Research on the Construction Mode of European Low-Carbon Buildings

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Abstract. In the background of global warming, developing low-carbon economy and low-carbon buildings is the development direction and social goals of revitalizing the economy and saving energy in Europe. This paper introduces the present status of the development of low-carbon buildings in Europe, summarizes the construction practice of low-carbon buildings, and explores the development model of low-carbon buildings in Europe.

1. Introduction

The construction industry, the second largest industry in Europe, is the main cause of energy consumption and environmental pollution. In Europe, construction is responsible for roughly 1/3 of total energy consumption with 35% of the total greenhouse gas emissions[1]. The impact of construction on the natural ecological environment is profound and far-reaching. Eliminating the negative impact of construction on the environment is one of the main ways to solve energy, climate and environmental problems. Therefore, European architects have always paid attention to protect culture and respect the environment in their design. The EU energy law and policy have not only paid attention to the safe supply of energy, but also attached importance to the reduction of greenhouse gas emissions, in order to build an environment-friendly and low-carbon society for all and achieve a win-win effect of environmental protection and energy conservation.

2. Development Status of Low-carbon Buildings in Europe

Europe keeps a positive attitude towards climate change due to its own economic development, realization of energy crisis and its pursuit of foreign relations, politics and interests. Therefore, Europe pays attention to improving the resource use efficiency and protecting the ecological environment, and gradually establishes sound regulatory policies for the development of low-carbon buildings. Europe has spared no effort in developing low-carbon buildings, not only to fulfill the international requirement of energy conservation and emission reduction, but also to continuously improve its ability of sustainable development. In some countries in northwest Europe, buildings with low energy consumption and high comfort are common. Although the cost of them is about 3% higher than that of ordinary buildings, the annual operating cost can be saved by 60% because of energy conservation and optimized combination[2].

Europe formulated the European Strategic Energy Technology Plan (SET-Plan) in 2007 and set the target for tackling climate change to promote the innovation, application and rapid development of low-carbon technologies. Europe carried on the research and practice of low-carbon buildings in earlier times and its technical fields are more advanced and mature. At present, policy makers have
promoted low-carbon buildings and technologies as measures to reduce emissions and conserve energy. The European Union and its member states have established professional research institutions. Public policy formulation, fund raising, popularization of low-carbon awareness among the public, and the practice and application of low-carbon building technologies are quite mature.

3. Practice of European Low-carbon Construction

3.1. Establishment of energy performance contracting system
In 2007, the EU Energy Performance of Buildings Directive (EPBD) introduced the Energy Performance Certificate. EPBD requires all newly-built residential buildings to have an Energy Performance Certificate (EPC) that provides information on residential energy efficiency and carbon performance. For example, the British government requires that since April 2008, all new residential buildings must obtain EPC and existing residential buildings should be renovated. While improving the quality and safety, the renovation cost of residential buildings should be halved to meet the standards similar to those of new residential buildings. The British government makes an evaluation on the energy efficiency of houses, quantifies the energy performance of houses, and issues corresponding Energy Performance Certificates (EPC) according to different quantified results. Only through this process can houses be rented, sold and mortgaged. Otherwise, houses cannot be traded. According to the report on the energy efficiency of the English housing in 2016, household energy performance has steadily increased. The proportion of residential energy efficiency assessment (EER) is shown in Figure 1. From 1996 to 2016, the ratio of A to C grade increased significantly from 2% to 30%, while the ratio of F to G grade decreased from 29% to 5%. The improvement speed of this energy performance is concentrated in the period from 2006 to 2016. The British government announced that by 2035, all British households will have an Energy Performance Certificate (EPC) with a grade of C or higher.

3.2. Development of Low-carbon and energy conservation technologies
In developing low-carbon buildings that are sustainable and responsible for the ecological environment, Europe comprehensively analyzes regional climate characteristics, seeks benefits and avoids disadvantages. Europe takes meteorological factors, construction sites and reasonable construction orientation into consideration and use them as low-carbon technical measures for constructing energy conservation buildings. In the application of low-carbon building technology in Europe, comprehensive consideration is given to the low-carbon technology of envelope structure, renewable energy technology and application of building carbon fixation technology, which is combined with the utilization of natural resources in Europe. At the same time, Europe pays attention to the coordination of low-carbon building technologies with other energy saving technologies in the
process of low-carbon building construction so as to maximize the benefits of energy conservation and emission reduction.

3.2.1. Low-carbon energy saving technology of building envelopes. The appearance of European buildings with high comfort and low energy consumption is simple and plain, but a large number of energy-saving and emission-reduction technologies are applied in wall, door, window and sunshade.

The thermal insulation of the building wall is an important part which is related to whether the whole low-carbon building can reduce carbon consumption and carbon dioxide emission. European countries mainly improve the thermal performance of wall structures through: first, adopting new wall materials with good thermal insulating properties; second, designing energy-saving building structures; third, adopting effective measures and construction methods that can save energy. Among them, the most effective low-carbon and energy-saving double-layer wall technology applied in Europe is the double-layer wall with air layer and outside heat preservation layer. For example, the new library of Technical University of Berlin in Germany uses this wall technology. The brick wall on the upper part of the window is provided with vertical ventilated seams.

Door and window parts are one of the important factors affecting building energy conservation and indoor thermal environment quality. Their energy consumption accounts for 40%-50% of the total energy consumption of building envelope. When designing low-carbon buildings, people should select appropriate door and window forms, materials and corresponding low-carbon technologies according to regional climate conditions, building functions, energy consumption and other factors, so as to achieve good effects of reducing carbon dioxide emissions and energy conservation in buildings. In addition, the airtightness of doors and windows is directly related to the cold and warm air penetration between indoors and outdoors, which has a greater impact on building refrigeration and heating, so sealing treatment should be adopted.

Sun-shading and low carbon technology can not only improve the thermal performance of exterior doors and windows, but also play a role in adjusting the indoor environment and eye comfort. In December 2005, the European Sunshade Organization (ES-SO) published a research report entitled "European Union 25 Countries sunshades system energy saving and CO2 emission reduction." The report pointed out that the application of sunshade technology can effectively reduce building energy consumption, which will reduce heating energy consumption by 1/10 in winter and cooling energy consumption by 1/4 in summer. European countries have already developed from the traditional sun-shading method to the current sun-shading technology with various structural forms and materials, and its sun-shading and energy-saving effects have also achieved satisfactory results. Among them, fabric sunshade technology is widely used in Europe, which has good performance in sunshade, heat insulation and wind resistance. Fabric sunshade products are people’s love because of their reasonable price, rich colors, diverse shapes and light weight. They can be used both indoors and outdoors and are easy to install. Besides, the thickness of the fabric can be adjusted according to requirements, the surface has certain anti-pollution performance, and they are easy to clean and maintain. At present, the technology of exterior shading for large buildings with intelligent control system has become quite mature and common in European countries. This technology can control the external shading system of buildings according to local weather and local climate changes.

3.2.2. Low carbon technology of building renewable energy. When making a study of low-carbon buildings, Europe not only pays close attention to the problems of energy conservation and emission reduction, but attaches importance to the conservation and recycling of water resources. Rainwater collection in low-carbon buildings is mainly to supplement water in residential areas within a certain range, relying on centralized residential roofs and surface runoff collection systems to collect rainwater through collectors set in roofs or green spaces. Canals and ditches are preferred to collect surface runoff rainwater. Water-seepage trough system should be adopted for treatment. For example, the water-seepage ditch built in Germany, on which plants are planted, is not only conducive to
rainwater infiltration and storage, but also benefit for carbon fixation, cooling and beautifying the environment.

During the construction of low-carbon buildings, renewable energy will replace the demand for fossil energy. The use of fossil energy based on traditional energy can be effectively reduced by encouraging the optimization of energy systems and the use of appropriate renewable energy. So far, renewable energy commonly used in European low-carbon buildings mainly includes solar energy, wind energy, geothermal energy, tidal energy and biomass energy including wood and its wastes, construction waste and biogas.

3.2.3. Building carbon fixation technology. The carbon fixation technology of European low-carbon buildings mainly uses the arrangement of greening at different positions in the buildings, selects different kinds of plants, and makes full use of various plant to reduce the carbon dioxide emission of buildings and improve the living environment of people. Therefore, the application of carbon fixation technology in low-carbon buildings is a way to maximize ecological benefits and emission reduction benefits. In general, building carbon fixation technology can be divided into three categories that are roof carbon fixation technology, wall carbon fixation technology and indoor carbon fixation technology.

Roof carbon fixation technology is to absorb heat and reduce the temperature through evaporation and photosynthesis of various greenery planted on the roofs, thus reducing energy consumption and carbon dioxide emissions. In addition, whether the roof uses carbon fixation technology has a significant impact on the relative humidity of the air from the roof.

The application of wall carbon fixation technology should be comprehensively considered. Firstly, the choice of wall carbon fixation technology varies with the different carbon fixation targets of building walls. Secondly, the types of wall carbon fixation technologies will be limited by the types of vegetation planted. Different vegetation types will lead to different carbon fixation levels. In the application of carbon fixation technology for low-carbon buildings, it is necessary to consider the requirements of the position of plants in building and the structure of buildings, so as to select suitable carbon fixation technology for walls. According to the different fixing methods of the vegetation on the building walls, there are three basic forms including climbing type, auxiliary part type and paving type. According to an actual measurement result of wall carbon fixation greening and building energy conservation, the indoor air temperature of buildings with wall greening is about 3-5℃ lower than that of buildings without greening, and the air relative humidity can be increased by 10%-20%.

Indoor carbon fixation technology in buildings is a technology that combines public spaces such as atrium, inner court and cloister of buildings with vegetation suitable for indoor planting, which can not only beautify indoor environment, but also improve indoor air quality and humidity. Among them, soilless culture technology is one of high-efficiency planting technology which is very suitable for indoor application. Soilless culture does not occupy much space and is clean and efficient, which will definitely be adored by people. If this technology is used in living rooms, activity rooms, sunshine gardens and balconies of residential buildings, it not only beautifies the environment, but also enables people to enjoy the pleasure of planting, satisfies people's desire to enjoy nature in an intimate way, and effectively promotes the emission reduction effect of the internal and external environment of residential buildings.

4. Conclusion
The main reason for the early development of low-carbon buildings in Europe is to reduce the impact on the ecological environment and reduce energy costs. While the buildings meet people's basic living requirements, potential social requirements will also emerge, such as improving the quality of life, saving household energy bills and comfortable and healthy living needs as the construction and development of low-carbon buildings [7]. In its development process, Europe first formulated a low-carbon development goal, perfected the legal guarantee system, vigorously developed low-carbon construction technology, and defined the market main responsibility to build a low-carbon life
consumption concept. The development of low-carbon buildings in Europe is moving forward to realize energy conservation and emission reduction, improve environmental quality and protect human health. Low-carbon buildings have been successfully developed under a reasonable construction management mode which is based on the formulation of active low-carbon strategic objectives and the development and application of low-carbon building technologies in European countries.

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