Analysis of the Use of 5G in Smart Grids Applications

Wélington Borsato Rodrigues, Alexandre Baratella Lugli and Benedito Donizeti Bonatto*

Associate Professor, Federal University of Itajubá, Brazil

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***[1]Corresponding author:** Benedito Donizeti Bonatto, Associate Professor, IEEE Senior Member, UNIFEI - Federal, Federal University of Itajubá, Brazil

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Introduction

Choosing communication technologies for smart grids is not simple, because each application has its own communication requirements. For example, substation automation needs a latency of less than 200ms, but an electric vehicle charging monitoring can have a latency of minutes [1].

There is a diversity between the technologies already used in each solution, such as the use of cellular technology of different generations (2G, 3G, Long Term Evolution (LTE), also called 4G, Worldwide Interoperability for Microwave Access (WiMAX), among others). Several technologies standardized by the Institute of Electrical and Electronics Engineers (IEEE) are also used, such as the IEEE802 series standards (Bluetooth, Zigbee, etc.). In addition, wired technologies are used, such as Power Line Communication (PLC) and fiber optics [2] and there are also some promising technologies that are still underused, such as 5G [3-10].

Table 1 presents a compilation of references in which you can find which communication technologies are used in each smart grid application. In Table 2, you can find the references that cite the technical specifications of each technology [11-18].

Table 1: References to the technologies used in each application.

Application	Reference for used Technologies	Application	Reference for used Technologies
Advanced Metering Infrastructure- AMI	[3]	Distributed Generation - DG	[10]
Energy Management System - EMS	[4]	Wide-area situational awareness - WASA	[11]
Distribution Automation - DA	[5]	Monitoring the Brazilian water resource	[12]
Demand Response - DR	[6] and [7]	Distributed Energy Resource - DER	[5]
Electric Vehicle - EV	[4], [8] and [9]		

Table 2: References to the technical specifications of each technology.

Technology	References for Technical Specifications	Technology	References for Technical Specifications
5G	[13-16]	Zigbee	[4], [23]
4G	[16-19]	NB-IoT	[9], [30] and [31]
3G	[16-19]	LoRa	[9], [22], [30] and [32]
WiMAX	[4], [20] and [21]	Sigfox	[18], [30] and [32]
Ingenu	[22-25]	6LoWPAN	[14], [33]
Wi-Fi	[23],[26-28]	DASH7	[9], [32] and [33]
Bluetooth	[23],[29]	GOES	[12], [33]

Finally, Table 3 is the result of the compilation of the information obtained by the references presented in Table 1 & 2. Information on latency, coverage, operating frequency and data rate of technologies already used in the context of smart electrical networks is presented. In addition, a cross-referencing of information between technologies and applications was also carried out, according to the literature, where the “x” represents that the technology was not mentioned in the literature as applied to a particular application and the symbol “✓” demonstrates that there was quotes regarding your application [19-26].

Table 3: Compilation of technologies, technical characteristics and application.

	Communication Requirements				Applied in:								
Technology	**Latency**	**Coverage**	**Operation frequency**	**Data Rate**	**AMI**	**EMS**	**DA**	**DR**	**EV**	**GD**	**WASA**	**MRH**	**DER**
5G	<1ms	Up to 100km	>6GHz Between 1GHz and 6GHz	Up to 10Gbps	✓	x	✓	✓	✓	✓	✓	✓	✓
4G	60-98ms	Up to 30km	700 MHz - 2500MHz	Up to 3,3Gbps	✓	x	✓	✓	✓	✓	✓	✓	✓
3G	212ms	Up to 31km	800 MHz - 1900MHz	Up to 56Mbps	✓	x	✓	✓	✓	✓	✓	✓	✓
WiMAX	<100ms	Up to 50km	5,8GHz	Up to 75Mbps	✓	x	x	x	x	x	✓	x	x
			3,5GHz										
			2,5GHz										
NB-IoT	1,6s to 10s	Up to 15km	900MHz	Up to 100kbps	✓	x	✓	x	✓	x	✓	x	x
			800MHz										
			700MHz										
LoRa	<1s	Up to 15km	unlicensed Sub-GHz	Up to 37,5kbps	✓	x	✓	x	✓	x	✓	x	x
Sigfox	<2s	Up to 50km	unlicensed Sub-GHz	100bps	✓	x	✓	x	x	x	✓	x	x
Ingenu	<10s	Up to 15km	2,4GHz	624kbps	✓	x	✓	x	x	x	✓	x	x
Wi-Fi	< 3ms	Up to 100m	5,8GHz	Up to 6,76Gbps	✓	✓	x	✓	x	✓	x	x	✓
			2,4GHz										
Bluetooth	<100ms	Up to 100m	2,4GHz	Up to 1Mbps	✓	✓	x	x	x	✓	x	x	x
Zigbee	<16ms	Up to 75m	2,4GHz	250kbps	✓	✓	x	✓	x	✓	x	x	x
			915MHz	40kbps									
			868MHz	20kbps									
6LoWPAN	<16ms	Up to 200m	2,4GHz	250kbps	✓	x	x	✓	x	x	x	x	x
			915MHz	40kbps									
			868MHz	20kbps									
DASH7	< 305ms	Up to 2km	915MHz	Up to 167kbps	x	x	x	x	✓	x	x	x	x
			868MHz										
			433MHz										
GOES	10s	Continental	402MHz	300bps	x	x	x	x	x	x	x	✓	x

In the line referring to 5G technology, the symbol “✓“ indicates in which applications 5G technology can be used [27].

All the analysis carried out showed that the use of 5G is coherent in most of the mentioned applications: In the advanced metering infrastructure, it is shown as a suitable technology mainly in WAN and NAN operations; In distribution automation, 5G meets all the requirements discussed; For demand response, 5G brings data bidirectionality and enables control and measurement of devices further away; For vehicular electrification [28-33], 5G allows monitoring of charging points, makes it even more possible to connect cars to the internet and creates new possibilities for V2G; In distributed generation, 5G facilitates the monitoring and maintenance of photovoltaic plants. For wide-area situational awareness, 5G meets range and latency requirements and will naturally be used, as cellular technologies are already part of this application. In water monitoring, 5G can optimize the off-grid systems of data collection platforms and increase the coverage area, but it does not prevent the existence of satellite systems, especially in the region in northern Brazil. For distributed energy resources, 5G comes as a promising technology for use in IEDs. The exception is with applications in which short-range technologies are more suitable, such as the energy management system, especially when applied to homes [33-35], buildings and data centers.

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