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The Importance of Clean Energy and Technology in the Development of Smart Cities

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ABSTRACT

In today's global context, reducing CO2 emissions and mitigating environmental impacts has become an important issue, leading to the inclusion of smart cities among the top priorities of every country. This article aims to provide solutions for creating appropriate policies and overcoming obstacles in this field, with a focus on the importance of clean energy in the development of smart cities. Specifically, by focusing on three important sectors, namely Energy, Transportation, and Buildings, the aim is to help create efficient roadmaps for developing smart cities. To achieve this goal, successful policies and strategies implemented in successful cities will be examined to overcome the barriers in these sectors and achieve smart city status. The article emphasizes the importance of local government and stakeholder collaboration. This collaboration plays a critical role in creating appropriate policies for increasing the use of clean energy in different sectors, as the ideas of politicians and energy experts cannot be implemented without the support and participation of local governments. Therefore, the cooperation and support of local governments and stakeholders are of great importance for the development of smart cities. In short, the article emphasizes the importance of clean energy in the development of smart cities, provides recommendations for identifying appropriate policies and overcoming barriers, and highlights the critical role of local government and stakeholder collaboration. Therefore, this collaboration can be considered as a successful step towards the development of smart cities.

1. Introduction

Humanity, facing critical challenges such as global warming and population growth, considers the transition to smart cities as a necessity [1], [2]. Despite the numerous benefits of smart cities, there are many factors hindering their development and, therefore, appropriate policies and planning must be implemented to successfully apply them [3], [4]. Additionally, appropriate management of infrastructure in the energy, transportation, and building sectors is a fundamental aspect of smart cities [5], [6]. The use of clean energy plays an important role in reducing CO2 emissions and is necessary for the comfort and welfare of citizens [7]. The provision of high-quality and safe city services is also an important factor [8].

This study aims to examine the development of smart cities [8], [9] and appropriate policies in the energy, transportation [10], [11], and building sectors [12]. Previous studies [6], [8], [9], [13], [14] have attempted to provide suitable policies for the development of smart cities in successful projects. In these studies, four important topics were examined: provider, consumer, regulator, and enabler, the importance of technologies for smart cities was investigated, a study was conducted that emphasized the relationship between city-energy-sustainability

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based on smart energy cities, and the main components, design tools, efficiency, and integration possibilities of renewable energy sources in smart cities were analyzed. In addition, the performance of a smart approach based on the integration of various technologies was also examined.

This study focuses on the development of smart cities and draws attention to the importance of appropriate policies in the energy, transportation, and building sectors. Appropriate policies must be implemented for the successful application of smart cities. These policies can promote the development of smart cities, reduce environmental impacts, and increase the comfort and welfare of citizens.

This article highlights several important aspects of the development of smart cities. It focuses on the role of suppliers, consumers, regulators and project promoters, as well as the importance of technology in smart cities. It examines the relationship between cities, energy and sustainability, particularly in the context of smart energy cities. The article also looks at the integration of renewable energy sources in smart cities, addressing components, design tools, efficiency and integration opportunities. It also evaluates the performance of smart approaches that integrate different technologies.

The study emphasizes the importance of appropriate policy measures in the areas of energy, transport and buildings for the successful development of smart cities. These measures are crucial for promoting the development of smart cities, reducing environmental impacts and improving the comfort and well-being of citizens.

Key points of the article include:

- The importance of reducing CO2 emissions and mitigating environmental impacts in a global context, with smart cities being a top priority.
- A focus on the energy, transport and building sectors to find solutions for creating efficient roadmaps for smart city development.
- An examination of successful policies and strategies in different cities to address the challenges in these sectors and achieve smart city status.
- The crucial role of local authorities and co-operation with stakeholders in developing strategies to increase the use of clean energy.
- Emphasizing clean energy as an important component in the development of smart cities, including recommendations for formulating strategies and removing barriers.

2. Motivation

Smart cities offer a significant opportunity to improve citizens' quality of life. Therefore, cities need to assess the benefits of smart cities in order to improve service quality. The progress of efforts to effectively deploy smart cities is observed to be positive, particularly in areas such as energy management, municipal services, public safety, traffic management, and building resilience, which include the use of Internet of Things (IoT) technologies [15]–[18]. The definition of smart cities is based on three fundamental elements: IoT, big data analytics, and cloud computing. The use of these elements helps cities optimize their services and improve citizens' quality of life. For example, in the field of energy management [19], smart grids can be used to manage energy consumption and production, reducing energy consumption in cities and enabling a transition to sustainable energy sources. Smart transportation systems can be used to optimize traffic flow and reduce traffic problems in cities [7], [12]. Additionally, citizens can access public transportation services more easily and effectively. In the building sector, smart buildings can be used to control energy consumption and improve building resilience. Smart buildings can also be effectively utilized in areas such as building security, fire prevention, and firefighting. In addition to the benefits provided by smart cities, the challenges encountered in implementing smart cities should also be addressed. These challenges include inadequate technological infrastructure, investment costs, and low technological infrastructure and insufficient funding in developing countries.

3. Methodology

The main purpose of this article is to emphasize the importance of clean energy and present a more accurate perspective on smart city development. This goal can be achieved by overcoming obstacles in various sectors and providing appropriate solutions, focusing on the successes of applied policies. Energy, transportation, and buildings have a decisive role in the successful implementation of smart cities. In this context, the development of smart cities is discussed in relation to clean energy sources, technologies used in smart cities, and the impact of clean energy and technology in smart cities.

The conclusion and discussion sections increase our knowledge and understanding of appropriate policies and necessary actions for a city's transformation into a smart city. In this context, the use of clean energy sources and adoption of smart

technologies are important factors for the successful development of smart cities.

Overall, this article emphasizes the importance of clean energy in smart city development. To this end, it aims to increase our knowledge and understanding of appropriate policies and actions for transforming a city into a smart city by reviewing research on the development of smart cities, clean energy sources, technologies used in smart cities, and the impact of clean energy and technology in smart cities.

3.1. Development of Smart Cities

Smart cities are a rapidly developing concept in urban planning, aiming to use information and communication technologies (ICT) to enhance the quality of life and sustainability of cities. Developing smart cities requires the integration of various technological components such as sensors, networks, and data analytics with urban systems such as transportation, energy, and public services. The goal is to create an efficient and livable urban environment that responds to the needs of citizens and supports economic growth [20], [21]. An example project image in this regard is given in Figure 1.

Figure 1 Relevant components of smart city areas [22]

The concept of smart cities has emerged globally in response to increasing urbanization and environmental problems faced by cities. The United Nations estimates that by 2050, 68% of the world's population will live in urban areas, up from 55% in 2018 [23]–[25] .This rapid growth puts pressure on urban infrastructure and services, leading to density, pollution, and resource depletion. Smart cities offer a solution to these problems by optimizing urban systems using technology and increasing resource efficiency.

The development of smart cities requires collaboration among various stakeholders, such as governments, the private sector, and citizens. Governments play an important role in facilitating the adoption of smart technologies by developing policies and regulations and encouraging investment in urban infrastructure. The private sector is responsible for developing and implementing smart technologies such as energy-efficient buildings and smart transportation systems. Citizens play an important role in providing feedback and participation in the development of smart city initiatives [20], [26]. Overall, the development of smart cities is a complex and dynamic process that requires the integration of various technological, social, and economic factors.

3.2. Clean Energy Sources

Clean energy sources are renewable sources that have little or no negative impact on the environment and can be sustained in a renewable manner [27], [28]. These energy sources are commonly referred to as renewable energy sources because they do not deplete with use and can be replenished. In contrast, fossil fuels such as coal and oil are limited resources that are rapidly depleting and have significant detrimental effects on the environment. There are several types of clean energy sources [29]–[35], including those shown in Figure 2.

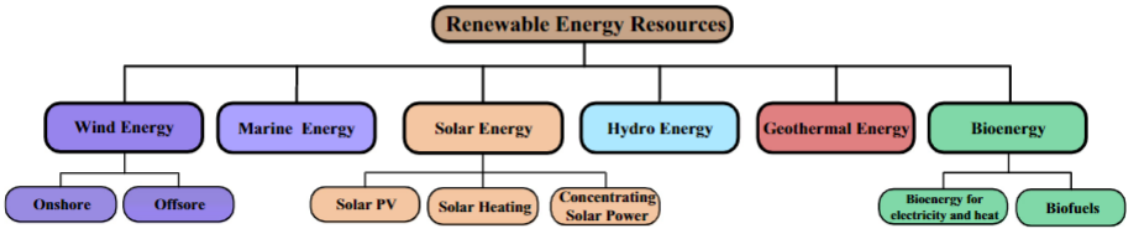

Figure 1 Renewable Energy Sources [36]

• ***Solar energy:*** Energy obtained from sunlight. Solar panels are used to capture this energy and convert it into usable electricity. Solar energy is abundantly available and can be used to power homes, businesses, and even entire cities.

• ***Wind energy:*** Energy produced by the wind. Wind turbines are used to capture this energy and convert it into usable electricity. Wind energy is also abundantly available and can be used to power homes, businesses, and even entire cities.

• ***Hydroelectric energy:*** Energy obtained from the flow of water. Hydroelectric power plants are used to capture this energy and convert it into usable electricity. Hydroelectric energy is also abundantly available and can be used to power homes, businesses, and even entire cities.

• ***Geothermal energy:*** Energy obtained from the heat of the Earth. Geothermal power plants are used to capture this energy and convert it into usable electricity. Geothermal energy is also abundantly available and can be used to power homes, businesses, and even entire cities.

• ***Biomass energy:*** Energy obtained from organic materials such as wood and crops. Biomass power plants are used to capture this energy and convert it into usable electricity. Biomass energy is also abundantly available and can be used to power homes, businesses, and even entire cities.

All of these clean energy sources have various advantages over fossil fuels. Firstly, they do not produce greenhouse gases that contribute to global warming and climate change. Secondly, they are renewable and replenishable unlike fossil fuels. Thirdly, they do not produce harmful pollutants that can be detrimental to human health and the environment. Finally, as technology advances and demand increases, they are becoming increasingly cost-effective.

3.3. Technologies Used in Smart Cities

Smart cities are an emerging concept that aims to optimize urban infrastructure and services using technology [37], [38]. Various technologies used in smart cities enable efficient resource management, reduction in energy consumption, and an overall improvement in quality of life.

One of the fundamental technologies used in smart cities is the Internet of Things (IoT), which connects devices and sensors embedded in urban infrastructure, such as traffic lights, waste management systems, and public transportation, to a central network [39], [40]. IoT sensors collect and transmit data that can be analyzed for optimizing resource utilization, reducing energy consumption, and increasing service efficiency. Figure 3 illustrates the application areas of Cloud-IoT.

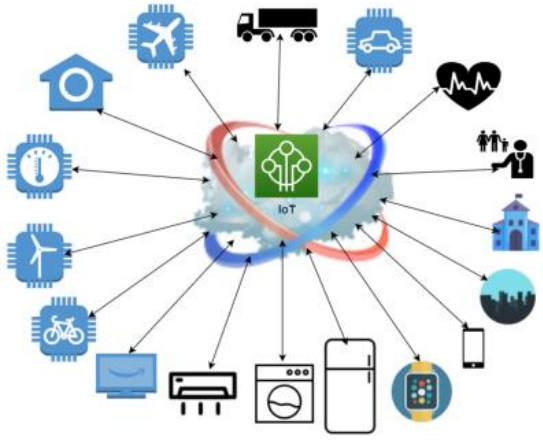

Figure 3 Cloud-IoT application areas [41]

Artificial Intelligence (AI) is used to analyze the large amounts of data generated by IoT sensors in smart cities to predict future events, optimize resource usage, and improve service efficiency. AI-supported systems can detect patterns in data and make real-time decisions, enabling proactive problem-solving and improving citizens' quality of life. For example, AI-supported traffic management systems can optimize traffic flow, reduce congestion, and enhance transportation services.

Smart cities also reduce their dependence on fossil fuels and mitigate the effects of climate change by using renewable energy sources such as solar, wind, and geothermal energy [42]. These technologies enable cities to generate their own electricity, reduce carbon emissions, and improve air quality.

Furthermore, smart cities communicate with citizens, provide access to city services, and enable citizen participation through various digital platforms such as mobile applications, social media, and websites. These platforms can increase citizen participation, transparency,

and accountability, thereby enhancing trust between citizens and government.

3.4. The Impact of Clean Energy and Technology on Smart Cities

Smart cities are urban areas that utilize data and technology to enhance the quality of life for citizens while reducing their environmental impact. The concept of smart cities has gained popularity in recent years due to the need for more sustainable and efficient urban development. One of the most important components of smart cities is the use of clean energy sources and technology.

Clean energy sources such as wind, solar, and geothermal energy are becoming increasingly popular in smart cities due to their environmental benefits and potential to lower energy costs [30], [34], [42]. These energy sources are also more reliable than traditional fossil fuels as they are not subject to price fluctuations caused by global political tensions or supply-demand imbalances.

In addition to reducing environmental impact, smart cities also utilize various technologies to increase energy efficiency and reduce emissions. For example, sensors and meters can be used to monitor and manage energy use in buildings, while electric vehicles and public transportation systems can help reduce the number of cars on the road and mitigate air pollution.

Clean energy and technology can also have a positive impact on the economy of smart cities. The adoption of clean energy sources can create new jobs in sectors such as renewable energy and energy efficiency, while the implementation of smart technologies can enhance the efficiency and productivity of businesses and government services [43].

In general, the use of clean energy and technology in smart cities has the potential to reduce environmental impact, create economic benefits, and enhance citizens' quality of life. As the need for sustainable urban development continues to grow, we can expect to see more cities adopting clean energy and technology as key components of smart city strategies.

Another important aspect of clean energy and technology in smart cities is their ability to increase resilience and prepare for potential disruptions. With the effects of climate change becoming more pronounced, cities need to be able to withstand extreme weather events and other crises. Clean energy sources such as solar panels and wind turbines can continue to generate electricity even during power outages, providing a reliable energy source for critical infrastructure such as hospitals and emergency services [44], [45].

Smart technologies can also help cities manage their resources more effectively in emergency situations. Real-time data from sensors can help identify areas that are in greatest need of resources, and autonomous systems can be used to quickly deliver essential supplies to these areas. Figure 4 presents a visualization of technology focused on smart cities.

Figure 4 Smart city-focused technologies [46]

However, there are also challenges related to the implementation of clean energy and technology in smart cities. One of the main challenges is the cost of implementing these technologies. While clean energy sources are becoming more affordable, the initial investment required for infrastructure and technology can be a barrier for some cities.

Another challenge is the need for skilled workers and expertise to maintain and operate these systems. As technology use becomes more widespread in cities, workers with specialized skills in areas such as data analytics, cybersecurity, and renewable energy will be needed.

In conclusion, the adoption of clean energy sources and technology is a key component of smart cities. These technologies can help reduce environmental impact, increase economic benefits, and improve resilience against potential disruptions. While there are challenges associated with their implementation, the benefits outweigh the costs and provide a path towards a more sustainable and efficient urban future [47], [48].

4. Result

Smart cities consist of six important components: smart people, smart governance, smart living, smart mobility, smart environment, and smart economy. All these components are equally important and their integration is crucial for creating a smart city. Therefore, it is important to structure the integration of each component properly.

This integration requires the use of technological advancements. The use of technology in smart cities can result in effective outcomes in many areas. However, a solely technology-based approach is not sufficient for

smart cities. It is crucial for governments and policy makers to establish and implement appropriate policies for the energy, transportation, and building sectors. This way, smart cities can achieve goals such as sustainability, efficiency, safety, and livability.

Tools such as systems that monitor energy consumption in new buildings, new technologies that promote energy conservation, and building management systems can assist in the development of zero-energy buildings. Successful smart cities have adopted policies and strategies in the energy, transportation, and building sectors that largely focus on the expansion of new technologies, the use of renewable energy, and energy conservation.

Policies in smart cities can vary depending on the characteristics of each city. For the sustainability of cities, governments and stakeholders must collaborate. Local governments can achieve objectives such as clean air, low-consumption technologies, and new transportation systems. Stakeholders can also support the policies of local governments to achieve these objectives.

In conclusion, the development of smart cities can be achieved by the integration of various factors such as the use of technology, the establishment and implementation of appropriate policies, and the integration of components. Therefore, it is important for research on the development of smart cities to consider these factors.

5. Conclusion

The development of smart cities is facing significant challenges due to the necessity to reduce CO2 emissions and meet energy demand. This study aims to identify and present effective policies related to the energy, transportation, and building sectors. Previous studies have shown that technologies and smart vehicles play a significant role in increasing efficiency and effectiveness in every sector. Solutions such as the use of IoT, the development of lighting programs, and energy conservation have led to successful results in smart cities concerning energy loss prevention. In the transportation sector, the use of electric vehicles (EVs) and smart transportation systems with traffic management ensure higher safety and timely transportation. In the building sector, IoT use results in reduced energy consumption and enables real-time adjustment of electricity consumption, management of ventilation and lighting, and adjustment of energy loads for grids.

Past policies, strategies, and technologies' successes and failures should be reviewed. However, it should be noted that each country and city has different needs, and what works in one region or country may not work elsewhere. Additionally, local governments' attention to stakeholder needs and cooperation among them, especially the use of stakeholder knowledge by local governments, positively impacts smart city development.

As a result, focusing on efficient policies in the development of green energy and solutions for attracting investment in clean energy development is crucial, based on the results of this study.

References

[1] A. Razmjoo *et al.*, "Investigating Smart City Development Based on Green Buildings, Electrical Vehicles and Feasible Indicators," *Sustainability 2021, Vol. 13, Page 7808*, vol. 13, no. 14, p. 7808, Jul. 2021, doi: 10.3390/SU13147808.

[2] M. Thornbush and O. Golubchikov, "Smart energy cities: The evolution of the city-energy-sustainability nexus," *Environ Dev*, vol. 39, p. 100626, Sep. 2021, doi: 10.1016/J.ENVDEV.2021.100626.

[3] P. B. Anand and J. Navío-Marco, "Governance and economics of smart cities: opportunities and challenges," *Telecomm Policy*, vol. 42, no. 10, pp. 795–799, Nov. 2018, doi: 10.1016/J.TELPOL.2018.10.001.

[4] G. V. Pereira, P. Parycek, E. Falco, and R. Kleinhans, "Smart governance in the context of smart cities: A literature review," *Information Polity*, vol. 23, no. 2, pp. 143–162, Jan. 2018, doi: 10.3233/IP-170067.

[5] S. P. A. K. Larsen and K. Gram-Hanssen, "When Space Heating Becomes Digitalized: Investigating Competencies for Controlling Smart Home Technology in the Energy-Efficient Home," *Sustainability 2020, Vol. 12, Page 6031*, vol. 12, no. 15, p. 6031, Jul. 2020, doi: 10.3390/SU12156031.

[6] J. Winkowska, D. Szpilko, and S. Pejić, "Smart city concept in the light of the literature review," *Engineering Management in Production and Services*, vol. 11, no. 2, pp. 70–86, 2019, doi: 10.2478/EMJ-2019-0012.

[7] Y. H. Lin, M. Der Lin, K. T. Tsai, M. J. Deng, and H. Ishii, "Multi-objective optimization design of green building envelopes and air conditioning systems for energy conservation and CO2 emission reduction," *Sustain Cities Soc*, vol. 64, Jan. 2021, doi: 10.1016/J.SCS.2020.102555.

[8] A. T. Hoang, V. V. Pham, and X. P. Nguyen, "Integrating renewable sources into energy system for smart city as a sagacious strategy towards clean and sustainable process," *J Clean Prod*, vol. 305, p. 127161, Jul. 2021, doi: 10.1016/J.JCLEPRO.2021.127161.

[9] B. Kim, M. Yoo, K. C. Park, K. R. Lee, and J. H. Kim, "A value of civic voices for smart city: A big data analysis of civic queries posed by Seoul citizens," *Cities*, vol. 108, p. 102941, Jan. 2021, doi: 10.1016/J.CITIES.2020.102941.

[10] L. Aelenei *et al.*, "Smart City: A Systematic Approach towards a Sustainable Urban Transformation," *Energy Procedia*, vol. 91, pp.

970–979, 2016, doi: 10.1016/j.egypro.2016.06.264.

[11] J. Allen *et al.*, "Understanding the transport and CO2 impacts of on-demand meal deliveries: A London case study," *Cities*, vol. 108, Jan. 2021, doi: 10.1016/j.cities.2020.102973.

[12] Q. Ma, H. Fukuda, X. Wei, and A. Hariyadi, "Optimizing energy performance of a ventilated composite Trombe wall in an office building," *Renew Energy*, vol. 134, pp. 1285–1294, Apr. 2019, doi: 10.1016/J.RENENE.2018.09.059.

[13] M. Shafiullah, S. Rahman, B. Imteyaz, M. K. Aroua, M. I. Hossain, and S. M. Rahman, "Review of Smart City Energy Modeling in Southeast Asia," *Smart Cities*, vol. 6, no. 1, pp. 72–99, Dec. 2022, doi: 10.3390/SMARTCITIES6010005.

[14] M. J. Nikki Han and M. J. Kim, "A critical review of the smart city in relation to citizen adoption towards sustainable smart living," *Habitat Int*, vol. 108, p. 102312, Feb. 2021, doi: 10.1016/J.HABITATINT.2021.102312.

[15] S. Zeng, Y. Hu, and C. Llopis-Albert, "Stakeholder-inclusive multi-criteria development of smart cities," *J Bus Res*, vol. 154, p. 113281, Jan. 2023, doi: 10.1016/J.JBUSRES.2022.08.045.

[16] P. K. Mall *et al.*, "FuzzyNet-Based Modelling Smart Traffic System in Smart Cities Using Deep Learning Models," *https://services.igi-global.com/resolvedoi/resolve.aspx?doi=10.4018/978-1-6684-6408-3.ch005*, pp. 76–95, Jan. 1AD, doi: 10.4018/978-1-6684-6408-3.CH005.

[17] S. Pandya *et al.*, "Federated learning for smart cities: A comprehensive survey," *Sustainable Energy Technologies and Assessments*, vol. 55, p. 102987, Feb. 2023, doi: 10.1016/J.SETA.2022.102987.

[18] A. van Twist, E. Ruijer, and A. Meijer, "Smart cities & citizen discontent: A systematic review of the literature," *Gov Inf Q*, p. 101799, Jan. 2023, doi: 10.1016/J.GIQ.2022.101799.

[19] S. Hilmi YILMAZ, E. Taskesen, K. Roshanaei, and M. Ozkaymak, "Energy Management with Intelligent Plug and Socket", doi: 10.35378/gujs.933310.

[20] G. Valença, F. Moura, and A. Morais de Sá, "How can we develop road space allocation solutions for smart cities using emerging information technologies? A review using text mining," *International Journal of Information Management Data Insights*, vol. 3, no. 1, p. 100150, Apr. 2023, doi: 10.1016/J.JJIMEI.2022.100150.

[21] J. Park and S. Yoo, "Evolution of the smart city: three extensions to governance, sustainability, and decent urbanisation from an ICT-based urban solution," *https://doi.org/10.1080/12265934.2022.2110143*, vol. 27, no. S1, pp. 10–28, 2022, doi: 10.1080/12265934.2022.2110143.

[22] P. Bellini, P. Nesi, and G. Pantaleo, "IoT-Enabled Smart Cities: A Review of Concepts, Frameworks and Key Technologies," *Applied Sciences 2022, Vol. 12, Page 1607*, vol. 12, no. 3, p. 1607, Feb. 2022, doi: 10.3390/APP12031607.

[23] D. Ahn, D. L. Goldberg, T. Coombes, G. Kleiman, and S. C. Anenberg, "CO2 emissions from C40 cities: citywide emission inventories and comparisons with global gridded emission datasets," *Environmental Research Letters*, vol. 18, no. 3, p. 034032, Feb. 2023, doi: 10.1088/1748-9326/ACBB91.

[24] B. Pejović, V. Karadžić, Z. Dragašević, and T. Backović, "Economic growth, energy consumption and CO2 emissions in the countries of the European Union and the Western Balkans," *Energy Reports*, vol. 7, pp. 2775–2783, Nov. 2021, doi: 10.1016/J.EGYR.2021.05.011.

[25] A. Marotta, C. Porras-Amores, and A. R. Sánchez, "Are Green Buildings an Indicator of Sustainable Development?," *Applied Sciences 2023, Vol. 13, Page 3005*, vol. 13, no. 5, p. 3005, Feb. 2023, doi: 10.3390/APP13053005.

[26] A. H. Rashed and A. H. Rashed, "The Impacts of Unsustainable Urbanization on the Environment," *Sustainable Regional Planning [Working Title]*, Feb. 2023, doi: 10.5772/INTECHOPEN.110089.

[27] A. Q. Al-Shetwi, "Sustainable development of renewable energy integrated power sector: Trends, environmental impacts, and recent challenges," *Science of The Total Environment*, vol. 822, p. 153645, May 2022, doi: 10.1016/J.SCITOTENV.2022.153645.

[28] A. Rahman, O. Farrok, and M. M. Haque, "Environmental impact of renewable energy source based electrical power plants: Solar, wind, hydroelectric, biomass, geothermal, tidal, ocean, and osmotic," *Renewable and Sustainable Energy Reviews*, vol. 161, p. 112279, Jun. 2022, doi: 10.1016/J.RSER.2022.112279.

[29] C. Wang, S. A. Raza, T. S. Adebayo, S. Yi, and M. I. Shah, "The roles of hydro, nuclear and biomass energy towards carbon neutrality target in China: A policy-based analysis," *Energy*, vol. 262, p.

125303, Jan. 2023, doi: 10.1016/J.ENERGY.2022.125303.

[30] A. Pidruchna and Y. Shurchkova, "Environmental Aspects of Geothermal Energy," pp. 397–410, 2023, doi: 10.1007/978-3-031-22464-5_24.

[31] F. V. Hackstein and R. Madlener, "Sustainable operation of geothermal power plants: why economics matters," *Geothermal Energy*, vol. 9, no. 1, Dec. 2021, doi: 10.1186/S40517-021-00183-2.

[32] J. C. Yong, M. M. Rahman, and R. A. Asli, "Renewable energy: A brief review," *AIP Conf Proc*, vol. 2643, no. 1, p. 030028, Jan. 2023, doi: 10.1063/5.0118959.

[33] E. Severnini, "The Power of Hydroelectric Dams: Historical Evidence from the United States over the Twentieth Century," *The Economic Journal*, vol. 133, no. 649, pp. 420–459, Dec. 2022, doi: 10.1093/EJ/UEAC059.

[34] A. G. Olabi *et al.*, "Wind Energy Contribution to the Sustainable Development Goals: Case Study on London Array," *Sustainability 2023, Vol. 15, Page 4641*, vol. 15, no. 5, p. 4641, Mar. 2023, doi: 10.3390/SU15054641.

[35] S. Nardini *et al.*, "Solar Energy: Applications, Trends Analysis, Bibliometric Analysis and Research Contribution to Sustainable Development Goals (SDGs)," *Sustainability 2023, Vol. 15, Page 1418*, vol. 15, no. 2, p. 1418, Jan. 2023, doi: 10.3390/SU15021418.

[36] O. Ellabban, H. Abu-Rub, and F. Blaabjerg, "Renewable energy resources: Current status, future prospects and their enabling technology," *Renewable and Sustainable Energy Reviews*, vol. 39, pp. 748–764, 2014, doi: 10.1016/J.RSER.2014.07.113.

[37] Y. Luo *et al.*, "Technology Roadmap for Flexible Sensors," *ACS Nano*, vol. 10, p. 34, Mar. 2023, doi: 10.1021/ACSNANO.2C12606.

[38] F. Arli, "Journal of Soft Computing and Artificial Intelligence The Critical Significance of Boron Mine in Future Energy Technologies," *Journal of Soft Computing and Artificial Intelligence*, vol. 03, no. 02, pp. 83–92, 2022, doi: 10.55195/jscai.1216892.

[39] V. Kumar *et al.*, "Challenges in the Design and Implementation of IoT Testbeds in Smart-Cities: A Systematic Review," Feb. 2023, Accessed: Mar. 14, 2023. [Online]. Available: http://arxiv.org/abs/2302.11009

[40] V. Kumar *et al.*, "Challenges in the Design and Implementation of IoT Testbeds in Smart-Cities: A Systematic Review," Feb. 2023, doi: 10.48550/arxiv.2302.11009.

[41] T. Alam, "Cloud-based iot applications and their roles in smart cities," *Smart Cities*, vol. 4, no. 3, pp. 1196–1219, Sep. 2021, doi: 10.3390/SMARTCITIES4030064.

[42] F. Martins, C. Patrão, P. Moura, and A. T. de Almeida, "A review of energy modeling tools for energy efficiency in smart cities," *Smart Cities*, vol. 4, no. 4, pp. 1420–1436, Dec. 2021, doi: 10.3390/SMARTCITIES4040075.

[43] "Türkiye'nin 2022 elektrik üretim kapasitesi artışında başrol temiz enerji kaynaklarında olacak." Accessed: Mar. 15, 2023. [Online]. Available: https://www.aa.com.tr/tr/cevre/turkiyenin-2022-elektrik-uretim-kapasitesi-artisinda-basrol-temiz-enerji-kaynaklarinda-olacak/2404313

[44] A. Orlowski and P. Romanowska, "Smart Cities Concept: Smart Mobility Indicator," *https://doi.org/10.1080/01969722.2019.1565120*, vol. 50, no. 2, pp. 118–131, Feb. 2019, doi: 10.1080/01969722.2019.1565120.

[45] M. E. López-Pérez, M. E. Reyes-García, and M. E. López-Sanz, "Smart Mobility and Smart Climate: An Illustrative Case in Seville, Spain," *Int J Environ Res Public Health*, vol. 20, no. 2, Jan. 2023, doi: 10.3390/IJERPH20021404.

[46] "OGC calls for participation in its 3D IoT platform for smart cities pilot - Geospatial World." Accessed: Mar. 17, 2023. [Online]. Available: https://www.geospatialworld.net/news/ogc-calls-for-participation-in-its-3d-iot-platform-for-smart-cities-pilot/

[47] D. Kumar, "Concept of Sustainable Energy System for Smart Cities," pp. 1–20, 2023, doi: 10.1007/978-981-19-8456-3_1.

[48] M. Shafiullah, S. Rahman, B. Imteyaz, M. K. Aroua, M. I. Hossain, and S. M. Rahman, "Review of Smart City Energy Modeling in Southeast Asia," *Smart Cities 2023, Vol. 6, Pages 72-99*, vol. 6, no. 1, pp. 72–99, Dec. 2022, doi: 10.3390/SMARTCITIES6010005.