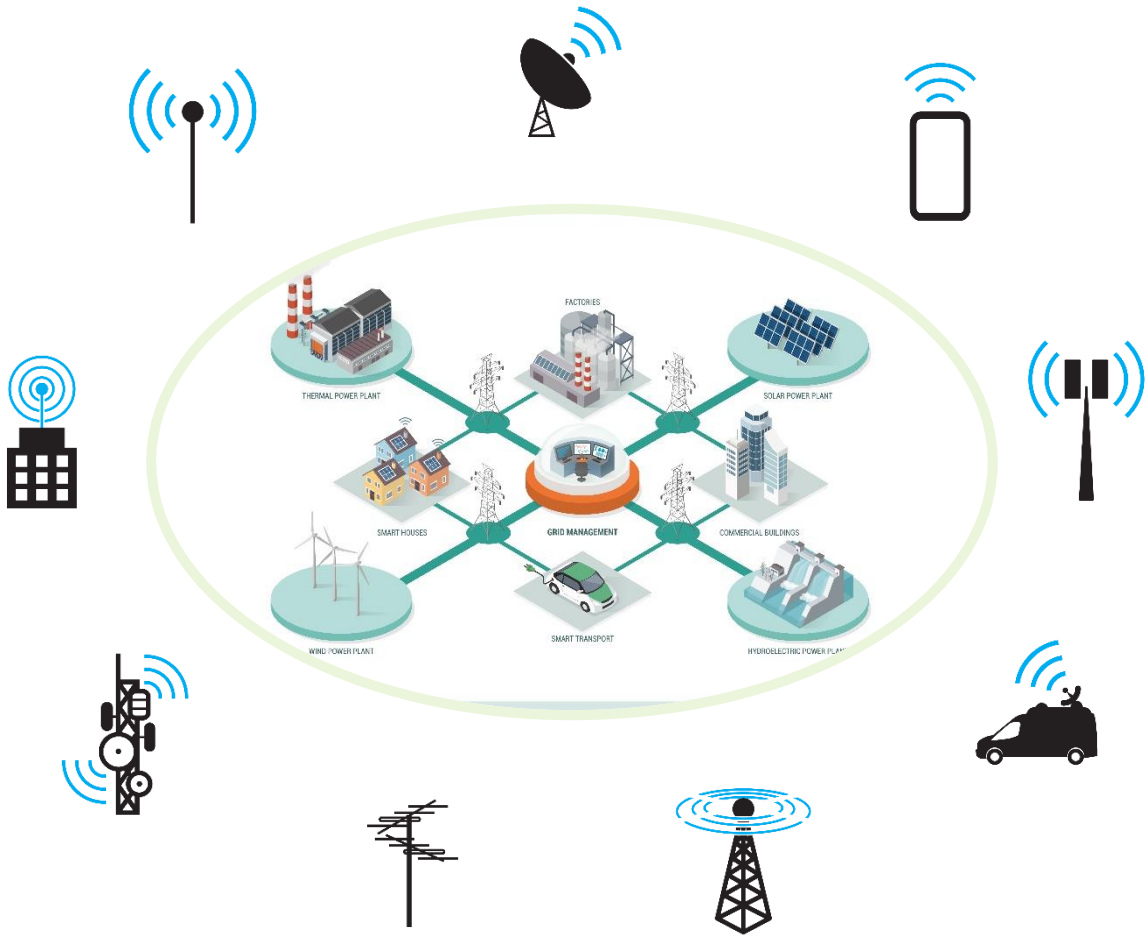
Spectrum for Utilities' Mission - Critical Applications



Report Americas

Survey on the need of radiofrequency spectrum for Utilities' mission-critical applications.

Summary

Introduction

The Global Advisory Committee ("GAC") is organized as an independent international advisory council of the Utilities Technology Council ("UTC"), a nonprofit corporation registered in the District of Columbia.

The primary purpose of the Global Advisory Committee is to represent UTC and its global independent operating units and affiliates - AUTC, EUTC and UTCAL on issues concerning deployment and implementation of utility telecommunications and technology services and applications.

Purpose

The main purpose of this document is to present to UTC members, Regulatory Agencies and wireless equipment manufacturers the findings of a study developed by UTC America Latina on the need to allocate specific frequency spectrum to electric, water and gas companies, to enable the deployment of wireless communications networks and systems to support their mission critical applications, which will ensure a proper management and control of each company's assets and an appropriate delivery of services to consumers.

Background

GAC carried out a survey among members and non-members, utilities companies, from September 2017 to October 2018, to assess the durrent use of frequency spectrum for supportingutilities' mission critical applications and to identify future needs on that aspect.

Many companies, from the utility sector and registered in the UTC GAC database were invited, of which twenty-eight (28) answered the questions presented. This sample is formed by seventeen (17) north american utilities and eleven (11) brazilian utilities.

The following pages present graphs and brief analysis of the main mission critical applications for electric power network operation in these companies, the technical requirements necessary for the telecommunications systems for these applications, the way in which frequency spectrum is used in wireless systems and which are the solutions available for attending such applications, under manufacturers' point of view and considering the modernization process of electric power networks.

The electric power networks modernization increasingly requires the use of telecommunication systems to improve the operation reliability and will progressively depend on the information collected in the field to secure the most reliable and efficient energy delivery. Without the reliability of telecommunications, the modernization of the electricity grid will be compromised.

Many companies have chosen to deploy their own private telecommunications networks to ensure the high levels of availability and reliability demanded by their customers and the national electric power regulatory agency (ANEEL).

Overview

Since the 1950s, utilities have been using telecommunications to monitor and control their electricity, water and gas networks.

Electricity is at the top of essential services list to society, whose unavailability or even temporary interruption can negatively affect whole chain of other public services that are also essential to society, such as transportation, health, banking and telecommunications.

The chain that makes up the electricity system is composed of three important sectors: generation, transmission and distribution. These segments operate in an integrated way, being extremely important the management, control, automation and monitoring of the events resulting from human actions and nature that constantly impact the electrical system.

The electrical networks "intelligence" is mainly based on the exchange of real-time information on measurement, supervision and control data, installed in strategic positions in generation, transmission and distribution networks, as well as in homes, offices, companies, with the purpose of making it capable of automatically detecting, analyzing, responding and restoring faults in the network.

As a result, the introduction of new applications and intelligent devices will increasingly require telecommunications networks capable of securing real-time traffic and meeting stringent security, ubiquity, resilience, reliability and availability requirements, inherent in the provision of mission critical services, essential to society.

Main mission critical applications

Mission critical applications are those a by utilities to ensure security, quality, availability, resilience, and reliability in providing basic services essential to society, whose loss or unavailability may lead to disorders not only social but also financial.

Utilities companies were invited by UTC GAC to participate in a survey to identify telecommunication needs to support mission-critical applications in their industrial plants. The main applications considered critical by the participating companies were:

i. Protection - is used to isolate parts of the electrical network when a fault is detected and, at the same time, prevent the propagation of interruptions to other points in the network protecting the equipment against damages.

ii. *Supervisory Control and Data Acquisition System (SCADA)* - is used to accurately control important electrical network devices and to monitor, in real time, parameters such as voltage, current, temperature and switching positions throughout the electrical system.

iii. *Remote measurement* - is used to remotely monitor consumption, power supply quality parameters and demand management.is used to monitor consumption, quality parameters of electricity supply and demand management.

iv. *Mobile voice communication* - is used to allow interaction between the Control Center and the field teams in routine and emergencies operational tasks in the electrical network.

v. *Fixed voice communication* - is used to enable communications between the Control Centers and the main power plants and substations in routine and emergency operational activities in the interconnected electrical system.

vi. *Video Monitoring* - is the system used to monitor sites with the objective of assisting the remote operation of substations, power plants, station security, security of people and monitoring of assets.

vii. *Digital Disturbance Recorder (DDR)* - are intended to record the operation of the electrical system and its protection during important events, such as electrical failures, frequency fluctuations and operational failures. DDRs or also called digital oscillographs are present in most electrical power system installations. These equipments perform a constant system monitoring seeking to record as many events as possible during the disturbances that occur in the electrical system. From the analysis of the data captured by the DDR it is possible to determine the type of fault that has occurred and to confirm that the protection subsystem meets the basic requirements of speed, selectivity, sensitivity and reliability.

viii. Synchrophasors – Used to monitor the stability of the electric power grid and assist in reducing catastrophic cascading failures.

ix. *Distribution Automation Networks* - application for monitoring and control of intelligent electronic devices deployed in reconnectors, keys and capacitors banks installed along the urban and rural feeders, and aims to maintain the minimum levels of electricity supply quality, increasing the system security, availability, reliability and resilience. The distribution automation of networks is one of the modernization stages of the electrical networks and it is intended to endow it with intelligence (smart grid). It is a system that optimizes the energy supply by minimizing losses of various natures; it is self-healing and enables the emergence of new energetically efficient applications.

Telecommunications solutions for mission-critical applications – Electrical companies' vision

Mission criticalapplications which are essential for the proper operation of the interconnected electrical system shall have all its requirements duly supported by the underneath telecommunications networks and systems.

The choice of telecommunications solutions is evaluated according to the level of criticality of each application. Table 1 shows the level of criticality of applications from the perspective of energy companies, and according to the answers obtained from the companies participating in the survey.

Application / Criticality	High	Medium	Low
Protection	83%	14%	3%
SCADA	83%	15%	2%
Fixed Voice Communication and data	99%	1%	-
Mobile Communication and data	74%	19%	7%
Remote Measurement	44%	46%	10%
Digital Disturbance Recorder (DDR)	59%	25%	16%
Video Monitoring	-	82%	18%
Distribution Networks Automation	100%	-	-

Table 1 – Level of Criticality of Applications in the electrical sector – According to respondents

Applications such as protection, SCADA, fixed and mobile data communication and distribution network automation were considered of high criticality, while the applications of remote measurement, RDP and video monitoring were considered of medium criticality.

All respondents, without exception, use telecommunications systems to support their applications. The requirements demanded for telecommunications systems are the same as those required for critical applications regarding availability, reliability, security, synchronism, resilience, latency, etc. The telecommunication solutions used are diversified and range from Power Line Communication to fiber optic networks and point-to-point and point-to-multipoint radio links.

Figure 1 shows the different telecommunication solutions used by energy companies to support their mission-critical applications.

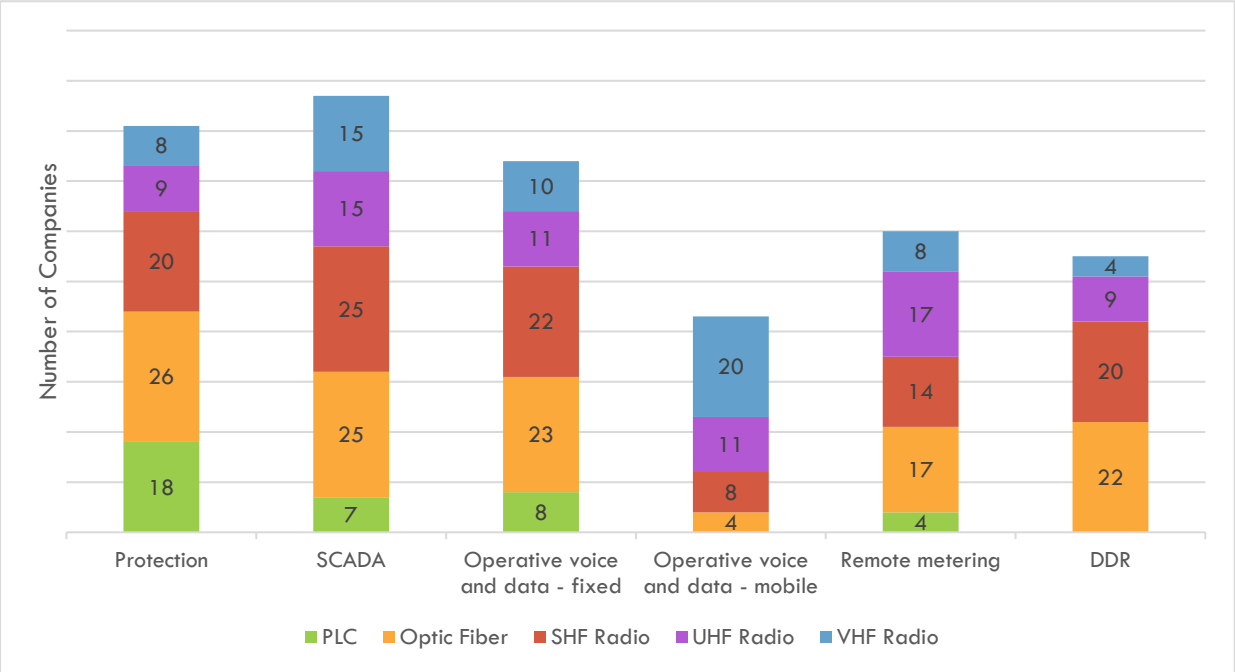


Figure 1 - Number of companies that use different telecom solutions to support their mission critical applications

Although optical fiber is widely used in the electrical sector to support its mission critical applications, the use of the wireless solution is also essential, so much in the backbone as in the access to power plants, substations, etc. Wireless solutions ensure that a great number of decentralized resources can be connected more easily and quickly. Wireless solutions are also essential for maintaining communication with the field team in activities related to maintenance and repair of the power grid.

Due to the applications criticality and the need for the electrical system operation safety, the use of wireless solutions by electric power companies will always be conditioned to the available frequency spectrum. The primary character of these frequencies becomes an extreme factor of importance for the reliability and safety of these companies' operation.

Protection

Protection applications are designed to ensure electrical equipment safety and reliability in substations and transmission lines, acting quickly and accurately the detect and isolate faults and minimizing the possibility of spreading disturbances to the rest of the interconnected electrical system.

Figure 2 shows the most commonly used protection applications by electric power companies. Among the twenty-eight (28) responding companies, twenty-six (26) use multiple protection applications requiring telecommunications systems with high reliability and availability.

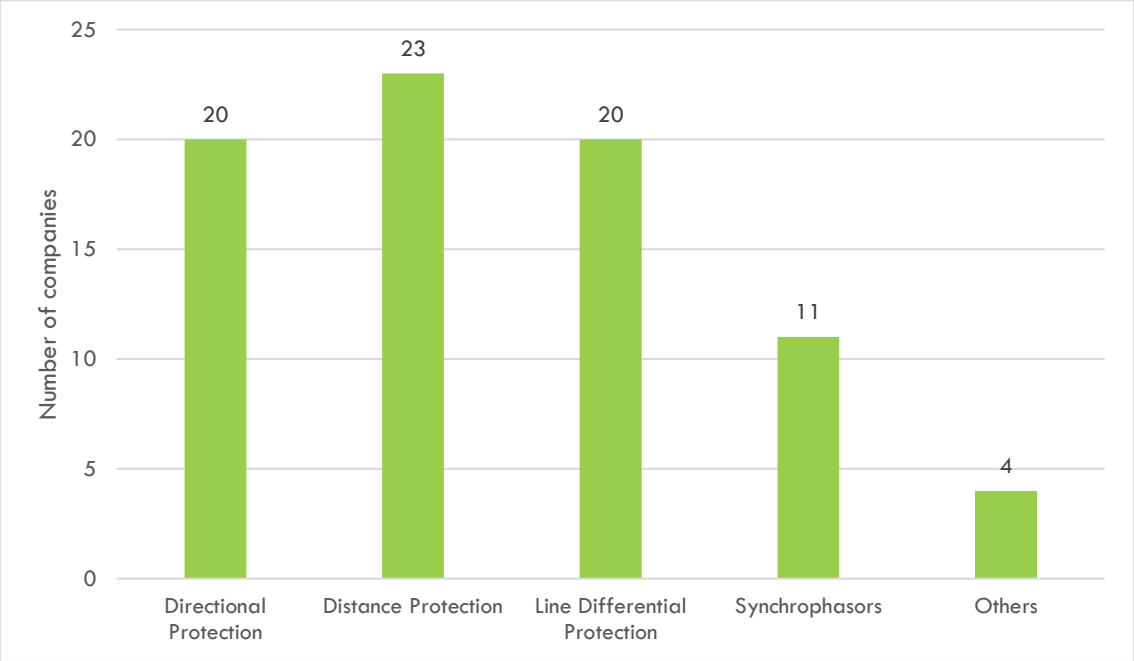


Figure 2 – Number of companies by type of protection used

Almost all participating companies reported that this type of application is of vital importnace to the operation of the electrical system. Table 2 shows the level of criticality considered for protection application by the most of participating companies.

Application Type	Criticality			
	High	Medium	Low	N/A
Directional Protection	65%	12%	0%	23%
Distance Protection	70%	15%	0%	15%
Differential Protection	85%	0%	0%	15%
Synchrophasors	23%	15%	8%	54%

Table 2 – Level of Criticality of protection applications - Percentage of companies

ONS in Brazil

The National Grid Operator (ONS) is the body responsible for the coordination and control of the operation of the energy utilities in the National Interconnected System (SIN) and for planning the operation of the isolated systems of the country under the supervision and regulation of the Agência Nacional de Energia Elétrica (Aneel).

ONS objectives:
(a) to promote the optimization of the operation of the energy system, aiming at the lowest cost for the system, observing the technical standards and reliability criteria established in the Network Procedures approved by Aneel;
(b) ensure that all actors in the electricity sector have access to the transmission network in a non-discriminatory manner; and
(c) to contribute, in accordance with the nature of its activities, so that the expansion of the SIN is made at the lowest cost and aims at the best future operating conditions.

The ONS is composed of associate members and participating members, which are the companies of generation, transmission, distribution, free consumers, importers and exporters of energy. Also participating are the Ministry of Mines and Energy (MME) and representatives of Consumer Councils.

In case of Brazil, ONS establishes that the teleprotection service must be provided through two independent telecommunication routes with individual availability of at least 99.00%.

The participating companies were almost unanimous in reporting that they use their fiber optic networks to meet this demand, additionally with other solutions such as power line carrier or microwave or UHF radio.

More details are showed in Figure 3.

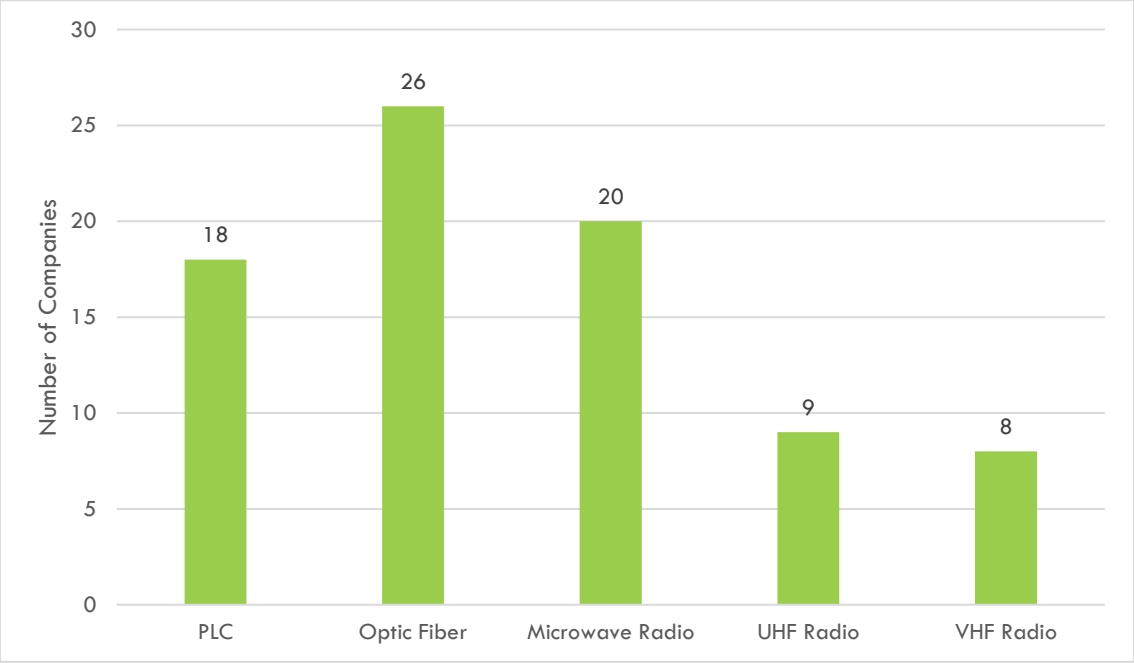


Figure 3 – Number of companies per telecommunications solution used in protection application

When inquired about the most appropriate frequency band for Teleprotection applications, when using wireless solutions, the companies indicated their preference for the following frequency bands:

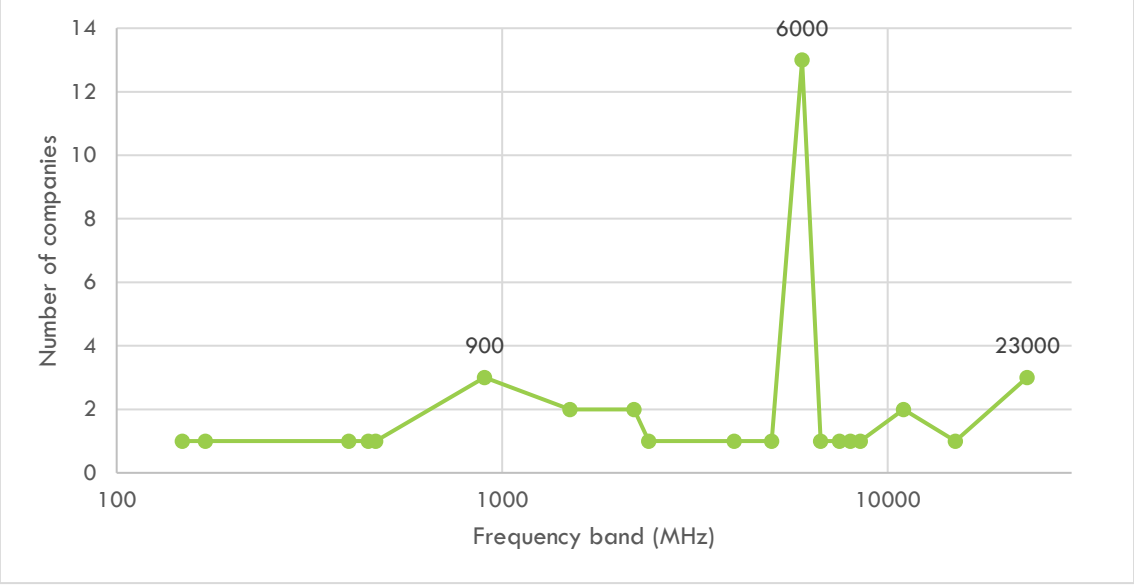


Figure 4 - Frequency bands utilized in protection applications

The wide frequency ranges informed by the companies in this research, makes clear the lack of a targeting for a more optimized spectrum use.

When questioned about the maximum latency supported by the protection applications, 68% of the companies participating reported to accept delays of up to 10 ms (39% from 6 to 10 ms and 29% up to 5 ms), while 25% reported to accept delays between 11 ms to 50 ms. More details can be found in Figure 5. In the case of Brazil, the ONS network procedures document, in its sub-module 13.2, establishes value smaller than or equal 140 ms as minimum requirement for the communication channels latency.

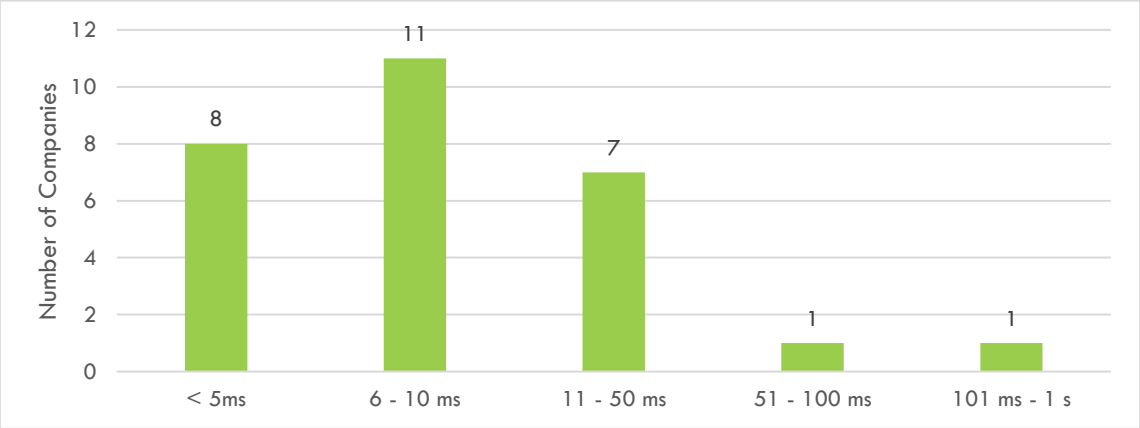


Figure 5 – Maximum Latency supported by protection applications

Concerning the minimum availability required for telecommunication systems for protection application, most of the respondents reported that they require a percentage equal to or greater than 99%. As can be seen in Figure 6, seventeen (17) companies consider availability of at least 99.99% for this type of application.

To ensure such availability, the companies use redundant telecommunications solutions typically duplicated fiber optic routes, or a fiber route backed up by a radio link (SHF or UHF) or even a PLC connection.

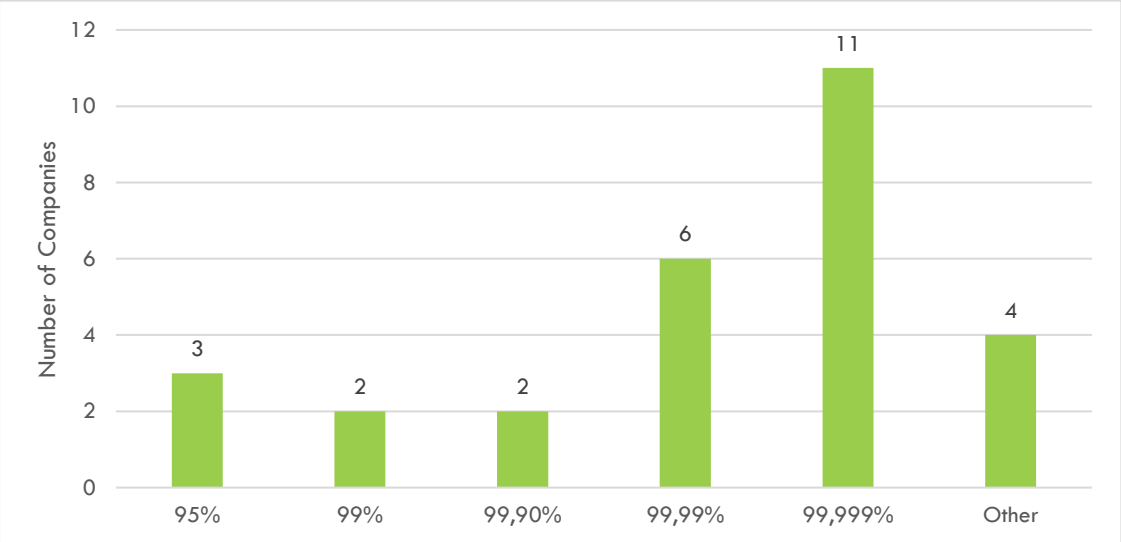


Figure 6 – Minimum availability for protection application

SCADA

The SCADA (Supervisory Control and Data Acquisition) systems are aimed to supervise, to perform data acquisition and to enable the visualization of a particular process, with the objective of controlling it, providing a high interface level to the system operator, informing in real time about all events of importance occurred in the industrial plant.

Most respondents use SCADA in substations, power plants and distribution networks. Those facilities, when connected to control centers, enable real time operation of the main process of the electric power system. Figure 7 shows the facilities where energy companies have SCADA systems installed.

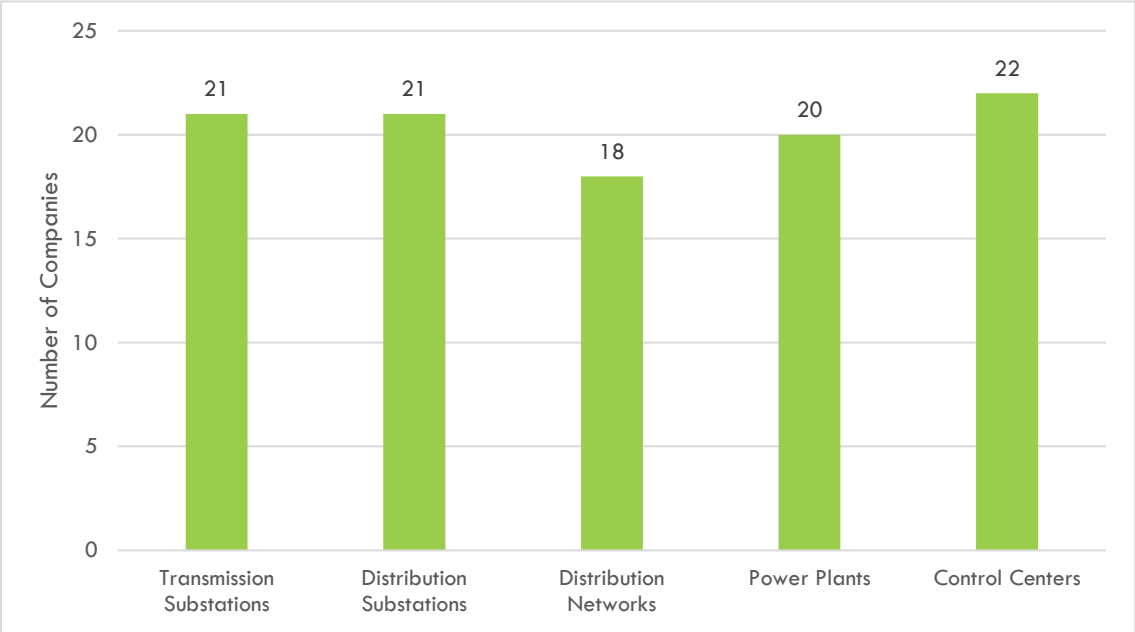


Figure 7 – Facilities that use SCADA systems

The criticality level required by SCADA applications is mainly high, as it can be observed in the responses presented in Figure 8.

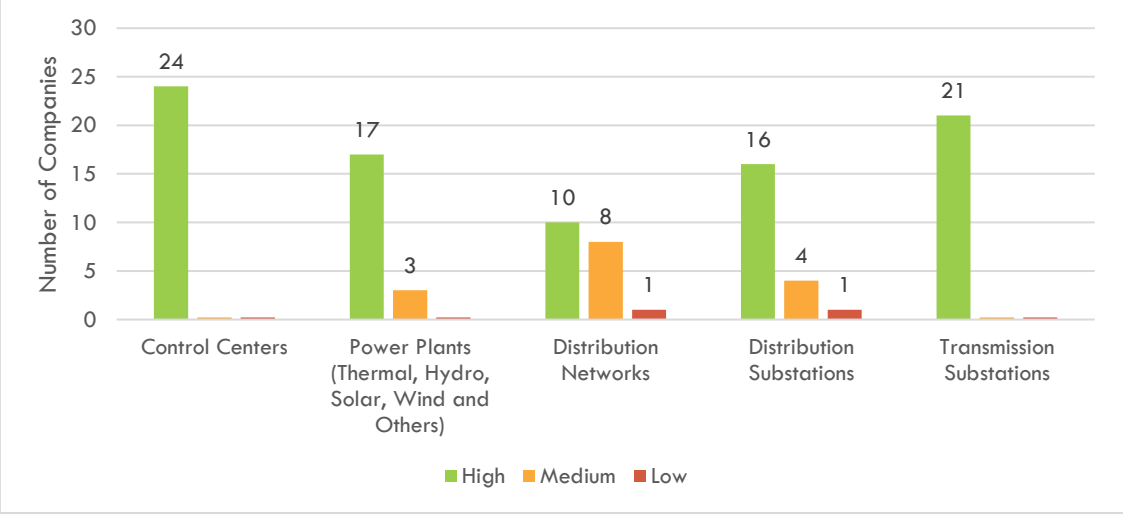


Figure 8 – Criticality level of SCADA systems

Most respondents utilize more than one (1) telecommunications system to support SCADA systems, as shown in Figure 9. It is worth mentioning that most of the companies reported utilizing optic fiber and SHF as one of the main method of data transmission for this type of application.

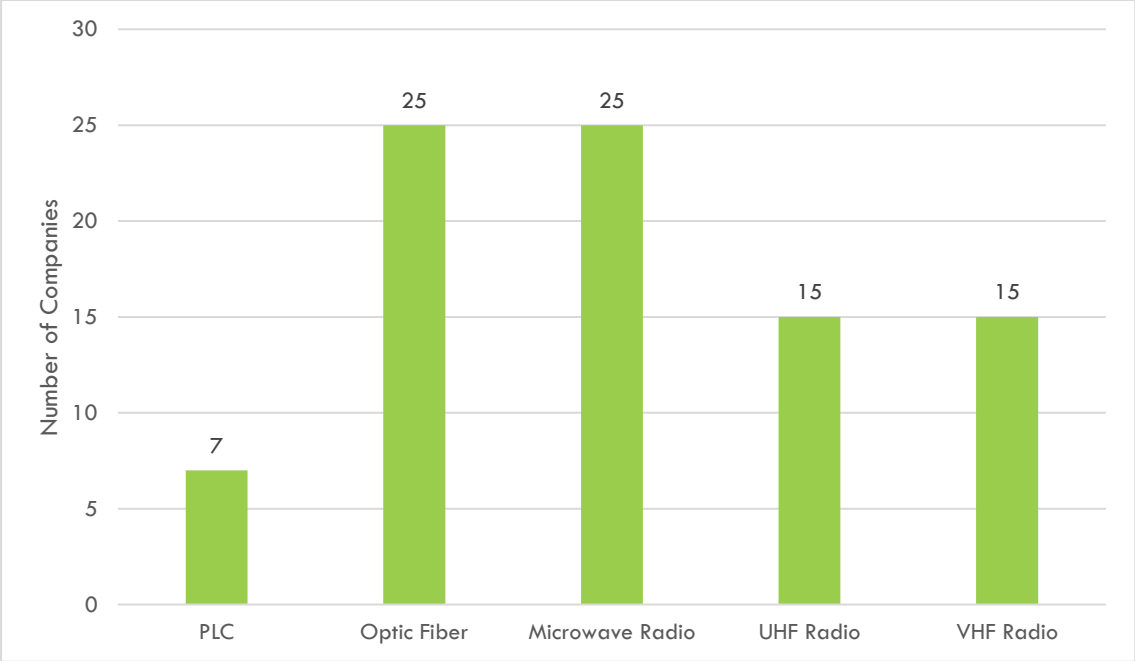


Figure 9 – Telecommunications systems used to support SCADA applications

When asked about the frequency bands more suitable to this use, companies indicated the following:

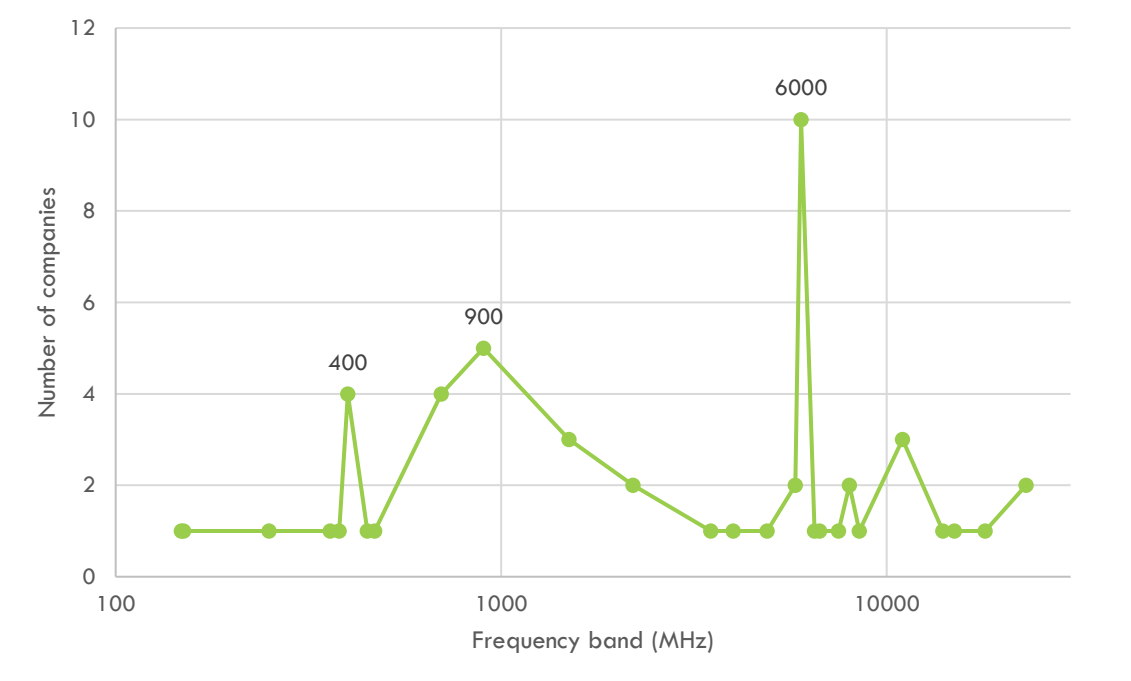


Figure 10 - Frequency bands utilized in SCADA applications

Alternative telecommunications solutions to support this application, such as satellite networks and public mobile networks, where also mentioned by some of the participants.

In this case it is evident, based on the responses, that there is not a guideline for a more optimized use of spectrum.

When asked about maximum latency supported by this type of application, 71% of the respondents stated considering a maximum of 100 ms. Among them, 35% claim that the maximum accepted is 10 ms. Figure 11 shows that 21% of the participants accept latencies higher than 100 ms in SCADA systems.

Only one company informed (in “others”) that consider a latency of 2 ms as the maximum accepted to support this type of application.

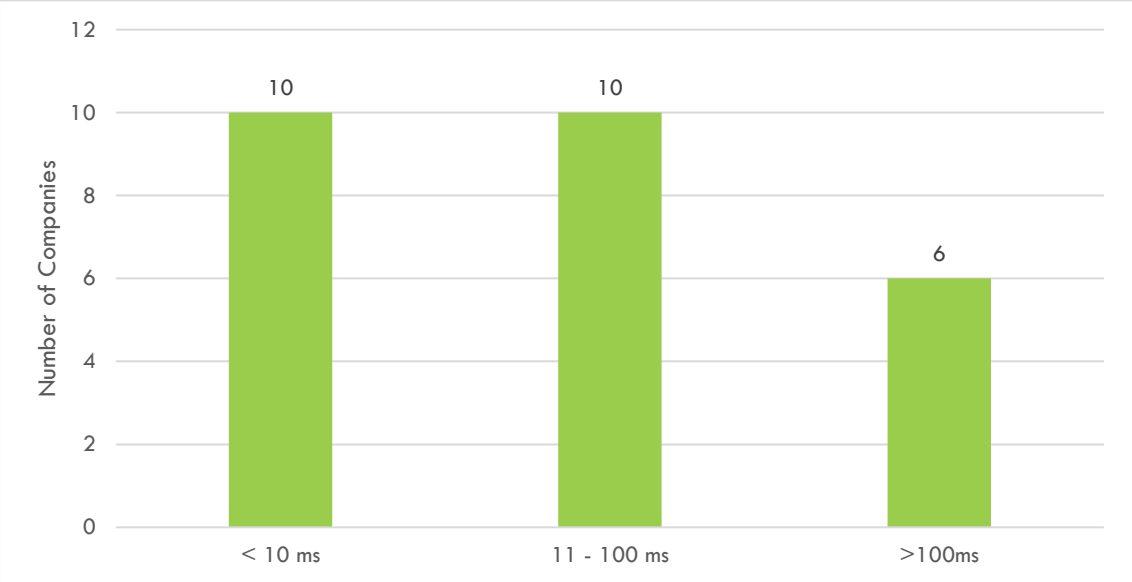


Figure 11 – Maximum latency allowed by SCADA applications

In Figure 12, most of the participant companies consider adequate an availability higher than 99%, and 79% reported that an availability higher than 99,9% is required.

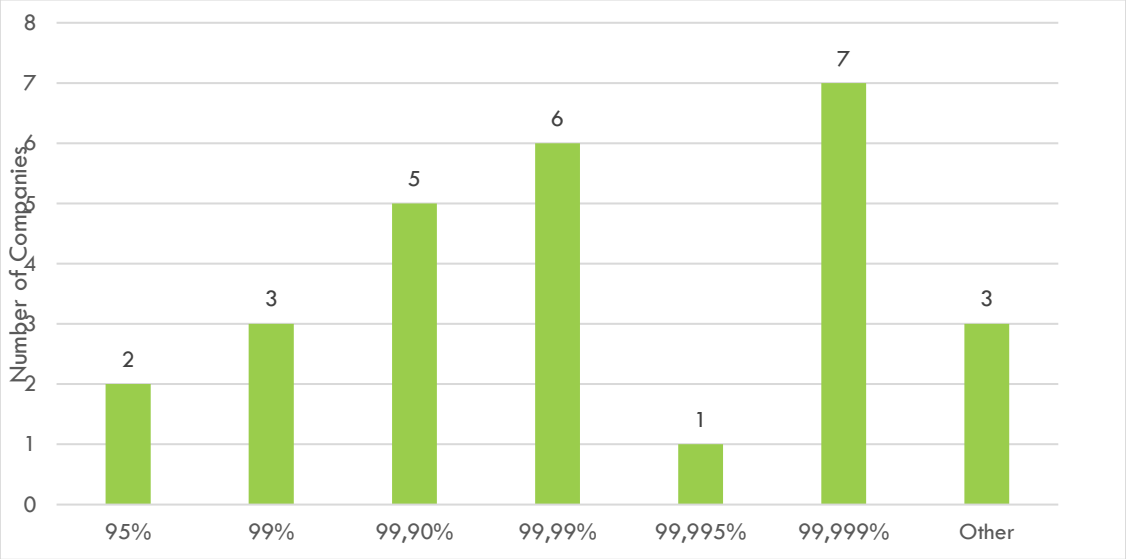


Figure 12 – Minimum availability required by SCADA applications

Operative voice and data

Figures 13 and 14 show, respectively, facilities where there is a demand of operative voice and data in energy companies, and the type of communication (fixed or mobile) required in each place. Fixed communication (point-to-point) is the predominant solution adopted for communications among operation centers, power plants and substations, while mobile communications are most utilized for communications between control centers and field.

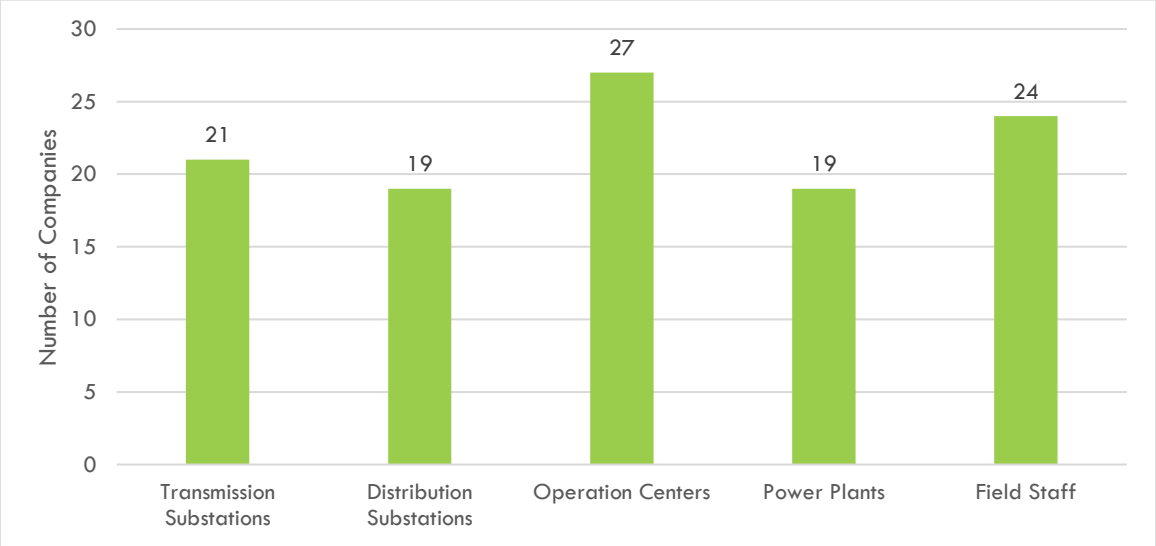


Figure 13 – Facilities that use operative voice and data

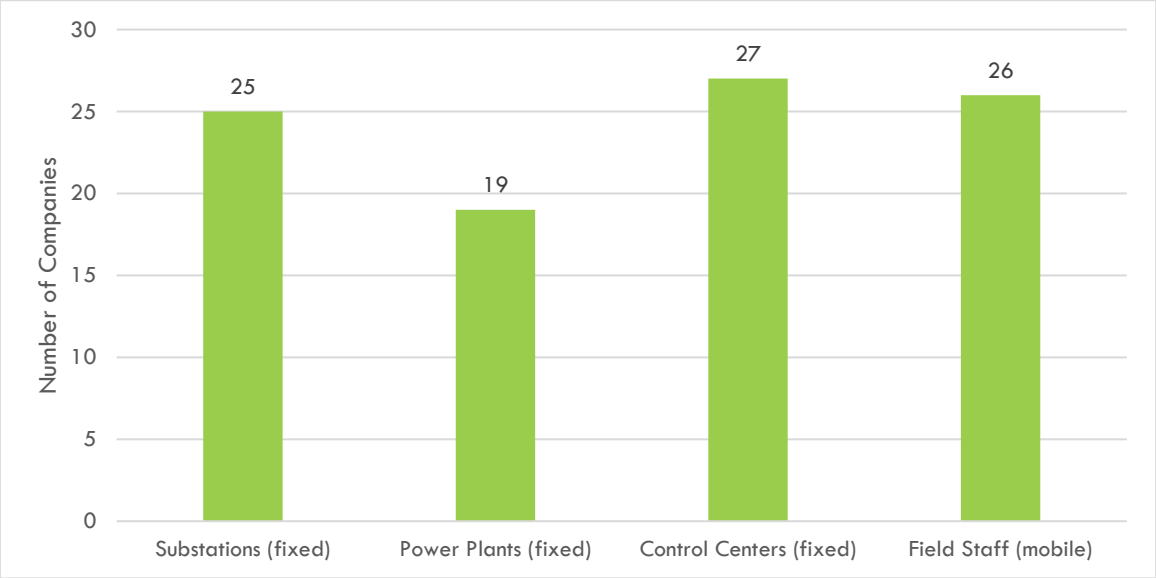


Figure 14 – Types of operative communication in companies

Regarding the telecommunication systems utilized for fixed operative voice and data communications most of the respondents stated they are utilizing optic fiber in substations, power plants and control centers, in addition to another type of solution to enhance the reliability of those facilities, as it can be seen in Figure 15.

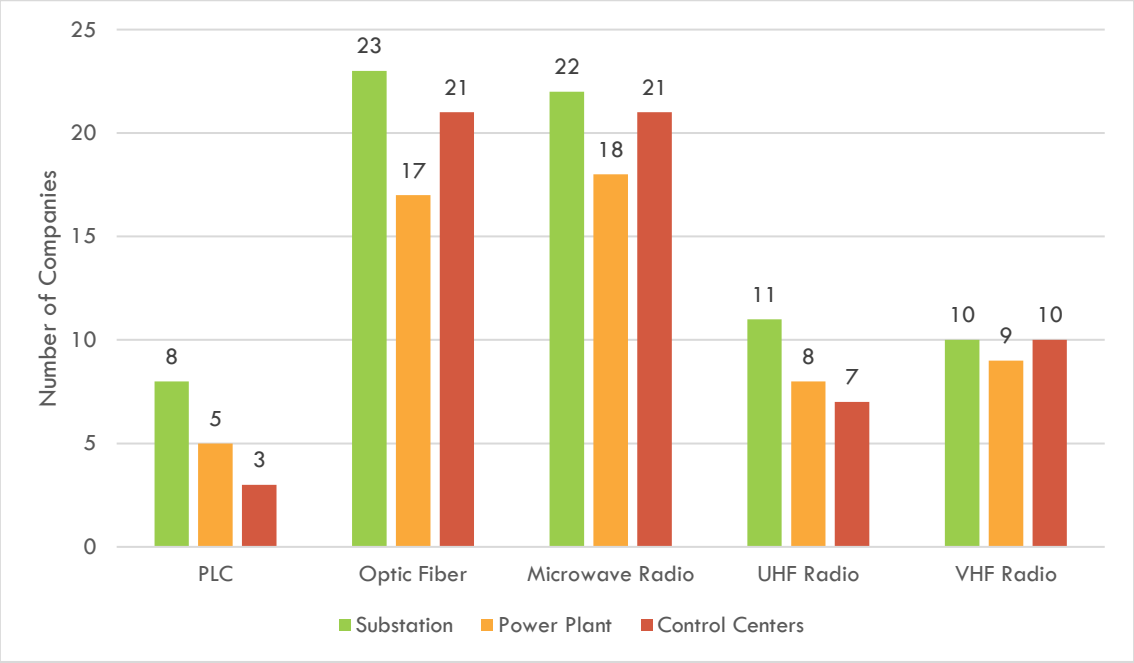


Figure 15 – Telecommunication systems used in fixed data and voice communications in Power plants and substations

The frequency bands considered more appropriate to this type of demand, according to the respondents are:

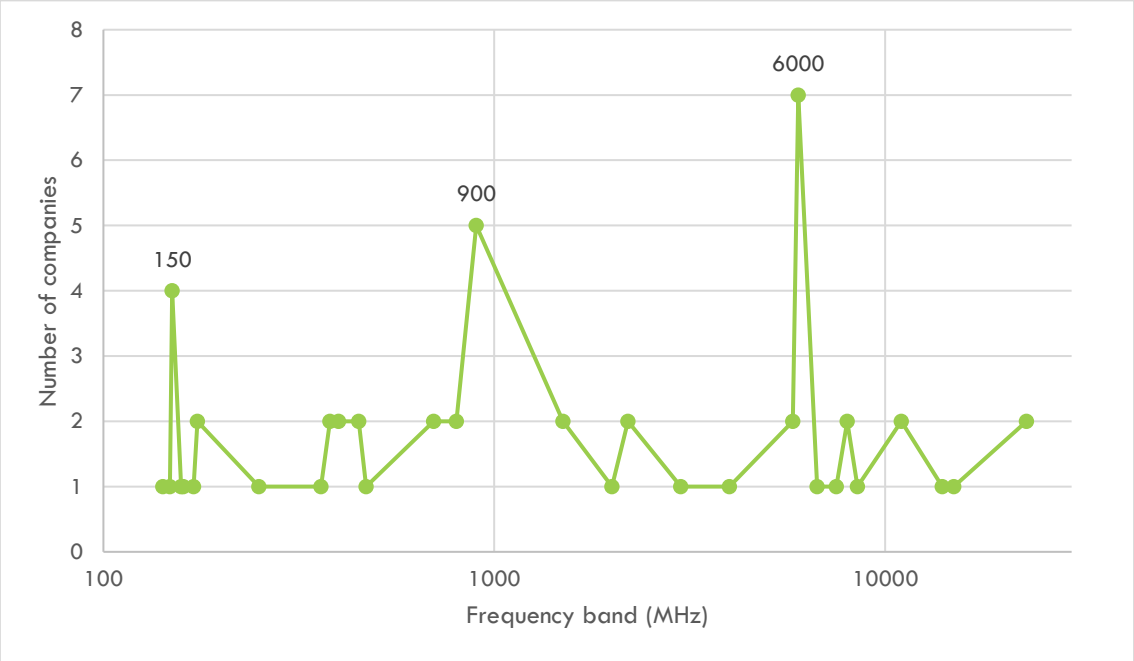


Figure 16 - Frequency bands utilized in operative voice/data applications

The presented responses show, once again, that there is no guideline to a better use of spectrum.

According to the participants, VHF radio is the most adopted solution to mobile communication between field staff and operation centers. In some situations, companies utilize UHF radios as well. Figures 17 and 18 below synthesize these responses.

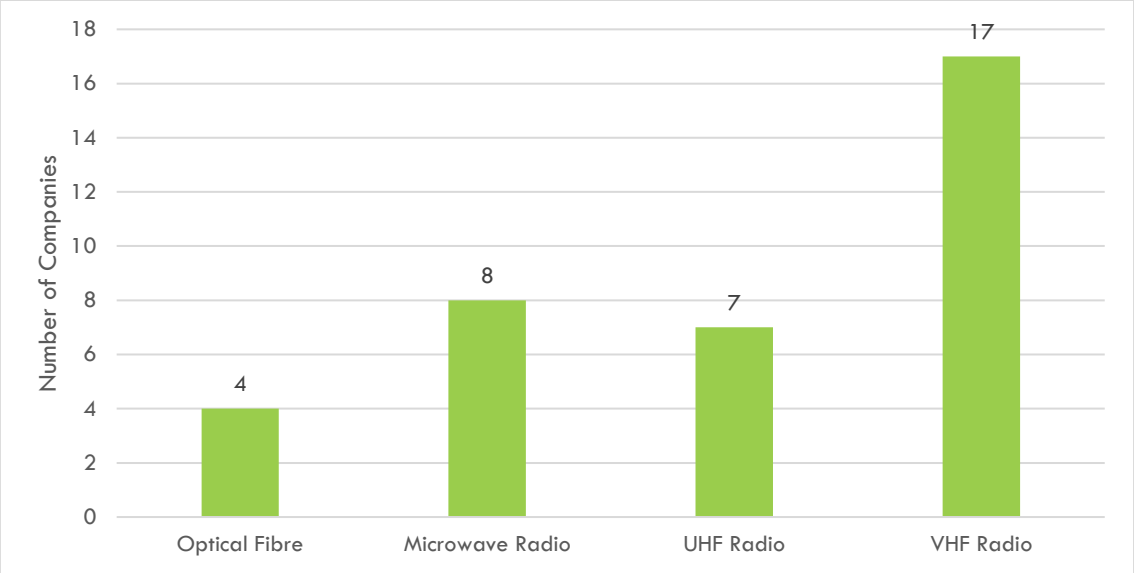


Figure 17 – Telecommunication systems used in mobile data and voice communications – Operation Centers

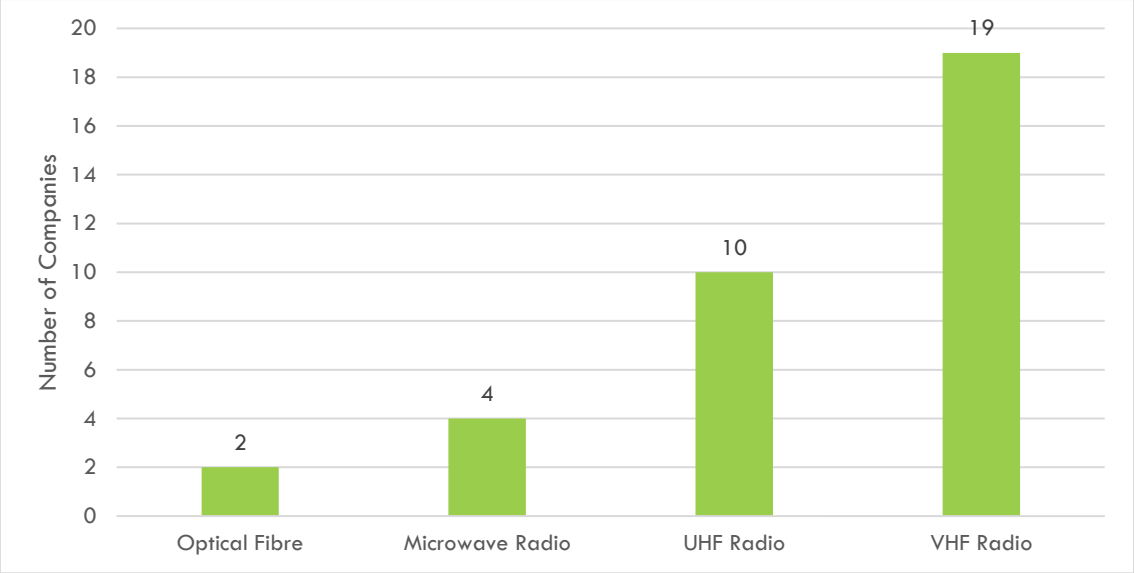


Figure 18 – Telecommunication systems used in mobile data and voice communications – Field Staff

It was pointed out by one of the participants that mobile carriers (2G and 3G) are also utilized as a communication alternative with field staff.

As this type of application is directly linked to the operation and maintenance of the electric system, the criticality level of this application was considered high by most of the respondents, as it can be seen in Figure 18.

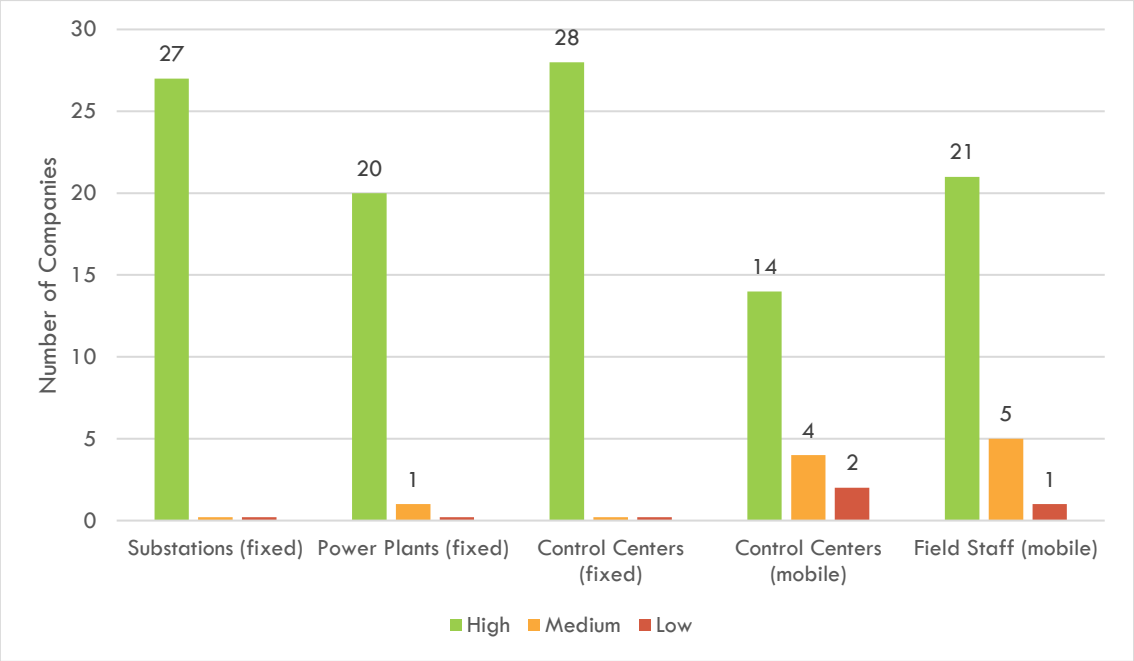


Figure 18 – Criticality level of operative voice and data applications

When asked about the minimum availability required for operative voice and data applications, the answers were diverse. Twenty-five (25) of the companies do not accept an availability index lower than 99%. The answers can be seen in Figure 19.

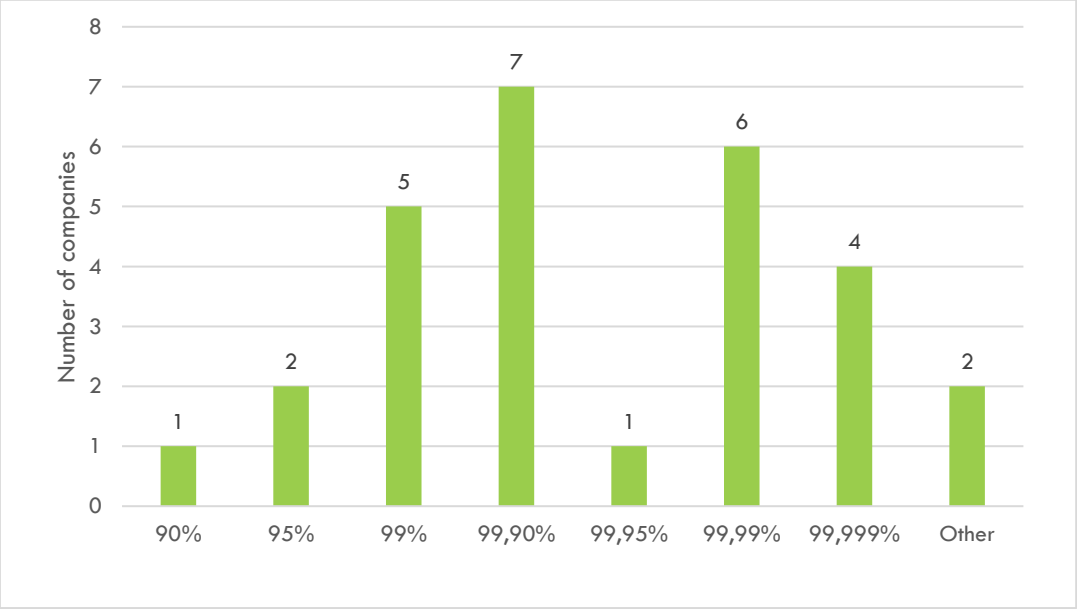


Figure 19 – Minimum availability required to this type of applicatio

Remote Metering

Twenty-five (25) companies use remote metering for billing, while twenty-three (23) utilize it for managing fault alarms and recovery confirmation. Figure 20 shows all the uses reported by the respondents. Companies could choose more than one (1) answer for this question.

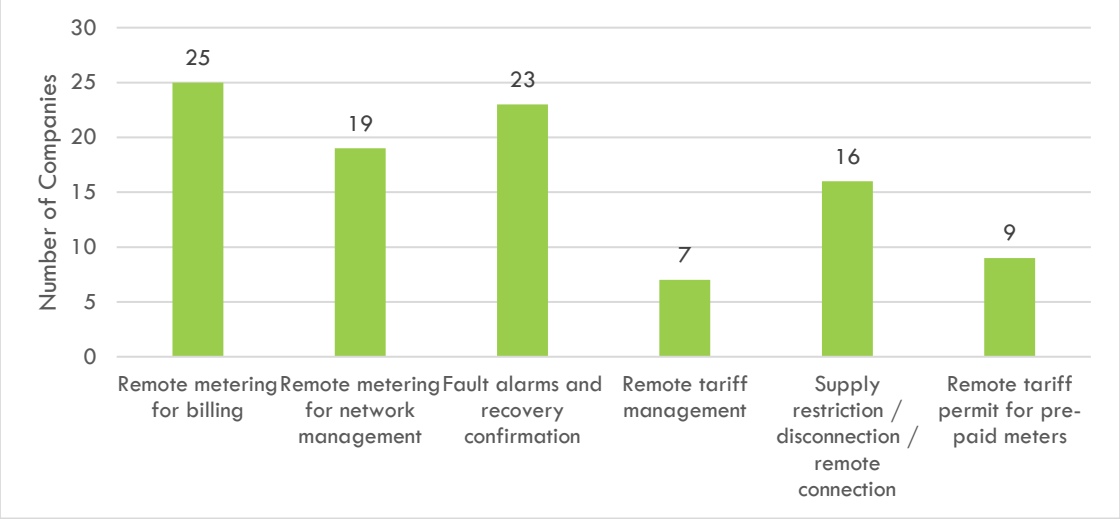


Figure 20 – Types of demands for remote metering

Most of the companies consider the criticality level for this type of application to be medium, as it can be seen in Figure 21.

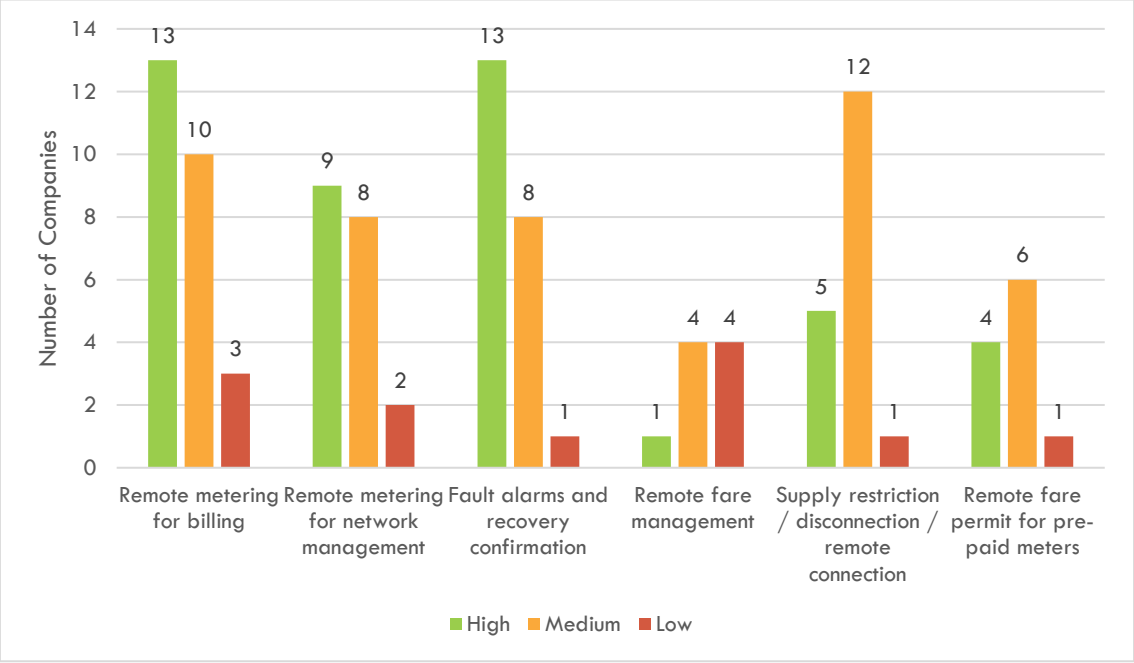


Figure 21 – Criticality level of remote metering applications

The telecommunication system most used by the respondent to support this type of application is optic fiber and UHF radio (17 companies). Figure 22 shows the information received.

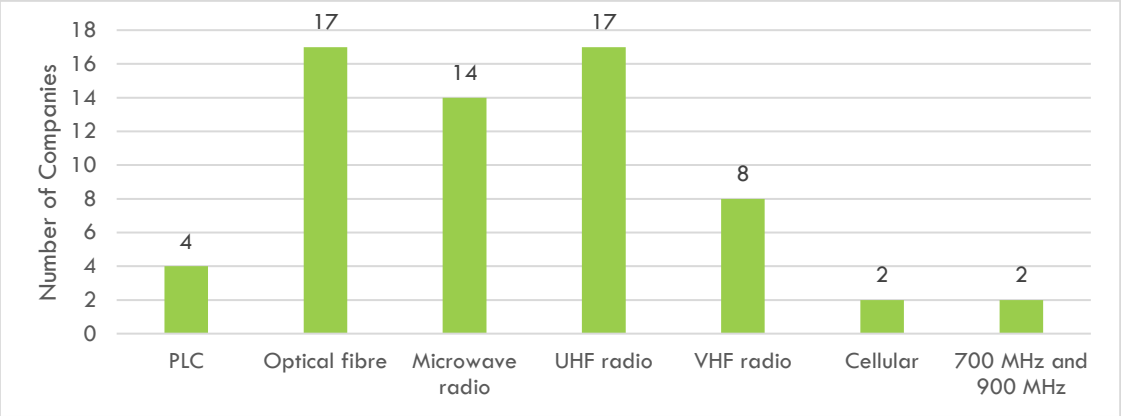


Figure 22 – Telecommunication systems used for remote metering

The most suitable frequency bands to attend the requirements of the respondents for this type of demand are listed below:

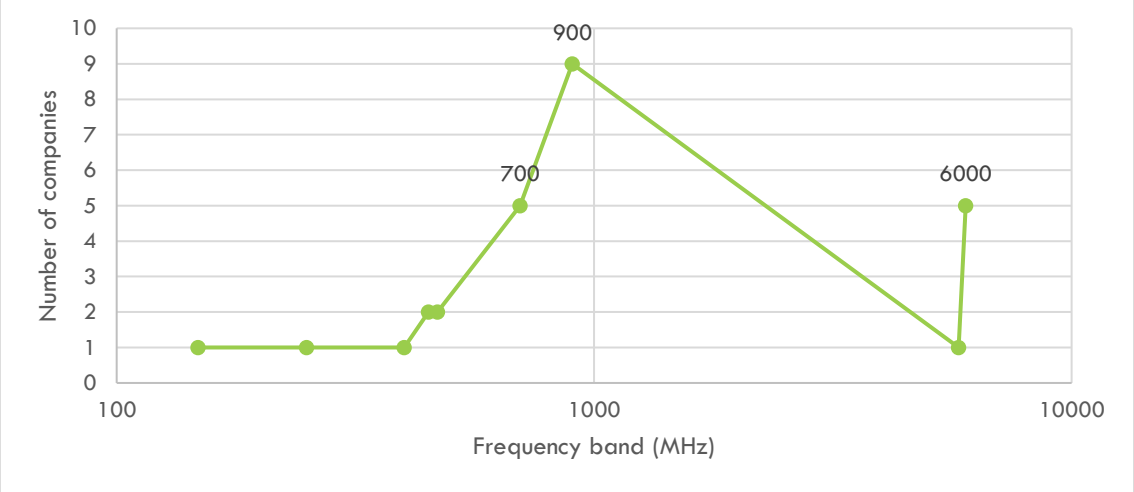


Figure 23 – Frequency bands utilized in remote metering applications

It is clear that there is no guideline for a better use of the spectrum.

To support this application, 3 (three) companies informed they are utilizing other telecommunications solutions, such as PLC Mesh, RF Mesh and mobile networks (2G, 3G and 4G).

As it can be seen in Figure 24, the majority of the respondents (18 companies) informed that remote metering can work with a maximum latency of 3 minutes. Other eight (8) companies accept latencies higher than 3 minutes.

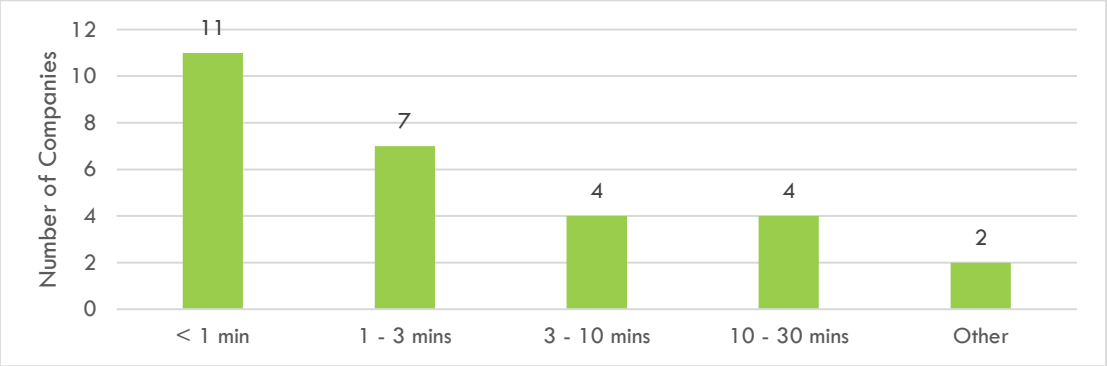


Figure 24 – Maximum latency permitted by this type of application

When asked about minimum availability, 32% of companies answered that 99% is the required availability index and 21% consider 95% as the minimum. More details can be seen in Figure 25.

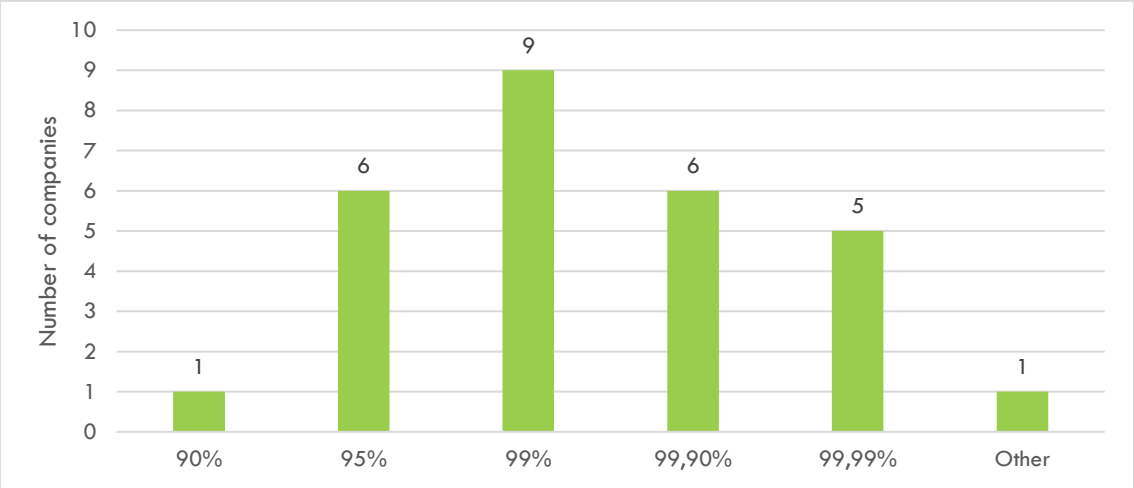


Figure 25 – Minimum availability permitted by this type of application

Digital Disturbance Recorder (DDR)

Digital disturbance recorders register the operation of the electric system and its protection during important events, such as electric failures, frequency oscillations and operative failures.

In case of Brazil, ONS stablishes the minimum requirements for installations of the National Grid (SIN), in accordance with the sub module 22 of the Grid Procedures.

Digital Disturbance Recorders (DDR), also known as digital oscillographs, are utilized in most of the installations of power electric systems and perform a constant surveillance of the system, recording significant disturbances, such as voltage and current out of the standard

Figure 26 shows, according to the answers of the participants, that DDR is utilized in substations, power plants and distribution networks.

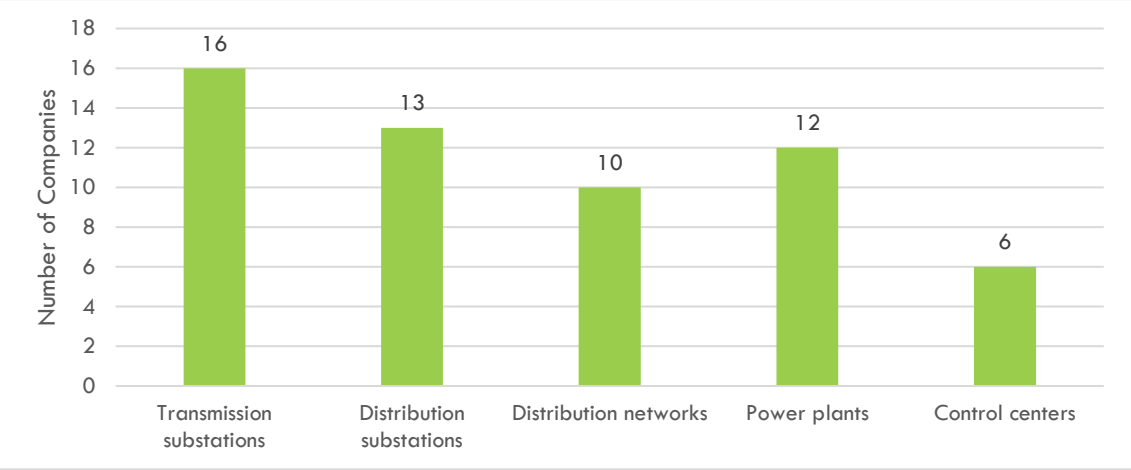


Figure 26 – Facilities that use DDR

The respondents considered the criticality level of this type of application varied, being the highest for substations. Figure 27 shows the answers received.

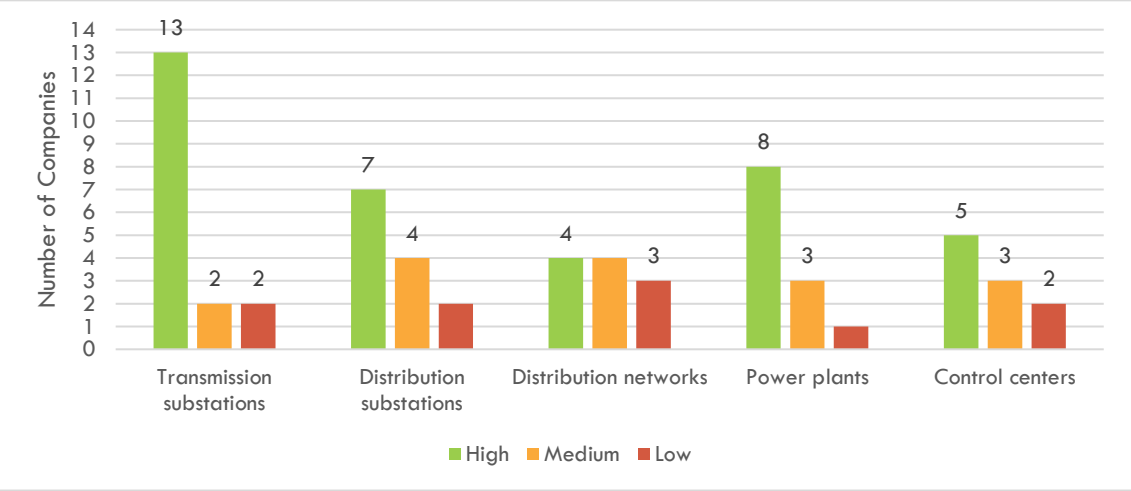


Figure 27 – Criticality level of DDR applications

Most of the respondents informed they are utilizing optic fiber as a telecommunication solution to fulfill this demand. The second most utilized system was microwave radio, as it can be seen in Figure 28. The companies could answer more than one item in this question.

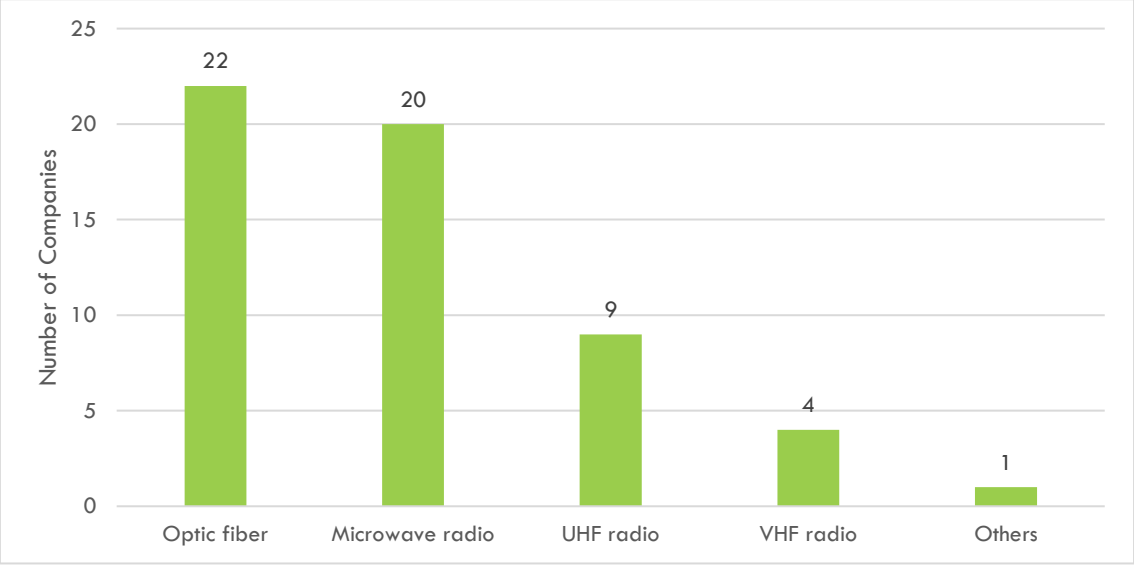


Figure 28 – Telecommunication systems used for DDR application

The frequency bands mentioned by the respondents for this type of demand are:

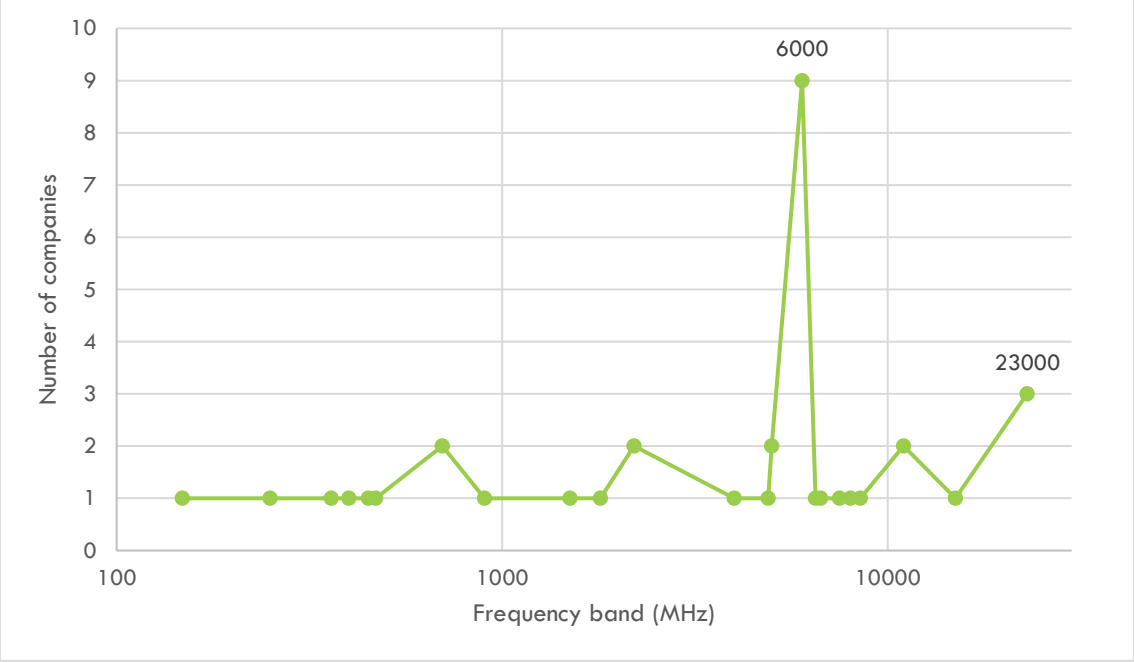


Figure 29 - Frequency bands utilized in DDR applications

When asked about the maximum latency supported by DDR applications, participants responded a variety of answers. Eight (8) of them informed that 1 s is sufficient for this type of application. Three (3) considers that a latency no higher than 5 ms is necessary. More information can be seen in Figure 30.

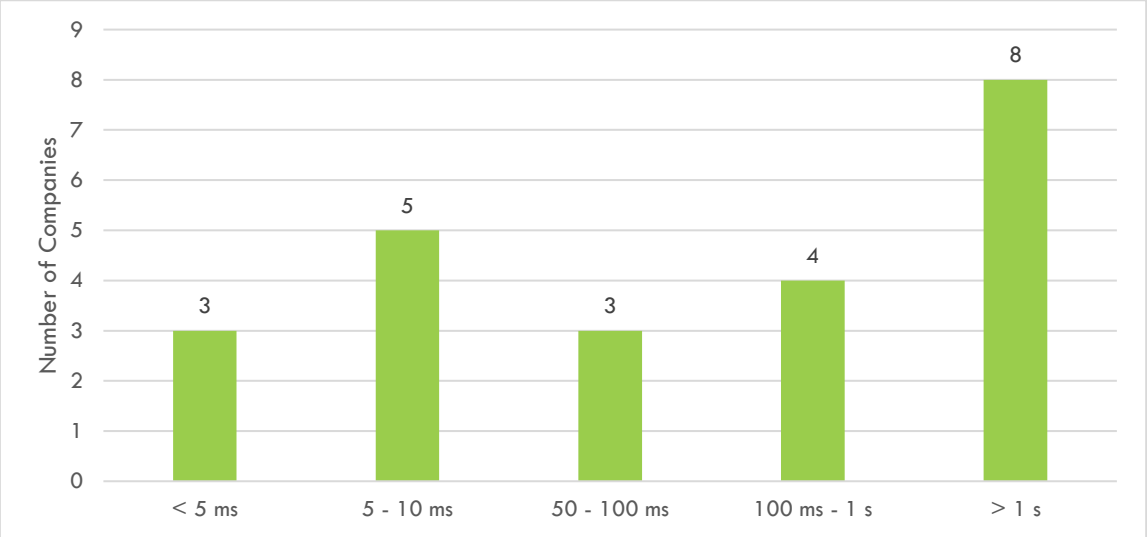


Figure 30 – Maximum latency permitted by DDR applications

Regarding the minimum availability, most of the companies (18) work with an availability between 95% and 99,9% for their DDR applications, as it can be seen in Figure 31. One (1) company require availabilities above 99,999% for this type of application.

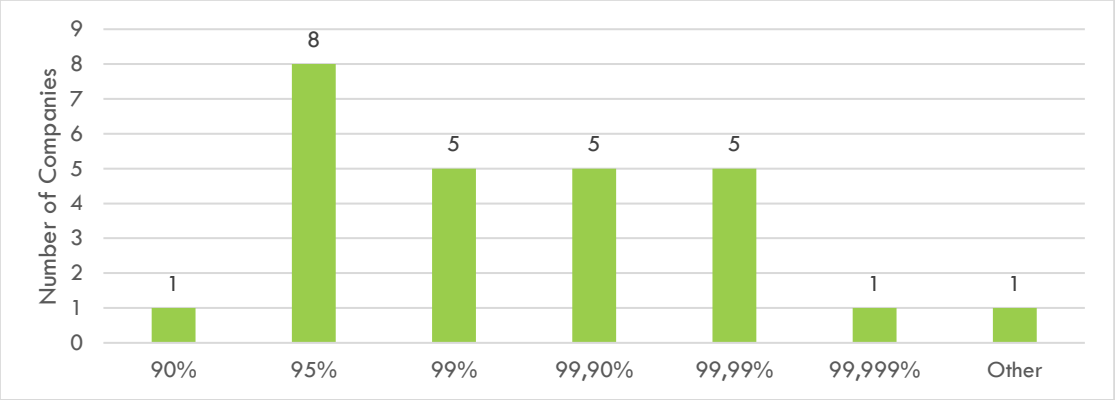


Figure 31 – Minimum availability permitted by this type of application

The following sections contain only data from Brazil.

Video Monitoring

Utilities are using an increasing amount of video monitoring solutions to support the operation of substations, power plants and distribution networks. In addition, those solutions are also important for personal and asset security of the facilities in which they are installed.

The image visualization resource of areas or equipment of interest in substations and power plants represent an important source of information for the decision making of the operators of the electric system in control centers.

Demands related to the physical security of facilities aim to increase the security of field staff and companies' assets in remote places, such as unattended substations, radio stations, etc.

Figure 32 shows that video monitoring applications is needed mainly in control centers, substations, power plants and telecommunications repeater stations.

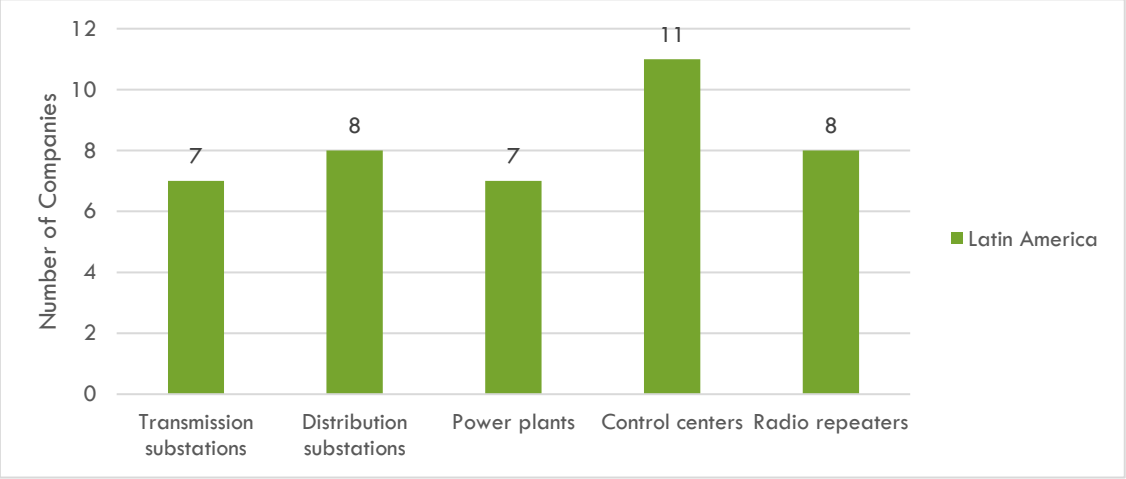


Figure 32 – Facilities that use video monitoring solutions

In Figure 33, it can be seen that energy companies need video monitoring applications in control centers, substations and power plants to support the operation of the electric system and in repeater stations to enhance the physical security of these facilities against vandalism and equipment theft.

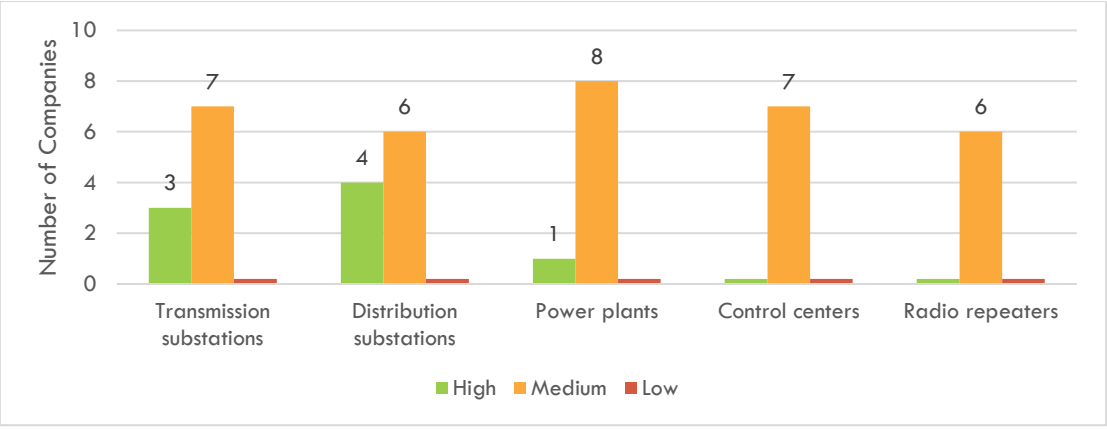


Figure 33 – Criticality level of video monitoring applications – Latin America

The majority of the participants utilize optic fiber as a telecommunication solution to this type of demand. Microwave and UHF radio are also used in this type of applications, as it can be seen in Figure 34. Companies could answer more than one item in this question.

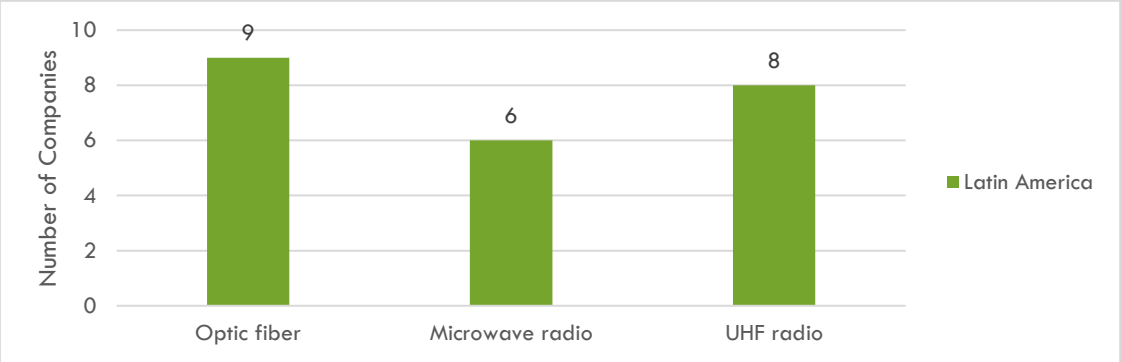


Figure 34 – Telecommunication solutions used in video monitoring applications

The frequency bands considered most suitable for wireless solutions for this type of demand, according to the respondents, are:

- **SHF (GHz):** 6; 6,5; 7; 8; 8,5; 11; 15; 23
- **UHF (MHz)**: 450; 700; 1500; 2000; 2200
- **VHF (MHz):** 250
- **Satellite (Band):** Ku; Ka; L; C
- **Unlicensed (MHz):** 900; 2400; 5400; 5800

Figure 35 shows that the majority of the participants consider satisfactory availabilities of 95% and higher to video monitoring applications. Six (6) of them work on availabilities of 99% or higher, as they understand the importance of those applications to the operations of the network.

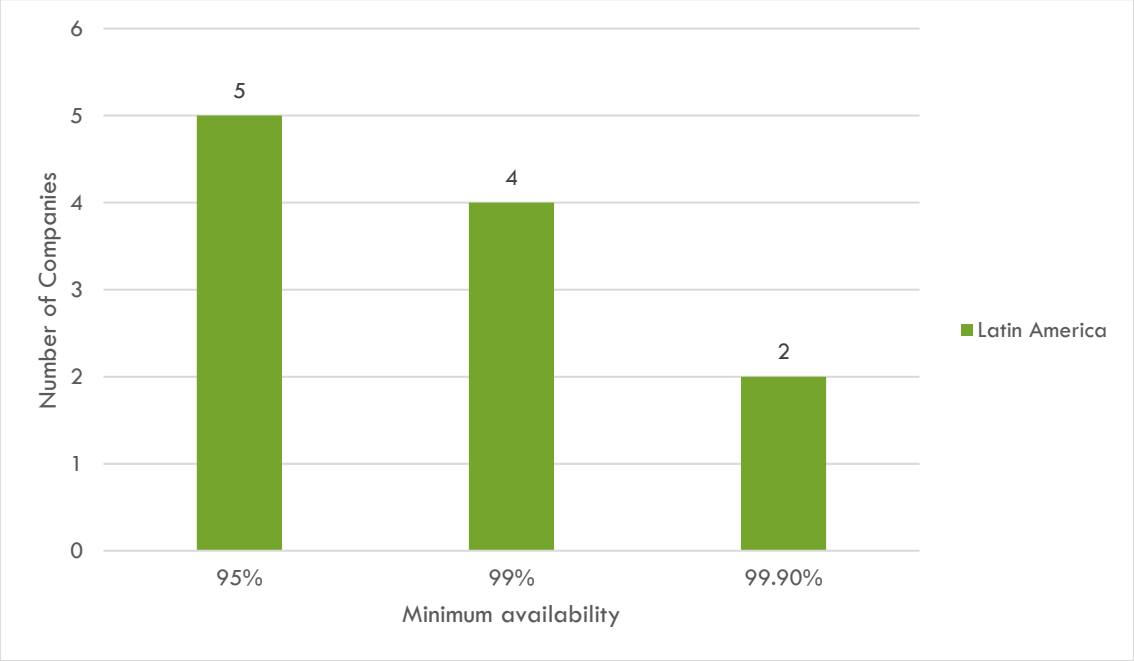


Figure 35 – Minimum availability permitted by video monitoring applications

Distribution Networks Automation

The distribution networks automation consists on the monitoring and control, in real time, of smart electronic devices implanted in reclosers, switches and capacitor banks installed over the rural and urban feeders and aims to maintain the minimum level of quality in the energy delivery, increasing the security, availability, resilience, reliability and stability of the system in an effective manner. The automation of distribution networks is one of the steps in the modernization of energy networks and seek to give them intelligence (Smart Grid).

Some of the characteristics of smart grids are:

- Digital control and automation of the electric network, utilizing intelligent controls, capable of getting ahead of disturbances and remedy them before they even happen, as well as operate in a resilient manner in attack or natural disaster events;
- Introduction of smart metering with the ability of working as an intelligent gateway to the consumer, enabling the provision of information, such as data about the individual consumption, as well as helping in control and decision making, in real time, regarding the energy usage;
- Integration of a great number of generation sources and energy storage of low and medium capacity, intermittent or continuous, enabling a higher dynamism to the consumer in purchase and sale of energy;
- Enable in a reliable and stable way the expansion of the capacity of energy supply, according to the demand;
- Exploring new market niches, through new products and services;
- Make the electric network ready to bear the increasing demand of future electric vehicles

As distribution networks have a wide coverage, since they are present in urban and rural areas across the country, the level of importance of this application to operators in control centers is always considered high and strategical to the operation of the electric system. The criticality level is considered high for this type of application, as it can be seen in Figure 36.

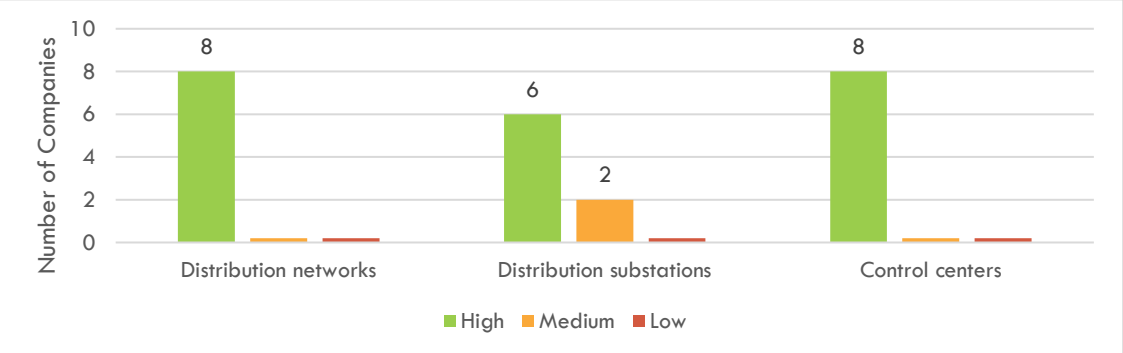


Figure 36 – Criticality level of distribution network automation applications – Latin America

Because the reliability and availability required to the automation of distribution networks is so high, the majority of the respondents utilize more than one system of telecommunication to supply those demands, as it can be seen in Figure 37. It is worth mentioning that companies use optic fiber or microwave radio as its main and redundant means of data transmission from a concentration point. UHF and VHF radio are used in

point to point and point to multipoint, depending on the project. Besides, in the “Others” option there were solutions mentioned, such as cellular phones, satellite, PLC, 6LowPan and LoRa to service remote devices.

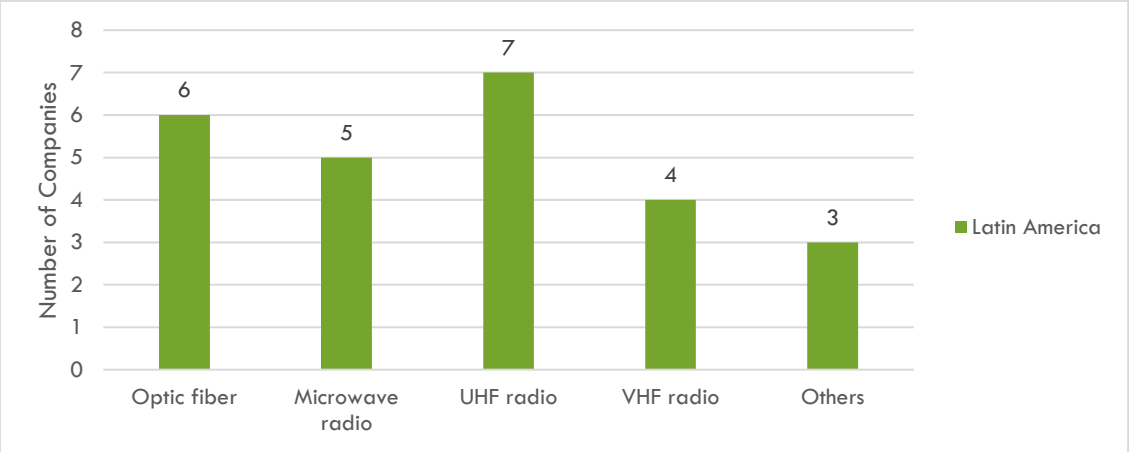


Figure 37 – Telecommunications solutions used in distribution network automation applications

When asked about the frequency bands most suitable to this use, companies pointed to the bands bellow:

- **UHF (MHz)**: 350; 360; 380; 400; 406; 450; 470; 700
- **VHF (MHz):** 145; 150; 170; 250
- **Satellite (Band):** Ku; L; C
- **Unlicensed (MHz):** 900; 2400; 5400

In Figure 38, most of the participants considered satisfactory to this type of application availabilities of 99% and higher. Availabilities of 99.8% and higher were considered advisable to 50% of the companies.

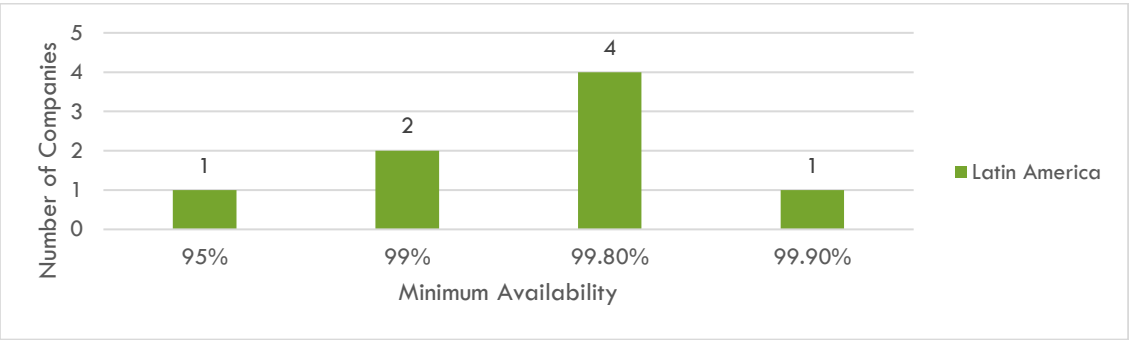


Figure 38 – Minimum availability permitted by distribution network automation applications

Additional Information

Table 3 below presents the information given by the respondents about the use of frequency spectrum in support to their mission critical operational applications.

Mission Critical applications	Microwave (SHF) (GHz)	UHF (MHz)	VHF (MHz)	Satellite (Band)	Not Licensed Frequencies (MHz)
Protection	**6**; 6,5; 7; 8; 15	380; 400; 430; **450**; 470; 1500; 2200	148; 150; 250		900; 2400; 5400
SCADA	**6**; 6,5; 7; 8; 8,5; 15	380; 400; 430; 450; 470; 700; 1500; 2200	140; 150; 170; 250	C; L; Ka; Ku	**900**; 2400; 5400
Remote metering	2,4; 4,5; **6**; 6,5; 7; 8; 8,5; 15	380; 400; 430; **450**; 470; 700	145; 170; 250	Ku; L; C	**900**; 2400; 5400
Operative voice and data - Fixed	2,4; 4,5; 6; 6,5; 7; 8; 8,5; 15	360; 380; 430; 450; 700; 1500; 2000	140; 150; 170; 250	C; L; Ku	**900**; 2400; 5400
Operative voice and data - Mobile		350; 380; 400; 430; 450; 700	140; 150; 170; 250	C; Ku; Ka	**900**; 2400; 5400
DDR	**6**; 6,5; 7; 8; 8,5; 11; 15; 23	350; 360; 380; 400; 430; 450; 470; 700	170; 250	C; Ku	900
Automation of the distribution network		350; 360; 380; 400; 430; 450; 470; 700	145; 150; 170; 250	C; L; Ku	900; 2400; 5400
Video Monitoring	6; 6,5; 7; 8; 8,5; 11; 15; 23	450; 700; 1500; 2000; 2200	250	Ku; Ka; L; C	900; 2400; 5400; 5800

Table 3 – Frequency bands used in mission critical applications

Energy companies are finding difficulties in expanding services of applications that use wireless solutions in UHF and VHF bands, with a bandwidth of 12,5kHz. For each new requirement, especially in existing sites, utilities often require the licensing of a new channel. If the adjacent channel is unavailable, a new frequency shall be requested to the telecommunication's regulatory agency, which causes the use of a great variety of frequencies without an optimization of the spectrum. Frequency bands with a larger bandwidth could optimize the spectrum (50kHz – 2 channels, or 100kHz – 4 channels). Because of the increase in the demand by applications for grid modernization, smart grid, distributed generation, IoT, demand management, etc., the use of solutions with higher bandwidths will be crucial to utilities.

Figure 39 shows the responses about the interest of utilities on prospective wireless technology solutions for each current mission critical application.

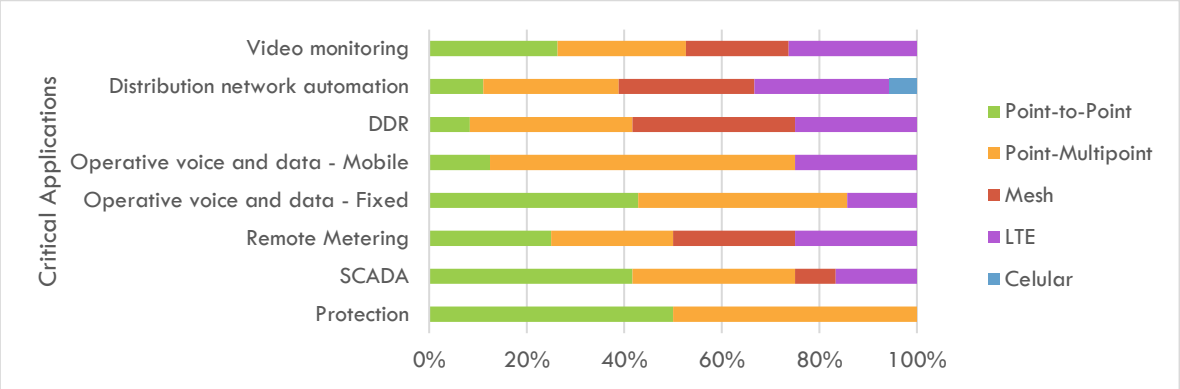


Figure 39 – Telecommunication solutions by type of application

It is worth noting that only two (2) types of wireless telecommunications are being utilized for teleprotection: Point-to-Point and Point-to-Multipoint

The public mobile service is generallyrestricted to support applications of distribution network automation and only one of the respondents utilize it. The LTE solution was considered by all respondents as an alternative to most of their needs, with the exception of protection. Mesh, according to the participants, will not be attractive for protection and support to operative voice and data.

Figure 40 shows the minimum data rate to the data channel, in kbps, required for each of the mission critical application, according to the participants.

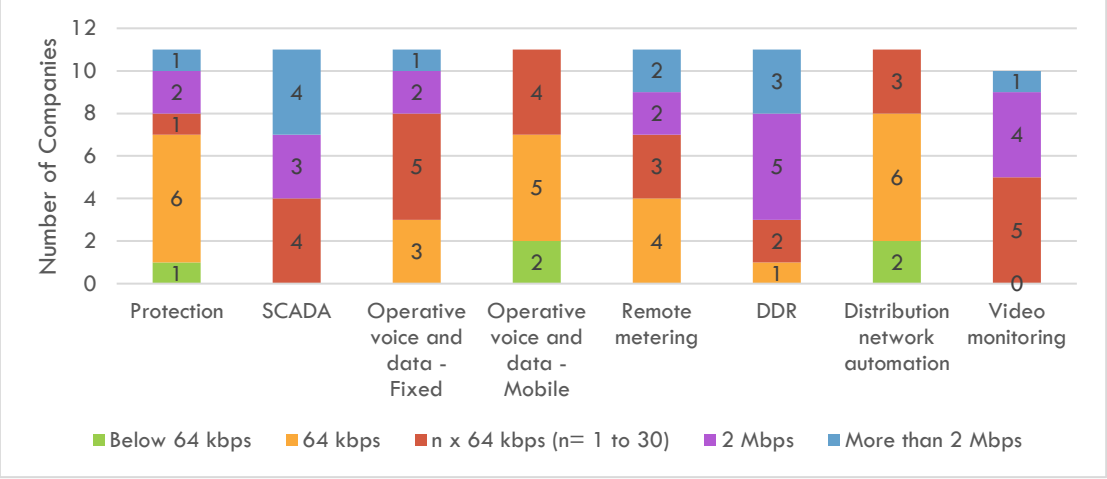


Figure 40 – Bandwidth required to each mission critical application – Energy companies' vision

Telecommunications solutions to mission critical applications – Technology providers vision

Various technologyproviders of wireless telecommunications solutions for mission critical applications were also invited to contribute to this report, answering to a specific survey sent to them. Twenty-four companies registered in the data base of UTC GAC were invited. From them, 25% answered the survey. One of those companies informed not having wireless solutions in its portfolio.

The questions had the intent of knowing the vision of technologyproviders concerning the needs of utilities, more specifically electric power companies, about the criticality of their applications to the operations of their plants.

A survey with brief information about the main critical applications of electric companies and the basic requirements in the current environment was presented to the technology providers invited.

Figure 41 shows the result of the survey sent to the manufacturers and providers of wireless telecommunications solutions in Brasil. By the answers presented, it is possible to conclude that 100% of the industry participants have solutions for the automation of the distribution network and 80% have solutions to support SCADA, operative voice and data, remote metering and video monitoring applications.

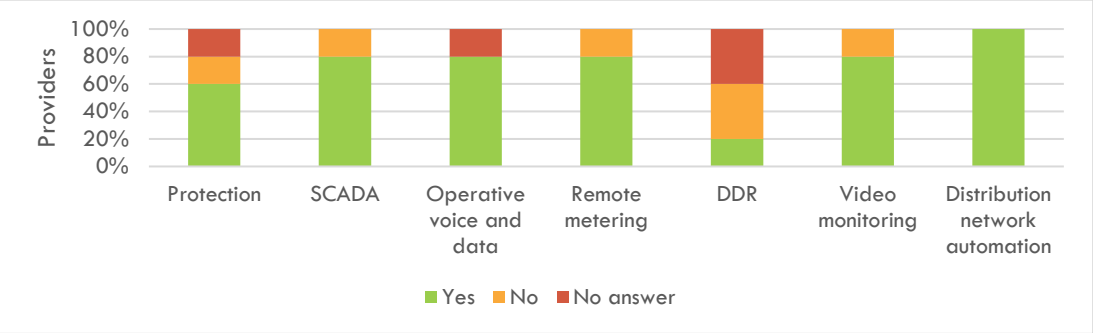


Figure 41 – Providers of wireless solutions for mission critical applications in Brazil

Figure 42 shows the result to the available wireless solutions, outside Brazil, to support mission critical applications of the electric companies. According to the respondents, 100% of the companies have solutions for the automation of the distribution network and 80% have solutions to support SCADA, operative voice and data, remote metering and video monitoring appications.

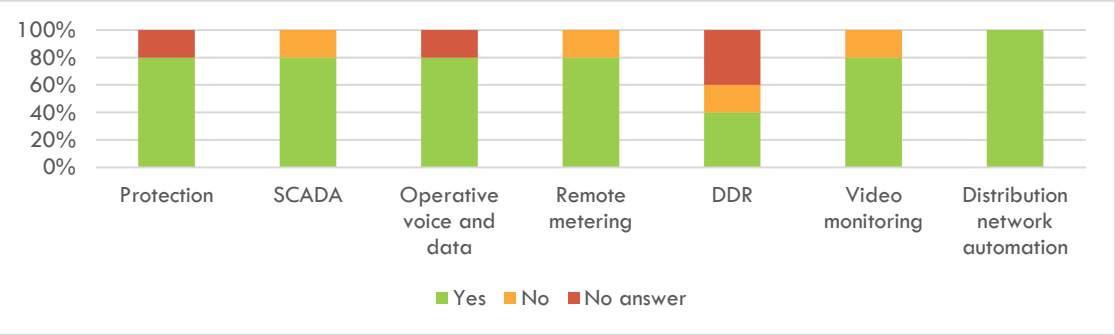


Figure 42 – Providers of wireless solutions for mission critical applications outside of Brazil

Table 4 shows the frequency bands of the wireless telecommunications solutions available, according to the consulted manufacturers, to support mission critical applications

Wireless Telecommunications Solutions	Protection	SCADA	Operative Voice and Data - Fixed	Operative Voice and Data - Mobile	Remote Metering	DDR	Video Monitoring	Automation
	Frequencies (MHz)							
LTE (3G/4G/5G) (Future)	450; 700; 800; 2.100; 2.500	450; 700; 800; 2.100; 2.500	450; 700; 800; 2.100; 2.500	450; 700; 800; 2.100; 2.500	450; 700; 800; 2.100; 2.500	450; 700; 800; 2.100; 2.500	450; 700; 800; 2.100; 2.500	450; 700; 800; 2.100; 2.500
Wimax	3.500	3.500	3.500	3.500		3.500	3.500	3.500
PTP Radio	150; 230; 350; 450;470; 900; 940	150; 230; 350; 450;470; 900; 940			150; 230; 350; 450;470; 900; 940			150; 230; 350; 450;470; 900; 940
PMP Radio	150; 230; 350; 450;470; 900; 940	150; 230; 350; 450; 470; 900; 940			150; 230; 350; 450;470; 900; 940		150; 230; 350; 450;470; 900; 940	150; 230; 350; 450;470; 900; 940
Microwave Radio	1400; 1900; 2500	1400; 1900; 2500	1400; 1900; 2500			1400; 1900; 2500	1400; 1900; 2500	1400; 1900; 2500
6LowPan and LoRa					900			

Table 4 – Wireless frequencies available by type of mission critical application according to manufacturers and providers of telecommunication solutionsl – Frequencies in MHz

Conclusion

As it can be seen in Table 5 below, there are products available in the 450MHz frequency that will support all of the informed applications. It is worth noting that in this case, to LTE solutions, the bandwidth should be higher than 1MHz (1,25 MHz, or 1,4 MHz).

(?????). The two solution alternatives can address the majority of the applications, what makes this band extremely attractive to utilities operations. It is observed that other bands also address a large part of the operation needs, but with restrictions to some applications.

[Precisamos melhorar esta parte]

Wireless Telecommunications Solutions		Protection	SCADA	Operative Voice and Data - Fixed	Operative Voice and Data - Mobile	Remote Metering	DDR	Video	Automation
	Frequencies								
LTE (3G/4G/5G)	**MHz**	450; 700	450; 700	450; 700	450; 700	450; 700	450; 700	450; 700	450; 700
Wimax	**GHz**	3,5	3,5	3,5	3,5		3,5	3,5	3,5
PTP Radio	**MHz**	150;170; 250; 450; 470; 900*	150;170; 250; 450; 470; 900*	150;170; 250; 450; 470; 900*	150;170; 250; 450; 470; 900*	150;170; 250; 450; 470; 900*	150;170; 250; 450; 470; 900*	150;170; 250; 450; 470; 900*	150;170; 250; 450; 470; 900*
PMP Radio	**MHz**	150;170; 250; 450; 470; 900*	150;170; 250; 450; 470; 900*	150;170; 250; 450; 470; 900*	150;170; 250; 450; 470; 900*	150;170; 250; 450; 470; 900*	150;170; 250; 450; 470; 900*	150;170; 250; 450; 470; 900*	150;170; 250; 450; 470; 900*
Microwave Radio	**GHz**	6; 6,5; 7; 8; 8,5; 15	6; 6,5; 7; 8; 8,5; 15	6; 6,5; 7; 8; 8,5; 15		6; 6,5; 7; 8; 8,5; 15	6; 6,5; 7; 8; 8,5; 15	6; 6,5; 7; 8; 8,5; 15	

**** Unlicensed frequency***

Table 5 – Most used frequencies – Energy utilities and providers of telecommunication solutions

Attention: *This survey does not intend to exhaust the discussions about this subject. We understand that the distribution of this final report can encourage the participation of the other utilities and manufacturers to present new information, which will increase the value of the work done.*