How 5G will impact on Vertical Industries Paper

5G Network Slicing enabling Smart Energy-as-a-Service

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***Abstract*—The 5G plays an enabler role by making some vertical industries smarter, faster and efficient harnessing Ultra-high bandwidth, Ultra-low latency, and an Ultra large number of connections which will change the operating and working modes of core services in vertical industries. In this respect, the 5G is to able to guarantee optimal communications of the energy grid deploying, operating and managing existing and new 5G communications techniques and energy infrastructures (in the context of the Smart Energy-as-a-Service) easier, safer, more secure and resilient from an operational and financial point of view.**

Keywords—5G, SDN ,NFV,VN, Smart Grid, 5G-PPP, eMBB, xMBB, mMTC)

I. Introduction

This paper covers heterogeneity requirements in terms of embedded devices, access networks and minimum devices. It defines and manage the impact of the 5G approach on the modern Smart Grid, clearly identifying both HW and SW requirements as well as communications ones such as response time for the electricity and the gas network assets, round trip delay, jitter and bandwidth requirements, networking & VNF functions, scalability, robustness and open interfaces, supporting migration of IT load to the edge cloud, security, privacy, trust, access control and interoperability requirements, flexibility, fast deployment and service programming model and tools including VNF deployments, VNFFG and SFC and even energy consumption of the 5G devices.

The paper collets the first results carried out by the NRG5 [1]. NRG5 The starting point has been the already outlined proof-of-concept (PoC) in the project application, which originates from fundamental 5G studies [2]. The traditional electricity business model in Europe is still subscription-based, ensuring stability for both suppliers and customers: stable income for utilities; stable supply for customers at predictable and affordable prices. But the huge wave of DERs such as renewable resources, batteries and the new and ongoing deregulation process are leading toward the new innovative business models in the utility sector that has occurred with new service provision and the search for cost efficiencies. For this reason, NRG5 stresses 5G current results co-developing a new 5G communication infrastructure in terms of security, privacy, trust and high availability, investigating on:

- **Security** deploying and operating a huge number of end- points, avoiding lock-in strategies,
- **Resilience** of infrastructure via Predictive Maintenance and self-healing via assets' virtualization and timely energy re-routing,
- **Highly Availability** via smart grid stabilization.

These challenges are also framed by the urgent need for protection against (combined) cyber and physical security threats and attacks, to avoid cascading effects to a great number of other critical infrastructures and services

NRG5 has a clear position in the 5G PPP Phase 2 – Pre-structuring Model [3]. The Use Cases identified in NRG-5 falls on a small set of basic 5G service classes, which have been consolidated and agreed in the context of 5G-PPP as follows:

- Enhanced Mobile Broadband (eMBB), also called Extreme Mobile Broadband (xMBB)
- Ultra-Reliable Machine Type Communications (mMTC), also called Ultra-Reliable and Low Latency Communications (URLLC), and
- Massive Machine Type Communications (mMTC)

This paper explains both the defined use cases and the reason behind their identification.

II. Three Typical Scenarios of a 5G Network Slicing Enabled Smart Grid

A. Use Case Scenario 1: Realizing decentralized, trusted lock-in free Plug & Play vision

In the Smart Grid paradigm, customers play an active role in energy flexibility, being equipped with components for decentralized energy generation and local (possibly moving) energy storage. In such a framework, smart metering devices are quickly proliferating in number and need to exhibit a far more complex profile than today, offering services including support for real-time measurements, service discovery, infrastructure automation and AAA.

This Use Case Scenario 1 applied especially in ENGIE (France) and Rgaz (Romania) addresses

a) mMTC via the vast number of smart meters and
b) uMTC/URLLC as most VNFs require real-time control of the smart energy services. It is important to note that all proposed VNFs may be applied well beyond utility networks to any type of mobile hardware constrained terminal.

From 5G point of view, this Scenario aims at helping to define a scalable cloud-based stack, optional multi-RAT access interface with the goal to enrich security and trust features forming the next generation smart meter as 5G device. The described approach shows the need for efficient *mMTC* communications and for the realization of the "*plug & play vision"* in metering resources. It is based on a novel and scalable *xMEC* paradigm offering a group of *VNFs* to facilitate distributed, scalable and trusted plug 'n' play functionality of hardware constrained devices.

B. Use Case Scenario 2: Enabling aerial Predictive Maintenance for utility infrastructures

The scenario describes Aerial Predictive Maintenance of distributed generation planning, energy transmission and distribution networks, like electricity cables and isolators, and gas/LNG tanks, pumps and pipelines, as an activity of utmost importance in achieving highest power network reliability. The targeted users are TSOs/DSOs/Generation Plant O&M Service providers. This Use Case proofs the involvement of semi-autonomous swarms of drones and parallel surveys from different views/cameras able to run complex, bandwidth demanding, computationally heavy and time critical applications, meeting:

a) operational requirements, such as to define the flight plan for each drone in a swarm, so that they have optimal coverage with minimal resources, taking into account the flight capability of each UAV/drone and the remaining energy,
b) communication requirements, either by cellular or satellite links controlling the drones flight and uploading captured video,
c) mission requirements, such as object (i.e. lines, pipes, tanks, blades, towers) online video analysis and inspection.

Low-delay, 5G-enabled Predictive Maintenance may significantly help in more efficient operation, accidents avoidance and fast restoration of energy networks, leading to reduced maintenance costs and increasing the QoE offered by the Utilities to the citizens.

This Use Case Scenario 2 applied especially in ENGIE (France) and ASM Terni (Italy) addresses

d) xMBB/eMBB communications via the vMPA VNF for video streaming from the drones and analysis to the xMEC and the utilities control centre,
e) uMTC/URLLC communications via the vDFC VNF for for stringent real time control of the flight of drones

C. Use Case Scenario 3: Enabling resilience and high availability via Dispatchable Demand Response (DDR)

This Use case aims at explaining the fundamental role to be played by 5G networks in smart grid as an enabler for aggregator and system operators of new slicing application tailored for optimize network operation and managing load flexibility. As regards power network operators, it is well known that TSOs and DSOs are facing increased network stability challenges while integrating growing shares of renewables for the purpose of network management. This problem requires novel real time operation approaches for the optimized management of electricity network. To deal with the above challenges, the power network operators are moving forward towards the large scale yet selective deployment of near real time Phasor Measurements Units (PMU), based fine grained monitoring wide area monitoring system (WAMS). PMU in fact can selectively and optimally be deployed to provide measurement data for:

- Phase synchronization
- Weather conditions or conductor temperature or tension for TSO- level Dynamic Line Rating.

PMU can provide 50/60 frames per seconds which will allow a real time improved state network estimation within the order of tens of milliseconds, thus greatly contributing to improve the near real time observability of the grid. The addressed 5G requirements are:

- massive machine-type communication (mMTC)
- critical machine-type (uMTC), because each PMU will be and embedded IoT device with built-in 5G native interface

III. CONCLUTION

5G network slicing fully integrates the software-defined networking (SDN)/NFV technology to flexibly match service requirements with network resources, meeting the specific function requirements of different vertical industries in the 5G era. For operators, 5G network slices will help build agile and flexible networks and extend services to vertical markets [4]. Operators provide different slicing capabilities to meet the technical requirements of differentiated services in vertical industries. Furthermore, 5G network slices can help operators to gain on-demand service assurance without constructing mobile private networks. In this way, vertical industry users can improve their capabilities of quickly developing personalized services and expand service markets as soon as possible. The first results carried out by one of the early studies of the NRG5 have been of proof that 5G allows the energy rerouting, for allowing Demand Response.

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