Smart5Grid: *Towards an Efficient Demonstration of 5G Solutions for the Smart Energy Grids of the Future*

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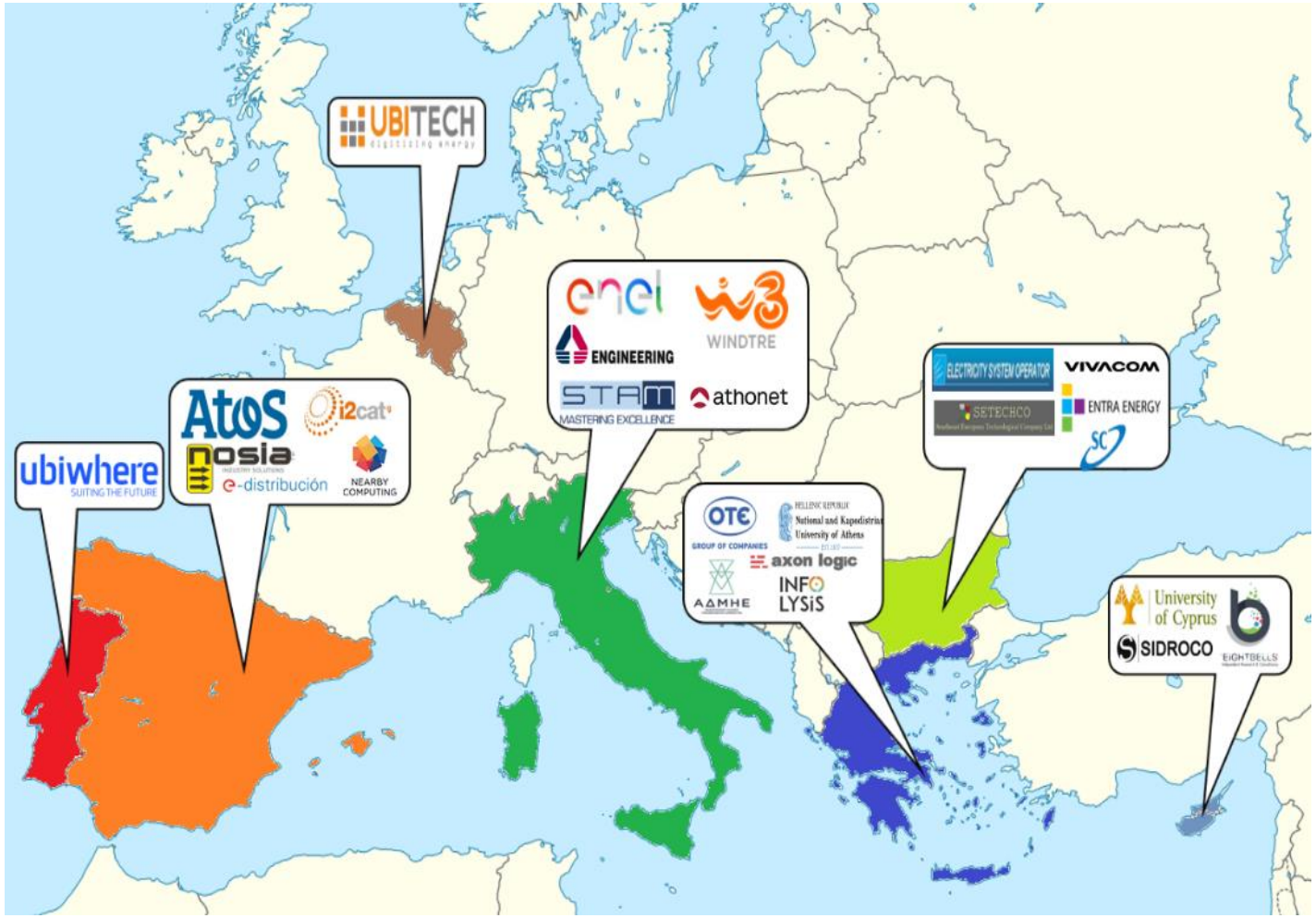
Demonstration of **5G** solutions for **SMART** energy **GRID**s of the future

25 Involved Partners from 7 EU member states



- European Call: H2020-ICT-2018-2
- Grant Agreement (GA) No.: 101016912
- Topic: ICT-41-2020
- Duration: 36 months *(01.01.2021 – 31.12.2023)*
- Overall budget (requested grant) of ~6 Million €
- Consortium members: 24 main partners *(from 7 EU member states)*
- Project Coordinator: ENEL (IT)

Composition of the consortium

Smart5Grid Consortium

Coordinator

enel

TELCOs

WINDTRE

GROUP OF COMPANIES

VIVACOM

Tech Companies

ENGINEERING

Atos

*gridspertise

Universities/Research institutions

i2cat

HELLENIC REPUBLIC
National and Kapodistrian University of Athens
EST. 1837

University of Cyprus
KOIOS

DSOs

*e-distribuzione

*e-distribución

TSOs

ELECTRICITY SYSTEM OPERATOR

admie

SMEs

EIGHTBELLS
Independent Research & Consultancy

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

*Linked third-parties of Enel Grids

Introduction_(1)

- The **"power grid"** *(networks of power plants, energy transmission towers, substations, poles and wires)* can be assessed as the **"largest machine in the world"**, as electricity is the most versatile controlled form of energy.

- For efficient transfer of electrical power, **"smart grids"** combine traditional grids with communication and information control technologies, targeting to achieve efficiency, cleanliness and security, and "reshaping" the modern landscape in energy transportation.

- The **fast development of 5G**, especially in **verticals** like the energy sector, will offer more opportunities for growth and market evolution, *also providing options for innovation and investments*.
- 5G networks will be an important ingredient for the development of smart grid technologies, *especially allowing the grid to "adapt better" to the dynamics of renewable energy and distributed generation*.

Introduction_(2)

The Way Forward…

- "Smart grid transformation" must rely on existing electrical infrastructures of the generation, transmission, distribution and consumption levels of a power grid.
- "Smart grid transformation" needs to connect energy metering and measuring devices through a communication network, *that enables real-time information flow and control among power devices*.
- 5G *(due to the multiplicity of its benefits such as flexibility, reliability, coverage throughput, latency and massive device support),* is the first communication technology expected to address the plethora of current and future challenges of the energy sector.

Framework for Innovation and Growth

- Large and interconnected power systems are seen as the "backbone" of the critical infrastructures in our society.
  - *So far telecom providers played little or no role in the communication infrastructure.*
  - *This status quo is expected to change drastically in the smart grid era!*

- The *Smart Grid concept and its deployment environments* intend to increase efficiency, resilience, reliability and security of the (evolved and greener) power grids, *by means of increased digital automation and control.*

- The Fifth Generation (5G) of communication networks provides features allowing the power grid to incorporate the service requirements of:
  - *Large bandwidth*
  - *End-to-end latency*
  - *High reliability*
  - *Massive connection type*

The Smart5Grid Concept

- The Smart5Grid EU-funded project is focused on boosting 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 aims to be an ecosystem where various "players" such as
  i. *Stakeholders in the energy vertical*
  ii. *ICT Integrators*
  iii. *Network Application (NetApps) Developers*
  iv. *Actors in the telecom industry*
  v. *Network Service Providers in general*

  could "come together" and "work together" towards the common goal of demonstrating the opportunities offered by the 5G technology in four meaningful cases, *specifically targeting to the Renewable Energy Sources (RES) production and distribution of energy in a vertical ecosystem*.

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 for a 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 conformant to suitable 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 liaisons and synergies with 5G-PPP Phase-2 and 3 projects and related WGs. To pursue extensive dissemination and communication activities, as well as to assess the perceived impact from the stakeholders & the wider community

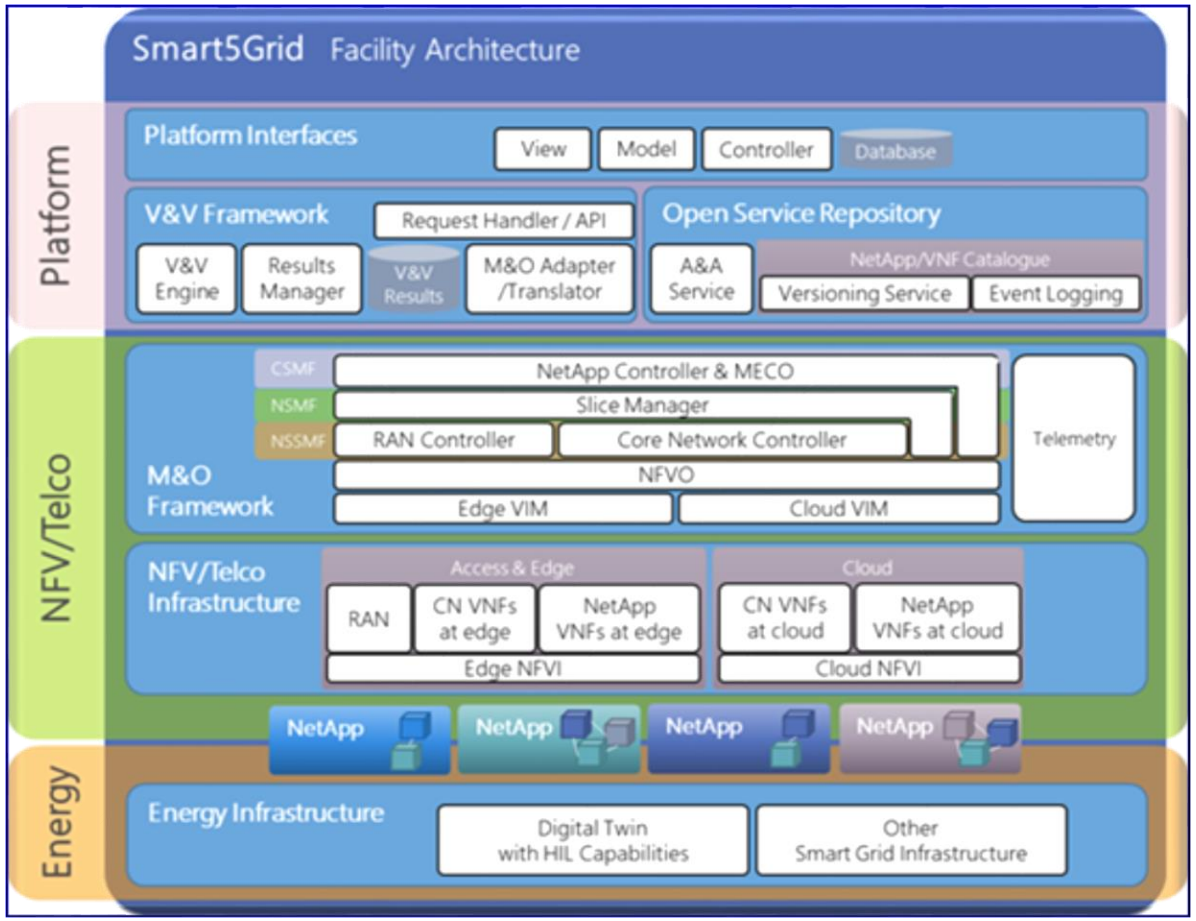
Smart5Grid - Motivation

Technology Features of the Project

- *Smart5Grid MEC Platform*
- *5G Core Service Based Architecture for the energy-specific vertical domain*
- *Open 5G platform for smart grids and 3rd Party Experimentation*
- *Open NetApp Repository for 3rd parties*
- *DevOps approach for energy specific NetApp development and deployment*
- *Network Slicing (eMBB, mMTC, uRLLC)*

Smart5Grid - Architecture

3 distinct layers – Platform, NFV/Telco, Energy



Smart5Grid - Proposed Use Cases

Italian Demo | Olbia

Automatic Power Distribution Grid Fault Detection

Spanish Demo | Barcelona

Remote Inspection of Automatically Delimited Working Areas at Distribution Level

Bulgarian Demo | (Southern region)

Millisecond Level Precise Distribution Generation Control

Bulgarian-Greek Demo | (Cross-border)

Real-time Wide Area Monitoring

Main Target of the Project

"The Smart5Grid 5G Experimental Platform aims to provide an experimentation environment for 3rd party developers to implement, verify and validate energy vertical applications as NetApps, composed of a chain of VNFs.

These applications, once validated, will be hosted at and be accessible on an Open NetApp repository, encouraging the reutilization of VNFs and fostering the introduction into the market of start-ups and SMEs".

List of Work Packages

WP Number	WP Title	Lead Beneficiary	Start Month	End Month
WP1	Project Management	ENEL	1	36
WP2	Use Case Elaboration, Open 5G Platform Architecture and Technical Requirements	ATOS	1	24
WP3	Integrated 5G Network Facility and Open Repositories	ENGINEERING	4	24
WP4	Technology Readiness Evolution for NetApps Development	UBIWHERE	7	36
WP5	Uninterruptible Smart Grid Operation due to 5G Connectivity	ENEL	13	36
WP6	Integrating High Levels of Variable Renewable Energy Sources into 5G connected smart grids	OTE	13	36
WP7	Exploitation and Impact Creation	8BELLS	1	36

UC1: Italian pilot - Overview

UC1 - Automatic Power Distribution Grid Fault Detection

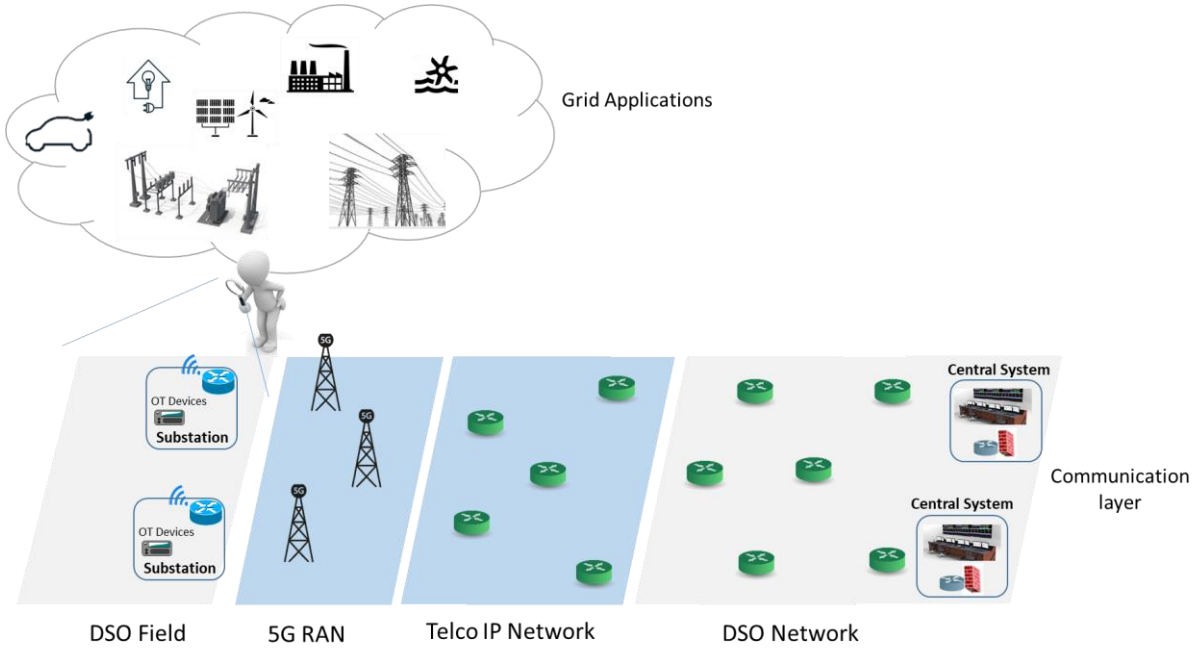
- The business scope of this UC is to verify, in a real-field scenario, *"how 5G network could improve the performance of the Remote-Control connectivity for real-time automation and monitoring of the distribution grid", especially in high populated geographical areas.*

- The final goal is to reduce the time and the effort needed while performing the troubleshooting *when a communication problem occurs between the central Hub and the field devices involved in the real-time self-healing automation system of Enel-Distribuzione Italy (EDI).*

- Monitoring the communication layer of this advanced automation system is highly important to ensure:
  - Reliability of the communication infrastructure, *within the given Service Levels (otherwise Real-Time self-healing's performances are not ensured).*
  - Operative costs reductions: *having a clear picture of the RAN connectivity allows sending EDI's technicians to the field only "when strictly needed", not as a normal part of the troubleshooting process.*

UC1: Italian pilot – Overview (cont'd)

UC1 - Automatic Power Distribution Grid Fault Detection



Purposes:

- **Improve the continuous accuracy of the communication layer** dedicated to the Automatic Power Distribution Grid-Fault Detection infrastructure.
- **Improve the performance of real-time self healing capability of distribution grid**, especially in high populated geographical areas.
- **Reductions of DSO's efforts for operating the communication infrastructure,** dedicated to the grid automation function and grid remote control.

Main Constraints

- **Grid stability:** *Tests to be executed on a real grid.*
- **Cyber security:** *Need to comply with DSO's and Telco Cybersecurity guidelines.*

UC2: Spanish pilot - Overview

UC2 - Remote Inspection of Automatically Delimited Working Areas at Distribution Level

Location: Barcelona, **EcoGarraf** Primary Substation (66 kV)

Partners involved:

e-distribución i2cat nosia - SEÑALIZACIÓN INDUSTRIAL - EQUIPAMIENTO PARA LA INDUSTRIA

Purpose:

Bordering the safety zone in a volumetric way, for different infrastructure types (e.g. transformers, aerial power lines), and **supporting field technicians by using 5G** *due to*

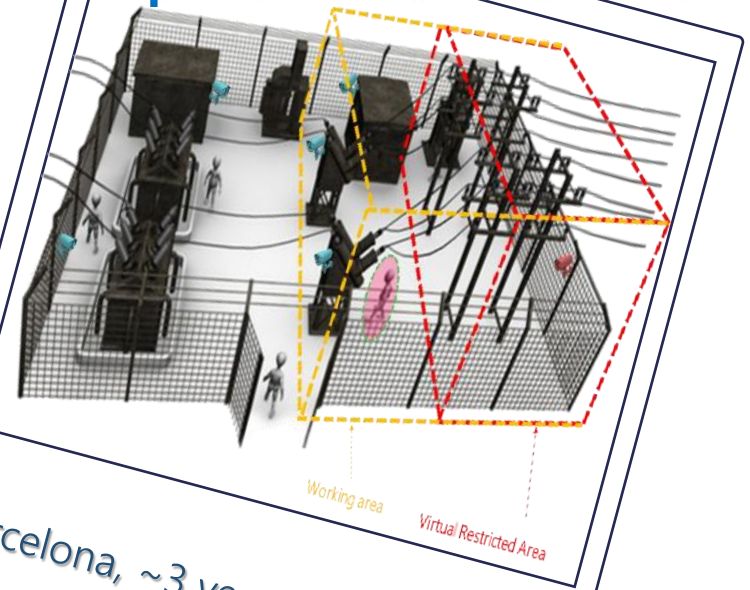
- *its ultra reliable low latency communications and*
- *enhanced mobile broadband joined to augmented reality, 3D modelling and sensors technology.*

Net App **safety**

smart area monitoring

sensors big data

private 5G network



Barcelona, ~3 years from now

UC2: Spanish pilot – Overview (cont'd)

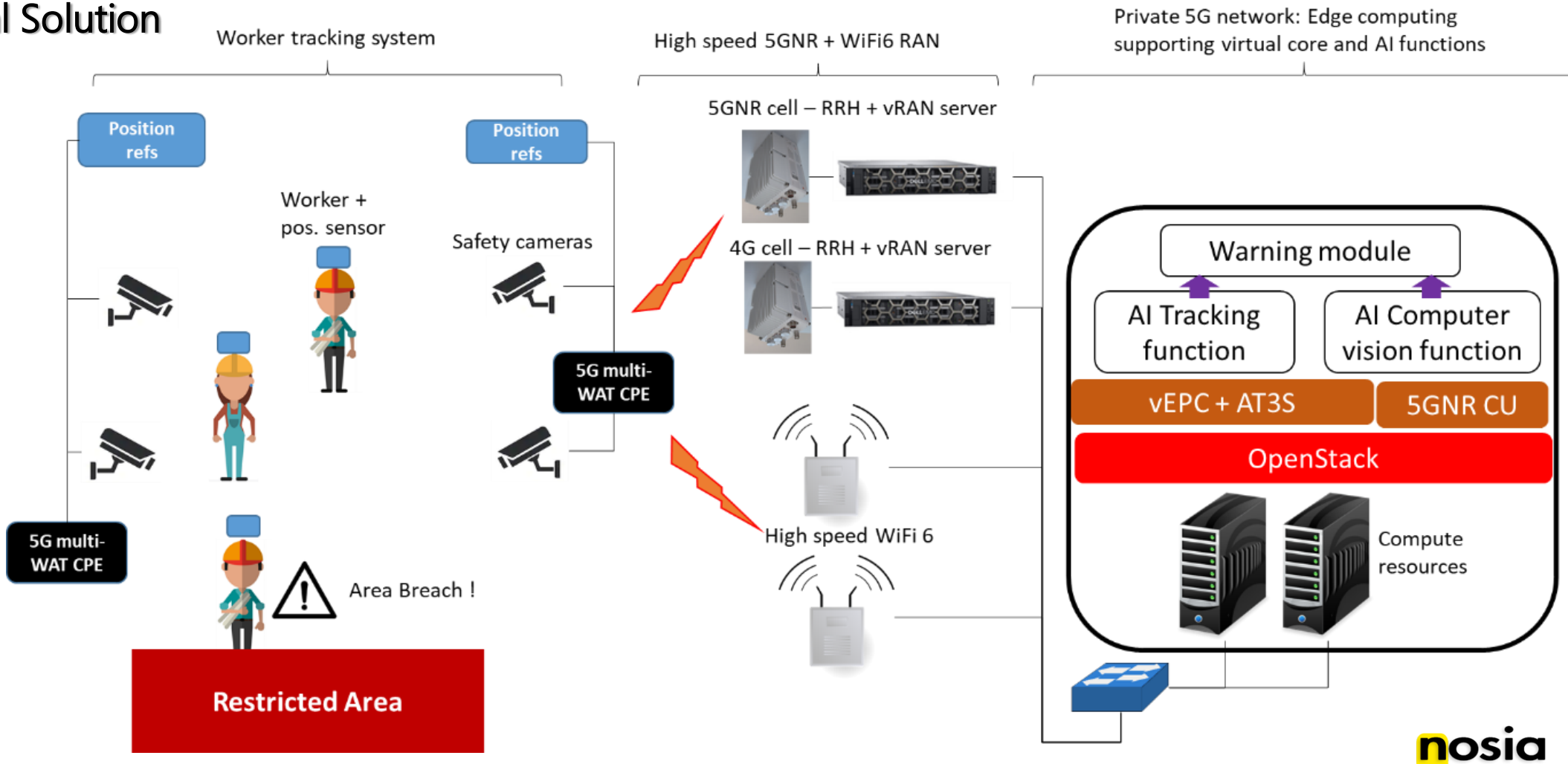
UC2 - Remote Inspection of Automatically Delimited Working Areas at Distribution Level

- Activities in a primary substation are considered of high-risk, due to high voltage energized equipment involved. The safety of the workers to perform such activities is a "top priority".
- The business scope of this UC is to introduce an automated process that enables the detection of workers and their working tools *that are accessing a primary substation and crossing the borders of a delimited (forbidden) area.*
- The detection, made via the use of cameras and other ultra-wide bandwidth (UWB) sensors has to be reliable and very fast, *which is "why a 5G network is chosen as the underlying technology" to provide low-latency and fast processing capabilities.*

UC2: Spanish pilot – Implementation

UC2 - Remote Inspection of Automatically Delimited Working Areas at Distribution Level

Technical Solution



UC3: Bulgarian pilot - Overview

UC3 - Millisecond Level precise Distributed Generation Monitoring

- *Smart5Grid enables the connection of thousands of Medium Voltage (MV) and High Voltage (HV) level decentralised RESs units and their inverters, to a platform with installed 5G communication protocols, which will allow their aggregation and control by the DSOs / TSOs in millisecond rates.*

- *Through the developed platform, the electricity producers owning renewable generation assets can use fast real-time cloud-based tools to formulate optimal energy scheduling, according to the power system needs.*

- *They will be able to monitor and rebalance the network by managing the distributed flexibilities provided by their decentralised energy resources (i.e., Wind Plants, Hydro Plants, Storage and Dispatchable Loads) according to the incentives provided by the grid services markets and business models (i.e., aggregators).*

UC3: Bulgarian pilot - Overview

UC3 - Millisecond Level precise Distributed Generation Monitoring

- The scope of UC#3 is the millisecond level precise Distributed Generation Monitoring, with a focus on renewable energy resources (RES).

- Real-Time (RT) monitoring of a wind farm is to be performed *by using the emerging capabilities of 5G telecommunication networks.*

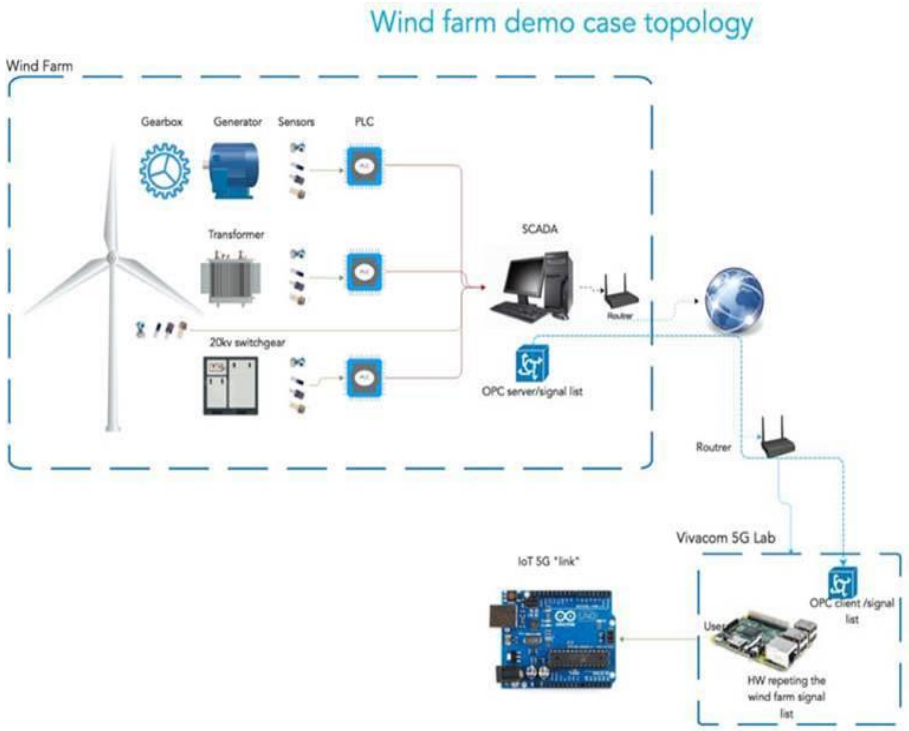
Why Real-Time monitoring?

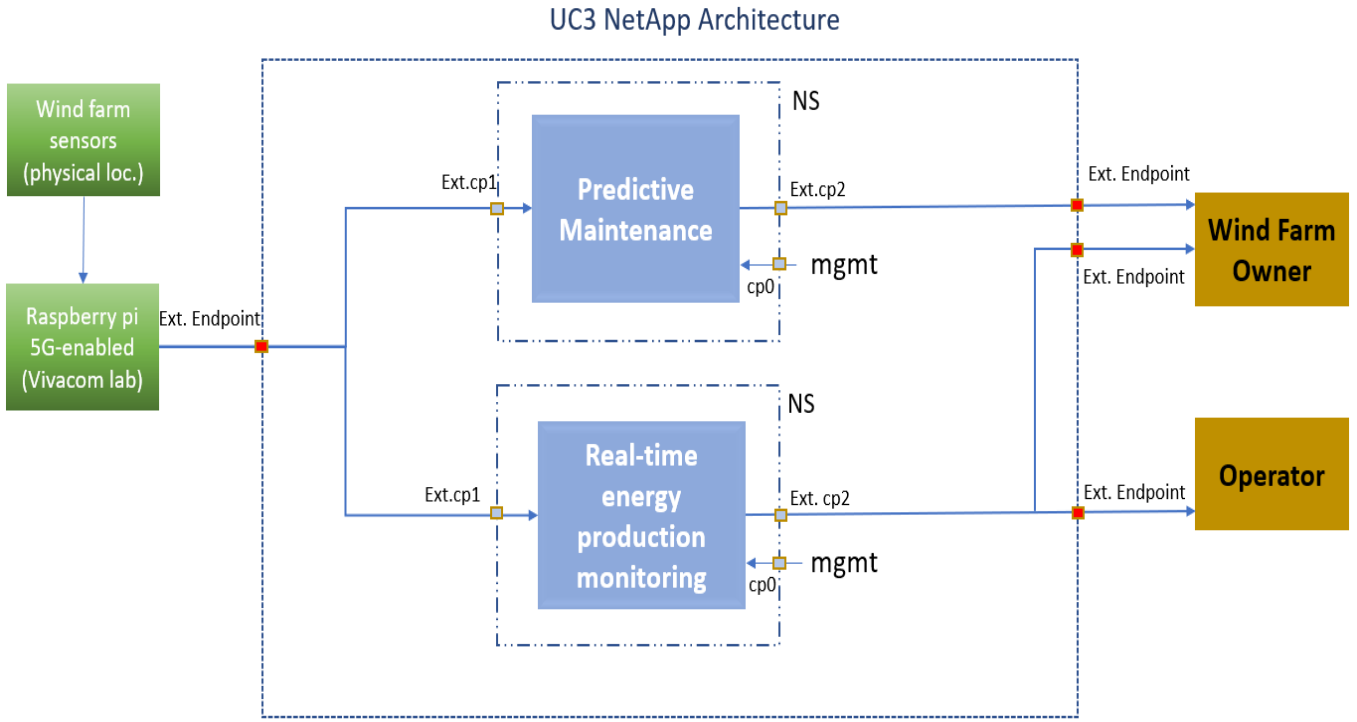
For 2 main reasons:

- The owners can predict and prevent on time potential future malfunctions which may result in financial losses.
- The owners acting as BRP (Balancing Responsible Party) and BSP (Balancing Service Provider) are accountable for the potential imbalances and for the provision of the committed services in the real-time market.

UC3: NetApp High-Level Architecture

UC3 - Millisecond Level precise Distributed Generation Monitoring





- **NetApp#1: *Real-time data collection for Operation and Maintenance*** *(This NetApp enables predictive maintenance capabilities to the wind farm owner, leveraging the data measured from the sensors existing in the wind farm).*
- **NetApp#2: *Real-time energy production and control monitoring*** *(This NetApp provides real-time data monitoring of the wind farm production in a millisecond basis to the owner and the system operator).*

UC4: Greek/Bulgarian pilot – Overview

UC4 – Real-Time Wide Area Monitoring

Inter-area frequency oscillations represent one of the major challenges that "face" modern power systems, *since their appearance is increasing due to the vast changes (i.e. increased penetration of renewable sources, growing energy demand, etc.) and constant expansion.*

The appearance of inter-area oscillations creates many issues *such as power quality degradation, limitation of transmission system capacity* and on several occasions it can even lead to system instability.

The detection and observation of inter-area oscillations is possible only with the use of synchronised measurements provided by the PMUs ((Phasor Measurement Units).

- *Exploiting PMU inputs for a robust, decentralised and real-time operational solution, implicates for a novel communication infrastructure that will support the Wide Area Measurement Systems (WAMSs) of each smart grid.*
- *This will take place with the aim to detect and counteract power grid disturbances in real time, while providing the observability needed.*

UC4: Greek/Bulgarian pilot – Overview

UC4 – Real-Time Wide Area Monitoring

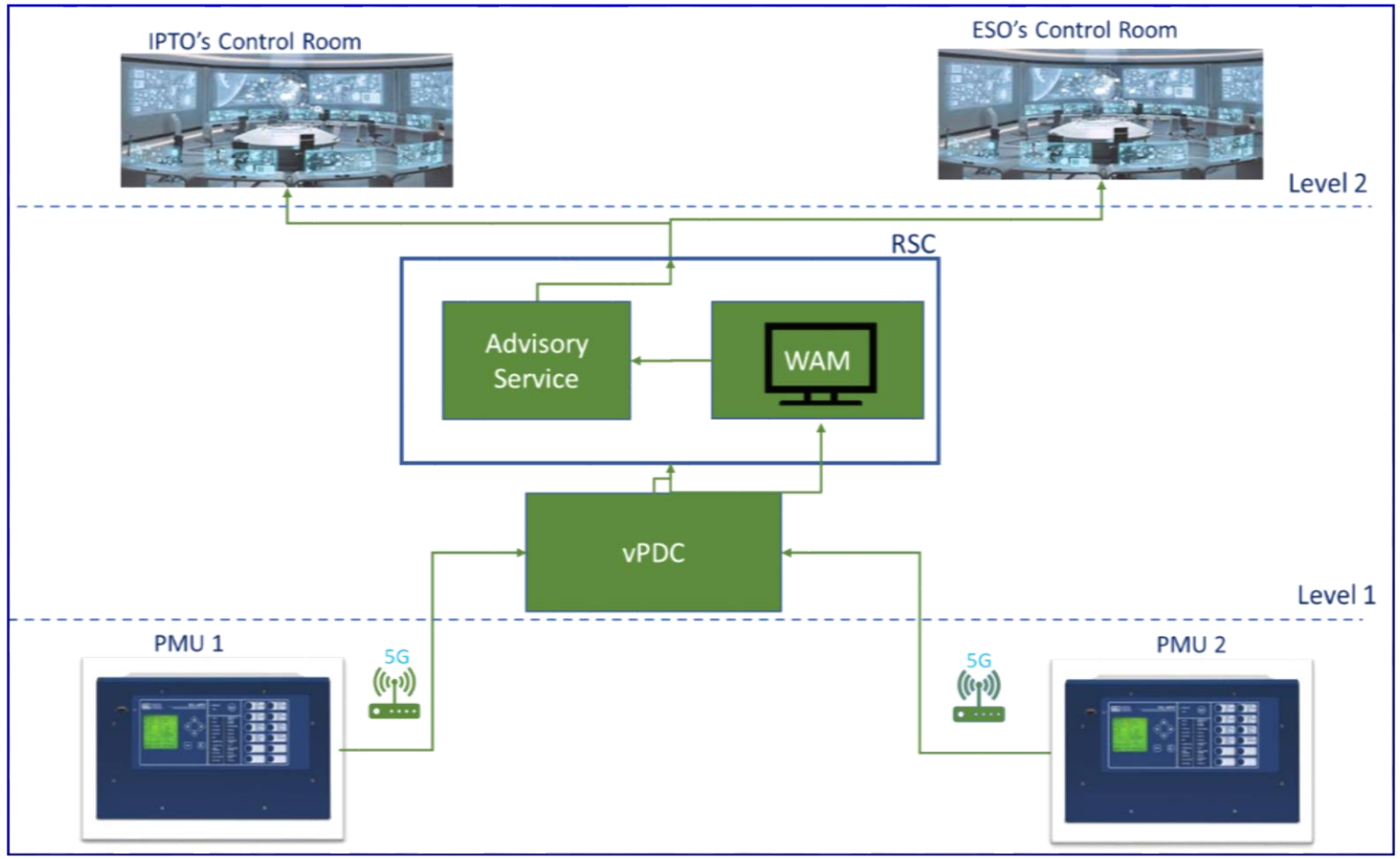
The scope of UC#4 is the real-time (RT) monitoring of a geographical wide area where cross-border power exchanges take place.

Interconnection flow between Greece and Bulgaria is monitored, *taking into account the advantages that the 5G communications infrastructure provides.*

- To achieve the enhancement of the interconnected power system operation, live monitoring of the interconnected power system flows is of vital importance.
- For that reason, a PMU-PDC scheme is used, *enabling high data number and granularity*.
  - Phasor Measurement Units (PMUs) measure grid current and voltage by amplitude and phase at several substations (nodes) of the transmission power system.
  - The high-precision time synchronization of the measurements from different substations allow better monitoring of system's state and detection of dynamic events.
  - PMUs are located in Thessaloniki (GR) and Blagoevgrad (BG) regions and will be used as the monitoring process of the Regional Security Coordinator (RSC).
  - A virtual Phasor Data Concentrator (vPDC) will be developed for the data gathering process according to C37.244 standard.
- The utilization of 5G contributes to the connectivity between the PMUs and the vPDC, offering its low latency and high reliability, *fulfilling the critical constraints of this UC.*

UC4: NetApp High-Level Architecture

UC4 – Real-Time Wide Area Monitoring



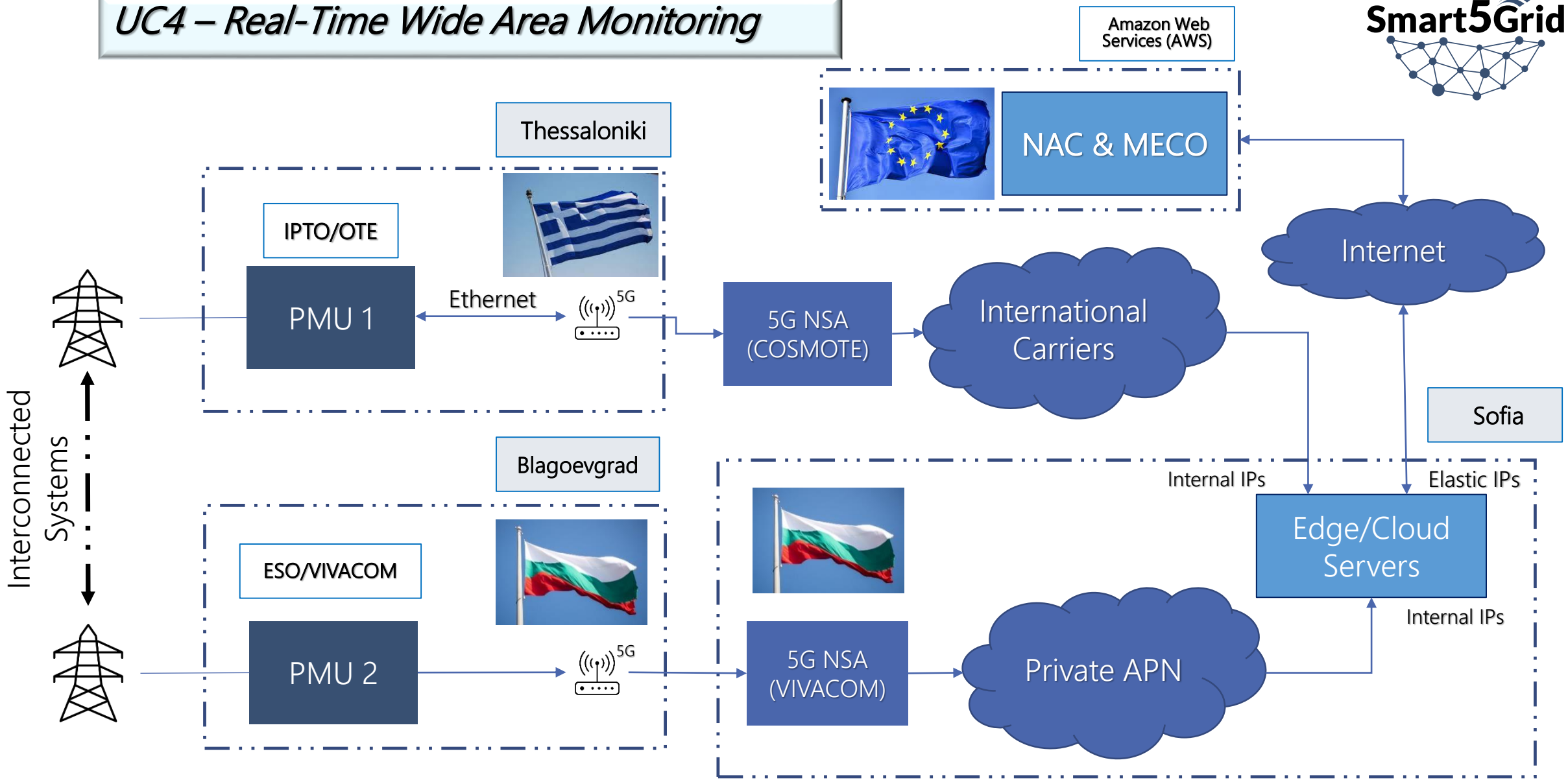
- The role of the **RSC (Regional Security Coordinator)** is to promote regional cooperation and to support the strengthening of the neighbouring power systems and market operations in the region.
  Live monitoring of the power flows between the countries is of vital importance for the RSC.

- **Phasor Measurement Units (PMUs)** will be used as the input in the monitoring process of the RSC.
  By incorporating time-stamped synchronized PMU measurements, high data granularity can be achieved.
- A **virtual Phasor Data Concentrator (vPDC)** will be developed for the data gathering process.

The utilization of 5G in UC#4 contributes to the connectivity between the PMUs and the vPDC, offering its low latency and high reliability needed, due to the criticality of this UC.

Greek/Bulgarian pilot - Field Platform Call Flow Diagram

UC4 – Real-Time Wide Area Monitoring



Synopsis

- Smart5Grid is an on-going research initiative, *supporting transformation of the power distribution grids towards smarter entities, via the beneficial incorporation of innovative 5G features.*
- Smart5Grid aims to identify high-level requirements for the communication network, *allowing the structuring of innovative and high performance smart grids.*
- Smart5Grid deploys an innovative platform, *via the adoption of 5G network infrastructure and the effective inclusion of suitable Network Applications (NetApps) consisted of chained VNFs.*
- Smart5Grid opens new options for the energy vertical sector!

Thank you for your Attention!

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https://smart5grid.eu/