CAPÍTULO 1

AN OVERVIEW OF TECHNOLOGIES AND THEORETICAL FOUNDATIONS OF SMART CITIES IN THE MODERN DIGITAL AGE

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Reinaldo Padilha França
School of Electrical and Computer Engineering (FEEC)
State University of Campinas (UNICAMP)
Campinas – SP
orcid.org/0000-0002-7901-6691

Ana Carolina Borges Monteiro
School of Electrical and Computer Engineering FEEC)
State University of Campinas (UNICAMP)
Campinas – SP
orcid.org/0000-0002-8631-6617

Rangel Arthur
Faculty of Technology (FT)
State University of Campinas (UNICAMP)
Campinas – SP
orcid.org/0000-0002-4138-4720

Vicente Idalberto Becerra Sablón
College of Electrical Engineering (EE)
São Francisco University (USF)
Campinas – SP
https://orcid.org/0000-0003-3127-1906

Yuzo Iano
School of Electrical and Computer Engineering (FEEC)
State University of Campinas (UNICAMP)
Campinas – SP
orcid.org/0000-0002-9843-9761

ABSTRACT. Smart Cities promote inclusion with technology at the service of people involving the use of innovation, and communication infrastructure, combining sustainability, and urbanism in order promoting the well-being of the community through four aspects, i.e., environmental, social, cultural, and economic, allowing urban connectivity, efficiency, among other aspects through digital technologies. Also considering the electric vehicles (EV) technology are known as zero-emission vehicles due to not polluting, i.e., it does not emit any harmful gases or considerable noise. Unlike combustion engines, the electric motor uses chemical energy stored in rechargeable batteries, which is then converted into electrical energy to power the car's electric motor, on the other hand, electric motors are quieter than combustion engines, another positive factor related to noise pollution from urban centers. Considering this, microgrids are local electric power networks that can serve some homes or neighborhoods, allowing residents to be partially or totally disconnected from the utility's electrical network, also related to the possibility of local energy generation and the increase in battery storage capacity. Considering that this model is an optimal

alternative to Smart Cities related in remote regions that require investment in infrastructure for transmission and distribution lines, acting as a factor of production of energy close to where it is consumed, minimizing energy losses in the transmission lines. Therefore, this chapter aims to provide a current overview of Smart City, approaching the role of EV and even the contribution of the microgrid to shaping the Smart City paradigm, as well as the relationship of this concept with other technologies, synthesizing the potential of technology.
KEYWORDS: Smart Cities, Smart Home, Smart Transportation, Smart Grid, Smart Government, Smart Industrial Environments, Artificial Intelligence, IoT, Data Analytics, Intelligent infrastructure, Sustainable Development**.**

1 | INTRODUCTION

Considering the global trend of technological solutions, cities are inspired by the concept of 'smart cities' to promote inclusion with technology at the service of people. Considering the emergence of new housing solutions combining technology, sustainability, and urbanism in order to serve a modern socially diverse audience, allowing urban connectivity, mobility, sustainability, quality of life, and even efficiency through disruptive technologies and digital applications [1].

In several countries around the globe, the smart city paradigm is a reality due to the recent technological advances such as the IoT (Internet of Things), AI (Artificial Intelligence), and 5G among the main novelty that is accompanying the implementation of this model of urban life. As these disruptive technologies, progress allowing new technologies and solutions to come to reality, companies, governments, and public administration are attracted to their expansion. Considering that the concept of a smart city involves cities that use technology, innovation, and communication infrastructure, promoting the well-being of the community through four aspects, i.e., social, environmental, cultural, and economic, however, it is not possible to consider smart cities if not connectivity exists [2].

Still considering that never at any point in history, people were in control of their own experiences and existence, and even having the keys to their possible success investing increasingly time in improving the interactions and conversations for their professional and personal advantage. Allied to this, digital data is the fuel of a smart city as also technology is the foundation that sustains refitment, remaking, i.e., transformation, providing productive and profitable human interactions as the basis for favorable processes, which converge business, technology, and data connecting all different aspects of the ecosystem to achieve a sustainable future [3].

Thus, the city needed to be 'smart', allowing residents to affect and be positively influenced by the environment and to connect with other residents and business opportunities. In doing so, it is possible to ensure that all residents or visitors have the feeling of being "smarter", more connected, through an immersive and interconnected environment, which is a reflection of the intelligent ecosystem, comprising inspiring applications. This is due to

technological solutions for integrated intelligent communication, allowing citizens to connect with content everywhere in the city exuding more intelligence for the citizen's experience [1] [4].

Still considering that electric vehicles (EV) are called zero-emission vehicles because it is not polluting, that is, it does not emit any harmful gases or considerable noise, since electric motors are quieter than combustion engines. Electric vehicles are divided into several types and are not always fully electric. Purely electric cars are more expensive, but maintenance is much cheaper and does not emit gases. The main reason why all-electric vehicles cannot completely replace combustion cars is the energy density of the batteries and the infrastructure needed to charge the batteries. There are still many more gas stations than charging stations [5] [6].

In the same context in which the electricity generated centrally by large hydroelectric, nuclear, and thermoelectric plants has been brought to consumers via a transmission network and high voltage cables. This system works like a cascade with electrical energy flowing in one direction, from high voltage lines to low voltage lines [6] [7].

Currently, this reality is changing through the so-called distributed generation, with the possibility of generating energy in small units such as in cogeneration plants, in the case of biomass, and renewable energy sources such as photovoltaics and wind, more and more small consumers become agents that inject electricity into the distribution network. While large power plants are instructed to supply the exact amount of electricity needed to meet grid demand, small generators provide energy as a by-product or according to climatic conditions, seen in cases of solar and wind energy. This new context is not only creating new business models in the energy market but also impacting investments in transmission, distribution, and the operation of the electrical system [7] [8].

In this sense, microgrids are local electric power networks that can serve some homes or neighborhoods, allowing consumers to be partially or totally disconnected from the utility's electrical network. This technology has become a reality due to the possibility of local energy generation and the increase in battery storage capacity. The more renewable energy connected to the local network, the more storage becomes a key part. Likewise, the better the storage capacity, the less the dependence on the utility's electrical network. Thus, the microgrid can operate autonomously using the energy generated locally in the event of a power outage from the utility network [9].

Microgrids are a great alternative in remote regions that require investment in infrastructure for transmission and distribution lines, considering that this model has also been adopted by the concept of Smart Cities, which cannot face large variations in voltage. Regarding the insertion of this model in the electrical matrix, it is through the production of energy made close to where it is consumed, minimizing energy losses in the transmission lines [10].

Therefore, this chapter aims to provide a current overview of Smart City, approaching

the role of EV and even the contribution of the microgrid to shaping the Smart City paradigm, as well as the relationship of this concept with other technologies, addressing its essential concepts and fundamentals from a concise bibliographic background, as also qualifying and singularizing the competence of technology.

2 | SMART CITIES, ELECTRIC VEHICLES, AND MICROGRID CONCEPTS

2.1 Smart Cities

Initiatives to build a smart city derive from resilient and innovative technological solutions that are inclusive and accessible to citizens, improving collaboration, transparency, and sustainability with safer and more compatible tools. In a smart city, it is possible to provide interaction and connection with the citizens of smart cities through safer, inclusive, and sustainable urban planning for a deep involvement of residents, companies, and governments. Improving government services for smart cities through the application of data analysis to enable city leaders and employees to make actionable and informed decisions and to provide better services to residents, as well as offering technology applications and services in a safe, compatible and secure way citizens' privacy [11] [12].

Based on the concepts of digital and social innovation, all residents and entrepreneurs will count on the technological and service mix, such as smart banks, free cinema, horizontal gardens, and bookcrossing, among others, providing digitalization generates empowerment of communities and people, generating inclusion Social. Contained the available infrastructure is also essential for this type of concept to be possible, considering that it is useless to create a smart city designed to be ecological, for example, if it is located in a territory without resources for this. Considering that unfortunately, the cities of today are not yet ready to receive this new concept, more agile, modern, cheap, which takes advantage of energies and sustainable solutions [13].

Highlighting smart solutions such as paving with rainwater drainage, considering that in large cities constant flooding is faced, which harms and puts the population at risk. Or even highlighting the underground energy, extremely important to avoid overloading the electrical system and reduce the risk of lightning strikes, in addition to the aesthetic issue. Or even considering an investment in infrastructure, with water and sewage network works, electric power network, underground wiring and solar energy production in common areas, as well as housing services such as health, gastronomy, commerce, culture and education in a common leisure space open to the entire population of the region [14].

The transformation that leads a city to be identified as 'smart' takes into account the characteristics and demands of citizens, incorporating intelligent solutions that provide answers to specific questions, helping to disseminate digital technologies that can bring benefits to people and the city where they operate [15].

Finally, a city can be outlined as intelligent when this city has the properties and

characteristics to collect and analyze huge amounts of data from several activities (action, movement, operation), such as urban organization and waste/garbage management, considering complex networks of sensors, computational devices, software, and intelligent solutions, and platforms are developed, digitally operated, and maintained through management. This concept concerns the most efficient solutions to solve public issues caused by the increase in urbanization, such as air pollution, traffic congestion, noise pollution, and unsustainable waste and garbage disposal, given its general objective of ensuring a better quality of life [13] [15].

2.2 Electric Vehicles

The electric vehicle has the competence to expressively decrease urban pollution, encompassing noise pollution due to the engine of an electric vehicle is very silent. Still considering with the proliferation of this technology, greenhouse gases (coal burning) and other pollutants emitted in the energy generation cycle, these being harmful to human health, this will be restricted to the surroundings of the factories, far from urban centers. Unlike combustion engines, the electric motor employs chemical energy stored in rechargeable batteries, converting it into electrical energy powering the vehicle's motor, which is responsible for converting it into mechanical and other energy, enabling the car to move and user comfort is allowed [5] [15].

Electric vehicles are those powered by at least one electric motor, as it is much more efficient than conventional ones powered exclusively by internal combustion engines (ICE). As there are tens of millions or billions of conventional vehicles circulating in the world, EV can considerably reduce avoidable waste of fuels, mainly of fossil origin. And even considering that the electric vehicle pollutes more to be manufactured, primarily related to the battery, however, this factor is compensated over the lifespan of the electric vehicle, or even considering if there is a diminution in gases emissions in the production and generation of energy these type of vehicle, so, the electric vehicle's advantage is even greater [6] [16].

Electricity in big cities tends to be cheaper, compared to fuels, even more, because of the more efficiency, it is considered that the cost per kilometer to power a vehicle electric is near one-third of the cost to power a gasoline vehicle. Besides, vehicle electric does not have a mechanical exhaust system and does not need oil changes [6] [7] [16].

Another advantage is the ease of supplying the electric vehicle at home, at the mall, or even in the office, given one of the great benefits of vehicle electric is the plugin system. Obviously, large cities around the world do not yet offer many places for loading, but this is easily manageable when demand exists, considering in the case of travel as the urgent need to create this option at road stations will be greater. However, this issue is one of the easiest factors to be solved, creating solutions that can be applied in parking, which can recharge the cars one by one, for example. Or even the user arrives to work with his electric vehicle and finds the battery fully charged at the exit, considering that this service can have

low cost in employment, or even be offered as a courtesy in valets. Still considering that in addition to lithium, these batteries generally utilize noble minerals extracted from the earth, such as lanthanum, dysprosium, praseodynamics, and even neodymium, among others [17].

EVs can be classified into five families according to how the electrical energy is made available onboard as EV with Battery EVB) is when the energy is supplied by a set of batteries that are recharged in the electrical network. Or even EV Connected to the Network or even a trolleybus, considering that the energy is supplied by the electric network [18].

Hybrid EV (EVH) is when power is supplied by an onboard generator that is powered by an m.c.i., these vehicles also use battery systems and capacitors to accumulate electrical energy, allowing the m.c.i. only operate in optimum conditions or stay off. Two basic types of EVH stand out, EVH "serial" where the wheels are driven only by the electric motor (s), and EVH "parallel" where the wheels can be driven by m.c.i. in parallel with the electric motor. Still considering the concept of "plugin" vehicles, which can be connected to the mains for charging batteries and have an onboard engine/generator for charging batteries, extending autonomy and/or adding power on slopes and stronger starts [5] [18].

Fuel Cell EV (EVCC) is supplied by fuel cells, electrochemical equipment that transforms hydrogen energy directly into electricity, also using important energy accumulation systems onboard, whether batteries or capacitors. This technology is the subject of much research today and several manufacturers are betting on it as the future of vehicles. The hydrogen will be distributed directly or produced from methane (Natural Gas), methanol, or ethanol [19].

EV Solar (EVS) considers that the energy is supplied by photovoltaic plates, however, it is unlikely that this type of technology will turn into a vehicle for practical use, due to the size restrictions of the vehicles that limit the dimension of the panels and consequently their power [20].

2.3 Microgrid

Technological developments in favor of energy security include efficiency in microgrid projects to contribute to the evolution of biogas. The microgrid comes with a possibility to serve consumers in situations of problems with electricity supply (by utilities). This operates in isolation, without connection to the conventional electrical network [9] [21].

The potential of biogas is linked to a rural property (places where the electricity supply is usually unstable), has the potential to be used to generate electricity, providing energy security; supply quality; and reliability. Considering that the electrical distribution network in isolated areas presents instability, since it serves consumers far from the load center, in areas called "end of the line"[21].

Considering that the efficiency of the microgrid with biogas is the generation of energy in isolation that will serve more than one consumer, being able to act in a range

of consumers, in micro-regions, compared to the production of electricity that is local and driven in cases of instability. Another situation that the microgrids act on is when the consumer units are too far from the load centers. The microgrid system allows proximity between power generation and use, which optimizes efficiency and reduces losses [22].

Microgrid's advantages contribute to the application of these systems in cities or farms far from cities, minimizing the emission of greenhouse gases and carbon; encouraging and improving the integration of distributed and renewable energy sources; enabling the use of smart grid technology. And even with regard to the quality of energy that can be controlled locally, with safety for the end-user and operator of the electric network, therefore, bearing in mind that the microgrids system allows dynamic and mainly safe control over the energy sources in relation to common alternatives used [23].

Considering that renewable sources, such as solar or wind, have gained interest in the Smart Cities paradigm, but from another point of view, it is important to keep the "light on" in a residence on days without wind or sun, for this, it needs to have a microgrid, i.e., an energy distribution network that has one or more generation sources. Considering that the structure is capable of managing all electricity production, using sophisticated software that helps to coordinate the sources to avoid variations in voltage and power outages [24].

In this sense, a microgrid is defined by the integration of several distributed generation resources, energy storage, and loads in a small system capable of operating connected to the main network and, influencing the expansion planning of the electric energy distribution systems, the form operation of these systems, energy analysis and the commercial relationship between company/consumer and company/market. In cases of emergency or scheduled events, to operate in isolation, controlling the frequency and voltage and providing conditions for recovery and black-start actions [24].

In addition to guaranteeing the supply of energy, the microgrid helps to reduce the emission of pollutants because non-renewable sources, such as diesel oil, are used only in times of energy need. The change in energy management also directly affects consumers, who become independent and have access to better quality energy [23] [24].

3 I THE ROLE OF EV IN SMART CITY

The prospects for the future of urban transport are directly associated with technological innovations in the field of mobility. Taking into account the use of electric cars, which can reduce emissions and the use of energy. However, for the change to achieve all possible benefits, it is necessary to drastically reduce the use of fossil fuels in power generation, which must be completely decarbonized [25] [26].

Electric cars have been one of the industry's biggest bets worldwide to offer their consumers greater energy savings and less pollution. In the context of the urban mobility revolution that impacts Smart Cities, this technology is among the three "revolutions" in

vehicular technology that there may be a reduction in emissions if cities adopt autonomous vehicles, electric vehicles, and vehicle sharing [27] [28].

One of the technologies in electric vehicle models is called regenerative braking, a mechanism capable of generating a small amount of energy from the vehicle that starts to stop. In cars that have this system, it is possible to use regenerative braking to partially charge the vehicle's battery. Thus, autonomy is already sufficient as one of the major reasons for using these vehicles in urban areas. It also relieves ecological awareness and is quieter. The so-called Eco mode, which is an ally for battery regeneration, limits the car's instant acceleration while decreasing the power of the air conditioner, to increase autonomy [29] [30].

In developed countries, there is already great adherence due it is sustainability, as it will collaborate to an environmentally cleanest planet, with zero emissions of polluting gases. It will be a solution to urban pollution, considering another benefit, is a low cost, when this technology is fully common and accessible, as it does not utilize diesel, or gasoline, or even gas, but electricity [31] [32].

What if the technology is implemented on a large scale, there can be a significant change in mobility patterns, which becomes multimodal. The use of electric vehicles impacts the reduction of global CO2 emissions, the reduction of estimated costs of infrastructure, and the operation of transport systems, resulting in savings [30] [31] [32].

Still, in developed countries, the adherence to electric vehicle technology is the result of a series of policies adopted, from lower or zero taxes on the sale of electric vehicles, as well as the provision of subsidies to stimulate the purchase of electric vehicles, to parking lots for electric vehicles this type of car being free, and there are more points scattered in those cities where it is possible to recharge the battery [28] [32].

With smart infrastructures, smart cities enjoy other benefits, such as better quality of life generated by the reduction of air pollution in cities, similarly to noise pollution, which is the excess of noise that affects the physical and mental health of the population, indirectly causing problems such as stress and sleep disturbances, due to the constant noise of cars on public roads and the noise of vehicle traffic, which is mitigated with electric cars that are quiet in nature [30] [32].

In underdeveloped countries that encounter problems in the development of Smart Cities while the number of owners of private vehicles with electric cars remains insufficient, charging stations are not used at full capacity. And taking into account that the buyer chooses not to buy an electric vehicle, because the existing charging infrastructures are not sufficient to guarantee the use of the vehicle according to his daily needs [32].

The vehicle electric does not require fossil fuels to operate it transforms electricity into energy to get around. It is the solution for zero pollutant emissions, because by using the energy it does not emit pollutants, one of the biggest problems faced today [5] [32].

Thus, without noise pollution and quiet driving, electric vehicles offer quieter and

smoother driving, as it is an electric vehicle and does not have a combustion engine, thus avoiding noise pollution that comes from the combustion engine noise and the absence of the system exhaust is a major source of noise in automobiles. Having a fundamental role in the development of Smart Cities. Since electric mobility has the strategic objective of making cities a clean place to live [6] [32].

The prerequisite is a global system of electric mobility, including purely electric driving with the interaction of various components, ranging from the battery to the customer experience, from the electrical grids to the charging infrastructure. From the point of view of cities, the development of charging infrastructure remains a subsidized activity. And electric mobility thus has great potential to transform the transport system, transforming these cities into intelligent ones [7] [32].

4 I CONTRIBUTION OF THE MICROGRID TO SHAPING THE SMART CITY

Electricity distribution grid that can operate in isolation from the distribution system, served directly by a distributed generation unit. Smart cities have used development incentives to promote sustainable practices [28] [33].

The microgrid can be understood as an autonomous grid in low or medium voltage, controllable, with distributed generation (DG) and energy storage capacity able to operate connected (on-grid) to the electrical power system or disconnected (off-grid) of that system. Smart cities and microgrids use real-time data and communication to efficiently manage energy assets and resources. The most suitable sources for use in microgrids are small units of the microturbine type, photovoltaic panels, and fuel cells, all integrated into the system employing power electronics. It supports economic growth and improves the quality of life through the Internet of Things (IoT) communications and sensor innovation [33].

The introduction of microgrids in conventional distribution grids directly influences the performance of the conventional protection system. Their function serves as islands of reliability in the larger regional and national electrical grids that continuously supply power through grid disturbances. The addition of distributed generation makes the grid active, with bidirectional power flow and changes in the short-circuit current values depending on how many sources are in operation at the time of the fault [34].

This paradigm evolution relies on ‘smart grid’ technologies that resynchronize and reconnect to the grid after the disturbance. The central data centers are the ‘brains’, using the command and control protocol to manage the distribution of electricity between a group of buildings, down to the neighborhood scale [33] [35].

To have a smart city, it is necessary to have a strong, robust, and reliable infrastructure. Cities absolutely must have electricity and communication. The provision of an economical, renewable, and resilient energy supply, while achieving the goals of Zero Net Energy. It impacts the inclusion of needs for electric vehicles and installations, strategies for integrating

microgrids following sustainable policies [32] [35].

A microgrid is a small-scale electrical grid that can operate autonomously or in conjunction with the main electrical grid in an area, and in the development of the communications network and the power grid, considering that in a smart city it is possible to have all advanced systems possible, but if there is no power, it is not possible to have anything. And in this parameter, the microgrids will be essential to ensure that these technological advances work [9] [35].

Microgrids can be a form of disruptive energy because it takes away the concessionaire's hegemony over customers. Where disturbances in the concessionaire's grid can cause voltage dips within the microgrid, impairing the quality and reliability of the energy offered to consumers. And one of the goals of the microgrids is to ensure uninterrupted energy supply for critical or sensitive loads, such as hospitals or industries. The microgrid can minimize the impacts felt by the load [9] [10] [35].

Soon, smart cities will not work without microgrids. A smart city would include several microgrids, interconnected with the distribution system. And a solution for this union would be a key, functioning as a microgrid controller, to integrate microgrids with other intelligent technologies. And so, the smart city would be completely managed through that controller [35].

Microgrids are often seen as a collection of small plants serving a small area of customers, who can still balance demand with sources and integrate renewable sources with other forms of distributed energy. The microgrid technology also brings respective benefits, such as the reduction of CO_2 emissions through the use of renewable sources, the increase in the reliability of energy supply, improvement in energy efficiency with the reduction of losses in the transmission and distribution system [33] [35].

During a possible power outage, a microgrid automatically leaves the main grid and continues to serve local customers through their on-site generators. Whereas in a smart city it may include microgrids or other forms of advanced distributed energy that can act alone without central control of the grid. And the customer will probably not even notice this exchange [35].

Despite their advantages, microgrids impose several challenges to their implementation for smart cities. Among these, we can highlight the coordination in the most diverse operating conditions and the use of a reliable protection system that guarantees selectivity. However, microgrids are a natural evolution of smart grid technology. Where several of its benefits can be listed in the context of a Smart City, among them greater reliability and energy efficiency, as well as the use of new forms of clean energy [9] [35].

5 | GOVERNMENT POLICIES IN CONCERNS OF SMART CITIES

Cities need to complete government policies and strategies to achieve evolution in

smart cities on their own. Since smart cities are powered by data collection from devices interconnected to IoT and online platforms, and considering the volume of data collected in a town, its residents, and its surroundings will be immense. These data are the lifeblood of smart cities; however, it should have a digital responsibility to cyber-protect this informations and use it in the right way and with cybersecurity. As well strict policies, regulations, and laws should detail how that data can be used and shared, and even how consent for data collection can occur [36].

With the need for interconnected smart cities to be able to share and compare data with each other, governments will be able to reduce costs and analyze larger data sets, allowing for more accurate and actionable insights. The development of policies, regulations, and even standards directed for smart city applications should provide digital interoperability, the democratization of access, even and digital data sharing increasing the effectiveness of solutions [37].

Regarding privacy and protection of personal rights must be preserved, reflecting on the use of private data is fundamental so that some city processes and operations work correctly, as traffic lights or even garbage cans connected, and digital privacy resident can become more limited. From digital innovation, smart cities will require to determine norms, laws, rules, and even regulations that specify how their citizens' digital privacy is assured [38].

Concerning cybersecurity valid to mention regarding the digital security of IoT devices is inferior, due to their networks become increasingly complex, so does the task of digitally protecting it. The regulation should ensure cybersecurity standards and restitution for damages caused by security breaches, for both governments and companies will require to be held accountable for undertaking rigorous digital security measures and processes that ensure intelligent devices [12] [39].

Defective technology can generate IoT devices to stop working or even malfunction, causing substantial issues, such as the poor performance of an operation of a process in the smart city. And these norms/laws/rules will define exactly who is responsible for the damage caused by this technology malfunction, as well as the standards that describe the reliability of an IoT device to be implemented in a smart city [40].

The requirement to guarantee equity is related to smart city solutions that help meet the demand of poorly served communities, however, these solutions can also aggravate inequalities if employed or applied incorrectly, limiting the effectiveness of these technologies. In this sense, governments should adopt public policies to ensure proportional distribution and application of technological solutions in smart cities [40] [41].

Since the arising of the paradigm smart cities, a profitable market for companies emerges. Policies and regulations need to be implemented to monitor the relationship and established contracts between the government and companies. Regarding hardware, software, and maintenance technologies for IoT devices and networks that will support

smart cities [42].

So, paradigm Smart cities help conventional cities to be safer, effective, and provides quality of life in a cleaner environment, as long as determined policies can be developed, and are appointed to protect citizens' data and ensure digital security. Promoting collaboration in the city ecosystem to favor cross-city learning and decreases barriers to knowledge sharing. Thus, it is important to highlight that the process of transformation of cities must be continuous, where every action taken contributes to the growth and is the basis for the next step. With the mentality that each city is unique and the challenge is to consider all the factors that can be worked on to make it more and more intelligent [1] [42].

6 I SMART CITIES TECHNOLOGIES

For Smart Cities to become reality, there are key technologies considering smart energy, where smart grids are part of the implementation of this paradigm, and streetlights are a highlight for many cities, as LED lights to save investment and money by making ubiquitous lighting cheaper. Digital communications and LED lighting, through energy efficiency, revolutionize the existing urban infrastructure, transforming it into paths of data and information with the ability to collect, analyze and share these data and propose insights with the potential to drive smart cities [43] [44].

Smart cities support multimodal transport, traffic lights, and smart parking making these city structures smarter, making city buses interconnected so that residents have real-time data about when transport will arrive at the point, prioritizing based on bus times buses so that vehicle traffic can flow better during peak hours, still making residents consume less time searching for vacancies and city blocks. In the same sense that traffic lights have cameras with properties to monitor traffic flow so that it is reflected in traffic signs, so smart cities greatly reduce vehicle traffic and allow resident transit easily by various public routes, using intelligent traffic systems to reduce accident deaths, pollution, and traffic time [1] [45].

IoT devices are the main components that connect everything in a smart city, and even keeping everything connected. It is the backbone that allows each movement and connects each point, taking into account the broad range of these devices (usually as sensors), and other endpoints creating and collecting data for it to work, capturing the information increasingly obtained directly from sensors that collect and share useful information, since with them complex urban intelligent systems can be managed in real-time [40] [41] [42] [45].

Sensors are integrated into all the physical devices that make up the IoT ecosystem, from smartwatches that count steps to automatons, and traffic lights, making most of the technologies used in everyday life have sensors that are performing collect and transmit data to the cloud platform. The network of interconnected objects and IoT devices, or even connects all objects, making them operate together [46].

IoT favors advanced connections between intelligent devices, wearables, smart

home appliances, connected vehicles, medical devices, smart buildings, smart agriculture, urban mobility, and all intelligent systems and digital services that exceed the limits of machine-to-machine (M2M) communication. As reliance on sensors grows, so does the need for them to be reliable and be able to tolerate the inevitable failures in systems to which it is connected [42] [47].

Efficiency in urban management for smart cities needs precision in the analysis and application of data, and this is where the geolocation technologies, resources, and services such as urban mobility operate, depend on this type of technology, offering the foundation on which all solutions for smart cities are structured, in the same way, that it provide the necessary location and structure for the collection and analysis of data and information, transforming each data in order to assist the software-based solutions that make up the infrastructure of smart cities [48] [49].

The huge volume of data collected by smart cities tends to be analyzed fast to make it profitable information. Even the data collected by street lights can be used to benefit citizens, since this volume of data from interconnected lighting systems and other IoT devices turns into precious insights about how resident digitally interact with cities, revealing a privileged location for a specific restaurant in a determined neighborhood, for example [50].

The large volume of data generated by smart cities would be inefficient if it were not for the use of Artificial Intelligence in their processing, generating information, importance, and value. AI collects, processes and analyzes the data created by the M2M interaction generated in contexts of cities, infrastructures, and smart markets, the employment of AI provides management to have an accurate digital understanding of how the smart city is operating, assisting in the planning of transport routes autonomous publics, in the management of the energy grid, deliveries by drones, autonomous postal services or medical care units [51].

Predictive analysis is needed to translate and filter data into significant and profitable information that makes city life better, and more productive. Just like open data portals are an alternative to publishing city information online, so that anyone (resident or visitor) can access it and use predictive analysis to estimate future patterns [50] [51].

One of the issues that happen with a smart city is a large volume of information, this large data set can be quite overwhelming, since the information received that is not used, becomes just useless data, being just accumulated. Cities will have properties to plan better from analyzing large volumes of data, enabling proactive maintenance for future demand, representing that an intelligent infrastructure means that a city can move forward with other technologies making significant changes in future plans of the city [52].

Mobility relates to both innovation and data that travel through technology, reflecting on the ability to enter and exit many municipal and private systems, which need to be interoperable and meet expectations, where data also needs to find unimpeded paths that move between systems, with due attention to intellectual property, cybersecurity, and digital

privacy concerns [50] [52].

Each of these technologies operates together making a city ever more intelligent, in this environment everything will be connected, from people and things like cars, traffic lights, lighting systems, public transport, everything must be integrated into a network, facilitating access to data and a wide range of services to the public. For this, it is necessary to have an efficient connection infrastructure, which involves solutions such as fiber optics, in addition to planning and preparing suitable new structures [53].

However, technology is essential for the development of cities, but it alone is not enough, the development of a city until it reaches the level of being considered a smart city needs to be based on the dialogue between the government and the population, in addition to analysis of the information collected, and thus enabling the creation of useful, integrated services that, in fact, meet the needs of the inhabitants. This management, together with IT services, makes it possible to make administration more efficient, improve the quality of life of its residents (in areas such as mobility and access to services), and provide an economically and environmentally more sustainable city [1] [53].

7 | DISCUSSION

A smart city is generally considered to be one that meets some or all of the criteria with respect to citizen participation, free access to information, transparency, improvement in the quality of services provided, use of technologies, enhancement of local history, efficiency in the use of resources (materials and immaterial), improving the population's quality of life, and above all providing an attractive environment for everyone, residents, and visitors.

In smart cities, citizens and essential services are connected, reuse water, treat waste, share products, services, and spaces, use clean energy, move around easily and enjoy quality public services, in addition to creating cultural ties that unite its inhabitants, promoting economic development and improving the quality of life.

The private sector has been meeting in global forums, to point out solutions and business opportunities in the Smart Cities market, among the adaptations, which must follow the population's desire, is aggregating education to avoid radicalization; total focus on face-to-face and even education until the adulthood; as well as the adoption of sustainable concepts and technologies; urban inclusion, as opposed to the isolation of the peripheries; and urban planning that includes spaces for teaching and education.

In Latin America, an example of this new concept of the city is Buenos Aires, Argentina, since the capital has improved urban mobility and reduced carbon dioxide (CO^2) emissions, in addition to investing in applications that enable its inspectors to report quickly to the population about any problem in the urban structure.

While in Europe, smart cities pass a lot through the use of technology, with a great bias of technological and robotic innovation, in Brazil, it is considered Smart that city that

already managed to meet the basic parameters of sanitation, infrastructure, public safety, and education, and that, despite the low transfer of resources, it manages to have efficiency in the processes, pay the salaries on time for its employees and still meet the social and environmental indicators, that is, it is that city that manages to have the dynamism to the point of having structured planning, with well-defined goals and follow this path with fiscal and socio-environmental responsibility.

However, in Brazil, the city of Curitiba is a highlight and reference in the country when it comes to mobility and urbanism, considering the more than 100 special traffic lights for pedestrians that were installed with sensors for magnetic cards, being used by people with special needs and the elderly, to make it easier to cross the streets.

With the characteristics presented and aligned with the protocols expected for the level of a Smart City, the cities that manage to reach it will have an increase in the offer of jobs in the public, hospitality and, mainly, of the creative economy, an area that has grown exponentially, having as its main process the creative act and resulting, among others, in the transformation of local culture into economic wealth.

So it is important and should also consider that this process is directly related to local geography, as it seeks to understand spatial patterns, relationships, connections, trends (evolution over time), the flows of people and goods and their correlations in geographic space, the that it represents in this sense and in the course of this process, seeking to study the city and the community, to develop a smart city policy by creating plans and strategies on how the objectives will be achieved; involve citizens, since the whole process starts from the empowerment of citizens and their participation.

This social and cultural evolution promises to generate new desires, making the city more and more used for pleasure and promoting ideals such as approximation, connectivity, inclusion, relationship, and sharing, since the concept also addresses the verticalization of cities, with sustainable practices and shortening distances with intelligent transport solutions, and a legislative transformation, which should make it possible and shorten paths to the wishes of the majority of the local population.

The concept of Smart Cities has gained strength on all continents and, making their benefits present in people's lives, in an increasingly degraded environment and with religious and political dichotomies, smart cities, betting on shared solutions, in social inclusion, in effective public services, can represent the opportunity to live in an ideal society.

8 | TRENDS AND FUTURE DIRECTIONS

Edge computing is a complementary technology that offers reduced latency and better customization of apps and, therefore, tends to boost applications in various segments, being fundamental in vehicle automation, IoT directed to a smart city. Whereas while cloud computing serves high-level business analytics and big data queries, edge computing uses

dedicated computing installed in the physical data source. This way, instead of dumping workloads in the cloud, it processes data locally, allowing decisions to be made instantly. Still considering that this is more suitable for applications that demand decisions in real-time and that, in this way, they cannot be subject to problems that affect the speed of data traffic, such as the various applications present in a smart city, and that, due to the possibility of local processing, they end up freeing up bandwidth and, thus, making room for cloud computing to serve the most appropriate demands [54].

Fog computing is a disruptive paradigm that realizes distributed computing, storage services, and network, and even expand the operations and services inherent in cloud computing, in addition to communication between cloud data centers to intelligent devices along the edge of the network. The main function of fog computing is to aggregate and filter data for cloud data centers and implement logical intelligence to end devices. Due to these characteristics, different fog computing applications can be operated in a smart city which is the fundamental key for IoT applications, ranging from traffic management to building energy monitoring [54].

5G technology offers several features that will impact device density and digital experiences in smart cities, as well as greater speed for uploading and downloading data, ensuring shorter latency times, ie, reducing the time between sending and receiving the signal, and the ability to connect multiple devices simultaneously. In this sense, 5G technology will essentially remove barriers to the full development of IoT not only in the residential environment but also in factories, public buildings, or on the streets [55].

Blockchain technology takes care of making checks and secure transactions on the Internet, revolutionizing the management of smart cities capable of coordinating, integrating, and controlling different urban services in a transparent, efficient, and private way. This is due to the properties and characteristics of Blockchain especially its potential for municipal governance due to its ability to transmit information in a secure way and without intermediaries [42] [55].

9 | CONCLUSIONS

Most cities have no control over planning the expansion of the power grid that supplies their locality and, therefore, are dependent on energy distribution concessionaires to develop economic growth plans and programs to attract industries, distribution centers, companies service sector, and large commercial stores. An alternative to reduce dependence on the local energy concessionaire is for cities to invest in energy efficiency programs to free up the energy supply for new ventures.

Among the key factors for the development of a smart city is investing in a new venture in the availability and quality of energy. Investing in distributed generation programs and creating energy microgrids in the smart city, taking advantage of local resources, including

a low voltage distribution system, with distributed energy resources (microturbines, small nuclear generators, photovoltaic systems, wind systems, biomass systems, among others), storage devices (batteries, Flywheel) and energy storage systems. In this way, smart cities and industrial centers can benefit greatly from microgrids with renewable energy generation.

Considering that microgrids are small and controllable energy systems comprising of only one or more generation units linked to close users that can be operated with or independently from the transmission system of the local energy concessionaire. Smart cities with good energy management implement energy efficiency programs in their buildings, public lighting, and other public facilities. Additionally, it encourages and coordinates energy efficiency programs with the community, including companies, businesses, and residential condominiums. These energy efficiency projects have the potential to reduce energy consumption and release a portion of energy that serves the city for new ventures, without the need for investments by the concessionaire to expand the network's infrastructure capacity in the city.

In this sense, through the combination of energy efficiency, microgrids, and distributed generation, smart cities can, through intelligent governance, build a controlled energy generation and demand environment, making it possible to attract new businesses and ensure quality energy for companies and homes. Also creating synergy between environmental sustainability actions and social actions to reduce the costs of residents with incentives for distributed generation.

In the same context as related to mobility, the technologies that will enable the creation of smart cities are ready, or at a very advanced stage of development, considering the proliferation of the autonomous car, and even the scale gain of electric vehicles. Since smart cities require the integration of different solutions in a dynamic and constantly changing environment to meet the needs of everyone (residents and visitors).

However, for smart cities to become effectively viable, the main infrastructure resource is the fast internet, with high speed and low latency, allowing technological processes of the most varied types, improving the quality of life, reducing traffic accidents and even pollution in urban centers. Considering also that these processes need to be democratic, without invading people's digital privacy, the technological properties to track adverse conditions are the premise of smart cities initiatives in the event of an invasion of digital privacy.

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