frontiers | Frontiers in Environmental Science

TYPE Review
PUBLISHED 30 August 2022
DOI 10.3389/fenvs.2022.989318

OPEN ACCESS

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SPECIALTY SECTION
This article was submitted to Environmental Economics and Management,
a section of the journal
Frontiers in Environmental Science

RECEIVED 08 July 2022
ACCEPTED 10 August 2022
PUBLISHED 30 August 2022

CITATION
Yu Y (2022), Explore the theoretical basis and implementation strategy of low-carbon Urban Community Planning.
Front. Environ. Sci. 10:989318.
doi: 10.3389/fenvs.2022.989318

Explore the theoretical basis and implementation strategy of low-carbon Urban Community Planning

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Cities carry out various human production and living activities, consume a lot of carbon energy, become the main source of greenhouse gas emissions, and have an increasing impact on the climate. Therefore, as the main battlefield of carbon emission management, cities have become the focus of low-carbon research. The concept of a "low-carbon city" appears in dealing with global climate change. In order to further study the application of low carbon cities, this research discusses how to achieve the goal of low carbon cities from low carbon communities by introducing the concept of low carbon cities and the planning views of experts and scholars on low carbon cities, and based on the theoretical research and practical experience of low carbon cities. In the course of the study, Qianhai Cooperation Zone and Bao'an Central District in Shenzhen are introduced as case studies to analyze the practical application of low-carbon city construction. Through this study, we found that the purpose of low-carbon cities is to provide physical space for resource savings, low waste emissions, high operating efficiency, green and sustainable urban activities. For the completely dispersed urban structure in some regions of China, the polycentric network structure is a favorable urban structure for these regions to achieve low carbon and efficient development. The polycentric network cities have high urban density and activity intensity, so corresponding low-carbon strategies can be effectively implemented according to different functional positioning, density and activity density. On the other hand, in order to achieve efficient and low-carbon urban development, the community should be the basic unit. Only when low carbon is realized in the community can the basic low carbon of urban life be guaranteed and the low carbon of the whole city be realized.

KEYWORDS

low carbon city, regional low-carbon planning, spatial structure, Qianhai cooperation zone, Bao'an central area

1 Introduction

Bin et al. (2015) pointed out that urban areas are the main source of energy use and related carbon emissions. Due to rapid economic development and urbanization, China is facing great pressure on carbon emissions control and energy supply. Urban planning is the key to the realization of low-carbon city construction. The low-carbon construction of the city needs to integrate the low-carbon concept into the current urban planning system, formulate a low-carbon target system, and implement it into specific special construction (Sizirici et al., 2021). At present, the research on low-carbon urban planning mainly focuses on the target strategy at the macro level and the energy utilization and building energy conservation and emission reduction technology at the micro level, without considering the actual operation (Lou et al., 2018).

The regulatory detailed planning of low-carbon cities requires the integration of low-carbon concept and effective guidance through planning management on the basis of traditional control planning technology, so as to realize the transformation of urban construction and development to low-carbon direction. The low-carbon control index system is the core content of its research (Lou et al., 2018). Only through the low-carbon index system can we judge whether the low-carbon control of urban construction meets the standard. As the most representative city, Shenzhen has made some progress in the practice of low-carbon cities. Taking the opportunity of building a regional pilot of green and low-carbon transportation cities, many regions have promoted the construction of energy conservation and carbon reduction (Ng, 2019).

In summary, it can be said that urban development has been seriously restricted by a large amount of carbon emissions. The research on low-carbon cities has been a necessary way to achieve efficient and healthy urban development. Only by achieving the low-carbon goal can urban development achieve essential improvements. The significance and main purpose of this study is to fundamentally realize low-carbon life, reduce urban carbon emissions and promote healthy urban development by exploring feasible ways to achieve low-carbon cities. This study will summarize the theory and practical development of low-carbon cities from three aspects: the relevant concepts and planning views of low-carbon cities, the theory of urban structure and carbon emissions, and the actual development of low-carbon cities. It mainly discusses how to achieve the goal of low carbon cities on the basis of achieving low carbon communities. Taking the Qianhai cooperation zone and Bao'an Central District as examples, it discusses the urban structure in line with the development of low-carbon cities and the development direction of low-carbon cities with low-carbon communities as the core and provides reference for future urban construction.

In the following sections, this research will review the literature through the literature review section, and then in the methodology section the methods used in the research will be specified. The findings and analysis will be reflected in the subsequent discussion section. The final section will conclude the entire study.

2 Literature review

2.1 Related concepts and planning views of low-carbon cities

Naseem et al. (2022) pointed out that environmental sustainability is considered to be one of the most urgent issues because of its significant impact on the world. In the 20th century, changes in the world climate patterns and global warming are considered to be the most serious environmental threats to mankind. Zhang et al. (2021) pointed out that carbon emissions have become the main source of global warming, and the construction of low-carbon cities has gradually become an important step to curb global warming and improve environmental quality. Only by improving air quality can human health and social welfare be guaranteed. Britain put forward the concept of low carbon in 2003. Its meaning is to make rational use of energy, reduce the loss to the environment, and create a sustainable ecological environment while reducing greenhouse gas emissions (Kahn, 2009). Aung and Chou (2014) pointed out that the realization of sustainable urban development should be considered from several factors: sustainable transportation, renewable energy efficiency, biodiversity in green space, effective material flow, sustainable housing and land use planning. In addition, Japan also put forward the concept of "low-carbon society" in 2007. Under the concept of low-carbon society, low-carbon cities have become the focus of economy and society, and have attracted more and more attention (Shen et al., 2018). Low carbon cities take urban space as the carrier to develop low-carbon economy, implement green transportation and construction, change residents' consumption concept and innovate low-carbon technologies, so as to minimize greenhouse gas emissions (Li et al., 2016).

From the perspective of social life and energy structure, different scholars have also conducted in-depth research on low-carbon cities. To build a low-carbon city with low emissions and high energy efficiency, the key is to deal with the relationship between energy consumption, environmental protection and economic development (Zhang et al., 2021). Glaeser and Kahn (2008) systematically studied the calculation method and application analysis of urban carbon emissions, and conducted an empirical study on the heating, transportation, air conditioning and domestic energy consumption of unit households in the centers and suburbs of ten typical large

cities in the United States. They put forward that the carbon emission standards of different cities and different regions are obviously different. The key factors are the regional distribution of cities, traffic factors and the energy utilization structure of domestic consumption. In terms of the contribution of low-carbon development to urban economy, according to the economic cost accounting of US $43 per ton of CO2 emission, scientifically put forward policy suggestions for realizing urban low-carbon development from the perspective of carbon emission Economics (Glaeser and Kahn, 2010). Moreover, in terms of land use for low-carbon development, they stressed that cities should not stop development because of the increased environmental load, but should emphasize the overall development of the region through policy adjustment and reasonable arrangement of land use plans. Moreover, in metropolitan areas, the restrictive factors of land use often push the urban development opportunities to the urban fringe, resulting in the rise of urban environmental costs. Therefore, an adaptive policy and development model should be found to encourage the environmental improvement of urban buildings, energy conservation and CO2 emission reduction (Glaeser and Kahn, 2008). In addition, in social life, waste recovery is also one of the effective ways to achieve low carbon. Liu et al. (2022a) pointed out that waste recovery should be based on the following six standards: elastic response capacity, rapid collection capacity, scientific sorting capacity, safe storage capacity, timely transportation capacity and harmless treatment capacity.

According to the data of Liu et al. (2022b), at the beginning of the 21st century, with the improvement of living standards and quality, the number of population and motor vehicles increased rapidly, resulting in more serious air pollution in China. According to the data of multiple meteorological stations from 1 January 2008 to 31 December 2012, more than 200 cities have pollution indexes with obvious regional differences, low carbon life is imminent. Chris (2007) quantitatively converted the national living expenditure and various material consumption into CO_2 emission through the statistics of electric energy, oil, natural gas and other energy in the household life of British citizens. The core of his research is how to reduce the per capita carbon emission of British family life from 6 tons per year to 3 tons per capita per year without changing the current living standards and welfare standards. In his research on low-carbon life, Chris discussed many aspects, including household heating, hot water supply, cooking, lighting, household appliances, car transportation or public transportation, flight travel and consumption patterns (Chris, 2007). He conducted empirical analysis through the sampling of British household survey, expressed and displayed the future scenario of carbon emission of British family life and the urgent demand for low-carbon lifestyle with convincing data, and put forward the low-carbon standard of British people's life (Chris, 2007). From the perspective of the comprehensive composition of urban carbon emissions, Siong and Kean (2007) based on the current situation of national carbon emissions and urban background, studied the proportion of carbon emissions of households, transportation departments and industrial departments, and put forward measures to reduce urban carbon emissions from the aspects of industrial distribution, building construction, low-carbon transportation and the application of new energy-saving technologies (Siong and Kean, 2007). Shehzad et al. (2020) pointed out from the perspective of high-tech technology that at present, high-tech technology has greatly changed human life. The whole manufacturing process of the energy sector, production sector, agricultural sector and service industry is wholly or partially based on information and communication technology (ICT), and ICT technology helps to improve energy efficiency and save energy in some areas of life. In addition, other scholars have conducted multi-dimensional analysis on urban carbon emissions, and analyzed the low-carbon progress of different countries and cities from the perspective of composition.

From the perspective of urban density and urban spatial structure, econometric, land use and transportation models are used to demonstrate the urban pattern and urban spatial structure in the development planning of Chicago metropolis (Sungwon and Bumsoo, 2020). Research on urban development focuses on energy consumption and CO_2 emissions related to traffic and urban density. Traffic is related to distance, while urban density is related to land use. The high density of land development and the shortening of traffic commuting distance inevitably require the compact development of urban space (Norman et al., 2006). In addition, contemporary urban land development is mainly reflected in community construction. Community structure has aroused great social attention in urban material and environmental protection (Hobson et al., 2016). The development of different communities makes people's daily living areas and urban ecological environment truly and perfectly integrate with each other. The damage to the ecological environment in people's daily production or life can also be minimized, which makes the overall spatial structure design of the city more reasonable and promotes the sustainable development of the city (Norman et al., 2006).

More than one view of compact development, which advocates low-density development, has been confirmed. In the analysis of the correlation between traffic energy consumption and urban density, there is a lack of specific research methods and quantitative indicators for the comprehensive balance of carbon emissions of high-density development (Newman and Kenworthy, 1999). The choice of urban transportation mode and the development of public transportation are the main factors that directly restrict the carbon emission in urban life, which is the best interpretation of how the urban structure affects urban carbon emission. There is a certain contradiction between the increase of cars and the compact development of urban space (Kenworthy and Hu, 2002). However, for urban areas with high density, the excess

energy consumption and emissions caused by traffic congestion are less than those caused by long-distance car traffic. The research does not give a clear answer, and there is a lack of quantitative research to demonstrate the relationship between the degree of urban environmental impact and urban development density.

2.2 Urban structure and carbon emission theory

Glaeser and Kahn (2010) through the empirical study of cities, the analysis shows that the per capita carbon emission is inversely proportional to the intensity of land development and the degree of mixed land use. Tufek-Memisevic and Stachura (2015) pointed out that the early urban formation principle was based on solving the problem of ecological city, emphasizing the importance of close connection with the natural environment and the walkability between the main urban elements. Williams (1999) conducted an empirical study on the United Kingdom and found that in addition to high-intensity development, cities also need to encourage the allocation of close employment, shopping and leisure facilities in order to significantly reduce urban carbon emissions. Yu et al. (2022) pointed out that the rapid growth of industry and the improvement of living quality lead to the increase of complex organic chemical pollution in wastewater, which poses a serious threat to the environment and human health. However, using clean and pollution-free solar energy as the driving force, semiconductor photocatalytic technology can effectively remove organic pollution. Sarker et al. (2018) believed that low-carbon urban planning is one of the key technologies for the development of low-carbon cities in China. They constructed the theoretical framework of low-carbon urban planning research in China and put forward the content of low-carbon urban planning research. A large number of empirical studies by the above scholars have proved that the urban form of compact layout, high density, nearby employment and service enjoyment is conducive to reducing the carbon emission of transportation, so as to effectively reduce the urban carbon emission. Kahn (2009) pointed out that urban spatial form has a certain locking effect on urban operation and plays a decisive role in urban spatial energy utilization and carbon emission. Crawford and French (2008) also believes that the key to achieving the low-carbon goal is to pay attention to the concept of low-carbon city in spatial planning. They pointed out that the basic form of a low-carbon city should have the characteristics of high density, high floor area ratio and high-rise. The urban spatial planning strategy under the low-carbon guidance should build ecological units and wedge-shaped green space systems, build green transportation systems, develop mixed intensive cities, and reduce carbon in three aspects: carbon source, carbon emission and carbon capture (Crawford and French, 2008). They also pointed out that the spatial operation mechanism and mode of low-carbon cities follow the law of functional complementarity and network correlation from macro overall coordination and mutual assistance to micro, and establish the collaborative control system of space, policy and economy with spatial planning as the main body, the technical system of urban planning preparation with multi-level planning coordination, and the collaborative planning approach of planning development countermeasures and guarantee system under the coordination.

The city is the inevitable product of the rapid development of industry and commerce. It is the place where human beings live in groups. In cities, a large number of production and living activities gather here. In urban ecosystems, the urban ecosystem is an open artificial ecosystem. The main activities in the urban system are human activities, and human activities are the main guidance. With the rapid urbanization and population growth, the global demand for natural resources has increased, and the ratio between GDP and ecological footprint is insufficient. This is because the growing demand for natural resource consumption contributes directly or indirectly to the production process, which often leads to waste in industries associated with environmental degradation (Naseem et al., 2022). In the process of urban development, greenhouse gas emissions are a very important issue related to the development of urbanization. Based on this, Fong et al. (2008) took Malaysia as an example to make an in-depth analysis on carbon emission reduction and green city development. He pointed out that on the basis of meeting basic social needs and healthy economic development, urban planning should continue to reduce carbon emissions to achieve sustainable urban development. Similar to the research of Fong et al. (2008), the research of Ewing and Rong (2008) is also based on green city construction. The difference is that Ewing and Rong (2008) extended the discussion of long-distance power distribution to urban housing planning from the perspective of energy. Ewing and Rong (2008) paid more attention to quantitative analysis, and their research paid more attention to low-carbon cities and urban spatial structure.

2.3 Practical development of low carbon cities

Britain is a pioneer in low-carbon urban planning and practice. Birmingham was once the center of the British Industrial Revolution, but it gradually declined with the depletion of resources and industrial transfer. After a long period of urban renewal and industrial transformation efforts, it has finally developed into a conference, exhibition, and commercial tourism city with a rich cultural connotation. McKendry (2018) pointed out that the successful transformation of the United Kingdom benefited from a clear industrial positioning, focusing on the development of tertiary

industry service industry, finance, consulting, retail, exhibition and other industries, cultivating creative parks, building knowledge cities, and establishing its own cultural industry zone to incubate high-tech enterprises with universities. Similar cities, such as Boston in the United States, as one of the first areas to complete industrialization and relocate traditional manufacturing industries in the United States, developing knowledge intensive emerging industrial sectors has become an important choice for Boston to get rid of the dilemma of industrial transfer. At present, a high-tech enterprise intensive industrial zone has been formed in Boston (Goldstein et al., 2020).

Denmark has made a beneficial attempt to develop a low-carbon economy based on cities and has achieved great success. For example, Denmark is becoming the first city in the world that no longer causes "global warming effect" (Dhillon and von wuehlich, 2013). All of the city's energy consumption comes from renewable energy. An integrated energy supply system provides all energy consumption demand electricity, heating and transportation power for urban residents, including a wind power station (Dhillon and von wuehlich, 2013). Cherry (2015) pointed out that some communities in Denmark are spontaneously organized by residents to build public residential communities, with solar energy and wind energy as the main energy, focusing on the use of renewable and new energy. In the process of use, they emphasize energy conservation and consumption reduction, minimize greenhouse gas emissions and maintain a beautiful environment in the community (Cherry, 2015). Solar energy enters residents' houses through underground pipelines in the form of hot water and radiant heat, which meets the energy needs of the community, which reduces the dependence on external resources and transportation energy consumption.

According to the practice of low-carbon city theory in various countries, Zhou and Zhou (2021) pointed out that China, as the largest carbon dioxide emitter, is working towards a green economy. As an important part of building a green economy, the pilot policy of low-carbon cities is being implemented in many large cities in China, and the scope of implementation will be further expanded in recent years. Wu (2019) pointed out that the low-carbon economy is becoming more and more important in contemporary society, which is a sustainable economic development model reflecting green energy consumption and low-carbon emissions. Its essence is to promote the rapid development of the green economy through the development and efficient use of green energy. Zhang et al. (2021) pointed out that the construction of low-carbon cities is an important strategy for countries to improve environmental quality, achieve cleaner production and achieve sustainable development. Peng and Deng (2021) also pointed out in the article that under the low-carbon economy, the utilization of emission reduction technology and the innovation of new energy are a major breakthrough, which is not only the innovation of industry, but also the innovation of economic development (Peng and Deng, 2021), which means that people's economic ideas have changed and they pay more and more attention to environment-friendly ways. Through the scholars' discussion of the low carbon economy, this paper believes that the low carbon economy is guided by the theory of sustainable development and involves many aspects of society. The application of low carbon in urban planning adopts the means of new energy development to build a more environmentally friendly city. In the process of developing a low-carbon economy, first of all, we need to change the economic development model, change the previous concept of only pursuing rapid economic development, and achieve the coordination between economic development and environmental protection (Yang et al., 2019).

2.4 Conclusion

In summary, by combining the above literature, it can be seen that scholars have studied the relationship between urban spatial planning and low-carbon city construction comprehensively and systematically. However, the research focus in low-carbon urban spatial planning is mainly on the overall structure of the city and the level of residential area, and there are relatively few cases of community as the research object and practice. In this regard, this study will add a case study of Qianhai cooperation zone and Bao'an Central District on the basis of the above literature to make up for the above deficiencies and supplement.

3 Methodology

3.1 Introduction

Methodology introduces the research methods used in this study. This chapter has three functions: to summarize the research methods, to focus on the methods used in the research, and to explain why this research method is suitable for this research. More specifically, this section describes in detail the data collection methods and how to integrate and analyze the data and finally obtain the reasoning results. This paper aims to form a more perfect low-carbon urban planning theory with low-carbon community as the main direction through the analysis of relevant theories and practices such as low-carbon urban spatial layout, combined with the problems existing in low-carbon urban space.

3.2 Data collection methods

This paper adopts the idea of combining theoretical research and practical exploration and uses mainly the methods of literature analysis and case analysis. This paper

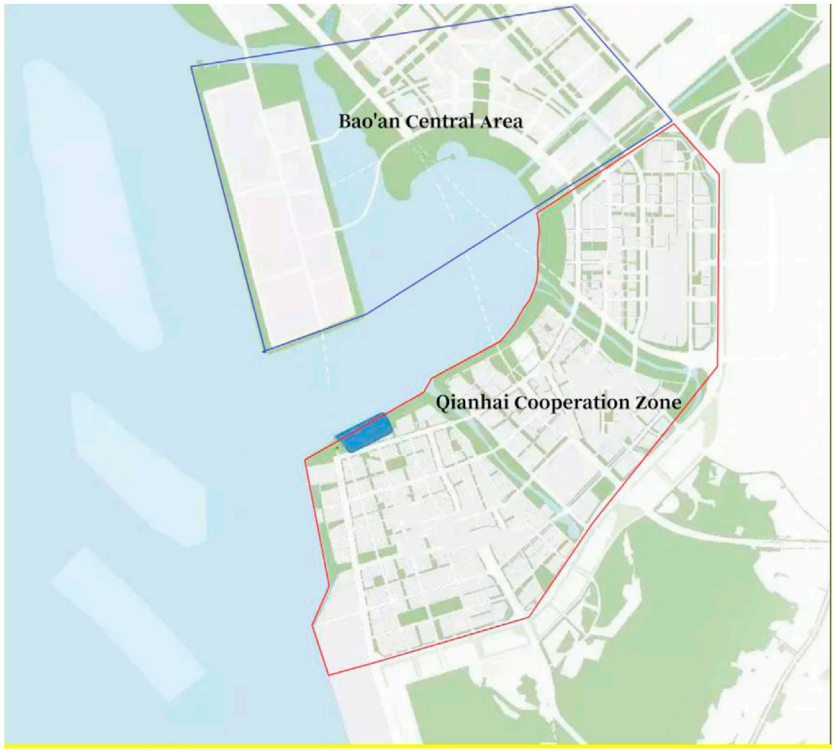

FIGURE 1
Low-carbon urban planning research area.

will use the relevant literature on the spatial structure theory of low-carbon cities in recent years, determine the research direction of this paper by analyzing the relevant theories and practices such as the spatial layout of low-carbon cities, combined with the existing problems of low-carbon urban space. This paper also adopts the case analysis method. This paper will collect relevant cases, analyze the location and market situation after analyzing the case background, and make a case study of Qianhai cooperation zone and Bao'an Central District in Shenzhen. Based on the collected basic data and practical cases, this paper makes a systematic analysis and sorting, and obtains the research results of this paper on the basis of analysis and research.

3.3 Conclusion

In summary, this chapter introduces the reader to how the research is carried out and the methods of data collection. From the perspective of the whole chapter, literature analysis and case analysis is the most effective method of this study, because all data comes from authoritative institutions and actual projects, which ensures the authenticity of the data and the reliability of the research.

4 Discussion

4.1 Case study—Low carbon spatial structure planning strategy

4.1.1 Planning background

Qianhai is a modern service industry cooperation zone between Shenzhen and Hong Kong. Bao 'an is the source of Shenzhen and Hong Kong culture. The two urban areas are naturally close. In recent years, Bao'an has accelerated urban construction, planned and implemented a large number of major projects with bay area characteristics in the central area closest to Qianhai, and made efforts to enhance the core engine function (ODonnell and Bach, 2021). As the forefront of reform and opening up in the new era, Shenzhen Qianhai is connected with the central district of Bao'an. Bao'an is the first choice for the spillover and radiation of Qianhai development. For the development of Qianhai, low-carbon planning mode should be adopted to build low-carbon buildings while maintaining the original characteristics (O'Donnell and Bach, 2021). Based on this, this paper takes the Qianhai cooperation zone and Bao'an central area as cases. As shown in Figure 1, low-carbon urban planning research is carried out for the area shown in the figure below.

FIGURE 2
Qianhai cooperation zone and Bao'an central area.

4.1.2 Planning principles

Łobejko (2015) discussed five forms of macro cities: core city, Star City, satellite city and linear city, and polycentric net. Łobejko (2015) emphasizes that the population density is different under different urban models. In the process of urban planning, the degree of separation or concentration of different cities and whether they reach open space are related to the urban model. Łobejko also believes that the multi-center network city is the most suitable urban model when the city develops to a certain extent.

The polycentric network plan in this paper is applicable to the Qianhai cooperation zone and Bao'an central area, as shown in Figure 2.

This model has also been confirmed by authoritative scholars as the most suitable model for urban development. Hildebrand Frey's research points out that if a fully decentralized urban form is adjusted, the most unrealistic thing is to transform into a core city, and it is also difficult to transform into a star city and a linear city. In contrast, the polycentric net is more flexible and can adapt to different local conditions. It can be said to be the most suitable urban model (Frey, 2003). Polycentric network cities have relatively high urban density and activity intensity at traffic nodes, and there are also dense linear urban belts on traffic corridors. Like a decentralized big city, a polycentric network city presents a triangular network structure, and its density is also very different. The density near nodes and linear dense zones is large, while the density in other areas is small. There are villages and parks in a certain area, or wedge-shaped green spaces and green belts in the grid. This urban model disperses urban activities into the urban network and forms an organic system (Frey, 2003). Nodes with different functional positioning, density and activity intensity constitute urban centers of different sizes. Between urban centers, high-density urban belts develop along traffic corridors, while in areas outside nodes and linear belts, urban development intensity decreases and the grid becomes sparse (Liu, et al., 2016). The polycentric network city provides various forms of center, living environment and life choices, with green space and other open spaces interspersed, and the form is more suitable for the landform.

4.2 Low carbon spatial structure planning strategy

Qianhai and Bao'an land have intensive and compact functional layout and mixed functions. Relying on public transport services such as rail transit, they focus on comprehensive functions such as finance and commerce, science and technology services, innovative industries, creative design, education and training, medical fitness and living, so as to form a development belt with the agglomeration

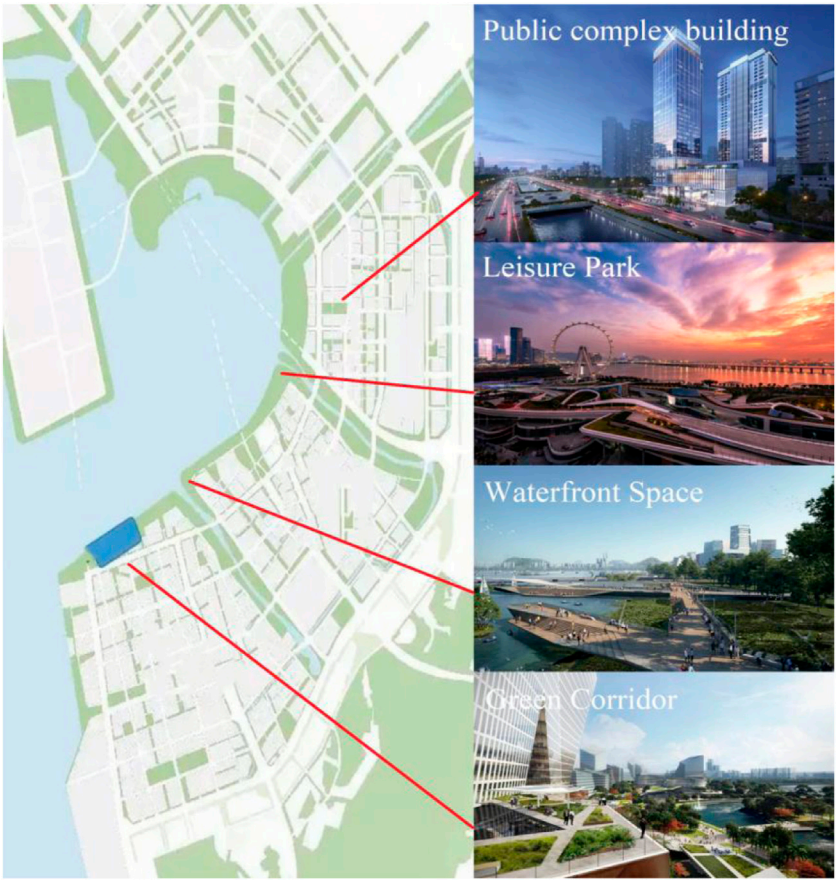

FIGURE 3
The forms of public space in the Qianhai cooperation zone.

of urban comprehensive service functions (Ng, 2019). In addition to meeting the basic support functions of living, the neighborhood also provides public facilities such as small conference halls, small libraries, small museums, etc. Different types of functional units such as office, business, apartment and residence are mixed to produce a coordinated effect between work and life and form a vibrant neighborhood (O'Donnell and Bach, 2021). For the Qianhai cooperation zone, we should advocate the three-dimensional combination of different architectural functional spaces, encourage the integrated development and utilization of underground space, create balanced, dynamic, diversified and accessible public places through three-dimensional pedestrian network, and build diversified and systematic urban space.

As shown in Figure 3, the forms of public space in the Qianhai cooperation zone are rich and diverse. Public space at all levels includes waterfront space, linear green corridor, pocket park and public open space in the building.

All kinds of public spaces are evenly distributed and accessible on foot. These public spaces can also be used to organize diversified public activities, such as urban exhibitions, cultural and creative activities, street performances, etc., so as to condense the vitality of the city (Chen, 2021). In the central area of Bao'an, development and construction face practical problems such as small plots, dense road network, three-dimensional composite functions, diverse development subjects, etc. In order to make intensive use of land, maximize the economic value of land and create a building group combining integrity and diversity, we should advocate the overall development with neighborhoods as the basic unit, encourage the compound development and interconnection of aboveground and underground space, create neighborhoods with the integration of neighborhood image, public space, underground space and traffic organization, and realize the concept of compact and intensive development (Chen, 2021). The overall development of the neighborhood puts forward high requirements for overall planning and coordination of the connection between the public space, slow traffic system, underground space and traffic organization of each plot in the neighborhood.

4.3 Recommendations

In order to better create the goal of a low-carbon city in Qianhai cooperation zone and Bao'an Central District, let's start with a low-carbon community and provide suggestions for low-carbon city planning in Qianhai cooperation zone and Bao'an Central District.

4.3.1 Suggestions on community low-carbon services and low-carbon configuration of industrial parks

Community is the unity of society and space. Regionality and sociality are the most basic essential characteristics of the community. Yang and Li (2013) pointed out that in urban residential areas, the population is the main pressure leading to carbon dioxide emissions. In this process, the community is the most important basic unit carrying population. Therefore, the community is the social foundation for building a low-carbon city (Yang and Li, 2013). Consider the construction of a low-carbon community from the perspective of low-carbon city construction, reduce the carbon emission in the process of community construction, use and management through comprehensive means such as energy, resources, land use, construction and transportation, and provide low-carbon services for residents' lives, leisure, entertainment, office and other aspects. The community is a good medium for promoting low-carbon concepts. Public participation is a necessary means to build a low-carbon community, which can enable community residents to master the necessary energy-saving knowledge and tricks, so as to truly practice low-carbon life (Hobson et al., 2016). Therefore, the community management institutions in Shenzhen should make full use of the various conditions and facilities of the community to create a low-carbon cultural network in the community. Rehman et al. (2022a) pointed out that the arrival of the era of industry 4.0 is triggering dynamic changes in sustainable development and promoting favorable impacts of various industries. The current era is an era of using information technology to promote industrial transformation. Information technology can be introduced into social services to improve service efficiency and strengthen the publicity and construction of low-carbon communities. The community can carry out various forms of thematic publicity activities in combination with the actual situation. For example, actively organize all kinds of news media to publicize and report low-carbon knowledge, establish low-carbon public welfare billboards or exhibition rooms in the community, hold low-carbon knowledge publicity meetings, explain to residents the skills and methods of practicing low-carbon life in daily life details such as electricity, home, travel and catering, and popularize the awareness of low-carbon life to the hearts of residents in each community (Ma et al., 2021).

Low carbon urban planning and design should treat the community as an ecosystem composed of multiple elements. By optimizing the system design, make the elements in the community space cycle and transform orderly in the community ecosystem, strive to create a livable environment with low pollution, low material consumption and low emission, and reduce the carbon emission of the community from the source (Hobson et al., 2016). In terms of spatial planning of low-carbon cities, priority should be given to "neighborhood structure", that is, set the spatial scale of neighborhood units based on people's walking distance, so that residents can meet the basic requirements of leisure, shopping and medical treatment without using private cars as much as possible, so as to reduce the carbon emission of community traffic (Sungwon and Bumsoo, 2020). At the same time, the community should reasonably plan and layout sidewalks, non motorized lanes and public transport channels, establish battery car charging stations in the community, and develop a people-oriented community transportation system and road system to facilitate residents to choose transportation modes such as walking, bicycle, battery car and bus, so that the concept of green transportation can not only be deeply rooted in the hearts of the people, but also be effectively realized. In terms of community environmental planning, we should make full use of the current greening, retain and transplant some trees, shrubs and grasslands, reasonably allocate vegetation types, design vegetation hierarchical structure, improve the comprehensive ecological benefits of vegetation and improve the function of vegetation to absorb carbon dioxide (Ma et al., 2021). At the same time, we should also pay attention to the construction and protection of community green plant belts, prevent the phenomenon of indiscriminate cutting during community construction, and ensure a certain rate of green coverage in the community. In terms of energy planning, Rehman et al. (2022b) said that all parts of the world are striving to achieve carbon neutrality and rely on renewable energy. Advanced logistics infrastructure and renewable energy consumption can effectively promote economic growth and national development. Low-carbon cities advocate the full and efficient use of all types of renewable energy, such as solar and wind energy. In this regard, we can make full use of the roof of community buildings, uniformly install solar water heaters, heat storage walls, solar curved zinc plates, etc., make full use of solar energy to produce hot water, and install wind power generation devices on the roof to reduce the burden of electricity (Yang and Li, 2013). Community landscape lighting, community road lighting and other public lighting can adopt solar lighting systems to achieve the purpose of community low-carbon energy through the utilization of clean energy such as solar energy.

It can not only save energy, but also provide a healthy and comfortable space for people's lives and real estate development. Therefore, in terms of community architectural design, we should combine the climate characteristics of Shenzhen. For example, in terms of architecture, we should use special materials on the roof and exterior wall of the building to

reduce energy consumption (Ng, 2019). Under the conditions of a natural ventilation system, natural conditions can be used to reduce energy consumption. In addition, community power generation facilities can also be used to form a low-carbon habit by using low-energy appliances and reducing the use of high-energy appliances. Energy saving building materials are required to be healthy and environmentally friendly, repeatable, recyclable and renewable, and have high energy efficiency (Hobson et al., 2016). Therefore, we should actively adopt applicable technologies and environmental protection technologies, configure green building materials, equipment and facilities, improve the performance of walls, roofs, doors and windows, strengthen the thermal insulation performance of residential buildings, and adopt the methods of natural ventilation, natural daylighting and natural dehumidification to fully improve the energy utilization rate and reduce the heating and cooling load of building air conditioning (Ma et al., 2021). In terms of building design, the simpler the building shape, the smaller the area and the less energy loss, the more energy-saving the building is. Therefore, while paying attention to beauty, we should also ensure that the design of the building is as simple and complete as possible, avoid complex contour design and reduce energy consumption.

4.3.2 Follow the example of a successful low-carbon community to plan Qianhai cooperation zone and Bao'an central district

In the low-carbon construction of Qianhai cooperation zone and Bao'an Central District, we can currently refer to the relatively perfect low-carbon community. Williams (2016) introduced three successful cases of low-carbon communities in the article, namely Hammarby, BedZed and Vauban. BedZed, located in London, is a city that has previously carried out low-carbon experiments. In 2002, BedZed replanned urban construction, waste treatment, water resources and transportation in order to create a sustainable city. BedZed is located in a suburb of London, which can accommodate 244 residents. The area takes the community as a unit, and limits the carbon dioxide emission by solving the carbon dioxide that may be generated by people in all aspects of life, such as clothing, food, housing and transportation. Williams (2016) emphasized that BedZed was innovative because it adopted the concept of zero carbon at that time. Specifically, in terms of planning and design, the problem of carbon dioxide emissions is solved by using the layout of low-energy houses, district heating systems and solar energy. In terms of community, BedZed also encourages residents to change their lifestyle and adapt to a low-carbon lifestyle by using shared resources (such as carpooling).

Hammarby, located in Stockholm, is an area where low-carbon urban planning began after BedZed in 2004. Hammarby's focus is to advocate a symbiotic life model and has carried out a series of transformations based on the ecological cycle system and energy-saving buildings. Hammarby is a high-density area compared to BedZed, which can accommodate 20,000 residents. In terms of structure, Hammarby uses the ecological cycle system to improve resource efficiency. Hammarby has vigorously publicized the residents of the community and called on people to build an inclusive and sustainable community. After that, other cities in Sweden began to use Hammarby's transformation model. Until now, Hammarby's transformation model has been used in many countries.

Another case mentioned by Williams (2016) is Vauban in Freiburg. This is a low-carbon urban planning project that started in 2007. The purpose of the project is to build a solar community through energy transformation and renewable energy plans. Vauban accommodates 5,000 residents and is also a high-density area. As an important experiment to promote the development of solar cities, Vauban integrates the framework of urban spatial planning and realizes the concept of solar cities through local building codes. It combines the concept of structural innovation and integrates community forums and relevant laws and regulations while using energy technology. It has had a certain impact on the low carbon community.

Low carbon life is also an important aspect of building a low carbon city. Low carbon life means that people try to reduce energy consumption in their daily life, so as to reduce carbon dioxide emissions, reduce air pollution and prevent the further deterioration of the urban ecological environment. The transformation of a low-carbon lifestyle depends on the joint efforts of the government and individuals (Goldstein et al., 2020). At the government level, strengthen the system construction of the low carbon lifestyle, strengthen the publicity of the low carbon lifestyle, and encourage people to establish a low carbon concept of life. Various forms of publicity theme activities can be carried out in combination with the actual situation (Glaeser and Kahn, 2010). Low carbon education will be included in the publicity and reporting through the media such as the large screen of the square and the electronic display screen of schools and communities. Strengthen low-carbon public welfare publicity, establish low-carbon public welfare billboards and billboards in the community of Qianhai cooperation zone and Bao'an Central District, popularize low-carbon knowledge, and introduce residents how to realize low-carbon life in daily life of lighting, water, electricity, catering and heating lamps. Carry out mass demonstration activities such as environment-friendly communities, green schools and green families (Goldstein et al., 2020). The government should also take the initiative to practice low-carbon environmental protection, actively promote green offices and green procurement, and promote the use of energy-saving products by the government. At the individual level, we should consciously establish the concept of low-carbon ecology and actively practice a frugal, green and low-carbon lifestyle. In addition, people can also be encouraged to choose green ways,

such as buses, bicycles or walking. When purchasing daily necessities, take the initiative to choose low-carbon products, such as new energy vehicles, energy-saving household appliances, water-saving appliances and other energy-saving, environmental protection and low-carbon products, choose green decoration materials, refuse disposable tableware when dining out, etc (Glaeser and Kahn, 2010).

To sum up, through these three successful cases, it can be seen that developed countries have carried out the relevant practice of low-carbon urban planning as early as the beginning of the 21st century. These successful cases can provide some reference for the urban planning of Qianhai cooperation zone and Bao 'an Central District. In urban planning, the community as a relatively small unit is the best choice for small-scale low-carbon experiments. For the community low-carbon practice in Qianhai cooperation zone and Bao'an Central District, we should publicize the community residents and carry out small-scale transformation of the community while changing people's lifestyle. For example, build some sustainable housing; ead solar energy to communities and improve the urban environment; build low-carbon infrastructure, etc. These methods can be piloted in some communities in Qianhai cooperation zone and Bao'an Central District and popularized on a large scale after achieving results.

5 Conclusion

5.1 Research conclusion

Through integrating and analyzing the low-carbon city theory of experts and scholars, as well as the comprehensive understanding and relevant exploration of the urban planning and management of Qianhai cooperation zone, this study believes that the spatial structure of low-carbon cities has its own characteristics, and its purpose is to provide material space for resource conservation, low waste emission, high operation efficiency and sustainable development, as well as green and sustainable development of urban activities. Under the background of industrialization and urbanization, multi-center network is considered as the ideal structure of low-carbon cities. The characteristic of urban structure is that the city is composed of primary and secondary centers. The urban center is connected by large traffic volume and high-speed traffic lines, and the traffic hub is the center of urban activities. Urban activities not only gather in the transportation hub, i.e. the urban center, but also expand the urban construction and activities on both sides of the transportation line. Multi center network cities can effectively implement corresponding low-carbon strategies according to different functional orientations and densities. In addition, the community should be the basic unit to realize a low-carbon city. Only by realizing low-carbon in life, service and resources can the low-carbon development of the whole city be realized.

5.2 Research implications

The significance of this study is that through analysis, it provides a possibility for the development of low-carbon cities, a low-carbon urban planning concept based on low-carbon communities and in line with modern urban development from the aspects of community services, community life and community resources. Low carbon cities should be refined and developed by communities. The community model can better achieve low-carbon indicators and meet the low-carbon conditions of cities. From the perspective of low-carbon city construction, low-carbon community construction should consider reducing community carbon emissions through a series of comprehensive means such as energy, resources, land use, construction and transportation, so as to provide low-carbon services for all aspects of residents' lives.

5.3 Limitations and future research directions

This study has limitations and can be carried out in further studies. Due to the epidemic situation and regional limitations, this study only proposes the possibility of low-carbon communities on the basis of integrating previous studies, and cannot establish corresponding practice models. This study focuses on community low-carbon, explores the possibility of community low-carbon behavior to realize low-carbon city, and rarely explores the direction of energy. Future research can continue to expand the possibility of low-carbon communities based on renewable energy applications, and promote the development of low-carbon social cities from two aspects of community low-carbon behavior and low-carbon energy.

Author contributions

YY: Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Resources; Supervision; Validation; Writing—original draft; Writing—review and editing.

Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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References

Aung, M. Y., and Chou, L. M. (2014). "AN assessment of sustainable cities," in *Sustainability matters: Asia's energy concerns, green policies and environmental advocacy*, 145–165.

Bin, Y., Jingjing, J., Lixin, M., and Peng, Y. (2015). Sustainable energy options for a low carbon demonstration city project in Shenzhen, China. *J. Renew. Sustain. energy* 7 (2), 023122. doi:10.1063/1.4918539

Chen, L. (2021). "Strategic positioning of the greater bay area of guangdong, Hong Kong and Macao," in *GUANGDONG-Hong Kong-MACAO greater bay area: Planning and global positioning*, 261–307.

Cherry, C. (2015). *Exploring discourses of decarbonisation: The social construction of low carbon housing*. Cardiff: Doctoral dissertation, Cardiff University.

Chris, G. (2007). *How to live a low-carbon live: The individual's guide to stopping climate change*. London: Sterling.

Crawford, J., and French, W. (2008). A low-carbon future: Spatial planning's role in enhancing technological innovation in the built environment. *Energy Policy* 36 (12), 4575–4579. doi:10.1016/j.enpol.2008.09.008

Dhillon, R. S., and von Wuehlisch, G. (2013). Mitigation of global warming through renewable biomass. *Biomass bioenergy* 48, 75–89. doi:10.1016/j.biombioe.2012.11.005

Ewing, R., and Rong, F. (2008). The impact of urban form on US residential energy use. *Hous. policy debate* 19 (1), 1–30. doi:10.1080/10511482.2008.9521624

Fong, W. K., Matsumoto, H., Ho, C. S., and Lun, Y. F. (2008). Energy consumption and carbon dioxide emission considerations in the urban planning process in Malaysia. *Plan. Malays.* 6. doi:10.21837/pm.v6i1.68

Frey, H. (2003). *Designing the city: Towards a more sustainable urban form*. Taylor & Francis.

Glaeser, E. L., and Kahn, M. E. (2010). The greenness of cities: Carbon dioxide emissions and urban development. *J. urban Econ.* 67 (3), 404–418. doi:10.1016/j.jue.2009.11.006

Glaeser, E. L., and Kahn, M. (2008). *The greenness of cities*. Cambridge: Rappaport Institute for Greater Boston/Taubman Center.

Goldstein, B., Gounaridis, D., and Newell, J. P. (2020). The carbon footprint of household energy use in the United States. *Proc. Natl. Acad. Sci. U. S. A.* 117 (32), 19122–19130. doi:10.1073/pnas.1922205117

Hobson, K., Hamilton, J., and Mayne, R. (2016). Monitoring and evaluation in UK low-carbon community groups: Benefits, barriers and the politics of the local. *Local Environ.* 21 (1), 124–136. doi:10.1080/13549839.2014.928814

Kahn, M. E. (2009). Urban growth and climate change. *Annu. Rev. Resour. Econ.* 1, 333–350. doi:10.1146/annurev.resource.050708.144249

Kenworthy, J., and Hu, G. (2002). Transport and urban form in Chinese cities: An international comparative and policy perspective with implications for sustainable urban transport in China. *disP - Plan. Rev.* 38 (151), 4–14. doi:10.1080/02513625.2002.10556818

Liu, X., Derudder, B., and Wu, K. (2016). Measuring polycentric urban development in China: An intercity transportation network perspective. *Reg. Stud.* 50 (8), 1302–1315. doi:10.1080/00343404.2015.1004535

Liu, S., Zhang, J., Niu, B., Liu, L., and He, X. (2022a). A novel hybrid multi-criteria group decision-making approach with intuitionistic fuzzy sets to design reverse supply chains for COVID-19 medical waste recycling channels. *Comput. Industrial Eng.* 169, 108228. [online]. doi:10.1016/j.cie.2022.108228

Liu, Y., Tian, J., Zheng, W., and Yin, L. (2022b). Spatial and temporal distribution characteristics of haze and pollution particles in China based on spatial statistics. *Urban Clim.* 41, 101031. [online]. doi:10.1016/j.uclim.2021.101031

Łobejko, S. (2015). *New Urbanism–concept and models*. Reviewer.

Lou, Y., Shen, L., Huang, Z., Wu, Y., Li, H., and Li, G. (2018). Does the effort meet the challenge in promoting low-carbon city?-A perspective of global practice. *Int. J. Environ. Res. Public Health* 15 (7), 1334. doi:10.3390/ijerph15071334

Ma, W., de Jong, M., de Bruijne, M., and Mu, R. (2021). Mix and match: Configuring different types of policy instruments to develop successful low carbon cities in China. *J. Clean. Prod.* 282, 125399. doi:10.1016/j.jclepro.2020.125399

McKendry, C. (2018). *Greening post-industrial cities*. Taylor & Francis.

Naseem, S., Mohsin, M., ZiaURRehman, M., Baig, S. A., and Sarfraz, M. (2022). The influence of energy consumption and economic growth on environmental degradation in BRICS countries: An application of the ARDL model and decoupling index. *Environ. Sci. Pollut. Res.* 29 (9), 13042–13055. [online]. doi:10.1007/s11356021165333

Newman, P., and Kenworthy, J. (1999). *Sustainability and cities: Overcoming automobile dependence*. Washingdon, DC: Island press.

Ng, M. K. (2019). Governing green urbanism: The case of Shenzhen, China. *J. Urban Aff.* 41 (1), 64–82. doi:10.1080/07352166.2016.1271623

Norman, J., MacLean, H. L., and Kennedy, C. A. (2006). Comparing high and low residential density: Life-cycle analysis of energy use and greenhouse gas emissions. *J. Urban Plan. Dev.* 132 (1), 10–21. doi:10.1061/(asce)0733-9488(2006)132:1(10)

O'Donnell, M. A., and Bach, J. (2021). Reclaiming the new, remaking the local: Shenzhen at 40. *chinaperspectives*. 2021 (2021/2), 71–75. doi:10.4000/chinaperspectives.11848

Peng, T., and Deng, H. (2021). Research on the sustainable development process of low-carbon pilot cities: The case study of Guiyang, a low-carbon pilot city in south-west China. *Environ. Dev. Sustain.* 23 (2), 2382–2403. doi:10.1007/s10668-020-00679-0

Rehman, A., Umar, M., Asadov, A., Tanveer, M., and Yu, Z. (2022a). Technological revolution and circular economy practices: A mechanism of green economy. *Sustainability* 14, 4524. [online]. doi:10.3390/su14084524

Rehman, A., Yu, Z., Umar, M., Zia-ul-haq, H. M., Tanveer, M., and Janjua, L. R. (2022b). Renewable energy and advanced logistical infrastructure: Carbon-free economic development. *Sustain. Dev.* 30, 693–702. [online]. doi:10.1002/sd.2266

Sarker, M. N. I., Hossin, M. A., Hua, Y. X., Anusara, J., Warunyu, S., Chanthamith, B., et al. (2018). Low carbon city development in China in the context of new type of urbanization. *Low. Carbon Econ.* 9 (1), 45–61. doi:10.4236/lce.2018.91004

Shehzad, K., Xiaoxing, L., Sarfraz, M., and Zulfiqar, M. (2020). Signifying the imperative nexus between climate change and information and communication technology development: A case from Pakistan. *Environ. Sci. Pollut. Res.* 27 (24), 30502–30517. [online]. doi:10.1007/s1135602009128x

Shen, L., Wu, Y., Shuai, C., Lu, W., Chau, K. W., and Chen, X. (2018). Analysis on the evolution of low carbon city from process characteristic perspective. *J. Clean. Prod.* 187, 348–360. doi:10.1016/j.jclepro.2018.03.190

Siong, H. C., and Kean, F. W. (2007). *Planning for low carbon cities-the case of iskandar development region*. Malaysia: Middle East, 1–19.

Sizirici, B., Fseha, Y., Cho, C. S., Yildiz, I., and Byon, Y. J. (2021). A review of carbon footprint reduction in construction industry, from design to operation. *Mater. (Basel, Switz.* 14 (20), 6094. doi:10.3390/ma14206094

Sungwon, L. E. E., and Bumsoo, L. E. E. (2020). Comparing the impacts of local land use and urban spatial structure on household VMT and GHG emissions. *J. Transp. Geogr.* 84, 102694. doi:10.1016/j.jtrangeo.2020.102694

Tufek-Memisevic, T., and Stachura, E. (2015). A linear city development under contemporary determinants. *Środowisko Mieszk.* 14, 190–195.

Williams, K. (1999). Urban intensification policies in england: Problems and contradictions. *Land Use Policy* 16 (3), 167–178. doi:10.1016/s0264-8377(99)00010-1

Williams, J. (2016). Can low carbon city experiments transform the development regime? *Futures* 77, 80–96. doi:10.1016/j.futures.2016.02.003

Wu, W. (2019). *Modern urban planning and design based on low carbon economy concept*. Eindhoven: Open House International.

Yang, L., and Li, Y. (2013). Low-carbon city in China. *Sustain. Cities Soc.* 9, 62–66. doi:10.1016/j.scs.2013.03.001

Yang, W., Zhao, R., Chuai, X., Xiao, L., Cao, L., Zhang, Z., et al. (2019). China's pathway to a low carbon economy. *Carbon Balance Manag.* 14 (1), 14. doi:10.1186/s13021-019-0130-z

Yu, C., Chen, X., Li, N., Zhang, Y., Li, S., Chen, J., et al. (2022). Ag3PO4based photocatalysts and their application in organicpolluted wastewater treatment. *Environ. Sci. Pollut. Res.* 29 (13), 18423–18439. [online]. doi:10.1007/s11356022185917

Zhang, H., Huang, L., Zhu, Y., Si, H., and He, X. (2021). Does low-carbon city construction improve total factor productivity? Evidence from a quasi-natural experiment in China. *Int. J. Environ. Res. Public Health* 18 (22), 11974. doi:10.3390/ijerph182211974

Zhou, S., and Zhou, C. (2021). Evaluation of China's low-carbon city pilot policy: Evidence from 210 prefecture-level cities. *PloS one* 16 (10), e0258405. doi:10.1371/journal.pone.0258405