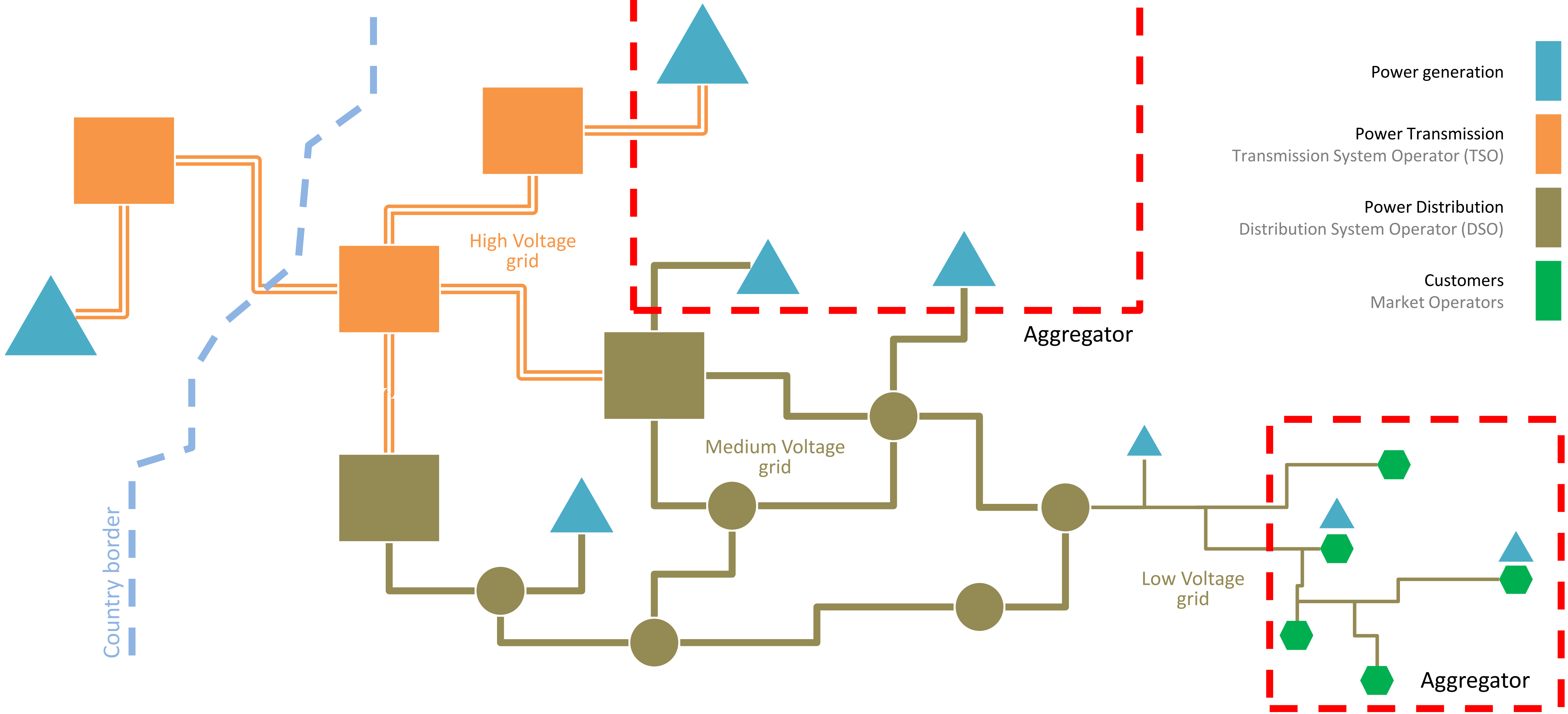
New solutions from 3rd parties

Need for digitalization

Security and reliability

# Energy Vertical

Smart grid



# Why 5G in the Energy Vertical?

Advantages and opportunities

### 5G vs FO and PLC communication

- Lower deployment costs
- Faster implementation
- Higher flexibility

### 5G vs 4G/Long Term Evolution (LTE)

- Lower latency (similar to Optical Fiber)
- Highest stability
- Virtually dedicated bandwidth (Slicing)

### Major highlights

- Virtual Edge computing, strengthening the system resiliency

### What we test in the project

- **NetApp**: an extension of the Network Virtualization Functionality (NVF) that provides an **abstraction of the 5G complexity** to allow the development of data-network functionalities to a broader group of people.
  EC aims to create a market segment for NetApps to support the penetration of 5G technology and foster digitalisation.

# Smart5Grid in a Nutshell

Representative Use Cases

- **Smart5Grid** intends to boost innovation for the highly critical and challenging energy vertical by **providing an open 5G experimentation platform** customized to support the smart grid vision.
- Enable energy **stakeholders**, ICT integrators, Network Application developers, telcos, SMEs, and/or network service providers in general **to test and validate their NetApps and create 5G Open Source repositories for wide use and towards standardisation**.
- **Four use-cases to capture a range of power system operation scenarios**:

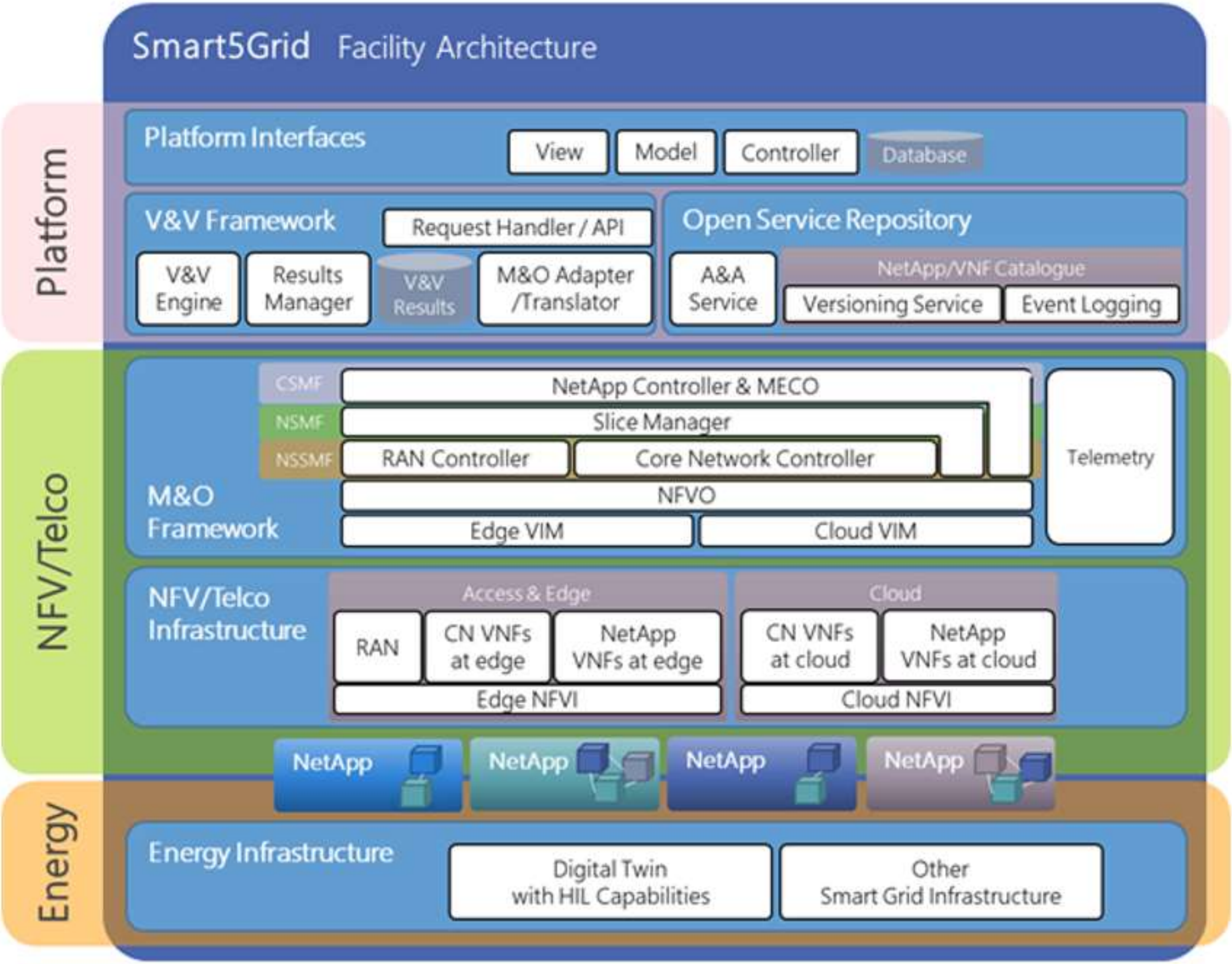
  **UC1**: Automated fault detection and self-healing in distribution grids (IT demo)

  **UC2**: Improved safety of maintenance workers in HV power substation by virtual volumetric delimitation of working areas (ES demo)

  **UC3**: Millisecond level monitoring of distributed renewable generation resources (BG demo)

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

# The Smart5Grid Infrastrutture




Three **interdependent and interfaced layers**:

- **The platform**: Open Service Repository (OSR), Verification and Validation (V&V) Framework, and dedicated API's and UI's
- **Network Function Virtualization (NFV)/ Telco** run by Management and Orchestration Framework (M&O) with NetApp Controller & Multi-access Edge Computing Orchestrator (MECO), supported by Communication Service Management (CSMF), Network Slice Management (NSMF), and Network Slice Subnet Management Function (NSSNF).
- Energy Infrastructure (digitally mirrored), **NetApps** run on top of HIL testbed


Italian Demo | Olbia


Smart5Grid
Spanish Demo | Barcelona


Bulgarian Demo | Southern region


Bulgarian-Greek Demo | Cross-border

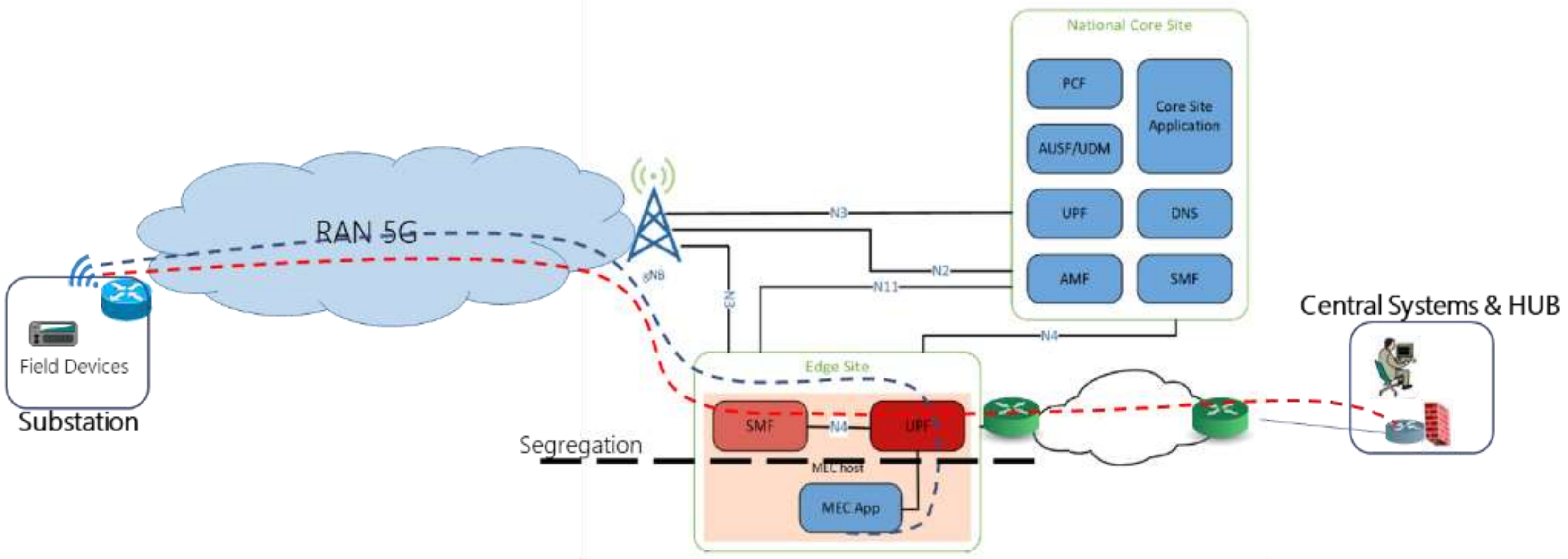
# Use Case 1

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

Public 5G RAN integrated monitoring for **RT identification and insulation of faults in the backbone distribution network (self-healing)** using an array (thousands) IEDs and a UC-specific NetApp to discriminate the source of a grid from a communication disturbance in a DSO (ENEL) self-healing automation system:

- 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 slicing with a 5G NetApp enabling effective and quasi-instantaneous operation of grid control and protection devices
- Extracting valuable data for end-users by automatic discrimination of network failures based on the communication between protection and fault detection devices on real power distribution infrastructures over a public 5G network
- Minimize SAIDI (System Average Interruption Duration Index) and CAIDI (Customer Average Interruption Duration Index) of the smart energy grid at DSO level

# UC1 Pilot 5G Setup



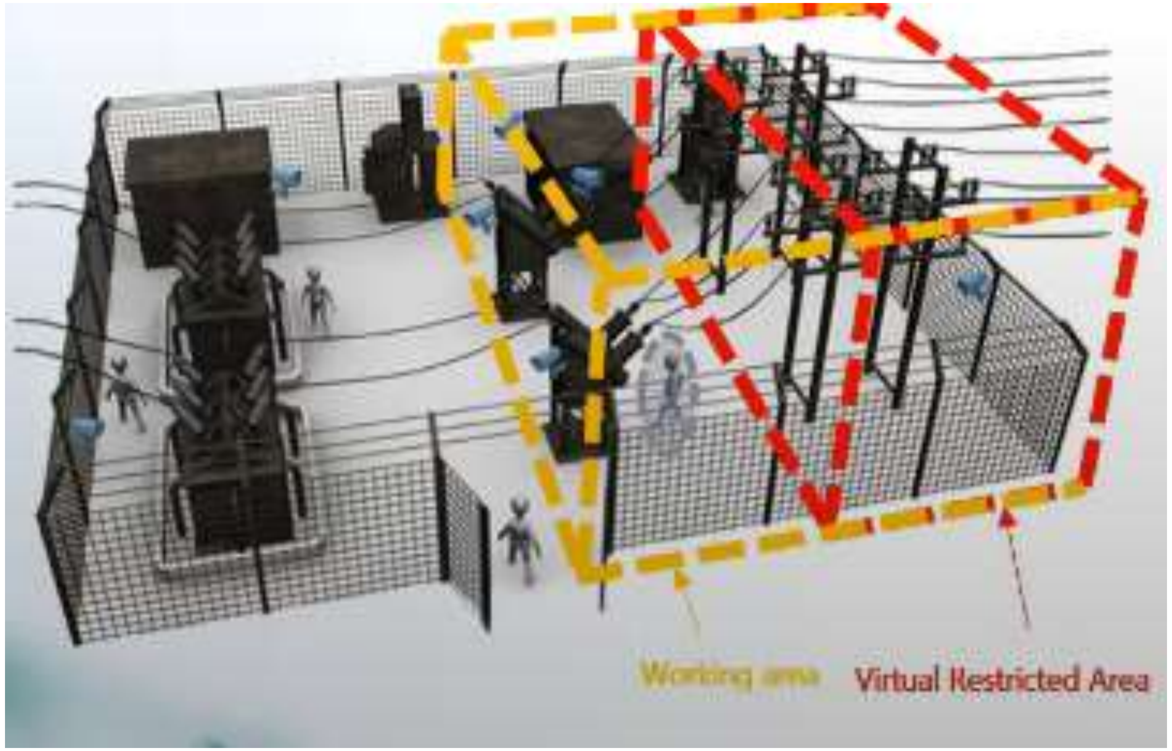

LEGENDA

Remote Control traffic in end to end tunnel

Monitoring Traffic by NetApp

# Use Case 2

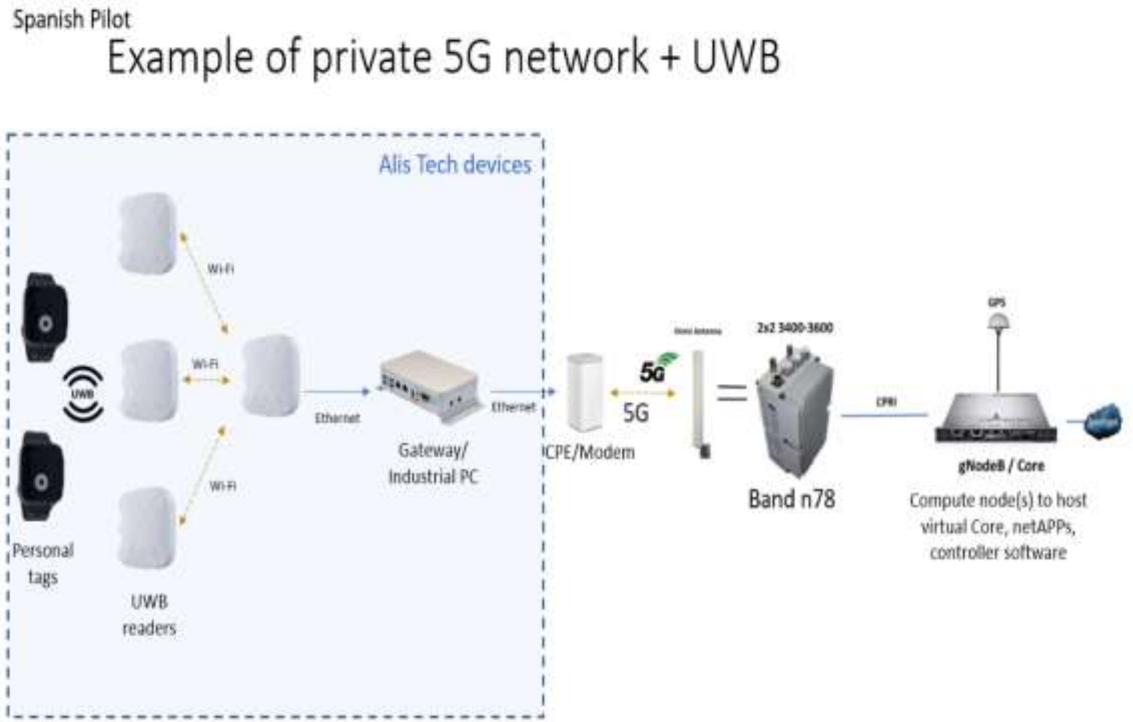
## Improved Safety of Maintenance Personnel by Automatically Delimited Working Areas at Distribution Level (ENEL, ES)

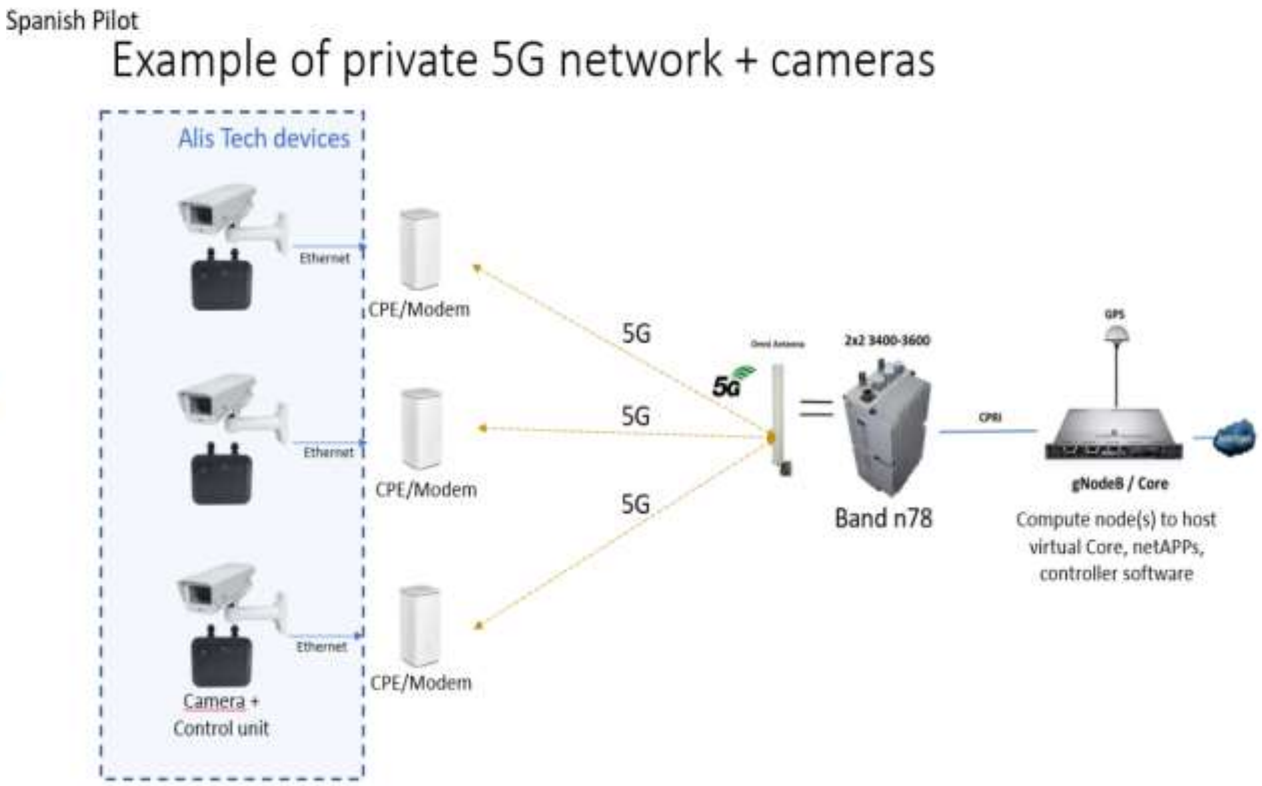



**Virtual volumetric delimitation of working areas** in a distribution grid substation through deployment of a **private 5G NR network** to improve personnel safety:

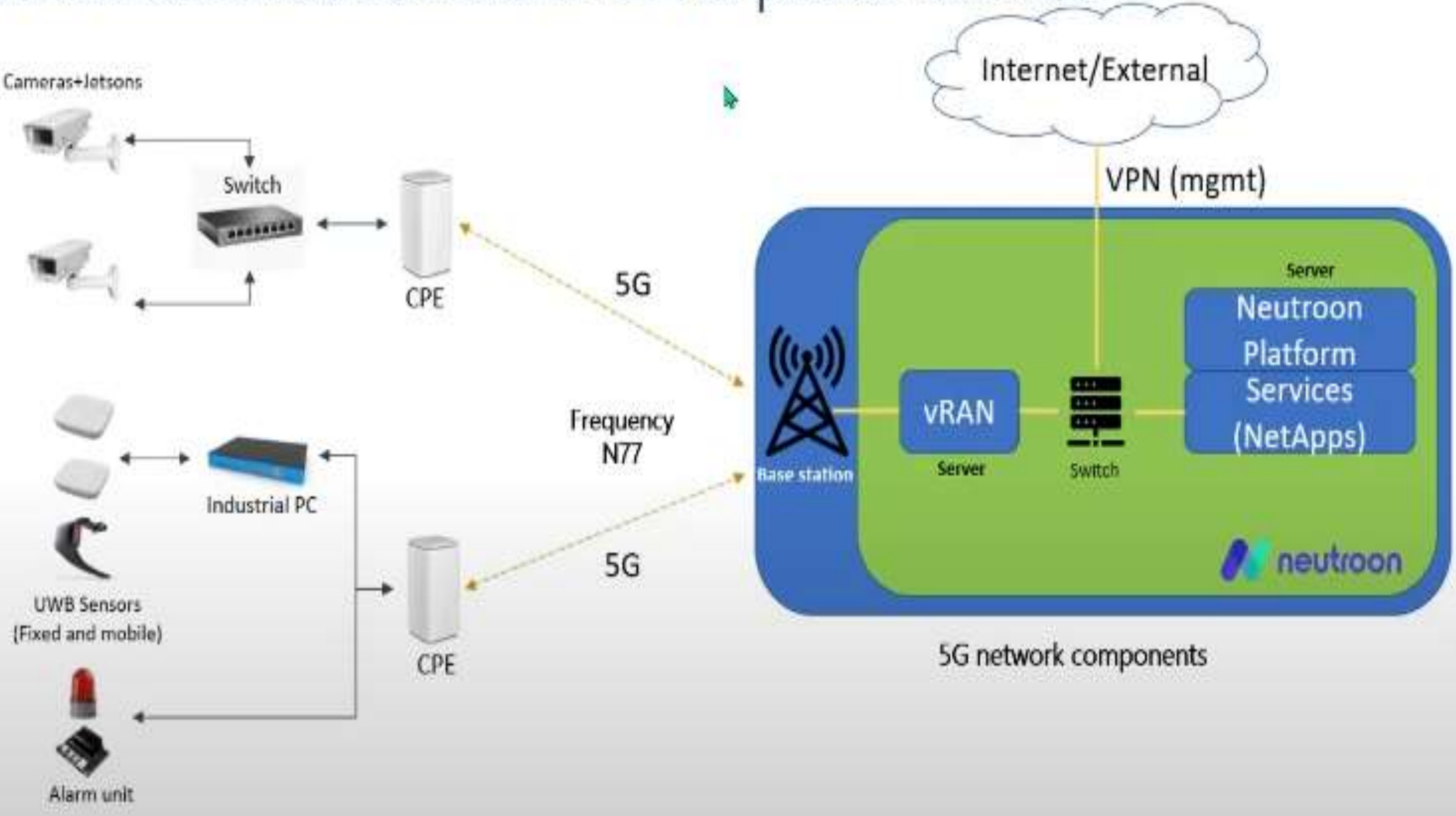
- Prevent the exposure of workers to dangerous working conditions
- 5G ULLC and eMBB data exchange between monitor devices (UWB sensors and cameras) and edge-based platform is processed by AI and ML algorithms
- Alarm triggered when violating the safety working area to prevent electrocution accidents

# UC2 Pilot 5G Setup



# UWB sensors and cameras & 5G NR private network




- RRU R15 band N77 (Ministry)
- Omnidirectional antenna
- vRAN R15 connection via CPRI
- 5G Core
- MEC server
- 5G CPEs outdoor
- Router and Switch

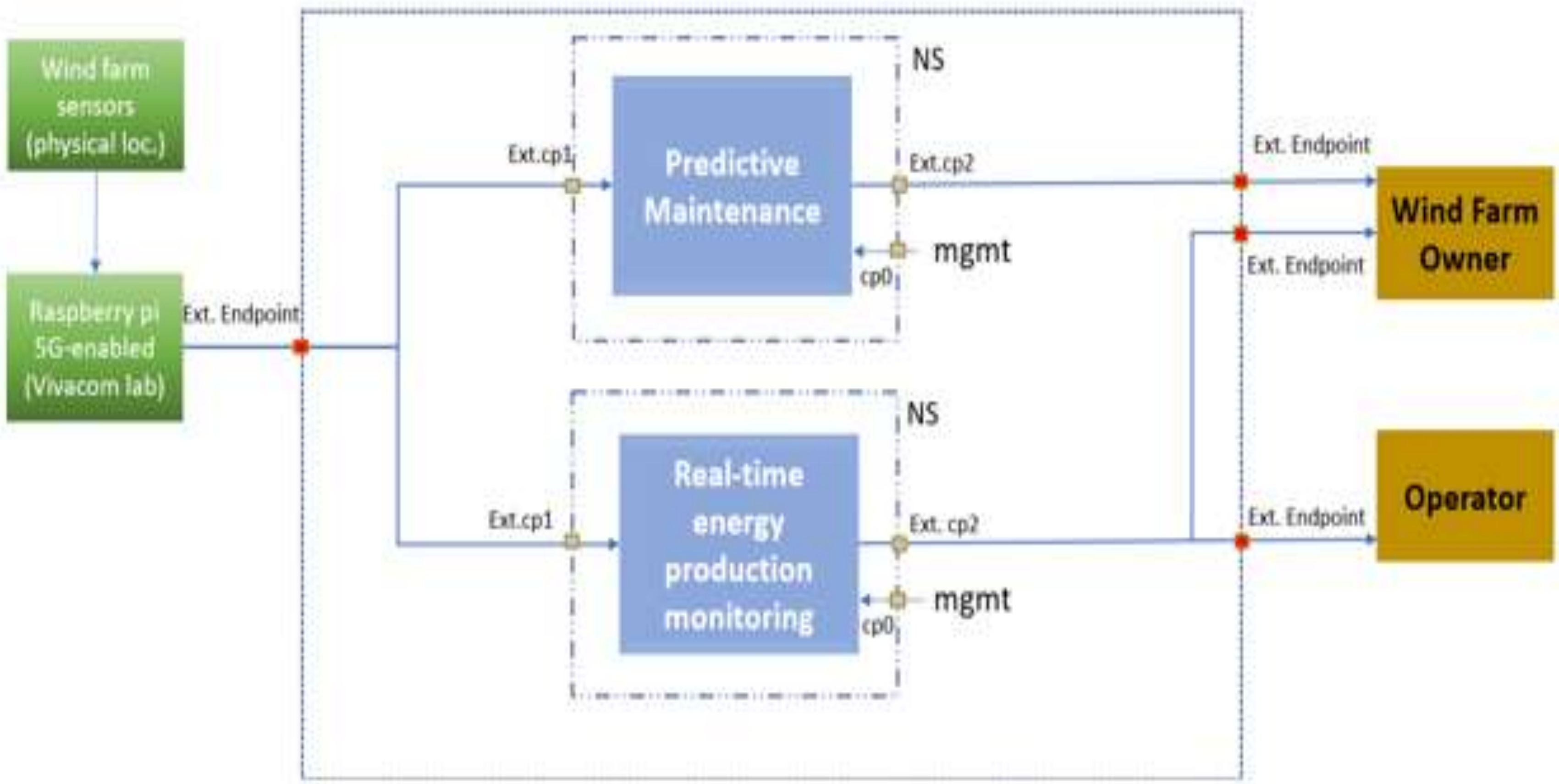
# Use Case 3

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

A pilot **NetApp demonstrator** of **precise monitoring** of **Distributed Renewable Energy Resources** (DRER) at **millisecond level**:

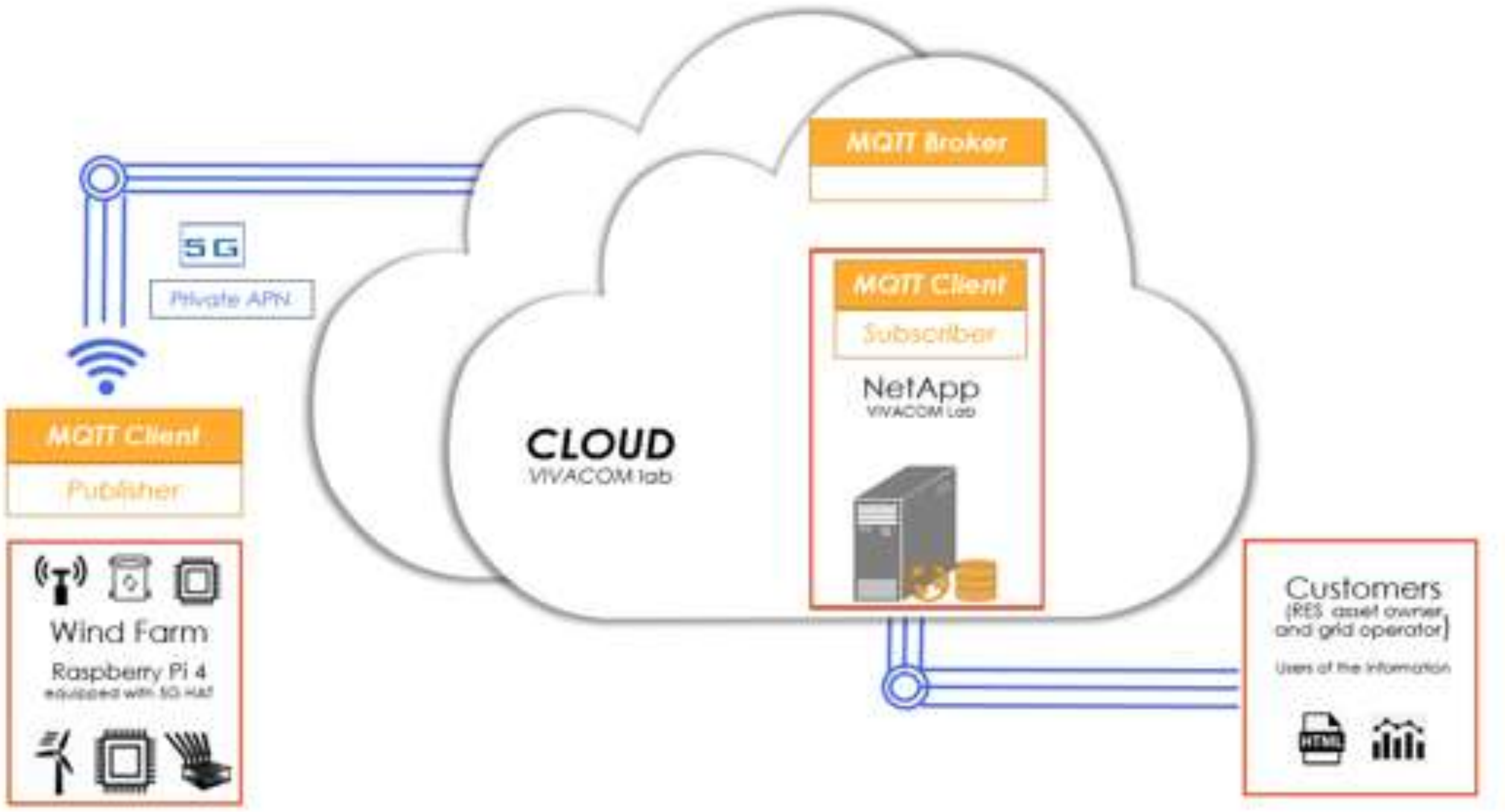
- URLL and mMTC network slicing for optimized scheduling to best fit power system needs
- High visibility of RES production improves power system control and reduces RES curtailment for balancing purposes; a higher share of RES in the energy mix transpires into clean energy production and lower carbon emission levels
- Capitalize on the Smart5Grid platform to meet demanding requirements of DRER management applications
- Facilitate seamless integration of high RES penetration into smart grids

# UC3 NetApp




UC3 NetApp architecture

# UC3 Testbed




UC3 High-level diagram using Message Queuing Telemetry Transport (MQTT) protocol

# Use Case 4

## Real-time Wide Area Monitoring (WAM) of synchronously interconnected power systems (ESO, IPTO, BG-GR)

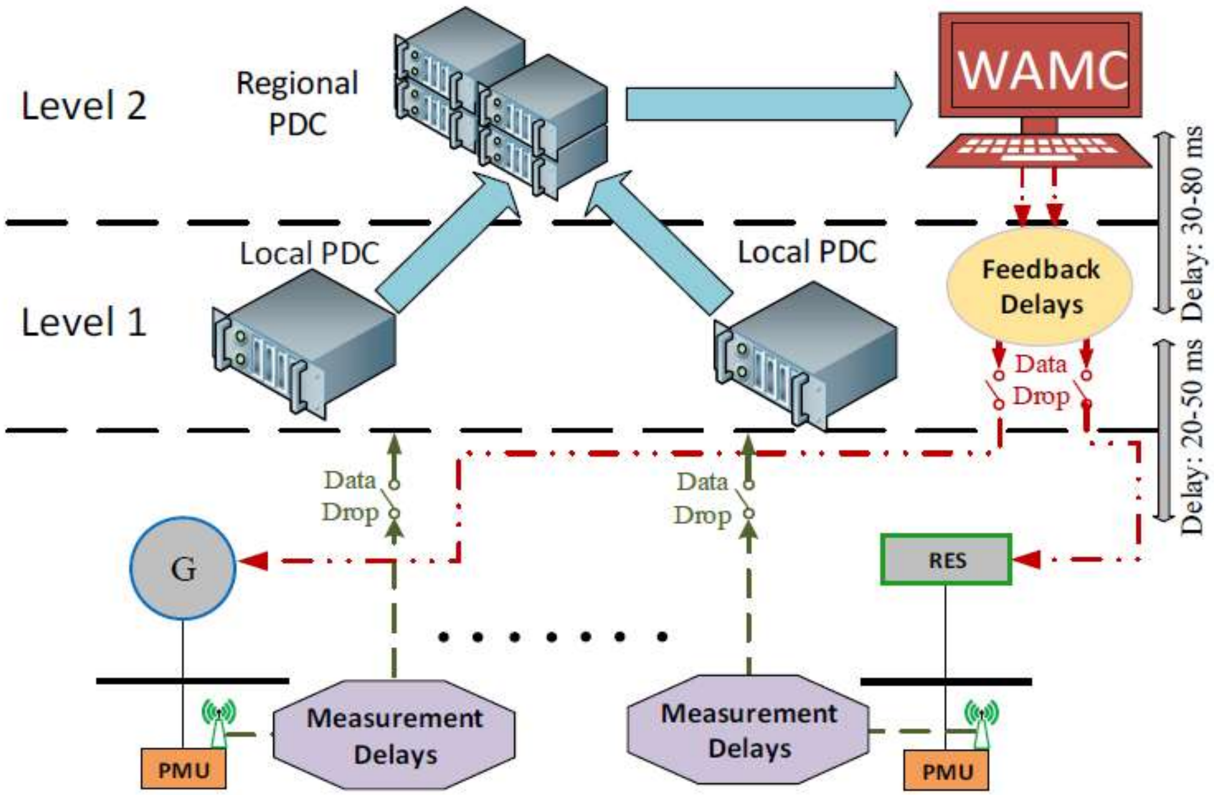
A pilot **NetApp demonstrator** of **5G** virtual PDC capabilities **for WAM of end-to-end electricity grids**:

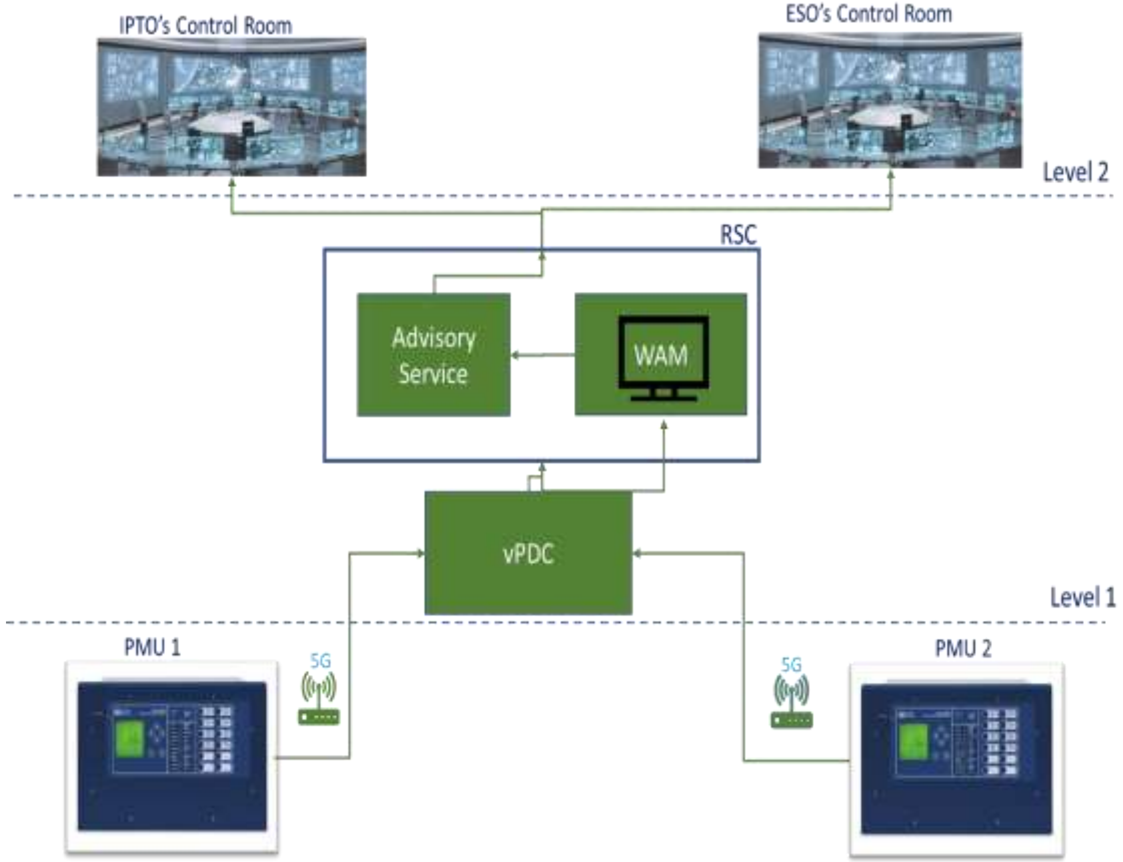
- Leveraging URLL data exchange via the Smart5Grid platform for precise real-time WAM measurements to counter inter-area *frequency oscillations and power swings,* boosting effective maintenance of inter-TSO grid stability and reliability

- Real-time (RT) 5G RAN to significantly minimize WAM data transfer delays to 5-10 ms 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

- Compare different measured variables (current, voltage and phase angle) sent from PMUs to vPDC for both RT and historical data; RT monitor of triggered events, shapshots of such events in various levels of detail; RT displacement of the Rate of Change of Frequency (RoCoF) across the entire monitored wide area to maintain grid stability

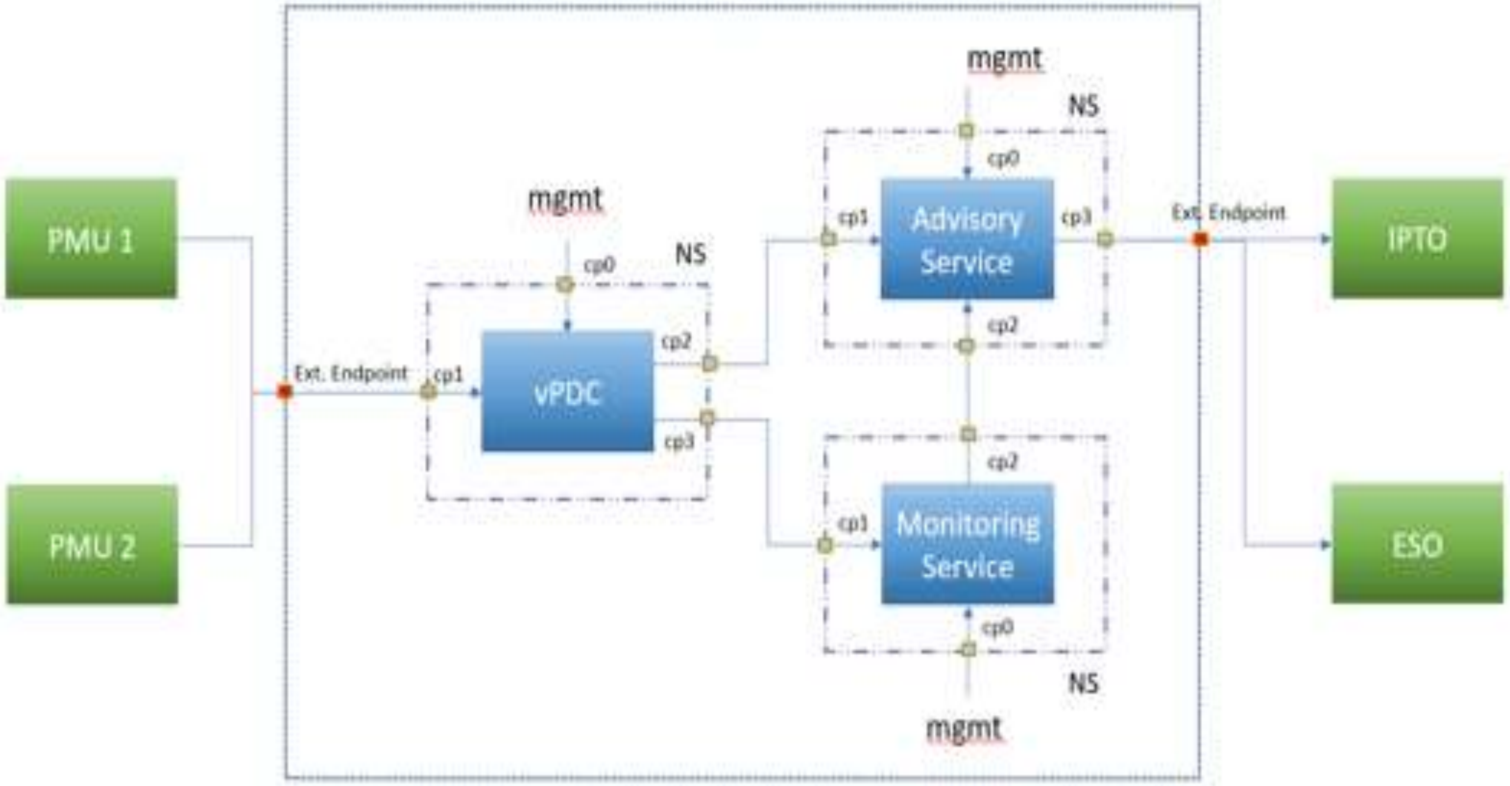
# UC4: Legacy vs 5G




**WAM with conventional vs 5G-enabled vPDC**

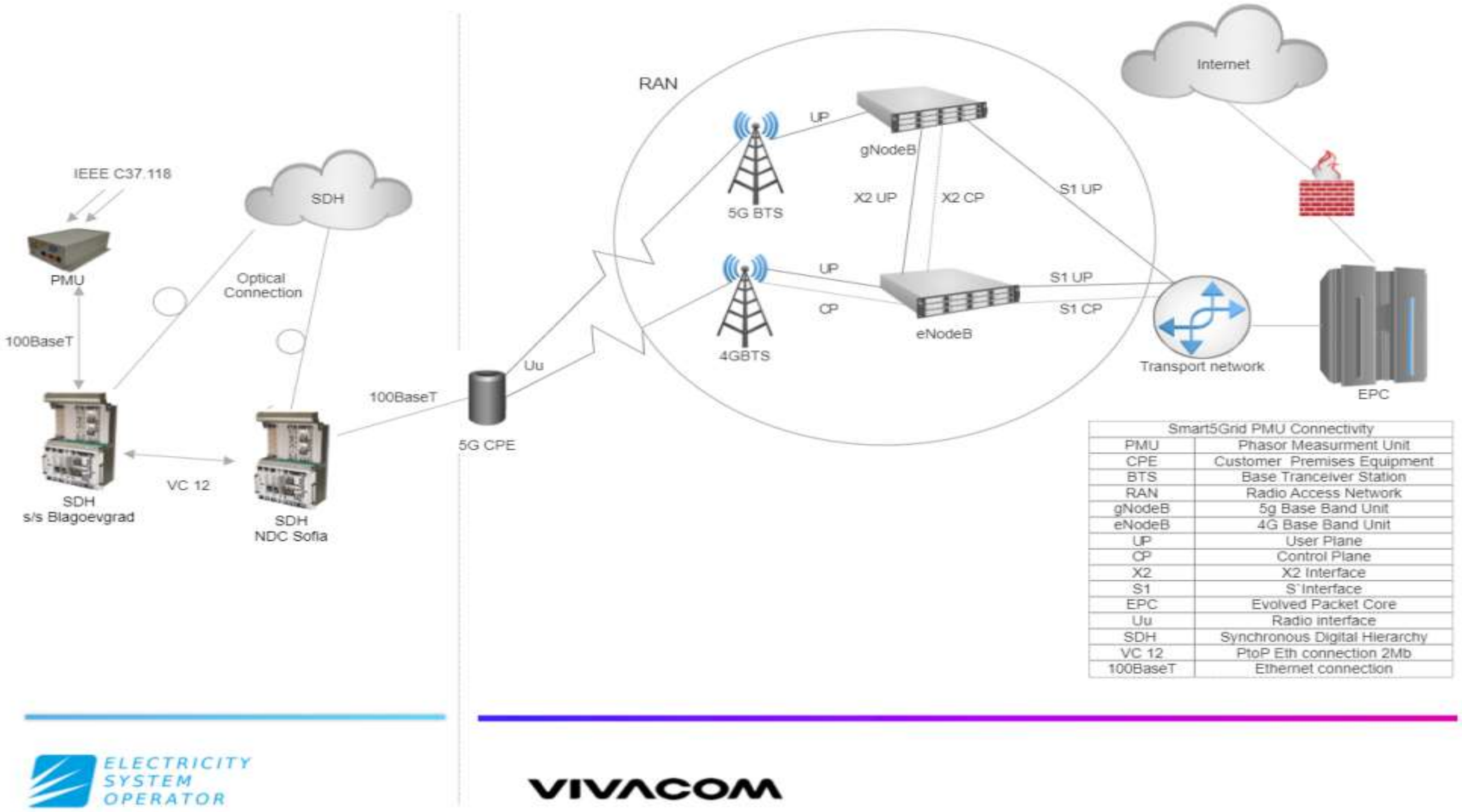
# UC4 NetApp




UC4 NetApp architecture

# UC4 5G RAN Setup

Smart5Grid




| Smart5Grid PMU Connectivity | |
|---|---|
| PMU | Phasor Measurment Unit |
| CPE | Customer Premises Equipment |
| BTS | Base Tranceiver Station |
| RAN | Radio Access Network |
| gNodeB | 5g Base Band Unit |
| eNodeB | 4G Base Band Unit |
| UP | User Plane |
| CP | Control Plane |
| X2 | X2 Interface |
| S1 | S`Interface |
| EPC | Evolved Packet Core |
| Uu | Radio interface |
| SDH | Synchronous Digital Hierarchy |
| VC 12 | PtoP Eth connection 2Mb |
| 100BaseT | Ethernet connection |

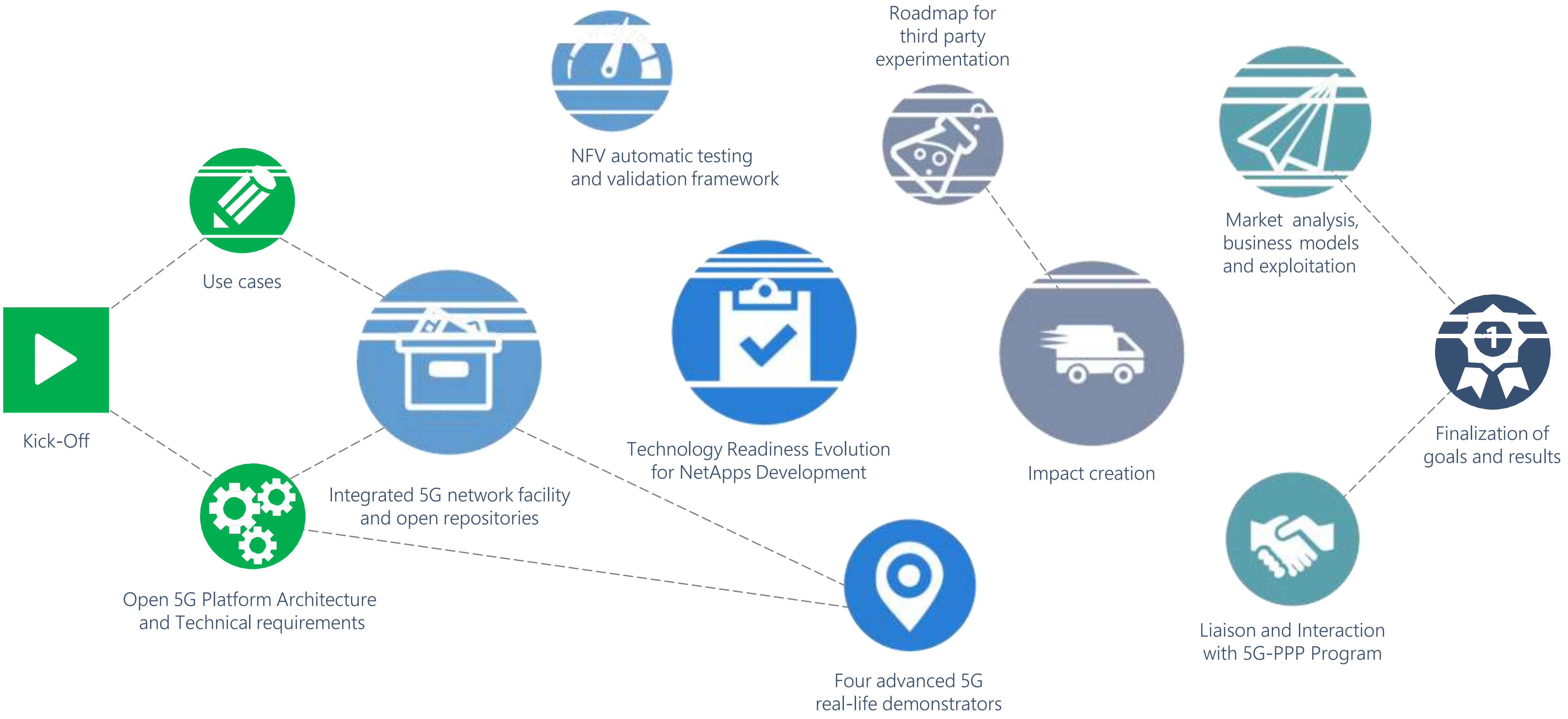
# Innovation Aspects

**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. virtual allocation of bandwidth) for distributed orchestration of network resources (both hardware and software).
- ✓ Orchestration of **eMMB, URLLC and mMTC slicing** tailored **for energy vertical use cases** running on **the same physical network infrastructure**

# Structure of the project

## Overall project plot



- NetApp Open Repository
- Test and validation facility

# Conclusions

Main project elements and expected results

Smart5Grid

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

# Follow us!

Check out our channels

[smart5grid.eu]

# Thank you!

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