Research and Development of Light Municipal Technology System Based on Green Development Concept

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Abstract. The application of a light municipal system will become an essential means to improve cities' total carrying capacity and realize the sustainable development of green ecology in urban and rural areas. The green technology system adopted by a light municipal system's regional development model can reduce traditional municipal facilities development's initial cost. The saved investment cost of early facilities is enough to offset the increased late green technology application cost. While the region realizes green development, the overall economy can also be fully guaranteed. This paper analyses the light municipal system's applicable conditions to popularize and apply this technical system in a broader range.

1. Introduction

The light municipal system realizes self-sufficiency in resources and energy through the internal facilities of the plot. Some traditional municipal facilities (such as tap water, electricity supply, and rainwater drainage systems) can be greatly reduced. In contrast, others (such as centralized sewage, heat, garbage, and other treatment facilities) can even be directly canceled, significantly reducing the municipal system's scale and load pressure [1]. Therefore, the light municipal system can save the investment of municipal heating facilities and the later operating costs, save energy, and conform to the ecological and environmental protection orientation and provide users with a safe and comfortable experience.

The light municipal system integrates the four major technical systems of ultra-low energy consumption buildings, decentralized sewage treatment, low-impact development concept, and distributed garbage collection, thus reducing the pressure of heating, water supply, drainage, and garbage collection generated by the traditional municipal.
Figure 1. Technical Composition of Light Municipal System

1.1. Ultra-low energy consumption building technology system
Ultra-low energy consumption buildings obtain energy through photovoltaic or photothermal systems, and at the same time significantly reduce the building's demand for external heat and electric energy, thus realizing self-sufficiency and reducing a load of traditional municipal services in terms of energy demand.

1.2. Decentralized sewage treatment technology system
The use of decentralized sewage treatment and reuse technology can significantly reduce the demand for tap water supply, and the construction water can circulate itself as much as possible to reduce or even cancel the external discharge of sewage and wastewater, thus reducing a load of traditional municipal administration in terms of water supply and sewage discharge.

1.3. Low-impact development technology system
The low-impact development technology enables the building to obtain the independent regulation and storage capacity for rainwater in the region, fully recycling the rainwater resources collected in the plot, thus reducing the demand for external water resources. Meanwhile, the total amount of rainwater discharged from the plot can also be significantly reduced, reducing traditional municipal administration load in terms of rainwater discharge.

1.4. Distributed garbage collection technology system
Small and efficient waste incineration equipment utilizes solid waste discharged in the construction area. The production of electricity and heat can be used in the region and be connected to the grid to become part of the distributed power generation network. Meanwhile, the impact of garbage on the urban environment can be reduced or even eliminated, and a load of traditional municipal services can be reduced in three aspects: traditional electricity, municipal heat, and municipal garbage collection [2].

2. Analysis of Advantages of Light Municipal Technology System

2.1. Reduce Dependence on Traditional Municipal Pipe Network
Traditional regional development is highly dependent on various municipal preconditions. Its operation consumes energy and water resources and discharges rainwater, sewage, solid waste, and waste gas, which all need the supporting supply, acceptance, and treatment of municipal facilities. At the beginning of the development and construction of a new plot, the traditional municipal facilities and pipe network must be properly laid before the plot can be constructed and put into use smoothly when it is completed. In the actual process, the project has a long construction period and needs to be constructed in stages and steps. It cannot reach the design load for a long time, wasting investment, and at the same time, the efficiency and economy cannot be guaranteed.
2.2. Reduce the Impact of Resource and Energy Constraints on Urban and Rural Development

Urbanization has dramatically increased the demand for energy, including electricity, coal, oil, gas, etc., bringing tremendous pressure to the ecological environment [3]. With the large increase in urban population and the sharp increase in overall water consumption, water resources shortage has become the most serious problem. Besides, the quality of surface water and groundwater such as rivers and lakes is seriously polluted, and many cities in our country are short of water resources to varying degrees. In terms of energy, the reserves of non-renewable energy are limited, and there are not many that can be easily exploited and utilized. The development and use of renewable resources will be the only way to solve the "energy crisis".

2.3. Promote the Construction of Environment-friendly Cities

Due to rapid economic development, global problems such as water pollution and air pollution have become increasingly prominent in China. Every year, the economic loss caused by water pollution alone has reached 40 billion yuan. Also, with the improvement of people's quality of life, the number of motor vehicles increases, which dramatically aggravates the degree of air pollution, and even photochemical smog has appeared in places like Beijing, Shanghai, and Guangzhou. There is no place to put a lot of garbage, which affects the urban landscape and makes many areas in China fall into the predicament of garbage siege. The atmosphere, water, and soil, which are closely related to life and health, are polluted, and the health of urban and rural residents is also threatened, which is a thorny problem in building an environment-friendly city.

3. R&D and Applicability Analysis of Light Municipal Technology System

3.1. Ultra-low energy consumption building technology

Ultra-low energy consumption building is a kind of green building that can adapt to natural conditions and climate characteristics. Compared with ordinary buildings, the thermal insulation performance and
airtightness of its enclosure structure are greatly improved. Ultra-low energy consumption buildings make full use of renewable resources, adopt efficient new wind-heat recovery technology, meet the heating and cooling requirements of buildings with the least energy consumption, and provide users with comfortable somatosensory temperature and indoor environment. Its basic principle is the theory of building heat balance, that is, to maximize the heat gain of the building itself, reduce the heat loss, and minimize the final heat demand. The core strategy is the house's sealing and thermal insulation, isolating the indoor and outdoor thermal environment to avoid heat loss.

The thermal insulation system is the most critical technical measure in passive buildings, mainly including walls, roofs, floors, doors, windows, etc. To put an end to any possible heat loss, high-performance thermal insulation and optimal airtightness are essential. However, due to different climates, thermal insulation structures' requirements are different in different places. The higher the latitude and cold areas, the higher the importance of thermal insulation systems and the higher the thermal insulation values requirements. The warmer the areas, the lower the requirement of thermal insulation, and the lower the importance of the thermal insulation system.

Compared with ordinary-buildings, ultra-low energy consumption buildings consume very little primary energy and easily meet indoor comfort. First of all, all kinds of small-scale decentralized and more flexible heating systems, such as biomass fireplaces, small heat pumps, etc., are adopted in the ultra-low energy consumption building areas. Then, the matching of central heating sources and pipe networks can be canceled, and the traditional related municipal facilities are no longer needed. Secondly, the investment scale and cost required for the early development of the project are greatly reduced, and a large amount of later operation and maintenance expenses can be saved simultaneously. Finally, the carbon emissions from building cooling and heating are remarkably controlled, and the adverse impact on the environment is greatly reduced.

3.2. Decentralized Sewage Treatment and Reuse Technology

At present, the decentralized ecological sewage treatment and reuse technology are advanced by the following three systems [4]: (a) Tidal soil biological treatment system, which is characterized by creating its unique aesthetic appearance through the use of animals and plants in the treatment process, so that it can provide a beautiful and comfortable environment. (b) Eco-enhanced water treatment system is characterized by good effluent quality. The equipment has excellent denitrification and deodorization effect and does not need to build a special deodorization device. Its appearance is beautiful, and it is harmonious with all kinds of beautiful ecological environment. In addition, the equipment can be operated remotely through the Internet, with high automation and good thermal insulation effect. (c) Solar water treatment system: It is composed of several different ecosystems, removing the particles and nutrients in wastewater after domestication. After gravity clarification, the sludge is pumped back into the water tank, and the clarified solution can be reused after further sand filtration and disinfection.

There are three kinds of application methods of decentralized sewage treatment system: (a) Application in and around buildings: Combined with architectural design, it is set in or around buildings. If the building needs a large amount of sewage treatment system, the primary sewage treatment unit, and the secondary sewage treatment unit of the core treatment module can be split. The primary sewage treatment unit is arranged around the building and combined with the surrounding landscape. The secondary sewage treatment unit is placed in the building and combined with the indoor landscape. (b) Outdoor application: Decentralized sewage ecological treatment system can be installed on both sides of the road in combination with road greening or can be directly installed on outdoor open space to form an outdoor landscape. When the sewage ecological treatment system is applied outdoors, attention should be paid to microorganisms' cold resistance in the surface green plants and core treatment modules. Therefore, this application is suitable for warm climate areas in the south or cold areas in the north, where overwintering measures can be provided. (c) Application in resort area: Decentralized sewage ecological treatment system can be combined with a garden landscape to form an "ecological garden". This kind of application is mostly found in resort areas. Resort areas are generally far away from urban areas, municipal facilities such as sewage pipe networks are not perfect, plant landscape
occupies a large area, and the landscape's ornamental requirements are also high. On the one hand, a decentralized sewage ecological treatment system can solve the problem of sewage treatment in resort areas and directly convert domestic sewage into reusable reclaimed water for greening. On the other hand, the system can be integrated into the plant landscape to provide nutrients for landscape plants' growth.

3.3. Low-impact Development Technology
The application of low-impact development technology can make the development plot have sufficient "flexibility" to adapt to environmental changes and cope with natural disasters. In the process of site development, a rainwater runoff management mode is established from the source to the middle and then to the end to maintain the hydrological characteristics before site development. The low-impact design of the plot is constructed by combining the six strategies of "infiltration, stagnation, storage, purification, utilization, and drainage" and following the layout principle of "Source-control, Middle-stagnation & storage, and End-discharge" to realize the change from rainwater drainage from urban drainage facilities to rainwater flood management in the whole process.

Low-impact development technologies respect naturalness, pursuing the development concept of low investment and maintenance, combining landscape with rainwater management, roof greening, and permeable pavement through organized confluence and transfer, and after pretreatments such as sewage interception, low-impact development facilities with rainwater infiltration, storage, and adjustment as the main functions, such as ecological grass planting ditches, sunken green spaces, rainwater gardens, and underground seepage storage, are introduced. Low-impact development facilities can be selected according to local conditions, economically and effectively, conveniently and easily, and realize multiple service values such as adaptive waterlogging prevention, rainwater regulation and storage, rainwater purification and regeneration, biodiversity restoration, diverse leisure and artistic experiences in building areas.

3.4. Distributed Garbage Collection Technology
Distributed garbage collection technology provides part of the energy, especially electric energy and heat energy, for buildings through a garbage disposal. The small-scale waste energy gasification waste incineration equipment used in the region can significantly improve the efficiency and effect of garbage collection and is currently a relatively advanced garbage collection technology on the market. The waste energy gasification system produces clean, renewable energy while incinerating waste. Biomass wastes such as garbage, fallen leaves, and straw generated in the region can all become fuels for waste energy gasification systems. Advanced gasification systems turn these low-cost local wastes into combustible gases for combustion, shortening the cycle of garbage collection, transportation, and treatment and meeting the strictest emission requirements. Distributed garbage collection technology has fully solved the problems such as shortage of waste sites, treatment speed not keeping up with the production speed, secondary pollution during transportation, and garbage discharge in building areas, which has reduced the impact of solid waste on the urban environment and improved the management and maintenance level of facilities.

4. Conclusions
Based on a comprehensive study and analysis of the applicable conditions of various technologies in the light municipal system, it is found that the light municipal system not only has a wide application range and low-impact on the surrounding environment but also can improve the utilization efficiency of energy resources. It is recommended to give priority to the following areas.
Table 1. Recommended List of Technical Applicability of Light Municipal System

|                      | Ultra-low energy consumption building technology system | Decentralized sewage treatment technology system | Low-impact development technology system | Distributed garbage collection technology system |
|----------------------|--------------------------------------------------------|-----------------------------------------------|----------------------------------------|-----------------------------------------------|
| Independent urban, rural communities (Northern Cold Region) | √                                                      |                                               |                                         | √                                             |
| Independent urban, rural communities (Warm areas of South China) | --                                                   | √                                           | √                                       | --                                             |
| Industrial Park      | √                                                      | √                                           | √                                       | √                                             |
| Nature reserves / Eco-sensitive zones                       | √                                                      | √                                           | --                                     | √                                             |
| Residential areas or resorts                                | √                                                      | √                                           | √                                       | √                                             |

4.1. All Kinds of Independent Communities, Industrial Parks, and Other Restricted Areas
The light municipal technology system balances its energy consumption through regional allocation while reducing energy and resource demand. It uses renewable energy to replace traditional fossil energy and improve the development plots' self-reliance ability to reduce the outside world's investment, reduce the impact on the environment through advanced technologies, and improve the management and maintenance level of facilities, and reduce carbon emissions. The final effect is to reduce the scale and load pressure of the municipal system significantly. Therefore, it is especially suitable for areas with limited conditions such as pipe network connection difficulty of traditional municipal infrastructure, outside urban built-up areas, relatively independent urban, rural communities, or industrial parks.

4.2. Nature Reserves and Eco-Sensitive Zones
In some nature reserves and eco-sensitive zones, the local energy generally depends on external supply to protect the local natural environment base. Ultra-low energy consumption building walls are made of thermal insulation and energy-saving materials with good sealing performance. The reduction of the demand for fossil energy also reduces the emission of carbon dioxide, sulfur dioxide, and other gases and inhalable particulate matter produced by its combustion, which can play an essential role in protecting the local ecological environment. Decentralized sewage treatment equipment has various appearance combinations, and its forms are rich in changes, which can be ingeniously integrated with surrounding environments such as buildings and parks. Decentralized sewage treatment technology can realize zero discharge of sewage, and its low-carbon ecological sewage treatment and recycling process can improve the quality of reused water, eliminate potential pollution risks, and realize diversified local utilization. Distributed garbage collection technology can solve the problem of garbage discharge inland and has low disturbance to nature reserves and eco-sensitive zones.

4.3. All Kinds of Residential Areas and Resorts with High Requirements for Environmental Quality
Ultra-low energy consumption building technology can make the building room temperature evenly distributed through a high-performance external insulation system and obtain more suitable somatosensory comfort. It adopts a new wind-heat recovery system to discharge indoor dirty air at any time and maintain indoor PM 2.5 concentration below a constant value; adopts moisture-proof and ventilation technology to reduce the risk of mold breeding on indoor wall and ceiling, which conforms to the principle of ergonomics; provides the garden landscape material with sewage ecological reuse
technology, and creates interactive hydrophilic and near-natural activity space between man and nature with low-impact development technology; uses a small-scale distributed garbage gasification system to convert the solid waste in the area into combustible gas instead of fossil fuel with high carbon emission, providing electric and heat energy for residential areas or resorts.

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