Review

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Strategic Synergies between 5G and Beyond and Smart Grids

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Review

Strategic Synergies between 5G and beyond and Smart Grids

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Abstract: This article provides a comprehensive review of the intersection of 5G technology and Beyond, and Smart Grids, focusing on the potential of Vehicle-to-Fog as an industrial alternative for addressing energy efficiency challenges in data processing. This study aims to investigate relevant articles and patents to understand the collaborative potential between 5G and Smart Grids. It explores how to establish new regulatory standards within the architectural framework of 5G to facilitate decentralized data processing and remodel energy consumption patterns. The hypothesis suggests that decentralized 5G architecture and Smart Grids can be most effectively applied through vehicular fogging powered by solar energy. A combined quantitative and qualitative methodology guides the exploration of articles and patents. The study concludes by advocating for new standards that embrace decentralized 5G data processing, emphasizing the potential of Vehicle-to-Fog and the future deployment of 6G technology in Smart Grids. These advancements can significantly enhance energy efficiency in the context of 5G and pave the way for future innovations.

Keywords: 5G and beyond; smart grids; technological innovation systems; energy efficiency; fogging vehicular

1. Introduction

Smart Grids have been in a constant state of evolution, especially in 5G and Beyond networks. Mainly, the discussion is about an intersection between data processing and energy consumption. The problems are in energy dilemmas generated by 5G and 6G networks. These kinds of Systems are up-grading drastically the consumption energy curve, which can be solution by Smart Grids in a Fogging Vehicular proposition.

On one side, it presented itself as an evolution from 4G to 5G, following the 6G. Approbation from 4G to 5G was more a revolution than an evolution regarding several benefits and opportunities. On the other side, energy consumption by Cloud and high data volume have brought a harsh energy curve. This way, this article has proposed a conceptual discussion about Green Transition from a digitization perspective.

It is so necessary for a theoretical scenario since the Technological Innovation Systems might result in an appropriate background to understanding the articles and patent productions and collaboration in this case. As this article will present, Electric Vehicles (EVs) connected with Fog is a decisive fostering for 5G and Beyond Innovation Systems.

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1.1. Speculators Proposition

As has been proposed by Li and colleagues (2021), 5G technology has emerged as a relational variable, operating in conjunction with other technologies such as Artificial Intelligence, Big Data, Cloud, Edge Computing, Blockchain, Machine Learning, and the Internet of Things (IoT) (Li, Wang, Zhang, 2021; Bourechak et al., 2023; Tskinner 2019; and Greengard, 2021). Likewise, 5G technology has evolved into an ultra-fast, low-latency, and high-reliability broadband technology (Noor-A-Rahim et al., 2022). The advent of 6G technology can be seen as a direct consequence of 5G, and separating the two becomes increasingly nonsensical. 6G technology aligns with the concept of sub-networks and converging RAN-Core as integral components of the emerging network and architectural paradigms (Chauhan, 2023; Viswanathan and Mogensen, 2020). While 5G technology is more like a revolution of 4G, 6G is seen more as an evolution, as it still depends too much on 5G technology to materialize.

Nevertheless, as said by Li et al. (2021), as a relational variable, 5G just makes sense together with other technological systems and sectors, such as healthcare, energy, or agriculture, from an intersection perspective (Bergek, 2002; Jacobsson and Bergek, 2004; Negro et al., 2007; Bergek et al., 2015; Weiss, 2022). Since this premise, this article parts from the Technological Innovation System (Suurs et al., 2009; Hekkert et al., 2007; Furtado et al., 2020; Kukk et al., 2016; Weiss, 2022; Markard et al., 2015) theoretical background to intertwine two specific sectors: Telecommunication and Energy in the purpose to understand the Smart Grids in 5G and Beyond networks. Smart Grids are intelligent electrical energy grid systems that can use these technologies to deliver greater energy efficiency, reliability (through Blockchain uses), and sustainability possibilities (Berghout, Benbouzid, and Muyeen, 2022; Strielkowski et al., 2023).

Applications and services offered over the Internet are referred to as Cloud Computing. The technology and software of data center systems offer these services (centralized platforms that store and organize data). Software as a Service (SaaS) is the name of the service itself. We'll refer to Cloud as the hardware and software in the data processing Cloud (Armbrust et al., 2009; Stanoevska-Slabeva, 2010). According to the research conducted by Hassan, Yau, and Wu in 2019, Edge Computing represents a sophisticated computing paradigm that empowers edge servers within compact cloud environments (also known as edge clouds) to seamlessly expand cloud resources towards the network edge. This allows for the execution of computationally intensive tasks and the efficient storage of vast volumes of data directly within user equipment (UEs).

The proposition put forth in this article presents a distinct approach to decentralizing cloud computing. With the establishment of sub-clouds driven by commercial interests, Edge emerges as the optimal form of decentralized cloud infrastructure. Conversely, Fog Computing represents the evolutionary advancement of Edge in terms of data processing capabilities, making it the ideal choice for the industrial implementation of Smart Grids utilizing 5G and Beyond. This assertion is substantiated by an extensive review of relevant literature and patents. Consequently, we present the following conceptual representation:

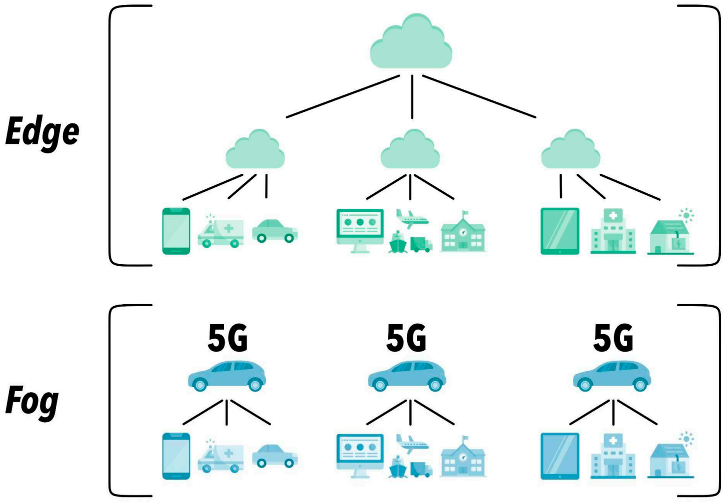

Figure 1. Fog as an Evolution of the Edge by V2G Perspective.

Patents is more impressive, as Vehicle-to-Fog works better in industrial applications than Edge and Cloud. Furthermore, scientific articles point in the direction of Fog and not Edge. That's considerable, as this article disclosed. Depending on the business interest behind Edge Computing, it is argued that it is the best data processing model. But Fog is a revolution in data processing.

In any case, the 5G technology will achieve the electrical system, intensifying the energy sector with digital possibilities. On the other hand, some energetic dilemmas have been discussed in this work from the perspective that these problems will be solved by their own Smart Grid System or in 6G in general. It is crucial to discuss Green Transition from a theoretical perspective, but also qualitatively and quantitatively, to suggest digital transformations and their best consequence, technological change.

1.2. Analyze Proposition

The starting point is the ***following question:*** how to generate new regulatory standards in 5G architectural terms capable of decentralizing data processing in Cloud Computing and Big Data, groundbreaking the sharp energy curve generated by 5G generating energy efficiency? The ***general objective*** is to investigate articles and patents, and their collaboration to an understanding of the Technological Systems of 5G and Smart Grids, in intersection terms. The ***working hypothesis*** is that the best industrial application for decentralized 5G architecture and Smart Grids in terms of energy efficiency is vehicular fogging energetically fueled by solar energy. As a result of this discussion, some ***gaps*** have been found in the literature review:

Table 1. Discussion Gaps.

GAP 1	Lack of TIS functional studies about articles, patents, and their collaboration on 5G and Smart Grids topics forecasting the 5G and Smart Grids' new backdrops.
GAP 2	Lack of studies oriented towards decentralized standards in proposals for 3GPP, IEEE, and ITU providing alternatives to data processing by Cloud solutions
GAP 3	Lack of connection between Electric Vehicles (EVs) and Vehicle-to-grid

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	focusing in Fog Computing, (V2Fog) as a possible industrial solution to 5G data processing by Cloud problem.
GAP 4	Lack of studies on Smart Grids connecting 5G and 6G technologies from an off-grid perspective, rethinking the perspective of the traditional grid.

After this, the present article has investigated the possible alternative solutions to these gaps from Innovation Studies and Green Transition perspectives.

2. 5G and Innovation Studies

As proposed by Lemstra (2018), there are two qualitative scenarios for 5G development in Europe with Policies and Regulation implications. The first is a revolutionary perspective, based on the successful 2G deployment, with leadership opportunities on 5G with the business model for 2G in Europe, when 3GPP appears in good hands. The 700 MHz band was available and the 4G market was fully competitive with the 5G entrance. In the Evolution image, from its possible perspective, mobile operators have gained importance as consumers have gotten access to more Bandwidth. Due to the 4G LTE evolution, the 5G appears as a result of incremental innovations, approbating the 4G LTE background. In developing countries, commonly, there has been a prominence of the Evolution Image, in other to in developed countries, the Revolution Image with particularities of evolutions.

From this perspective, Oughton and colleagues (2022) proposed a quantitative scenario approach to demonstrate that the UN Broadband Commission can keep 4G LTE and 5G technology non-standalone (NSA) universally affordable. The authors proposed three module axes for an estimation calculation of universal access: (1) demand forecasting; (2) supply of fibers and required build-out; (3) estimate spectrum costs. In conclusion, it becomes evident the difference among government political choices.

Teece (2019, 2022) argued that the global economy is better-connected thanks to wireless technology. The Open Innovation paradigm opened up new possibilities for improving customers' experiences, with new prospects for using devices. The Open RAN and its derivations, from the RAN networks' perspective, have the promise to democratize access. In the same way, the R&D possibilities with Open Innovation brought to the digital economy new markets and new horizons to the "technology markets". 5G technology has been, according to Teece (2019), upstreamed the innovation, with new *spillover* possibilities.

Liu and colleagues (2017), on the same perspective, demonstrated encompasses of wireless communication and the possibility of creation and regulation of standards since the applications of 5G key technologies engineering. As Shen (1999), Liu et al. (2017) strove to tell the History of China's Telecommunications, from 3G to 5G with essential user-focused issues from the Innovation Systems perspective. The conclusion is precise that the Innovation System, or the Technological System, in developing countries, has problems and failures that affect directly or indirectly users, and the system itself. Liu et al. (2017) used social and counting sciences to explain how the Chinese 5G innovation system was developed from a historical and econometric perspective with interviews.

Mendonça and colleagues (2022) have a compelling article, focusing on knowledge production on 5G technologies and systems issues, with a quantitative approach using VOSviewer software, and the Web of Science database. They connected the Innovation Studies with a particular 5G technology vision and analyzed the collaboration in 5G article production too with an engineer looking at the market and regulatory aspects. Their approach is focused on Systems for the techno-economic paradigm for Telecommunications, and these authors see Innovation as a coordinated and participative process to enable the global economy. Besides that, they supervised a machine learning building process to accredit a tex-metric analysis.

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2.1. Research Approach

All this literature has been used to prove the robustness of Freeman and Perez (1988) perspective for economic cycles came from Keynes' logic to demonstrate how innovation works in different perspectives with deterministic economic behavior. The contribution of Freeman and Perez (1988) consists in translating the logic of the digital and gig economy, based on digital platforms and 5G transversely. The combination of 5G technology and its corresponding mechanisms, as argued by Li et al. (2021), alongside Manuel Castells' (1999) confluence perspective on technology, gives rise to a constellation-like manifestation of techno-economic paradigm and institutional change. This amalgamation exhibits a dynamic interplay between evolutionary and revolutionary dynamics, resulting in a transformative and impactful landscape.

Correlated to this, the "neo-Schumpeterian" viewpoint - commonly referred to as "innovation studies" is by nature policy-relevant and empirics-friendly, as proposed by Fagerberg and colleagues (2012). But it is possible to shape some Science and Technology Indicators which would forecast Policies, with oriented missions to clear decisions (Mazzucato, 2018). After all, the 5G technology backdrop is less than a digital innovation race (Lundvall, 2021), and much more of a so-called learning curve (Lundvall, 2016) in resolutions' gaps of 4G and so on (5G for 6G, etc.).

In any case, the digital economy's evolution depends on the disposition of the actors on an interactive dynamic disposition inside the firms and organizations. This overview result reflects on the industrial process of digitalization and the neo-Schumpeterian dynamic of capitalism (Nelson et al., 2018), which is stimulated by the digitization process, enough with the 5G technology access into the market and society. The impacts on society will be discussed in the next item.

2.2. Context of Green Transition Perspective

The linkages among technologies, economy, and ecology from a perspective of accomplishing environmentally sustainable development are significant (Kemp and Soete, 1992). They flow from an evolutionary perspective (Geels, 2002, Schot and Geels, 2008; Verbong and Lorbach, 2012), in which technological change is a non-linear and complex problem disclosed in green technologies. According to Kemp and Soete (1992), the barriers to this proposal are more institutional than economic and social. This must be done with a specific focus on Policies designed by all society.

In contrast, Smith and colleagues (2010) put forth a discourse aimed at addressing environmental degradation within the context of industrial development, emphasizing the pursuit of greener innovation. Consequently, a comprehensive multi-level perspective on socio-technical transitions (MLP) emerges, presenting a framework capable of analyzing the broader contextualization of innovation within entire production and consumption systems (Grin, Rotmans, and Johan Schot, 2010).

However, case studies' integration into a profound theoretical discussion has raised concerns regarding the introduction and critical assessment of MLP. Nonetheless, both approaches are indispensable to the ongoing debate. Therefore, it becomes imperative for Geels to undertake an in-depth examination that elucidates the theoretical potential of comprehending the real interconnections between different levels.

2.3. New policy models for the induction and diffusion of renewable energies

As Kemp and Soete (1992) proposed, the challenge of “friendly-environmental Policies” discussion is necessary to comprehend technological change. These Policies should be much more from a bottom-up perspective, than a top-down parameter (Goldemberg, 2000). It is necessary for the formulation of an international technological ecology agenda.

The so-called Renewable Portfolio Standards (RPS) have already adopted by the Kyoto Protocol. An RPS initiative is a bottom-up approach at both regional and national levels that can be applied by Member States to remove market barriers for renewable energies, ensuring its continued participation in a competitive environment after a restructuring of the electricity generation sector.

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This bottom-up initiative is crucial for a participatory approach to a co-design Policies viewpoint with all civil instances of societal participation (Page et al., 2016; Moser, 2016).

On the other hand, the Anthropocene era, with human action in geological performances, brings a Great Acceleration of the human-environment relationship and the global earth temperature. It has been discussed in many working groups, such as the Conferences of Parts (COP, UN) and the 2005 Dahlem Conference (Hibbard et al., 2010; Steffen et al., 2015), etc.

According to Ferreira and Martinelli (2016), mitigation of the problem or adaptation to the effects of changes in the climate system can be associated with climate change policy responses. Mitigation measures include replacing fossil fuel sources with biofuels, energy consumption from renewable sources, carbon markets, changes in consumer patterns, waste elimination, and energy efficiency to support reducing and stabilizing greenhouse gas emissions from the traditional model of transports. Brazil and China are similar cases study because they are bigger developing countries, with similar pollution emissions, but there are differences in how to deal with these emissions in political terms (Ferreira and Martinelli, 2016).

This way, it is necessary for the economic innovation viewpoint for climate change to be an alliance between private and public actors, and investors in R&D on alternative-energy technologies with the participation of all actors (Mowery et al., 2010). At the same time, it is also crucial to a transformative innovation policy, an economic and technological policies agenda focused on mission-oriented policies with a clear direction: targetable, measurable, and time-bound with a practical approach (Mazzucato, 2018). It is elementary an international agenda for technology, economy, and ecology in a global way, but also in a regional and local perspective, which needs to be correlated in a precise viewpoint, since Geels (2002) and Schot and Geels (2008), until a forecasting initiative to an international eco-technology agenda.

2.4. Renewable Energies to Sustainability Perspective: data for solar energy using

As per the findings of the IPCC Report (2023), the historical and current global trends of greenhouse gas emissions have been disproportionately influenced by unsustainable energy utilization, lifestyles, consumption patterns, and production practices. These factors exhibit significant disparities across regions, countries, and even among individuals. Furthermore, renewable energy adoption emerges as a viable solution. The following figures illustrate the projected global growth of renewable energy adoption up until 2050.

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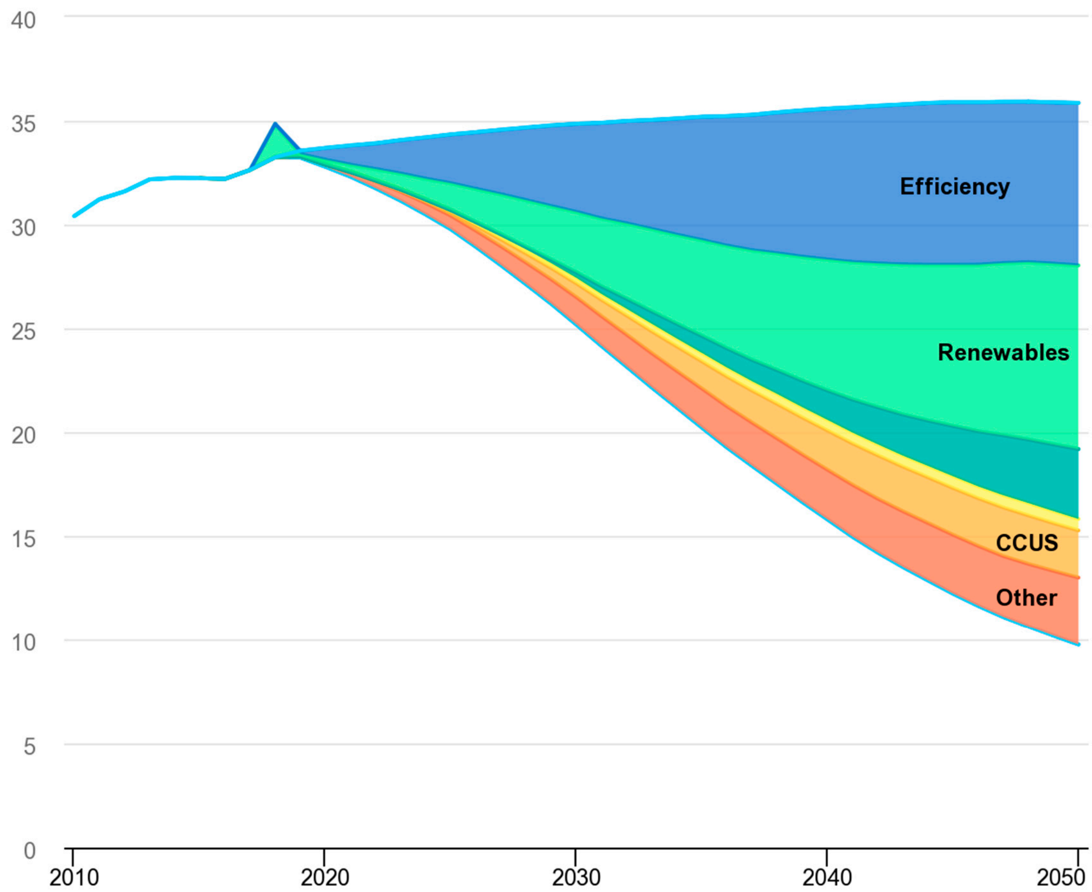

Figure 2. Reduction of CO2 Emissions through Measures in the Stated Policy Scenario as Compared to the Sustainable Development Scenario, 2010-2050 (Global Energy Review 2021 – Analysis - IEA, 2021).

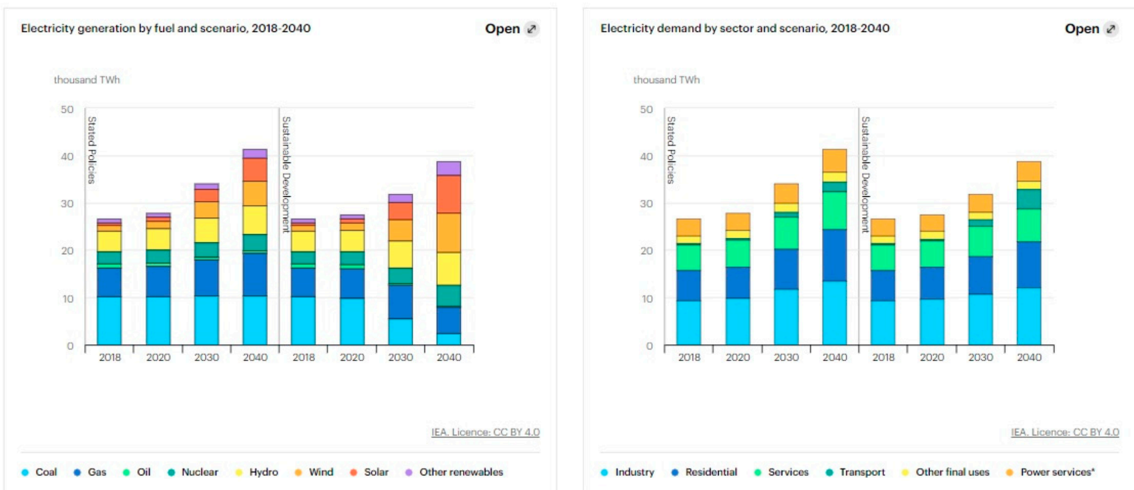

Figure 3. Fuel used to generate electricity and scenario, 2018 to 2040 (Global Energy Review 2021 – Analysis - IEA, 2021).

The presented graphs provide insightful data that highlights the anticipated rise in electricity demand, driven by factors such as increased household incomes, electrification of transportation and heating, and the growing demand for digitally connected devices. This upward trajectory in electricity consumption played a significant role in the record-high global CO2 emissions witnessed

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in the power sector during 2018. However, it is crucial to acknowledge that the availability of various low-emissions generation technologies positions electricity as a crucial focal point in our collective efforts to combat pollution and address climate change.

Moreover, decarbonized energy sources have the potential to significantly reduce CO2 emissions across industries that rely on electricity-based fuels, including hydrogen and synthetic liquid fuels. Achieving universal access to electricity can largely be accomplished through the widespread adoption of renewable energy solutions. In this context, the article proposes the utilization of renewable energy, specifically solar energy, as the most optimal form of vehicular fogging in Smart Grids, leveraging the application of 5G technology to power electric vehicles energetically. See also IEA (2023), and Ruhlow (2021).

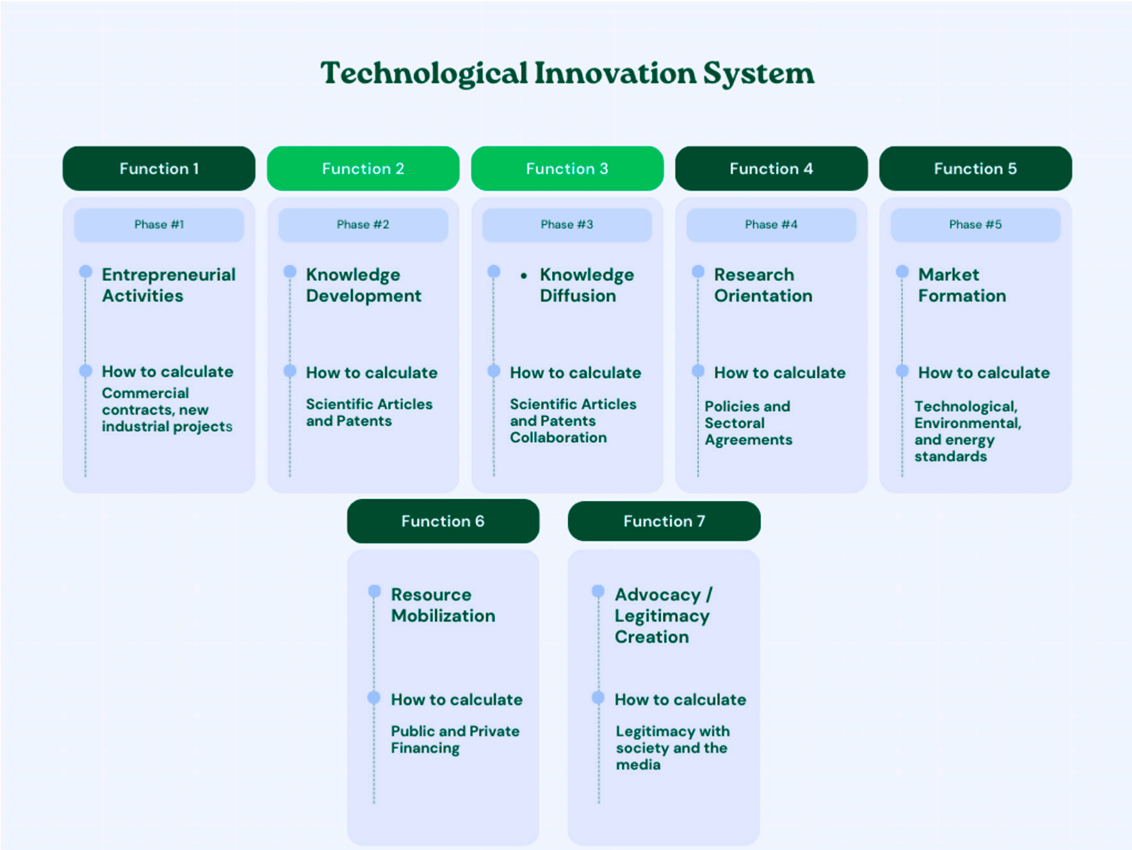
3. Theoretical Background

Technological Innovation System (TIS) (Suurs et al., 2009; Hekkert et al., 2007; Kukk, 2016; Furtado et al., 2020; Weiss, 2022, Markard et al., 2015) has been accepted as the configuration of actors, institutions, and technologies are capable of driving the intensity and the direction of Innovation. In this sense, Innovation has assimilated as a singular socio-technical conjunction result of technological infrastructure issues seen here as Critical Infrastructure, that is, physical and virtual or digital (Kurtz et al., 2022).

Furthermore, it is worth mentioning that, for TIS approach, innovation is an interactive process stimulated through the functional performance of multiple actors, with introducing technology premise in the market through the consolidation of its system within a specific context (Furtado et al., 2020; Suurs et al., 2009; Hekkert et al., 2007; Jacobsson and Johnson, 2000; Carlsson et al., 2002; Markard, 2012; Weiss, 2022).

In addition, according to this background, interactions occur between public and private actors - such as universities, research institutions, State, development agencies, and industries in favor of the diffusion of technologies such as 5G and Smart Grids – and also their consolidation in society in general (Bergek et al., 2015; Weiss, 2022). Overall, there are seven TIS functions.

Table 2. TIS Functions (based on Hekkert et al., 2007; Suurs et al., 2009; Furtado et al., 2020; Jansen et al., 2011).



Besides that, the TIS theoretical background has evolved, since Bergek and colleagues (2008), with contexts patterns that proposed new horizons to this perspective because they integrate technological systems into some socio technical elements, interacting with them (Bergek et al., 2008; Furtado et al., 2020; Borges et al., 2023; Bulah et al., 2023; Norouzi et al., 2023; Zou et al., 2023; Martin et al., 2023; Apell et al., 2023, De Oliveira, 2022). TIS approach associated with emerging technologies, such as 5G, has been discussed by MIT, and others (MIT ID INNOVATION (2022).

4. Methods

Taking into consideration an intersectional perspective (Bergek, 2002; Jacobsson and Bergek, 2004; Negro et al., 2007; Bergek et al., 2015; Weiss, 2022), the analysis of Transition Innovation Systems (TIS) has placed significant emphasis on two consecutive functional components: (F2) knowledge development and (F3) knowledge diffusion (Laes, Pieter Valkering, and Yves De Weerdt, 2019) within the domains of 5G and Smart Grids TIS sectors, which hold pivotal importance in addressing technological requirements. In light of the matter at hand, the electric vehicle, specifically its vehicle-to-grid potential, emerges as a viable industrial application. The operational functions of this paper have predominantly revolved around F1 and F2, as clearly demonstrated in the diagram below:

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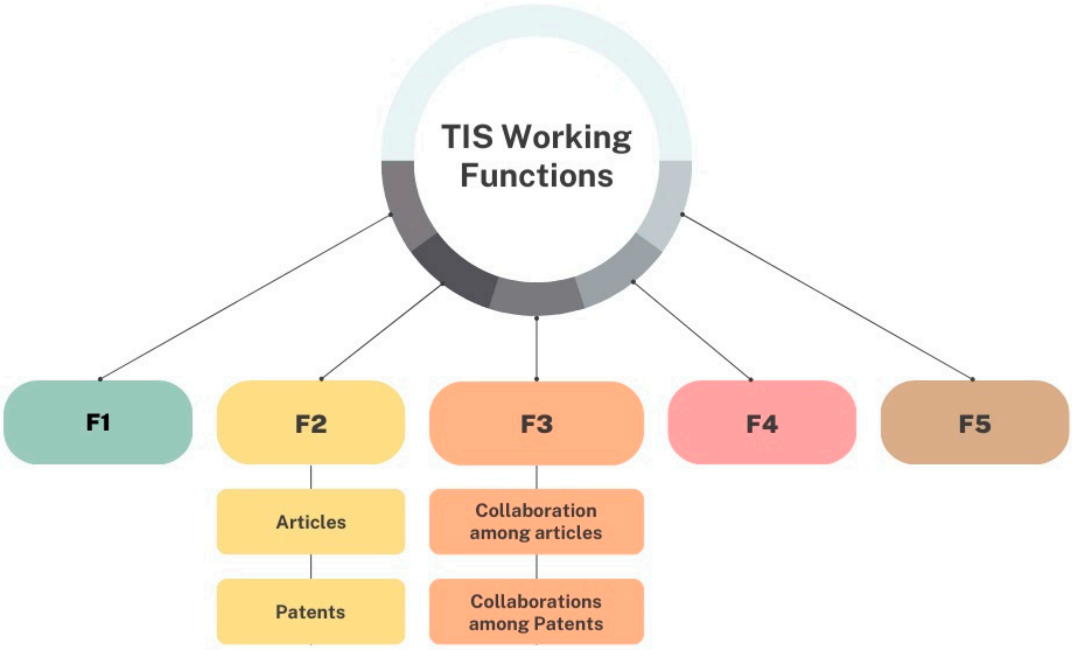

Figure 4. TIS Working Functions.

This article worked with Function 2 and Function 3. As a result, with this working function in progress, it is possible to have some clues also about Functions 1, 4, and 5. In other words, knowledge production and knowledge diffusion give us some elements of entrepreneur activities in 5G, 6G, and Smart Grids; resource orientation, and market formation around the innovation actors, who are the articles and patents' authors. According to this TIS framework background, 5G technology TIS is understood in interaction with Smart Grids TIS to encompass the dynamics of innovation from the actors of both network systems. The 5G Innovation System will leverage Smart Grids TIS, bringing innovations, and reconfiguring the global Technological Innovation System. The groundbreaking technologies which composed the global TIS are in most part small technologies which together direct and reflect on the technological system evolution.

4.1. Quantity Measures: a systematic review

4.1.1. Sample characterization

The characterization of the sample takes place in 5 steps, summarized in the following scheme:

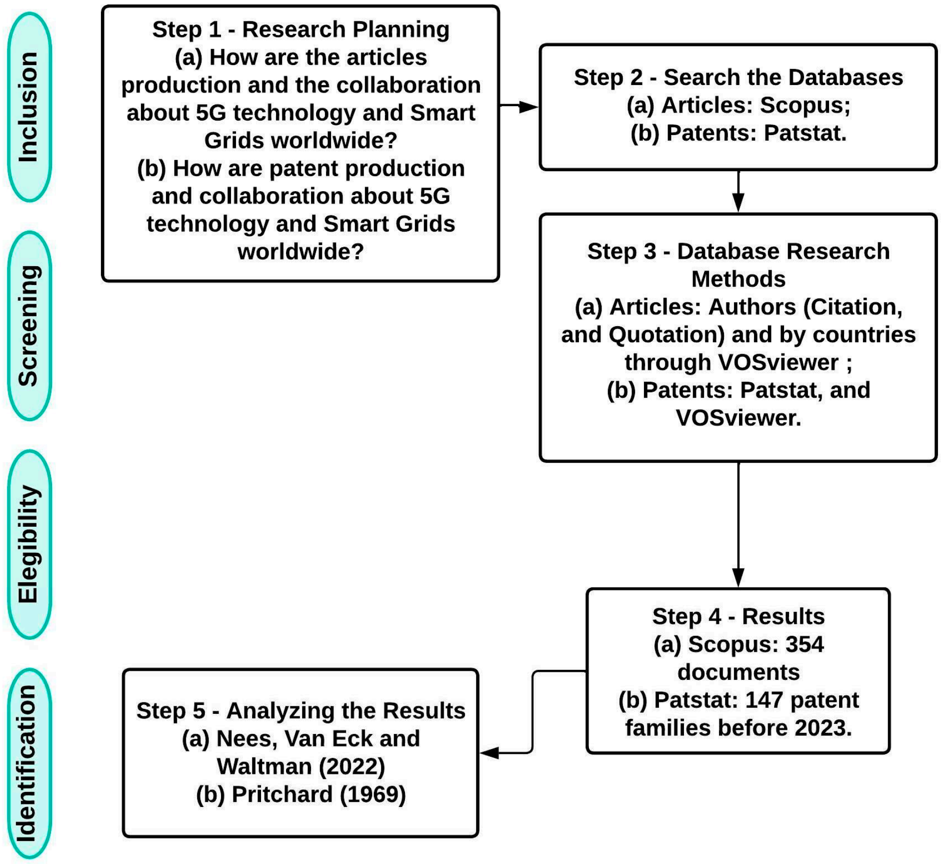

Figure 5. Systematic Research Steps (based on Fernandes et al., 2022).

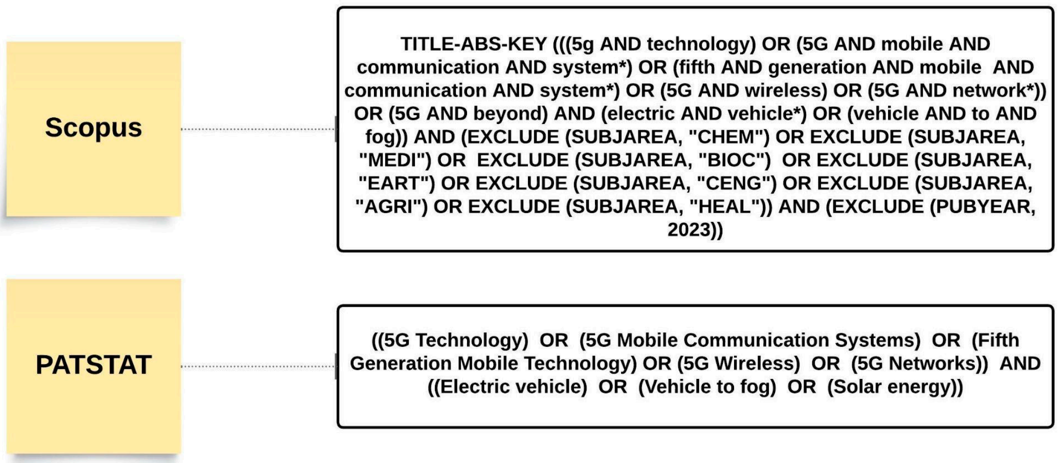

Figure 6. Systematic Research Formulas.

The orientation of this search has employed an equation with these keywords. This research has been accomplished in two stages, one related to the results of the first graph and the other to the results of the second. The equation has been based on decentralized energy forms.

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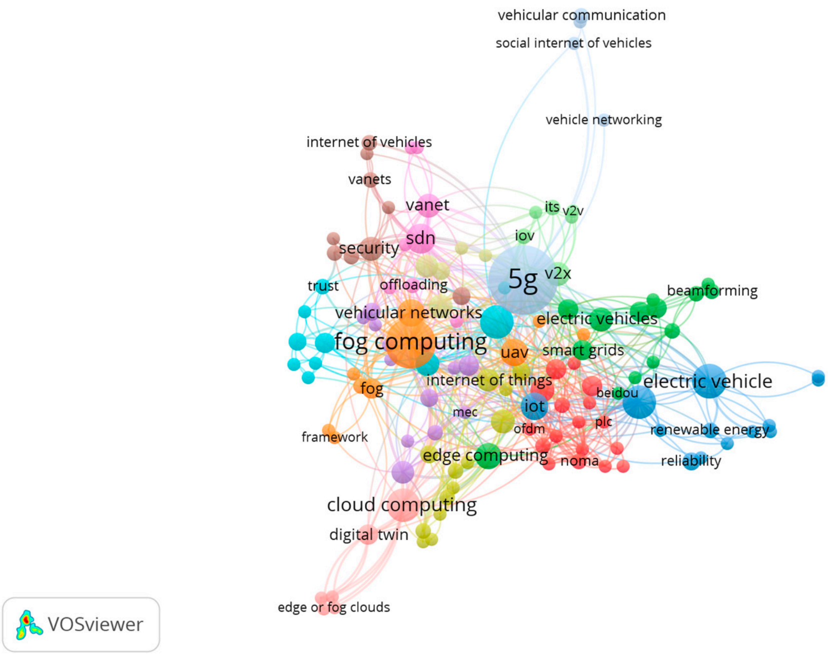
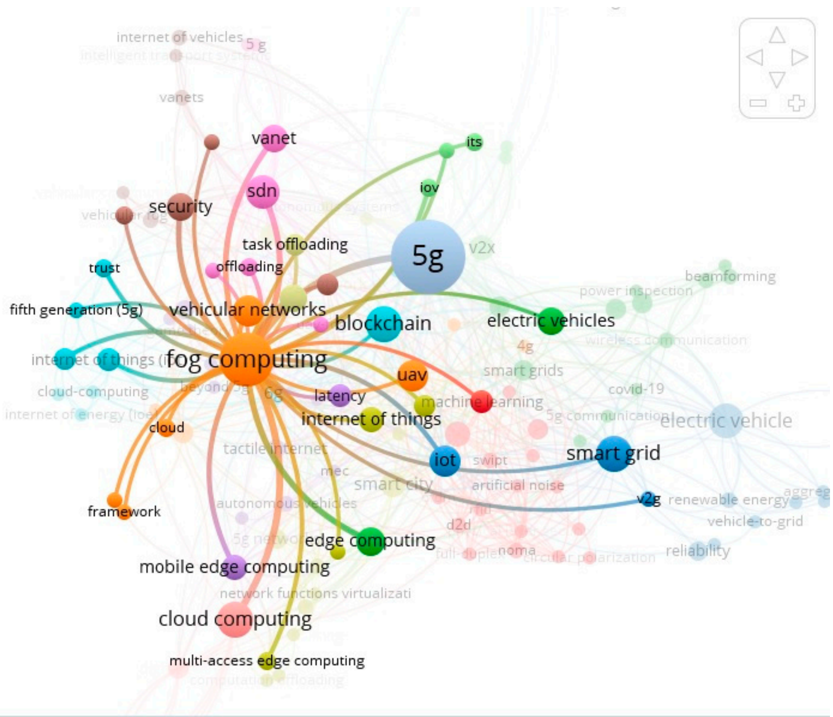
4.2. Articles: Cluster Charts



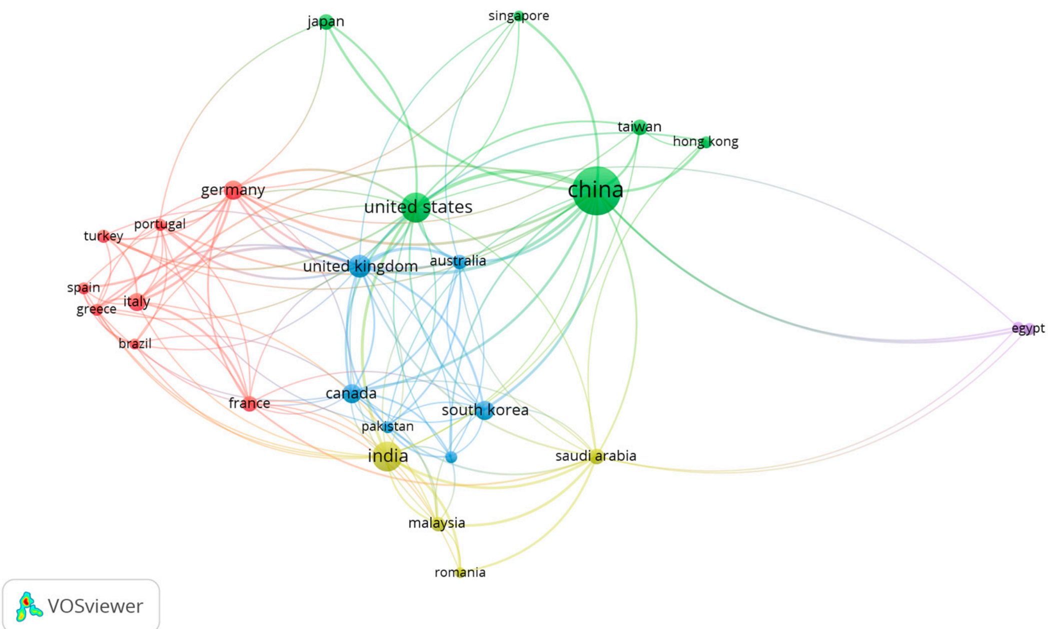
Graphic 1. Publications worldwide by co-occurrence, authors' keywords with articles' impact factor.

This graphic reveals a multiplicity of areas connected with the 5G technology and the Smart Grids subjects. As an interacted figure, which connects Telecommunications with Energy sectors, all the clusters are linked together with a complex and non-linear prism of themes. On the other hand, Fog is linked with the Vehicular Network, which is linked to a framework. Fog Computing is a framework that depends on the industrial application which wants to reveal. In the green cluster, Smart Grids are linked with Electric Vehicles and Beamforming, but also with Edge Computing. 5G is linked with V2X which is a vehicular principle. It is necessary to have a closing in a specific interesting area. Certainly, it is possible to have a good perspective of Electric Vehicles and Fog Computing as below.



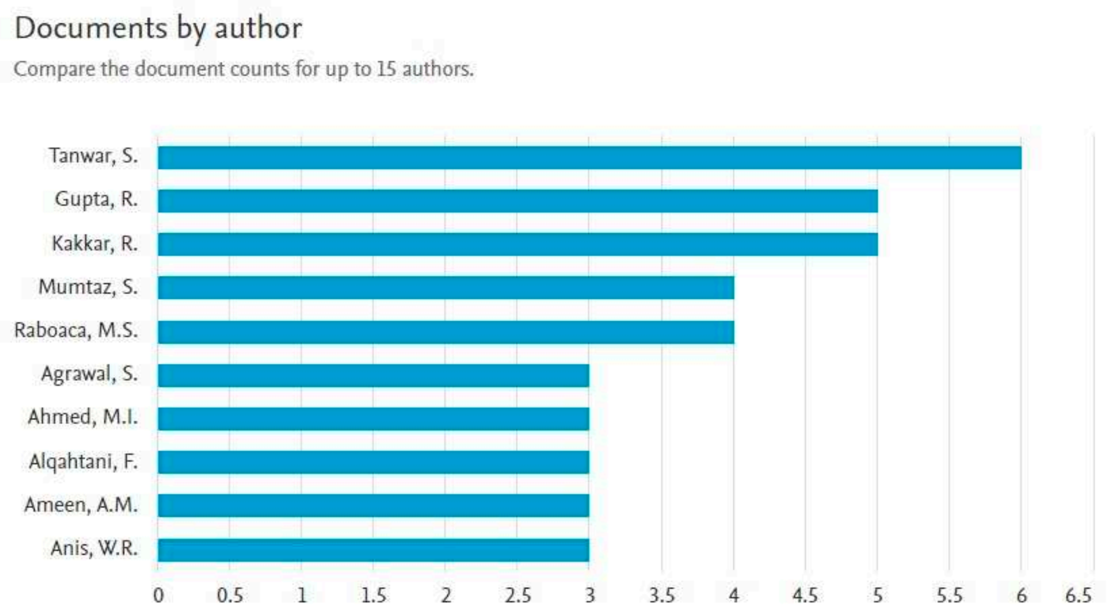
Graphic 2. Closed Map in Fog Clustering.

What is mainly important is to link the 5G, Fog Computing with Vehicular Networks, Electric Vehicles, and Smart Grids in the article's collaboration perspective. It brings perspectives for Beyond 5G paradigms. After all, even if this is not on the map, it will be achieved with learning curves of 5G to beyond. After all, the nearest cluster of Fog Computing is vehicular networks.



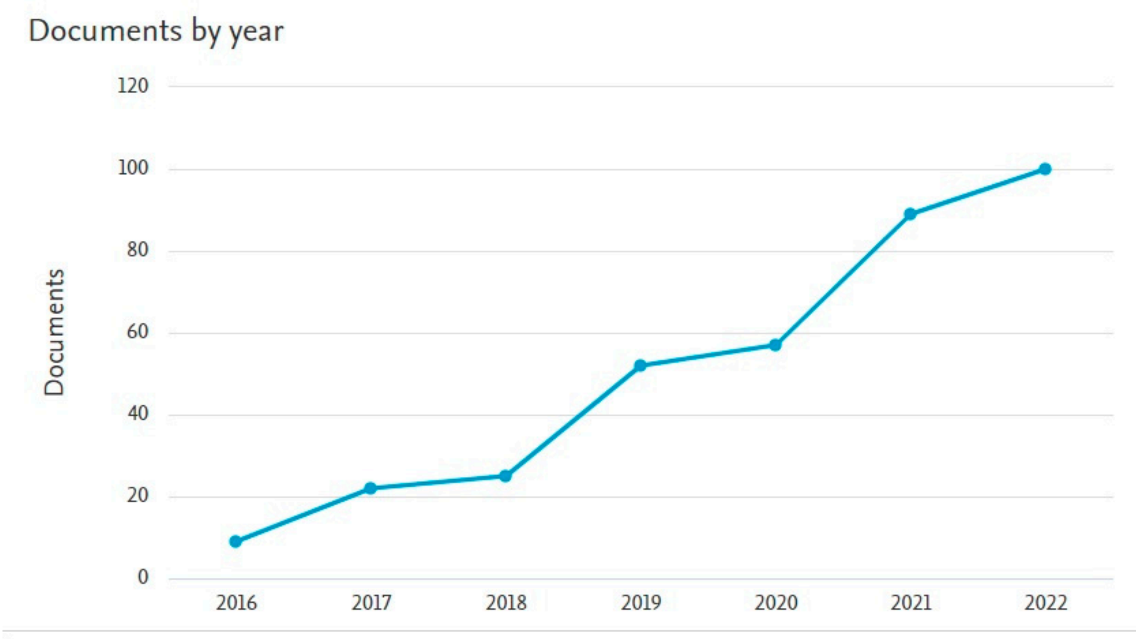
Graphic 3. Publications by countries.

Germany, Portugal, Turkey, Italy, Spain, Greece, Brazil, and France have articles in Journals with the best impact factor, followed by India, Malaysia, Romania, and Saudi Arabia. On the other hand, China, the United States, and the United Kingdom have the most articles in collaboration.



Graphic 4. Documents by authors.

Tanwar is the most cited author worldwide, followed by (1) Gupta, R., and Kakkar, R.; (2) Mumtaz, S., and Raboaca, M. S.; (3) Agrawal, S., Ahmed, M. I., Alqahtani, F., Ameen, A. M., and Anis, W. R. These four clusters are best-cited authors worldwide with the best h-index.



Graph 5. Documents by year involving 5G technology and Smart Grids.

From 2016 to 2022, it is possible to see an accentuated curve of publication numbers with a graphical representation picked in 2022. This way, the publication curve is accentuated and prosperous.

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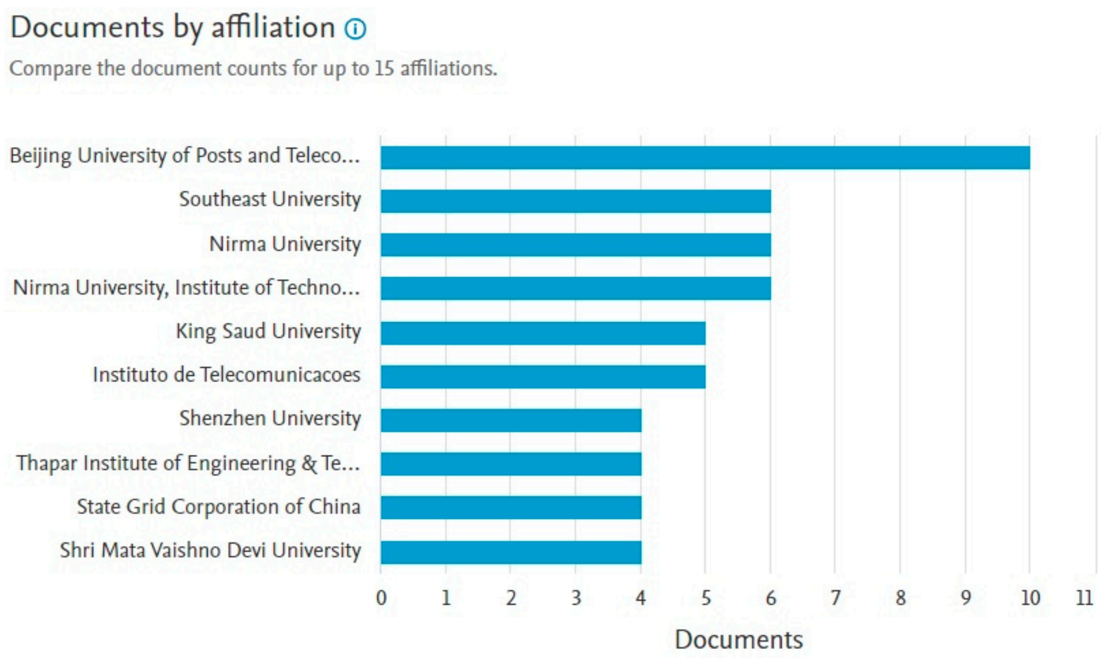
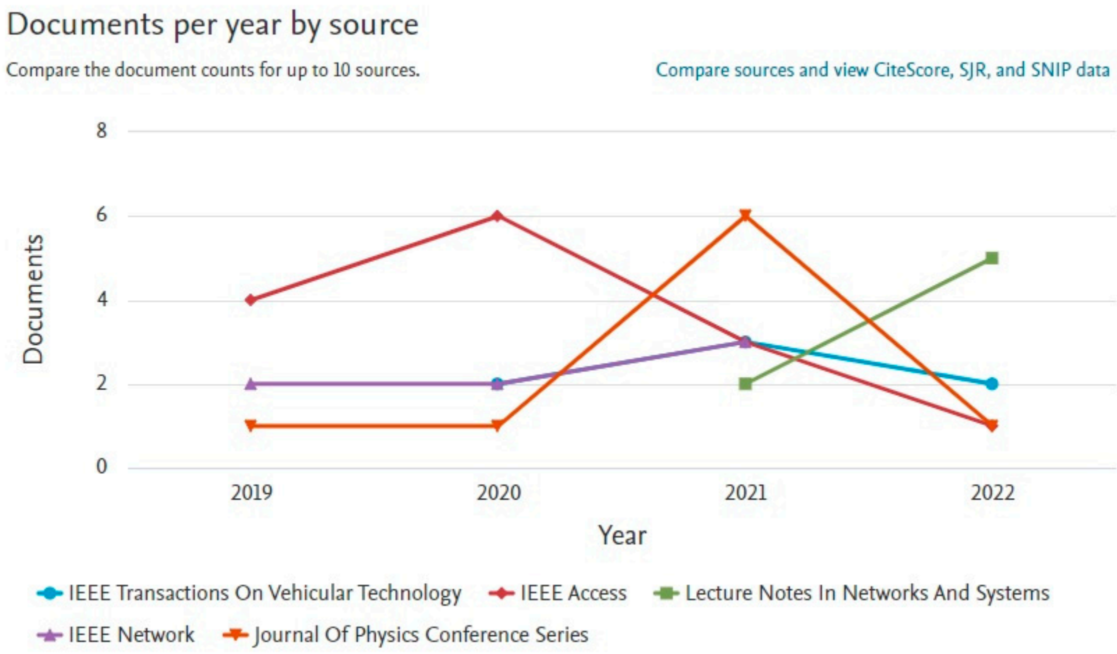


Graph 6. Documents by Institutions.

Beijing University of Posts and Telecommunications has the most articles following: (1) Southeast University, Nirma University, and their Institute of Technology; (2) King Saud University, Instituto de Telecomunicações de Aveiro; (3) Shenzhen University, Thapar Institute of Engineering and Technology, State Grid Corporation of China, and Shri Mata Vaishno Devi University in India.



Graph 7. Documents per year by Source involving 5G technology and Smart Grids:.

IEEE Access had a peak in 2020 with a decline after this. On the other hand, the Journal of the Physics Conference Series had a height in 2021, similar to IEEE Network, with a substitution of IEEE

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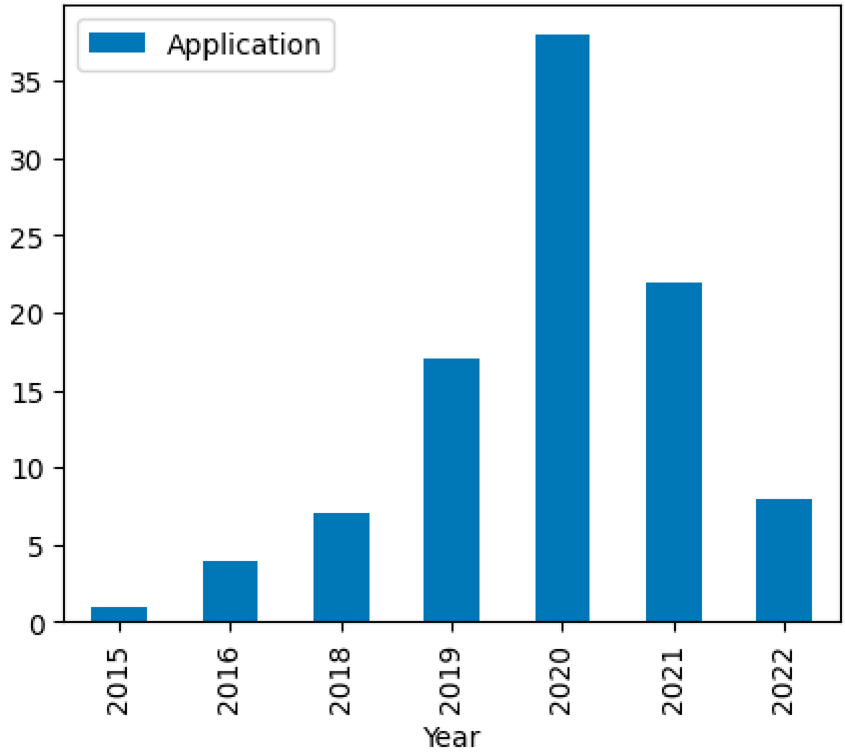
Transactions On Vehicular Technology. Lecture Notes in Networks and Systems started in 2021 year with a peak in 2022.

4.3. Patents: Graphics and Cluster Collaboration Challenges



Graphic 8. Technological Overview of Family Patents by Timeline.

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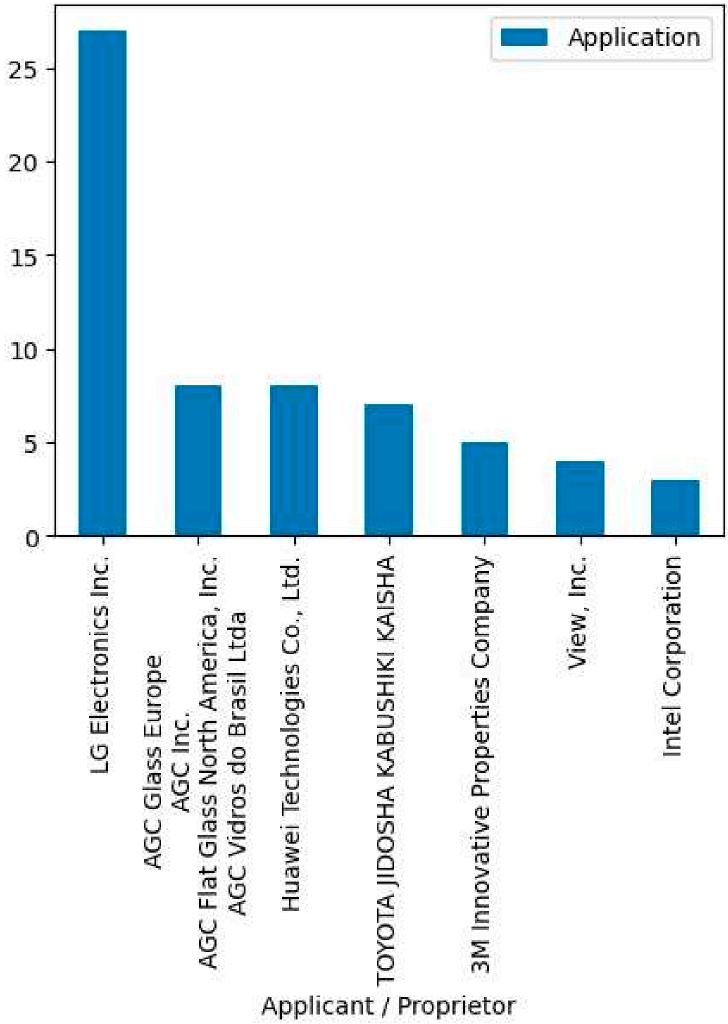
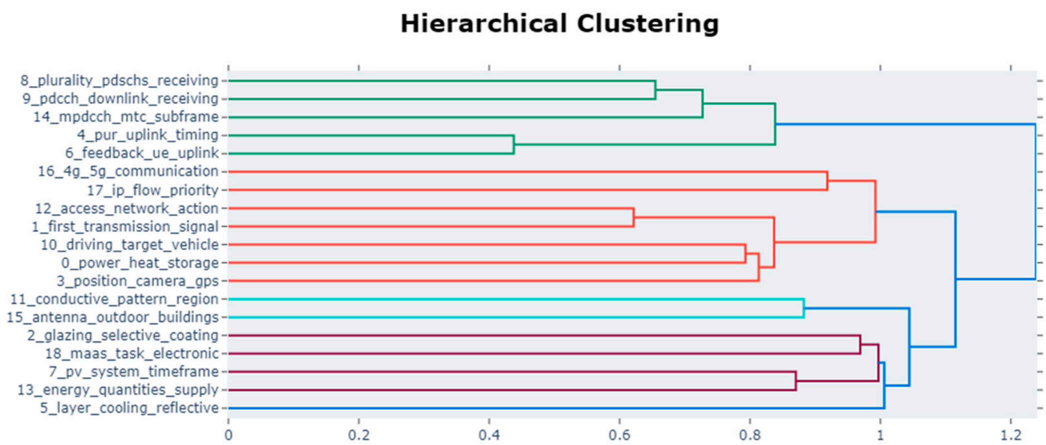
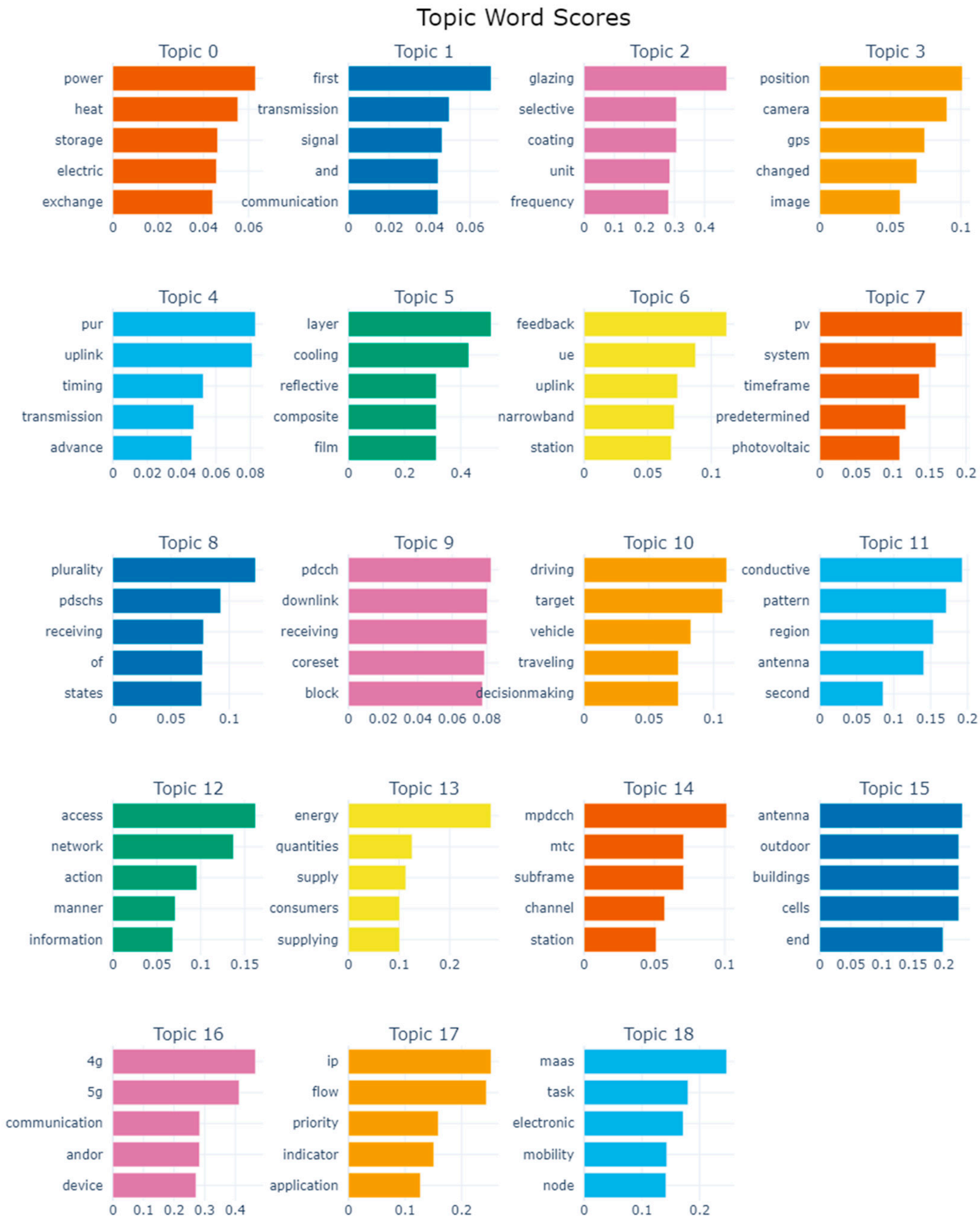


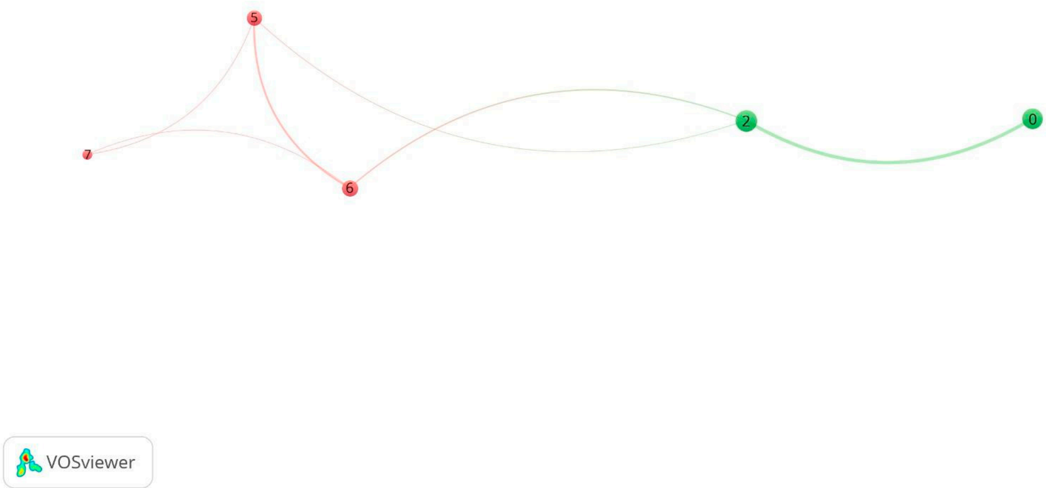
Graphic 9. Technological Overview of Family Patents by Enterprises.



Graphic 10. Technological Hierarchical Clustering.



Graphic 11. Technological Overview of Common Terms.



Graphic 12. Technological Overview of Patent Collaboration.

5. Quality measure: Narrative Random Review based on Scopus

Liu and colleagues (2022) have put forward a proposal stating that 5G technology holds the potential to address the issue of high energy consumption by electric vehicles through the facilitation of collaborative energy commerce. However, the current reliance on a centralized scheduling system poses performance bottlenecks and lacks adaptability within a distributed network. Furthermore, there exists a lack of transparency in the cutting-edge vehicle-to-vehicle (V2V) power supply. To tackle these challenges, the authors suggest a blockchain-based collaborative energy trading scheme specifically designed for 5G-enabled social vehicular networks. This scheme utilizes a distributed market mechanism to ensure reliable energy trading without dependence on a centralized dispatch center.

In their research, the authors have developed a price matching and trading engine for V2V energy trading using game theory, aimed at enhancing societal welfare. Blockchain technology is employed to maintain a transparent record of energy trading data, while smart contracts enable efficient transaction matching and predictable pricing. Simulation results confirm the efficacy of the proposed scheme in improving social welfare and alleviating network burden.

The research objective of this article is to explore the Social Internet of Vehicles (SIoV) possibilities. Focusing on enhancing energy management to reduce EV energy consumption, which remains a significant challenge in Smart Grids development and autonomous transportation systems, the authors aim to pave the SIoV realization way (Liu et al., 2022a).

Gupta and Gupta (2022) (also Jwwthu, 2023, and Alsamhi et al., 2021) have constructed a survey on unmanned aerial vehicles (UAV) based on Fog Computing, the UAV-Fog network. The authors proposed in this article a green perspective for aerials vehicles based on Fog Computing, which they believe is a green paradigm using 5G technology. Green UAV-based fog computing is a viable option for balancing environmental concerns while also providing energy-efficient data computing and air-to-ground network communication to develop an intelligent world with improved Quality of Service (QoS). The essay covers an in-depth study of green technology and UAV-Fog applications. They also highlight research questions, existing challenges, lessons learned, and the UAV-Fog network's future path. This article is an example of a linkage between telecommunication issues and the energy performance of green transportation and transitions to a sustainable society until 2023 with ODS (Gupta and Gupta, 2022; Alsamhi et al., 2021; Jwwthu, 2023).

Baccarelli and colleagues (2017) have a significant article on the Fog Computing paradigm to create a framework for Fog of Everything, bringing together the Smart Cities principle from a Smart Grid perspective. These authors consider smart devices capable of introducing the largest volume of data in a heterogeneous environmental transfer based on Fog. On the other hand, according to these authors, it is still not possible to unbind Cloud Computing. It is possible to have an integrative perspective, on the Fog-Cloud complementary. On the other hand, they present a Smart Grid perspective integrated with the Fog paradigm in Internet of Energy (IoE) terms, which brings together the Internet of Everything concept. This way, according to Baccarelli et al. (2017), this Smart Cities discussion steps up open issues about the Internet of Energy based on environmentally suggestive data processing. Keshari and colleagues (2022) proposed a crucial survey on vehicular fog computing (VFC). According to a survey review, these authors proposed some VFC architectures based on sensing, communication, computing, and storage, proposing a mathematical model to support fog computing instances on vehicular possibilities (Baccarelli et al., 2017; Keshari et al., 2022).

Chen and colleagues (2023) have presented a comprehensive review article aimed at facilitating a smooth and efficient transition from fossil fuels to renewable energy sources. Their work provides a meticulous evaluation of the application of smart meters in power grid control and optimization. Within this article, the authors establish a strong correlation between the concepts and strategies of Smart Grids and smart meters in the context of transitioning towards renewable energy sources.

By linking Smart Grids and smart meters, Chen et al. (2023) emphasize the importance of focusing on the consumer's energy generation domain. They highlight that smart meters play a vital role in reducing carbon emissions while enabling the expansion of power transmission and distribution. The authors propose the implementation of communication interfaces utilizing wireless technologies, such as 5G and 6G networks, as well as incorporating Electric Vehicles (EVs), Cloud Computing, and Smart AI into the system (Chen et al., 2022). These technological advancements are crucial in achieving an effective and sustainable energy transition.

Bourechack and colleagues (2023) have also presented a comprehensive review encompassing various industrial sectors, including Smart Grids, Smart Agriculture, Smart Environment, Smart Healthcare, Smart Industry, Smart Education, Smart Mobility, and Security and Privacy. Their study offers a qualitative comparison that places significant emphasis on the confluence of functions and applications of artificial intelligence at the network edge, along with the crucial supporting technologies for edge analytics. Additionally, the authors explore the significance of integrating Edge Computing and AI into IoT-based applications, proposing potential solutions at various levels of artificial intelligence. Furthermore, they highlight the importance of leveraging 5G intelligent applications through Edge Computing to enhance Smart Services, particularly within the context of Smart Grids (Bourechack et al., 2023).

Prajeesha and colleagues (2023) have conducted a comprehensive review on the significance of Edge Computing in Smart Grid systems, with a particular focus on addressing power grid challenges such as fraud, inflexible energy rates, and outages. As an alternative to Cloud Computing, Edge Computing emerges as a promising solution. The authors highlight the role of intelligent sensors that are traditionally based on the Cloud while emphasizing that Edge Computing pertains to the proximity of network terminal devices. It is a novel technology that leverages the Radio Access Network (RAN) to access resources and capabilities at the network edge.

Minimizing the distance between users and resources and reducing the number of potential failure sites, Edge Computing enhances system dependability. The use of RAN is intrinsic to the functioning of Edge Computing, and thus, the two are interconnected. The article proposes Smart Grids as a solution to overcome the limitations of traditional power grid systems, with a specific emphasis on the application of Edge Computing and video surveillance as alternative solutions (Prajeesha et al., 2023).

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A significant article by Chafi and colleagues (2022) concludes by highlighting the critical role of Smart networks in harnessing the resources of 5G networks, particularly in the context of the Internet of Things (IoT) applications, such as massive machine-to-machine communications (M2M) or ultra-reliable low-latency communications facilitated by dedicated equipment (D2D). The authors emphasize the distributed utilization of cloud services, which enables Fog and Edge Computing infrastructures and applications to leverage all available resources, including network equipment and connected devices. This comprehensive approach aims to optimize cost, energy, and latency based on predetermined optimization criteria (Chafi et al., 2022).

Regarding the concept of Vehicle-to-grid, particularly concerning 5G and Smart Grid, there are several thought-provoking articles. For instance, Liu et al. (2022) introduce a novel concept called the Social Internet of Vehicles (SIoV), which is closely connected to the concept of the Social Internet of Things (IoT). From this perspective, vehicles are considered "socially connected" entities capable of sharing information and services reliably with other social entities. Leveraging the resources provided by 5G technology, SIoV opens up new opportunities and challenges. A notable challenge is addressing the issue of mileage anxiety in electric vehicles, which can be mitigated through collaborative energy trading.

However, the success of this collaborative commerce hinges on the presence of a trustworthy central authority for scheduling, as there are trust-related concerns in vehicle-to-vehicle (V2V) communication. To address this, the authors propose solutions grounded in Game Theory and Blockchain technology. These solutions introduce price matching and trading mechanisms for V2V energy trading, with maximizing social welfare (Liu et al., 2022b). By adopting these approaches, the potential of collaborative energy trade in resolving mileage anxiety and fostering efficient energy exchange among vehicles can be effectively realized.

Shehab and colleagues (2022) (also Ziad Qais Al-Abbasi, Farhan, and Alhumaima, 2022) focus on exploring solutions at the levels of 5G and beyond (6G) networks. They highlight the importance of achieving high energy efficiency and spectral efficiency while supporting a large number of connected devices, particularly in the context of the evolving Internet of Things (IoT) for smart cities. According to these authors, there is an urgent need to examine the sustainability of future wireless networks and how they can be designed to be energy efficient and environmentally friendly.

The researchers propose several green technologies that can contribute to the energy efficiency of these networks, including green IoT, energy harvesting, renewable energy sources, Smart reflecting surfaces (IRSs), non-orthogonal multiple access (NOMA), simultaneous wireless information and power transfer (SWIPT), mmWave, terahertz (THz) communication, massive MIMO, beamforming, ultra-dense networks (UDNs), and device-to-device (D2D) technology (Ghasan Fahim Huseien, 2022). However, they have not yet established correlations between energy efficiency, the need for Energy Internet of Things (EIoT), and the increasing demand for data traffic, along with the significant energy costs associated with data centers.

Therefore, there is a gap in the research regarding the interrelationships among EIoT, energy efficiency, and the deployment of 5G networks (Shehab et al., 2022; Ziad Qais Al-Abbasi, Farhan, and Alhumaima, 2022). Further investigation is needed to establish a comprehensive understanding of how these elements can be effectively integrated to address the challenges of energy consumption and sustainability in future wireless networks.

Huseien and Shah (2022) underscore the significance of the Internet of Things (IoT) in the context of Smart City applications, given its ability to generate vast amounts of data. They highlight the challenge of effectively identifying and selecting appropriate activities that generate substantial data volumes, utilizing technologies such as Big Data analysis, Artificial Intelligence (AI), Machine Learning (ML), and Deep Reinforcement Learning (DRL). While these approaches offer promising avenues for making informed decisions, the authors do not establish a correlation between these concepts and the management of real-world data centers.

Examining the case of Singapore and Malaysia, the authors highlight the introduction of the Smart Nation concept by the local government. This national initiative aims to develop technological solutions that promote sustainable information communication, network infrastructure, and big data

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technologies (Huseien and Shah, 2022). However, their focus primarily revolves around indoor environments, including buildings and smart homes, without adequately addressing critical aspects such as the use of Renewable Energy and Smart meters (Huseien and Shah, 2022).

To further advance the understanding and implementation of Smart city solutions, it is crucial to bridge the gap between IoT-generated data and the efficient management of data centers. Additionally, incorporating renewable energy sources and employing smart meters can enhance the sustainability and effectiveness of Smart city initiatives. Future research should strive to explore these interconnections and develop comprehensive frameworks that address the challenges and opportunities associated with integrating IoT technologies into broader urban contexts.

Rahman et al. (2022) present a compelling and suggestive article on Vehicle-to-Fog (V2Fog or V-Fog), highlighting the significant potential of decentralizing energy production and purposefully deconstructing hardware production. The authors emphasize the role of virtualization technology, which enables hardware-level isolation and platform independence akin to data centers. They propose organizing energy distribution at the Electric Vehicle level, leveraging wireless sensor networks (WSN).

Building upon the work of Messina et al. (2014), the authors note the alignment between the Fog Computing perspective and the development of a trust model tailored to assist cloud providers in making informed decisions regarding Virtual Migration between clouds based on reliability and reputation. Similarly, Aslam et al. (2013) have employed a token-based approach to ensure the migration of Virtual Machines (VMs) to trusted cloud platforms. However, the current literature lacks empirical evidence to substantiate these structures, and the emphasis on confidence in MV allocation within vehicles is relatively limited (Rahman et al., 2022).

To further advance the understanding and implementation of V-Fog systems, it is imperative to address the aforementioned gaps. Future research should focus on validating and optimizing the proposed structures while placing greater emphasis on trust and confidence in the allocation of MVs within vehicles. By addressing these aspects, researchers can contribute to the development of robust and efficient V-Fog systems that leverage the benefits of decentralized energy production and virtualization technology.

6. Conclusions

New regulatory models are essential for data collection processing by Fog Computing to the International Telecommunication Union (ITU), 3rd Generation Partnership Project (3GPP), and the Institute of Electrical and Electronics Engineers (IEEE) at a transactional level until 2030. Smart Grids could be based on new data processing parameters. In the same way, Public Policy developers, both in Telecommunications and Energy sectors, must give attention to a specific focus on encouraging green technologies and renewable energies in a decentralized generation. The data processing collected by Cloud and Big Data could be decentralized by the EVs dynamic, using renewable energy as parameters of green transportation and energy resources.

The literature reviews appointed directions to distributed energy needs evolving traditional energy sources, and centralized data storage forms with Cloud through Edge and Fog Computing, using Smart Grids as the best solution to the data traffic and the sharp energy curve of 5G use and beyond. Smart Grids within the 5G and 6G context should have a decentralized energy source of data processing, using renewable energy especially the EVs connected to these sources, like vehicle-to-grid or vehicle-to-fog - the best industrial application to 5G/6G technology in energy problematic. The best solution to the energy problem in 5G/6G terms is not Edge use. On the other hand, EV applicate to the Vehicle-to-grid or its best alternative, the Vehicle-to-fog, the most decentralized in renewable energy terms solution.

In Technological Innovation System terms, knowledge production and its collaboration remain the vehicle-to-grid and vehicle-to-fog as alternatives to 5G technology coupled with demand for data traffic questioning. TIS Functions 2 and 3 appoint to these directions. Renewable energy sources and technologies, possibly their uses, such as Edge, Hybrid, and Fog Computing until vehicle-to-grid and fog, are forecasting forms to deal with the demand for data traffic. Finally, it is necessary to think in

V2G off-grid, which results in V2Fog and vehicle-to-grid beyond the traditional power grid systems, using the EVs. It has been discussed by World Economic Forum (Schell, 2022).

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