# Implementation path in data collection and analysis of low carbon fresh air system

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**Abstract.** Low carbon energy conservation in the fresh air system is an important way to achieve China's carbon peak and carbon neutrality goals, which is also important to the collection and analysis of energy data. Therefore, this research studied the current research status and the path of low-carbon fresh air systems at home and abroad, investigating the coupling simulation of EnegyPlus and GenOpt software, and considering the use of particle swarm optimization algorithm to optimize and tune the temperature control model. A ventilation system called TELDOAS based on LD abroad can effectively recover waste heat from fuel cells, thereby reducing performance. Through research on the current situation, it is possible to effectively apply low-carbon fresh air systems to practical production. The fresh air system has broad prospects in terms of the increasing awareness of health, demand for energy efficiency and environmental protection, building standards requirements, and technological innovations. With the growing emphasis on indoor environmental quality and the need for sustainable development, the application of fresh air systems will continue to expand.

**Keywords:** Low-carbon fresh air system, Proportional integral differential control, Response surface method, Multi objective optimization particle swarm optimization algorithm, TELDOAS, Liquid desiccant air conditioning system.

## 1 Introduction

The structure of fresh air system consists of the main engine, air duct, window inlet and exhaust outlet. The principle of fresh air system is that when the main engine is running, the dirty air goes to the outside and the fresh air is introduced through the exhaust outlet and from the window inlet, respectively. Under the action of the pressure field formed by the main engine, the fresh air goes to the indoor area to meet the needs of life and work. The function of fresh air system is to provide fresh air for the room for improving the indoor air quality and living comfort, to remove dirty air (such as smoke, odor, carbon dioxide, etc.) for keeping the clean and fresh indoor air, and to adjust the humidity to avoid the too dry or wet air. With the economy developing in our society continuously and the living standards of people improved, the effect of heating system


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and primary air system in people's daily life and work have been increasing. The primary air system has been used extensively in various occasions, such as families, offices, shopping malls, which plays a key role in improving life quality. However, as citizen play close attention to the environment, more theories of environment and resource saving were raised, traditional technology in refreshing air cannot satisfy requirement of society any more. Therefore, low energy consumption and high efficiency have become the pursuit of new air system technology development. In recent years, in order to promote the achievement and development of the dual carbon goal, various regions across the country have provided policy support, thereby promoting the application of low-carbon fresh air systems. In summary, with the progress of technology and society, fresh air systems of energy-saving and low-carbon have become the trend of technological development environmentally, friendly and healthy. Agha-Hossein [1] et al. established a method to monitor relationship between energy consumption and public buildings. Oh et al. [2] created an integrated approach focusing on indoor environmental quality improvement by deploying using data-driven indoor environmental quality reports. Dai et al. [3] conducted long-term monitoring of environmental conditions to analyze energy consumption and indoor ambient air quality under different ventilation modes. Qi et al. [4] analyzed the relationship between energy consumption and indoor environment under different energy consumption levels. Schibuola [5] et al. established an optimized method to controlled ventilation system. Wang et al. [6] designed an optimal fresh-air utilization strategy based on isocost line.

The issue of carbon emissions may appear to be an environmental issue on the surface, however in reality, it is ultimately a development direction issue. Starting from low-carbon, approaching zero carbon, and finally achieving zero carbon, each of these goals is higher than the last, which is also the only way to actively respond to global climate changing and achieve green, low-carbon and high-quality development. China solemnly promises to achieve carbon peaking by 2030 and carbon neutrality by 2060, which is a very important commitment regarding as one of the most important goals of the country [7].

The fresh air system is an independent air treatment facility that has two types: supplying air and exhausting air. The system of supplying air purifies and filters outdoor air before delivering it into the indoor environment, while the exhausting air system removes stale indoor air and exhausts it outdoors, meeting the requirements of ventilation and air exchange in indoor spaces. In addition to ventilation, the fresh air system also has functions, such as odor removal and dehumidification. It provides fresh air by treating the outdoor air and delivering it indoors, allowing us to enjoy fresh air even without opening windows. The fresh air system can eliminate mold and unpleasant odors, effectively removing cooking smells and mold growth, thus preventing the proliferation of bacteria and viruses. It also plays a role in dust and noise prevention. By using the fresh air system, we do not need to open windows, avoiding the entry of a large amount of dust from outdoors. With doors and windows closed, it also reduces indoor noise disturbances to some extent. However, the fresh air system has some drawbacks. For example, it is relatively expensive. Additionally, the installation process can be complicated and requires professional design and installation. Communication with other construction workers is necessary before installation to avoid obstruction of air outlets. The maintenance and upkeep of the fresh air system can also be troublesome, such as regular replacement of filters.

## 2 Current situation and implementation path

### 2.1 Research on data collection and analysis of low carbon fresh air systems in china

Experts and scholars have extensively studied the control strategies of fresh air systems from various perspectives and its ennergy-saving technology of exhaust air heat recovery. Finally, a control strategy of ventilation emission based on gas pollutants such as $CO_2$ was studied. They are committed to scientifically and effectively reducing system energy consumption as much as possible while ensuring the healthy and comfortable indoor environment and the normal operation of the fresh air system, thereby achieving energy conservation and efficiency. Although the research content varies, the goals are consistent.

Zhang et al. [8] conducted multiple simulation studies on the control of the fresh air system in VAV air conditioning, and established a simulation module that includes three objective functions: temperature, enthalpy, and energy consumption for optimization control. Afterwards, the building energy consumption generated under the three control module control strategies was analyzed and compared multiple times. Finally, it was found that the objective function can be used to optimize the control strategy, effectively reducing the energy consumption of the fresh air system and achieving low-carbon.

In order to find the reason for the poor control effect of indoor $CO_2$ concentration, Tian et al. [9] used CFD method to conduct numerical simulation research on the airflow organization under measured working conditions. By analyzing the impact of different airflow organization design parameters on indoor $CO_2$ concentration, an optimized design scheme for indoor airflow organization was proposed. Finally, coupling simulation was conducted using Energy Plus and Gen Opt software to optimize the relationship between indoor air quality and energy consumption. Based on the dual objective optimization method, the optimal ventilation rate of residential buildings was studied in the Figure 1.

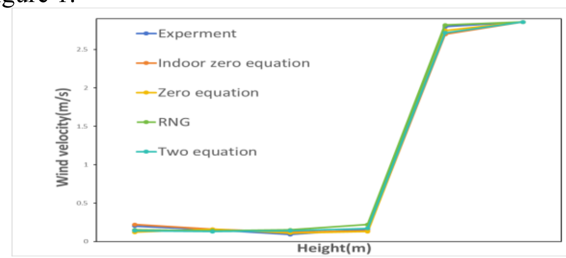


**Fig. 1.** Comparison of predicted and experimental wind speeds for different turbulence models [9].

The general form of the control equation for steady-state incompressible indoor airflow can be written as [10]:

$$\frac{\partial}{\partial t}(\rho\phi) + \nabla\cdot(\rho u_i \phi) = \nabla\cdot(\Gamma_\phi \nabla\phi) + S_\phi \tag{1}$$

By discretizing the mass, momentum and energy of the incompressible gas in the room, and combing with the average turbulent energy model proposed by Lauder and Spalding, the temperature field, velocity field and concentration field were successfully solved [11]. In order to obtain the optimal three Proportional Integral Differential (PID) control parameters, Wang et al. [12] analyzed the temperature control model by establishing a room temperature model by using the optimized Particle Swarm Optimization (PSO) algorithm to make subtle adjustments and overall optimization tuning to the temperature control model. On this basis, the study also proposed an almost new model reference adaptive PID control method based on particle swarm optimization parameter tuning for temperature control of indoor fresh air systems. After simulation verification of MATLAB, this control method has a shorter adjustment time and smaller overshoot, demonstrating good control performance, achieving low-carbon optimization of the fresh air system.

The indoor temperature control model is [12]:

$$T^{'}(s) = 0.25063e^{-54} \Big/ 540s + 1 \tag{2}$$

The PID control system consists of a controller and a controlled object. The PID control system diagram is shown in the Figure 2:

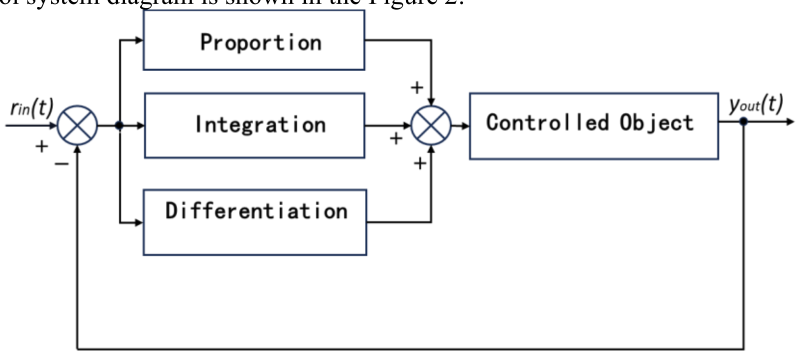


**Fig. 2.** PID control system diagram.

## 2.2 Research on data collection and analysis of low carbon fresh air systems abroad

For low-carbon fresh air systems abroad, Lim et al. [13] studied a liquid desiccant air conditioning system, which uses a liquid desiccant assisted fuel cell dedicated fresh air system to energy-saving retrofit public office buildings. This system is also known as the thermoelectric and LD assisted dedicated fresh air system (TELDOAS).

The system consists of a LD system, an enthalpy wheel (EW), and two thermoelectric heat pumps (TEHP). EW is a type of silicone load that provides pre dehumidification, pre cooling, and pre humidification preheating during the heating season by exchanging water vapor and heat between fresh air and return air; In the LD system, the desiccant solution needs to be heated and cooled to meet the performance of regeneration and dehumidification; TEHP is a sandwich structure composed of TEM and two heat exchangers (one for heat absorption and one for heat removal).

In order to study this system Lim et al. introduced three simulation cases, the most critical of which was the proposal of TELDOAS for fuel cells. The simulation case using the proposed system is called "FC-TELDOAS-HP". In this situation, TELDOAS is used for three functions: ventilation, dehumidification, and humidification. TELDOAS can only be used for ventilation during the cooling season, where electronic warfare rotates the process air through enthalpy exchange with the exhaust gas to achieve cooling and dehumidification purposes. Secondly, through the heat and mass transfer between liquid desiccant solutions and air, process air can be dehumidified and cooled on the absorber. TBLDOAS can also be used for humidification during the heating season addition to ventilation. The process air plays a heating and humidifying role in regenerators and electronic warfare. From the above case, we can discover that by using this model to renovate existing buildings and conducting simulation case calculations, the energy self-sufficiency rate of buildings can be improved.

In addition, Kim et al. [14] studied a system suitable for apartment residential buildings, which essentially assists with a dedicated fresh air system based on liquid desiccants, with the aim of improving the dehumidification and energy performance of the central ventilation system. Their proposed central ventilation system, which combines the organic wolf like cycle (ORC) and operates through liquid desiccants, making a significant contribution to achieve zero energy consumption in buildings while utilizing both electrical and thermal energy simultaneously.

## 3 Conclusion

Based on this study, we can conclude that in China, in order to achieve low-carbon fresh air systems, we can adopt multi-objective optimization particle swarm optimization algorithm to control the fresh air system, retrofit exhaust heat recovery energy-saving technology, and demand ventilation control strategies based on pollutants such as $CO_2$ to achieve our goals. In addition, we can also refer the ideas of foreign researchers to improve the energy self-sufficiency rate of buildings through energy transformation, ultimately achieving the goal of low-carbon fresh air systems.

In conclusion, the fresh air system has broad prospects in terms of the increasing awareness of health, demand for energy efficiency and environmental protection, building standards requirements, and technological innovations. With the growing emphasis on indoor environmental quality and the need for sustainable development, the application of fresh air systems will continue to expand.

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