Prospects of Smart Cities in Energy Saving and Transportation Data Visualization under the Background of Dual Carbon

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Abstract: Smart cities play a crucial role in the construction of low-carbon, energy-saving and emission reduction and the visual interconnection of transportation data. In terms of energy saving, through the development of emerging technologies led by AI, IoT, etc., it can further achieve the optimization of energy management and urban operational efficiency, thus realizing the purpose and original intention of reducing energy loss and improving energy utilization; in terms of energy storage, smart cities can adopt the combination of smart grids and electric power storage, and the promotion of smart grids, especially photovoltaic power generation, which can help to improve the utilization rate of renewable energy. In addition, and further promote the improvement and refinement of urban optimization services. Future smart cities will play an increasingly critical role in improving the efficiency of traffic management in terms of traffic data collection and visualization. This paper introduces the application and outlook of smart cities in energy saving and traffic data visualization, and hopes to provide new ideas for improving urban management, improving the quality of life of residents, and promoting sustainable development of cities in the context of the implementation of the "dual-carbon" goal at the present time.

1. Introduction

In its Fourteenth Five-Year Plan for a Modern Energy System, China clearly states that it will reach its carbon peak by 2030 and achieve carbon neutrality by 2060. This goal is known as the "dual-carbon" goal. To achieve this goal, China needs to further develop a green lifestyle and accelerate the pace of low-carbon and environmentally friendly urban construction.

In this "dual-carbon" context, the construction of smart cities also needs to be "Chinese" according to China's current development [1]. Through the construction of efficient, intelligent and integrated IoT devices and the development of AI technology, we can reduce the loss of human and material resources in the life of the smart city. As well as, in order to implement the concept of green saving and the real implementation of the "dual carbon" goal, new energy, clean energy such as photovoltaic power generation [2], the corresponding deployment of urban transportation, construction, infrastructure and other sectors, in order to improve the efficiency of urban operation, and to promote the improvement of the standard of living in the city.

At the same time, the innovation of digital technology also provides ideas for the implementation of the "dual-carbon" target environmental program [3]. We need to give full play to the characteristics of the smart city in the context of the new era, through the combination of big data, AI and other technological means, through multiple sensing, digital twins [4], to collect a series of data in the smart city in the context of "dual-carbon" in the climate monitoring, carbon emissions from transportation, the amount of electricity supply and use, etc., and give full play to the characteristics of the smart city in the context of "dual-carbon". The smart city combines the advantages of advanced information technology to process and allocate urban management resources, builds a digital management platform, realizes information interconnection and real-time sharing [5], and collaborates in urban planning and governance. Combined with the data visualization technology, the collected and processed data can be displayed visually to analyze the situation of the smart city in a more vivid and three-dimensional way, so as to better improve the quality of life of the residents and to meet the original intention of energy-saving, environmentally friendly, and highly efficient development of the city.

2. Application of smart cities in energy saving

2.1 Smart grid combined with power storage

Smart grids can be operated by performing power generation and reserving excess power through power storage systems, which can support the power system through energy storage systems [6]. Therefore, incorporating smart grids into the energy management system of smart cities will play a crucial role. As an important part of the smart grid, PV power generation has

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shown a growing trend in various scenarios, especially in those regions where user-side grid parity has been achieved. According to the International Energy Agency (IEA), solar photovoltaic (PV) power will need to account for at least 25 percent of the global electricity supply by 2050 in order to achieve net-zero emissions. The northeastern region of Heilongjiang, China, for example, is considered to have a huge potential for PV power generation due to the high cost of coal-fired power generation and the good conditions for PV power generation, which can effectively realize the function of smart grids to improve the efficiency of renewable energy use in urban energy management.

And in the construction of the smart city, through the rooftop solar power generation system, combined with the battery storage unit, the excess power generation will be supplied to the power plant, and then through the power management system real-time distribution to the subordinate unit infrastructure, such as new energy vehicle charging piles, street lamps, traffic signals, etc., to achieve the purpose of saving the cost of electricity and maximizing profits. Therefore, through the smart grid system, cities can achieve real-time optimization of the energy supply chain.

2.2 Optimization of urban facility services by smart cities

Smart city construction, mainly through smart industry, smart government and other related urban structure optimization brought about by the progress of people's livelihood policy services [7], to improve the efficiency of government services, as well as driving science and technology toward the development of new energy and energy-saving direction, all further make the urban resource utilization rate has been improved, conducive to the sustainable development of the environment.

In the optimization of urban structure, the old urban system has the disadvantages of large volume, poor synergism, and low efficiency, but through the development of new related intelligent industries led by AI technology, the purpose of saving resources and energy can be effectively achieved. Such as in the intelligent building energy saving, smart city through the combination of intelligent building management system with AI technology to the relevant equipment, etc. to quantify the energy consumption and application, realize the efficient use of energy, and the use of better performance of thermal insulation materials, as well as the use of green building materials and the further promotion of the city life can be reduced as much as possible in the waste of energy. Moreover, with the development of smart agriculture, smart manufacturing and other fields in the new city, it can effectively promote the transformation of urban construction towards low-carbon and high-quality development while stabilizing the growth rate of the urban economy.

3. Application of traffic data visualization in smart cities

As the pace of urbanization continues to accelerate, problems such as traffic congestion, environmental pollution, and irrational urban planning are becoming more and more prominent, and have become a problem that restricts the sustainable development of cities. As an effective means to solve these problems, smart cities are receiving extensive attention around the world. Among them, traffic data visualization, as an important part of smart cities, provides city managers and the public with an intuitive and efficient way of displaying traffic information, which is of great significance for improving the efficiency of urban traffic operation and the travel experience of citizens.

3.1. Information collection and geographic information systems (GIS)

With the development of advanced means such as remote sensing satellites, geographic information systems (GIS) are able to collect and store important geographic information about the earth's surface, such as geographic location, environmental conditions and resource distribution [8]. These geographic information, after orderly organization, classification, statistics and in-depth analysis, can reveal the inherent laws and interconnections of geographic information and provide a scientific basis for urban planning.

In the process of smart city construction, these geographic data processed by GIS provide a scientific basis for urban planning, ensure the rationality and sustainability of urban construction, and then improve the efficiency and level of urban management. By fully utilizing the geographic information and data support provided by the GIS, the construction of smart cities can be more in line with the laws of nature and improve the science and feasibility of construction [9]. The schematic diagram of information collection and GIS is shown in Figure 1:

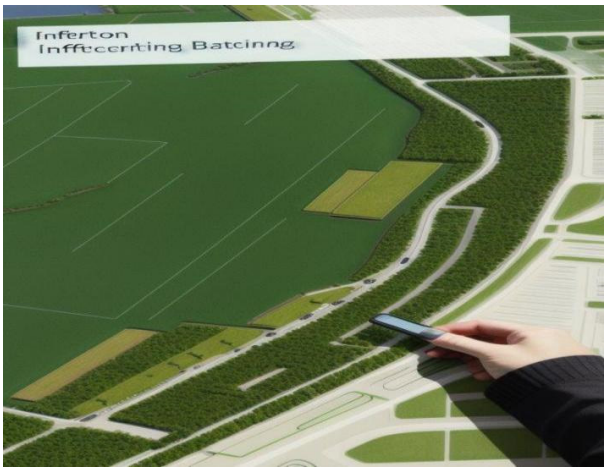

Figure 1 Information collection and geographic information systems

3.2. Data fusion and smart cities

With the advent of today's big data era, the construction of smart cities for the future, data fusion is not only a technical means to realize the docking of data and collaborative work, but also a powerful measure to break down information barriers and data silos. Data fusion refers to the integration of data from different sources, time scales and other aspects, ultimately forming a unified format and a comprehensive data set of different aspects. For the smart city, data fusion in the application of more often, it can be mixed data sources from different departments for real-time system summary, the value of different data isolation for the overall analysis, so that it can be effective for decision-making, layout planning, etc., to provide effective intelligence support and information sharing channels, to achieve the visualization of traffic information, and to promote the efficient use of data and intelligent management of the smart city.

Therefore, data fusion is applied in the field of smart city transportation to synthesize the factors affecting roads, pedestrians, vehicles, weather and other aspects to facilitate the management of its dynamic system. Usually, smart cities are often paired with digital information means such as IoT systems and data collection devices. Taking the IoT-based smart city as an example, when acquiring and managing and controlling traffic information, it will combine the public sensing network that collects the information with the relevant management departments throughout the networked urban areas [10]. The data fusion technology needs to ensure the security of the collected and transmitted data before it can be applied in the various transportation departments of the smart city. For example, in order to ease peak traffic conditions, the traffic management department can combine real-time traffic monitoring video, historical traffic flow and vehicle navigation data to predict and quantify the traffic flow and road congestion in the following hours, so as to facilitate the analysis of the traffic flow of the road, research and judgment of the traffic visualization data, to facilitate the deployment of road management and control to alleviate traffic congestion. Therefore, the combination of data fusion and smart city, in improving traffic safety, ease congestion, as well as the city's various collected traffic data for real-time quantification and visualization, provides technical support. And for the relevant management of transportation departments, provides data support.Adopting scientific and technological means to effectively provide the basis and means for decision-making on the sustainable development of urban transportation and to promote the improvement of the management level of sustainable development.

Smart city projects are built on a solid foundation of interoperability and data processing capabilities. With the rapid development of digital information technology, smart cities have access to an increasing number of data points that originate from a variety of sources, including cell phones and satellites. The deep integration of these data drives problem reporting and maintenance in a more proactive and efficient direction. Digital information technology builds a strong nervous system for smart cities, allowing for a more unimpeded flow of information, which greatly improves the living environment, optimizes public utilities and transportation networks, and in turn injects new vitality into the sustainability of smart city construction and maintenance [11]. The related smart city data fusion conceptualization diagram is shown in Figure 2:

Figure 2 Smart city data fusion system

3.3. Data collection and traffic data visualization

Smart city data collection and transportation data visualization are important components of modern urban planning and management, and together they constitute a key technology area in the construction of smart cities, aiming to optimize the operational efficiency of urban transportation systems, enhance the travel experience of residents, as well as promote the sustainable development of the city through the integration of advanced information technology tools.

As reported by the United Nations in 2014, the majority of the world's population now lives in cities, and with the continued growth of vehicular traffic, the transportation sector is facing enormous challenges, especially in urban areas. Therefore, transportation road planning for future smart cities requires the collection of relevant traffic data to capture traffic information about vehicles, speeds, and directions of travel. According to a survey of data collection and visualization practice datasets at the Sathorn-Surasak interchange in Bangkok, Thailand [12], it was shown that by improving the richness of the collected road traffic datasets, it would help future studies to focus on the high-resolution features of key road intersections. This is indispensable for studying future smart city traffic vehicle movements. Meanwhile, through fine data collection and efficient fusion analysis, it can provide scientific basis for urban traffic management, optimize traffic planning and resource allocation, and improve urban management efficiency. Traffic data visualization in its research cases is also not limited to the basic flow display, but goes deeper into the spatial and temporal distribution of traffic flow, dynamic changes in the degree of congestion, and the analysis of the impact of traffic accidents. Therefore, combining data collection with future smart city traffic data visualization can not only help decision makers to make a quick response, but also identify potential traffic problems at the planning stage, so as to optimize the urban traffic layout at the source.It improves the safety of road traffic and lays the

foundation for solving future transportation problems. This is in line with the sustainable development goal of "taking into account both current and future development needs".

In order to effectively visualize traffic data, data collection is a crucial part. By installing devices such as traffic flow monitors, bus arrival time recorders, and cameras, we can collect traffic data in real time [13]. These data not only include basic information such as vehicle flow, speed, and direction, but also dynamic information such as weather, road conditions, and traffic accidents. After integrating and visualizing these data, city managers can intuitively understand the urban traffic situation, so as to make more reasonable traffic planning and scheduling decisions. Let's take the display of road traffic data of China's smart cities in 2022 in Figure 3 as an example, and then we can intuitively analyze the traffic situation of the road section or area through visualization images:

Figure 3 Road traffic data collection and visualization pattern for smart cities in China in 2022

4. Conclusions

As an important way to promote sustainable urban development and achieve the "dual-carbon" goal, smart cities have a promising application in energy management, urban service optimization and traffic data visualization. As technology continues to advance, smart cities will be able to more accurately allocate energy and manage resources, improving the efficiency of city operations and the quality of life of residents. By matching data collection, data fusion and other means, all kinds of transportation data of the smart city will be brought together to facilitate decision-making by relevant departments and help the formulation and improvement of relevant policies. In addition, in the process of realizing the goal of "dual-carbon", smart cities will also promote the popularization and application of green energy, reduce carbon emissions and protect the environment. The construction and development of smart cities is crucial to the realization of China's "dual-carbon" goals. By integrating and applying advanced information technology, China can ensure stable economic growth while promoting low-carbon, efficient and environmentally friendly urban development. This will not only help improve the efficiency of urban transportation operations, but also improve the travel experience of citizens. In the future, with the further development of digital information technology, we have reason to believe that smart cities will play an even more important role in their ongoing construction.

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