# Research on Computer Carbon Reduction Control System of Energy Saving and Emission Reduction Comprehensive Enterprise

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**Abstract.** Construct an energy-saving and emission-reduction plan that minimizes the overall cost of the energy network. Applying the Hybrid optimal method solves the problem. Research on the optimal design of multi-energy cooperative integrated energy systems. Establish a central system control strategy, an energy system network structure, and an integrated energy management and control system. Finally, the coordination control problem of the proposed multi-energy cooperative integrated energy supply system is verified. The scenario comparison method is used to study the energy distribution effect under different scenarios. The results of this project show that adding flexible loads to the carbon market can significantly improve the overall economic and environmental benefits of the electricity market.

**Keywords:** Energy saving and emission reduction; carbon emission control; system coordination; optimization control; energy system.

## 1. Introduction

The traditional energy consumption mode based on fossilization has brought about environmental problems such as greenhouse gases and haze, while the single energy utilization mode of gas, electricity, heat and cold lacks elasticity and is difficult to achieve the optimal energy utilization mode. It is necessary to build a renewable energy system with multi-energy synergy and energy trapezoid. The physical platform of multi-energy integration and synergy is supported, and the complementarity and system characteristics of various energy forms are comprehensively displayed, so as to rationally adjust the energy structure and achieve the purpose of transformation and upgrading of the energy system. Energy optimization is carried out based on multi-energy integration and coordination. The optimal combination of energy conversion, distribution and storage can be realized by using the correlation mechanism of efficient energy modes in time and space, so as to realize energy production, distribution and storage [1]. In addition, the potential of users' participation in power system integration should be fully tapped and collected to obtain large-capacity "virtual energy units" to ensure the safe and stable operation of the upper power system. At present, we are faced with the problem of not being able to achieve unified collaborative regulation of energy. Therefore, it is necessary to strengthen the central control of energy and carry out in-depth exploration. Modeling of demand response potential, corresponding frequency and duration should be established, so as to improve the interactive response ability of power generation side, grid side and demand side. Two kinds of flexible loads, electric and thermal, are considered, and their characteristics of transferability, transferability and reduction are considered [2]. The whale optimal method (WOA) is used to simulate the calculation. Combined with scenario comparison, this paper studies the effect of carbon market in power system in optimizing energy structure, reducing carbon emission, reducing system cost and improving environmental benefits with flexible load, and discusses ways to realize low-carbon development of power system.

## 2. Network architecture of energy systems

Through the acquisition network, measurement and control equipment, monitoring system, terminal and main system, a collaborative network structure of comprehensive energy system is

constructed. It is shown in Figure 1 as the network structure of the energy system. The biggest feature of the system is that it has two directions of communication, it can complete the collection and processing of data center information, through the interactive information flow to transmit data, so as to achieve the comprehensive energy operation management, energy services, real-time monitoring and other services. Among them, the measurement and control device level are mainly responsible for the collection of each energy, which provides a basis for the user to monitor and control the energy [3]. Collecting network adopts physical network technology to access various environmental protection and energy use equipment in the power network. The terminal and supervision system can monitor the operation of regional energy equipment by collecting calibration data. At the same time, it can also quickly respond to the control allocation command of the energy control state system, so as to optimize the allocation of energy and reduce the energy consumption of the equipment [4]. The principle of the communication network is: special network, auxiliary public, to achieve a complete coverage of the energy system of the communication network, and the transmission and control. At the main system level, with the support of big data technology and cloud computing technology as the core, the energy supply and consumption of the whole region are comprehensively analyzed and monitored, and the optimal allocation is made.

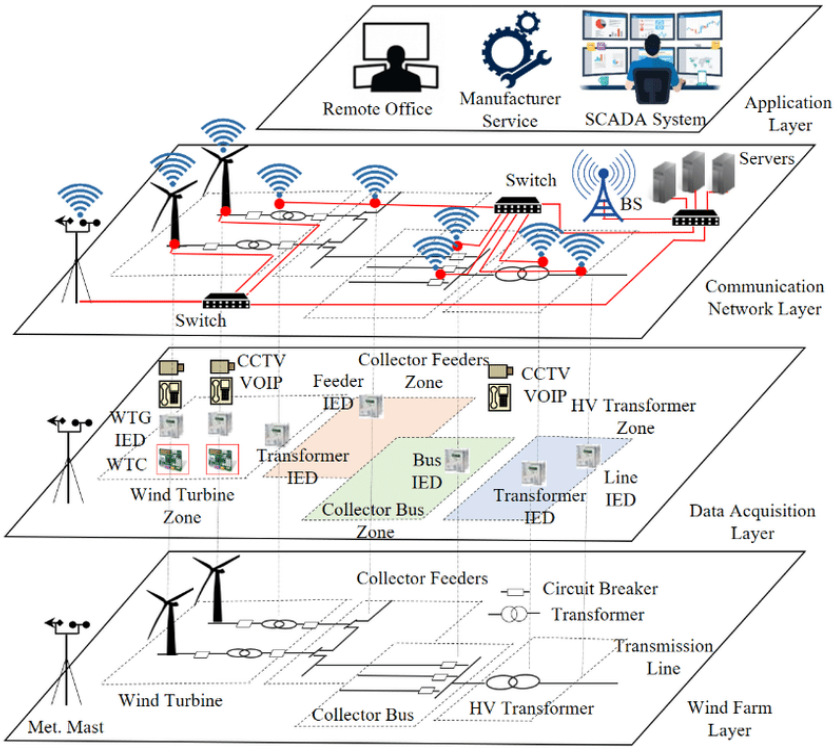



**Figure 1.** Network architecture of an energy system

## 3. Integrated energy control system

The regional comprehensive energy control system is the core of the comprehensive energy system in the park. It realizes the maintenance of the system through real-time monitoring and optimal scheduling of energy, and adopts the energy optimization matching technology to realize the intelligent linkage of energy production devices and optimize the scheduling, maintenance and monitoring of the whole life cycle of energy [5]. It is integrated with 3D modeling technology to monitor the condition and energy flow of the device, and is linked to the condition diagnosis of the device so that it can be forewarned. During operation and management, dynamic management and planning management are integrated, aiming at synthesis, economy and green. Under the same restrictive conditions, each energy subsystem can be effectively regulated, and dynamic real-time management can be carried out according to specific needs. An integrated energy control system is shown in Figure 2.

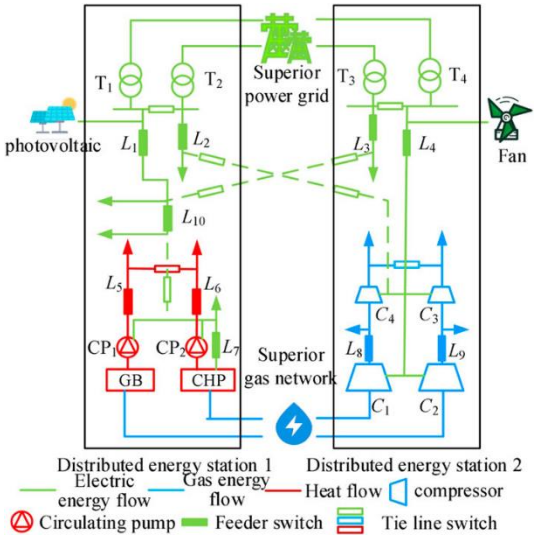



**Figure 2.** Regional integrated energy control system

## 4. Carbon trading cost model

### 4.1. Carbon trading mechanism

Carbon trading is a trading system that allows people to buy and sell carbon emissions in a market. This project aims to promote the optimization of energy structure and energy utilization and achieve emission reduction targets. Each carbon dioxide emission is distributed through government agencies [6]. If a region's total emissions reach a certain limit, its excess credits can be sold through carbon trading. If carbon dioxide emissions exceed a certain limit, the excess carbon dioxide will be purchased through carbon trading. In order to maximize benefits, each carbon emission company will actively formulate corresponding energy-saving and emission reduction policies.

### 4.2. Calculation of carbon trading costs

IES carbon trading cost model established based on carbon trading mechanism is shown in Equation (1):

$$f_{CO_2} = C_t(E_{out} - E_{all}) \tag{1}$$

Where: $f_{CO_2}$ is carbon trading cost. A positive $f_{CO_2}$ indicates excess carbon emissions and carbon credits must be purchased. A negative $f_{CO_2}$ represents revenue from the sale of carbon credits. $C_t$ is the market price of carbon trading on that day. $E_{out}, E_{all}$ is the total emission of $CO_2$ and the carbon emission quota respectively [7]. Considering that carbon emissions in IES are generated during the production, transportation and use of various energy sources, this paper proposes a two-stage method to measure carbon emissions in IES:

$$E_{out} = \sum_{i=\Omega}(c_i^{pre} + c_i^{run})P_i \tag{2}$$

Where: $\Omega$ is the energy equipment set. Including energy supply equipment and energy storage equipment. $c_i^{pre}$ is the carbon emission coefficient of energy equipment $i$ corresponding to energy production and transportation stage. $g/(kW \cdot h); c_i^{run}$ is the carbon emission coefficient of energy equipment $i$ at the corresponding energy use stage. $g/(kW \cdot h); P_i$ is the operation output of energy equipment $i$.

### 4.3. IES low-carbon economic scheduling model

#### 4.3.1. Objective function

IES low carbon economy optimization operation objective considering flexible load: The sum of day-ahead running cost $f_{IES}$ and carbon trading cost $f_{CO_2}$ is minimized by reasonable arrangement of output of IES controllable units and optimal scheduling of flexible load under the condition that constraints of each unit are satisfied.

$$\min f = f_{IES} + f_{CO_2} \tag{3}$$

$$f_{IES} = F_{NET} + F_{DG} + F_{MT} + F_{GB} + F_{BAT} + F_{HST} + F_L \tag{4}$$

Among them:

$$F_{NET} = \sum_{t=1}^{T} K_{NET}(t) P_{NET}(t) \tag{5}$$

$$F_{DG} = \sum_{t=1}^{T} [K_W P_W(t) + K_{PV} P_{PV}(t)] \tag{6}$$

$$F_{MT} = \sum_{t=1}^{T} K_{MT} P_{MT}(t) \tag{7}$$

$$F_{GB} = \sum_{t=1}^{T} K_{GB} P_{GB}(t) \tag{8}$$

$$F_{BAT} = \sum_{t=1}^{T} K_{BAT} \mid P_{BAT}(t) \mid \tag{9}$$

$$F_{HST} = \sum_{t=1}^{T} K_{HST} \mid P_{HST}(t) \mid \tag{10}$$

$$F_L = F_{shift} + F_{tran} + F_{cut} \tag{11}$$

$F_L$ is the total compensation cost of dispatching flexible load. $K_{NET}(t)$ is the time-of-use price. $P_{NET}(t)$ is the power exchanged with the grid, and the power purchase is positive. $K_W, K_{PV}, K_{MT}, K_{GB}, P_W(t), P_{PV}(t), P_{MT}(t), P_{GB}(t)$ is the operating cost factor and output power of fan, photovoltaic, gas turbine and gas boiler respectively.

### 4.4. Constraints

#### 4.4.1. Constraints on load balance

The electrical and thermal power respectively meet the following load balance constraints:

$$P_{NET} + P_W + P_{PV} + P_{MT} - P_{BAT} = P_{LOAD} \tag{12}$$

$$Q_{HT} + Q_{GB} - Q_{HST} = Q_{LOAD} \tag{13}$$

Where: $P_{LOAD}, Q_{LOAD}$ refers to the demand of electricity and heat load respectively.

#### 4.4.2. Constraints on upper and lower limits of output

The output of each new energy and each energy conversion equipment must meet the upper and lower limits:

$$0 \le P_{W/PV} \le P_{pred} \tag{14}$$

$$0 \le P_{WT/GB} \le P_N \tag{15}$$

Where: $P_{W/PV}, P_{pred}$ is fan/photovoltaic output power and corresponding new energy output predicted value respectively. $P_{WT/GB}, P_N$ is output power of gas turbine/gas boiler and rated power of corresponding equipment respectively.

$$E_{cap,\min} \le E_{cap}(t) \le E_{cap,\max} \tag{16}$$

$$P_{ex,\min} \le P_{ex}(t) \le P_{ex,\max} \tag{17}$$

$$0 < S(t) + R(t) \le 1 \tag{18}$$

$$\sum_{t=1}^{T} P_{ex}(t) = 0 \tag{19}$$

## 5. Example analysis

In this paper, IES in a small community were selected as the subjects. Considering flexible load, carbon trading and time-sharing pricing, wind power, photovoltaic, gas turbine, battery and heat storage tank are studied [8]. The planned cycle is 24 hours, and the planned time interval is 1 hour. The operational indicators of the integrated energy system are shown in Table 1. The daily electricity characteristics and the maximum new generation power are shown in Figure 3.

**Table 1.** Operating parameters of IES

| Type | Lower power limit /kW | Upper power limit /kW | Running cost/yuan · (Kwahu) $^{-1}$ |
|---|---|---|---|
| Power grid | - | - | Time-of-use tariff |
| Fan | 0 | Predicted value | 0.52 |
| Photovoltaic | 0 | Predicted value | 0.72 |
| Gas turbine | 0 | 200 | Natural gas price |
| Gas-fired boiler | 0 | 100 | Natural gas price |

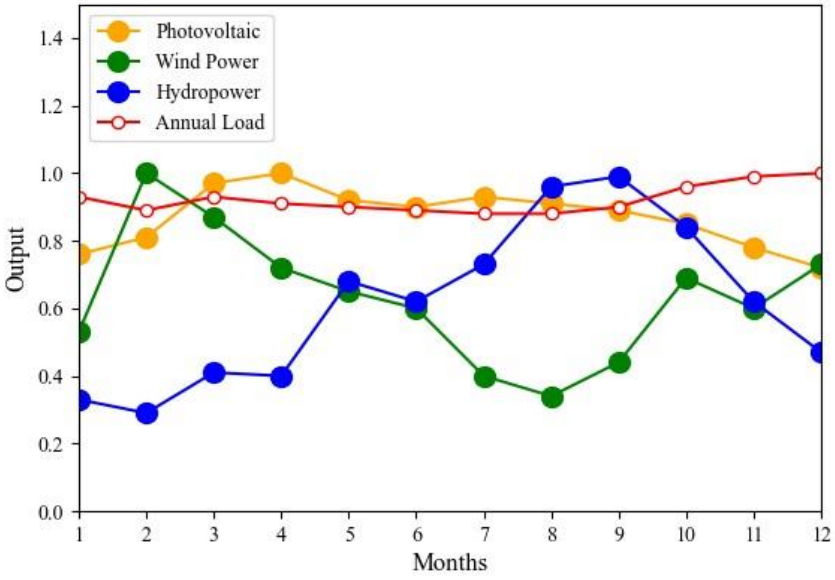



**Figure 3.** Daily load and wind-power curve

The carbon emission coefficients listing the energy involved in IES in the community are shown in Table 2. Where, the total carbon emission coefficient is the sum of the emission coefficient of the two stages. The carbon emission quota is shown in Table 2, and the carbon trading price is 150 yuan/t.

**Table 2.** Carbon emission coefficient and quota coefficient

| **Energy type** | $c_i^{pre}$ **g/(kW·h)** | $c_i^{run}$ **g/(kW·h)** | **Total carbon emission coefficient g/ (kW·h)** | **Quota g/ (kW·h)** |
|---|---|---|---|---|
| Coal power (grid) | 1357.3 | 0.0 | 1357.3 | 831.3 |
| Natural gas | 121.3 | 467.0 | 588.2 | 441.7 |
| Wind power generation | 44.8 | 0.0 | 44.8 | 81.3 |
| Photovoltaic power generation | 56.8 | 0.0 | 160.9 | 81.3 |
| Energy storage | 95.1 | 0.0 | 95.1 | 0.0 |

The electrical load on the demand side includes basic electrical load, transferable electrical load 1, transferable electrical load 2, transferable electrical load and reducible electrical load [9]. Heat load is divided into basic heat load, transferable heat load and transferable heat load. The distribution of each flexible electrical and thermal load is shown in Figure 4. The parameters of variable load are given in Table 3.

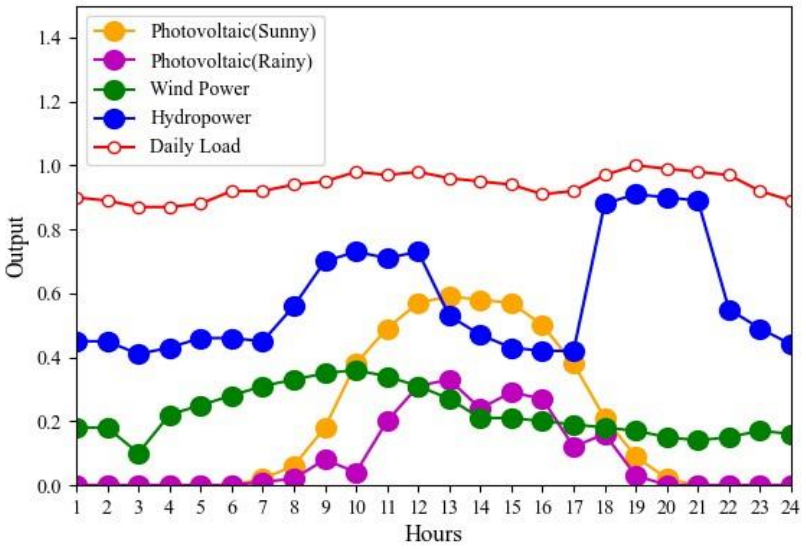



**Figure 4.** Distribution of flexible load before optimization

**Table 3.** Flexible load parameters

| **Type** | $t_D / h$ | $t_{sf-} \sim t_{sf+}$ | $F_{cost}^{shift}$ **/ yuan·(kW·h)$^{-1}$** |
|---|---|---|---|
| Transferable electrical load 1 | 3 | 5:00-21:00 | 0.2 |
| Transferable electrical load 2 | 2 | 7:00-23:00 | 0.2 |
| Transferable heat load | 3 | 5:00-21:00 | 0.1 |

The power load of the power system is mainly generated by new energy and gas generating units, and a small part is made up by the purchase of the power system. Charge and discharge batteries between 8:00 and 15:00, when the wind energy is most abundant, to effectively increase the utilization of new energy. From 16:00 to 24:00, the peak power consumption was alleviated to a certain extent due to a large amount of battery release. During full operation, the generating capacity of the gas-fired units can reduce emissions and reduce the impact on the power system during periods of wind exhaustion and peak demand.

## 6. Conclusion

An optimal model for low carbon economy of integrated energy system in carbon market is established considering the flexible load of user side. The low carbon economy optimal scheduling

problem of energy system is studied. The results show that the carbon market can effectively improve the energy consumption level of the integrated power system under different scenarios. Through the implementation of this project, the energy-saving and emission reduction effect of the addition of flexible load on the energy and power market is clarified, which lays a theoretical foundation for the in-depth exploration of energy conservation and emission reduction decisions under the energy and power market.

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