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# Research on Control Strategy of Multi-energy Complementary Microgrid for Wind-solar Hydrogen Production

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**Abstract:** The multi-energy complementary microgrid system is an effective supplement to the areas not covered by the large power grid, and can effectively solve the problem of electricity consumption in remote areas. Based on the research of wind power, photovoltaic, energy storage, hydrogen production and fuel cell systems, this paper builds a wind-solar hydrogen storage multi-energy complementary micro-grid DC network system, and puts forward cooperative control strategies of the system under different working conditions, so as to achieve stable operation of the system and maximize energy utilization. Finally, PSCAD simulation software is used to establish a simulation model for each distributed unit to verify the stability and rationality of the control strategy. The simulation results show that the control strategy can achieve efficient, cooperative and stable operation between different energy sources on the premise of ensuring the power quality of the microgrid.

**Keywords:** Multi-energy complementary, microgrid, collaborative control strategy, simulation.

## 1. Introduction

With the rapid development of renewable energy, micro-grid, especially low-voltage micro-grid, has become a research hotspot due to its characteristics of low carbon, environmental protection and strong adaptability [1]. Multi-energy complementary micro-grid system, also known as hybrid power generation system or new energy micro-grid (isolated network operation), through local conditions, make full use of a variety of renewable energy or traditional energy composed of local power supply system, and integrated energy storage system, power electronic conversion system and energy management system, can provide high quality, economic, uninterrupted power supply to end users. It is an important means to solve the problem of power supply and energy shortage in remote areas [2].

At present, the research of multi-energy complementary system is more about the wind-wind-storage complementary power generation system and wind-wind-diesel-storage complementary power generation system. With the increasing demand for energy in society, people's demand for low-carbon and renewable energy continues to increase. As one of the important choices in the field of energy, hydrogen energy has attracted more and more attention in the fields of transportation, industrial production, wind farms and photovoltaic farms with severe power restriction [3]. As an emerging form of energy, solar hydrogen storage energy system not only takes into account the advantages of renewable energy such as wind and solar energy, but also further improves the sustainable utilization rate of energy through efficient storage, conversion and utilization of hydrogen. This paper focuses on the micro-grid system based on "wind power + photovoltaic + energy storage + fuel cell", from the aspects of networking system, collaborative control strategy, simulation, etc., to improve the stability, economy and conversion efficiency of the multi-energy complementary system, so as to promote green environmental protection, low-carbon economy and sustainable development.

## 2. Multi-energy Complementary System Structure

The overall system control scheme is shown in Figure 1. It adopts three control modes: equipment layer, PLC coordination control layer and SCADA remote scheduling layer. For the equipment layer, each device has its own independent control system, which can disconnect the power output by itself in case of failure, and automatically control the operation by receiving the working mode issued by the PLC coordination controller when working; For PLC coordination control layer, PLC communicates with AC/DC converter, DC/DC converter or the controller of each unit through can/485, reads the parameters in the device, such as current, voltage, power and other data, and controls the operation mode of the device according to the control strategy; For SCADA remote scheduling layer, this layer mainly receives power prediction information, executes optimal scheduling strategy of the whole system, issues control commands through communication with PLC through ModbusTcp, and can remotely monitor data, store data, and control the operation mode of equipment. A touch screen is installed on site and the PLC is connected through Modbus Tcp to facilitate local monitoring and operation of the device. The whole equipment preferentially selects photovoltaic and wind power generation for power supply when the power generation is surplus, the priority is to charge the electrochemical energy storage equipment, and then hydrogen energy storage. When the power generation is insufficient, the electrochemical energy storage should supplement the power grid in time, and then start the electrolytic hydrogen generation. The overall control scheme is shown in Figure 1.

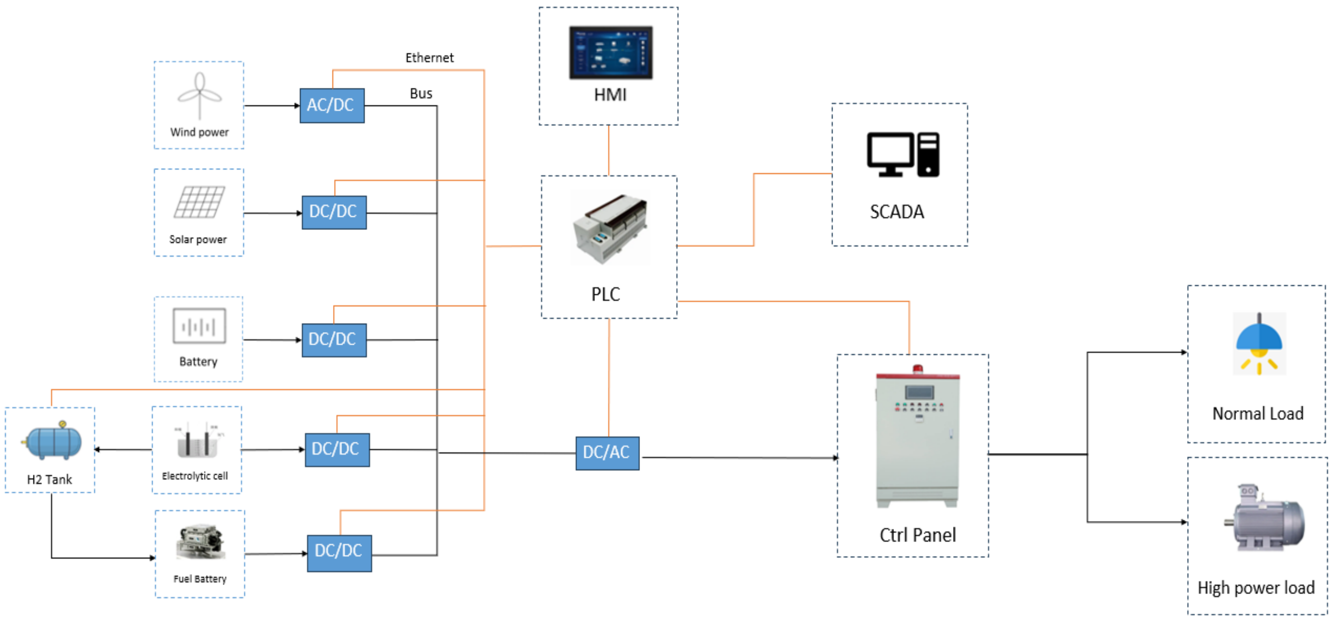


**Figure 1.** Multi-energy complementary microgrid system networking scheme

# 3. Multi-energy Complementary Micro-grid Collaborative Control Strategy

## 3.1. Multi-energy complementary microgrid collaborative control scheme

The main function of the cooperative control system is to maximize the power of the hydrogen production system on the premise of ensuring the stable operation of the system. According to the current wind power forecast information, SOC value of the energy storage system and other parameters, the power of each unit of the system is rationally allocated in a timely manner. The overall control principle is to rationally schedule the generation of wind power units and the charging and discharging state of energy storage units. Ensure the stability of the bus voltage and frequency value to maximize the output power of the hydrogen production system. The energy management system adopts a three-layer control architecture, which is divided into remote monitoring layer, energy management layer and field equipment layer, as shown in Figure 2 [4-5].

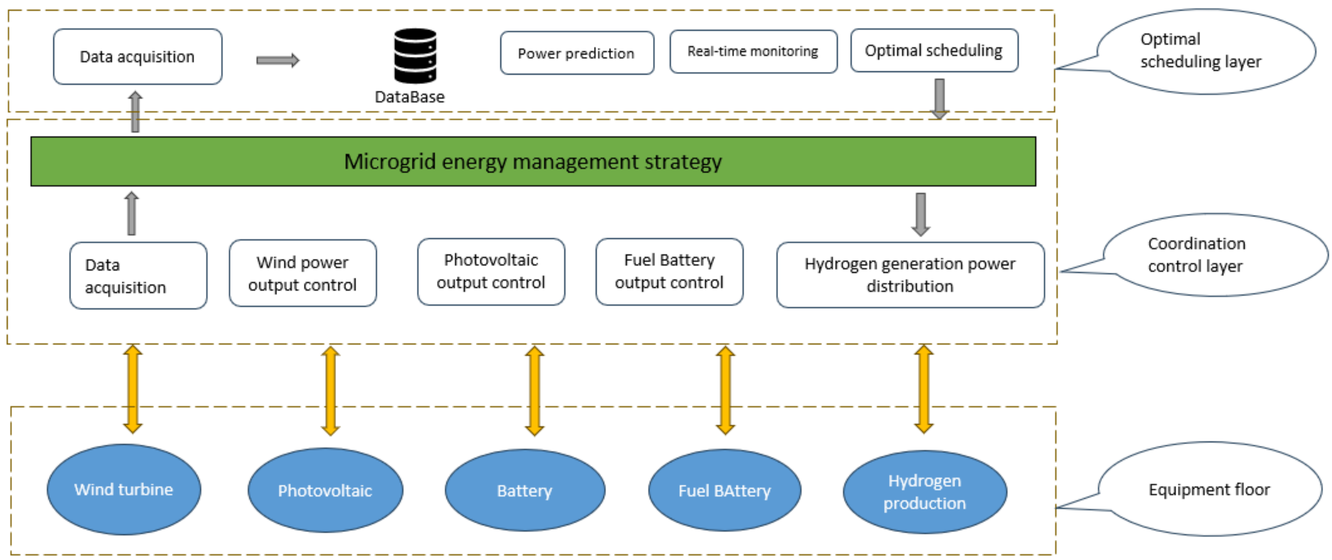


**Figure 2.** Collaborative control system architecture of multi-energy complementary microgrid system

## 3.2. Multi-energy complementary micro-grid collaborative control strategy

According to the DC bus voltage value, the system can be divided into the following operating modes: island balance operating mode, energy excess operating mode, energy insufficient operating mode. By monitoring the variation of bus voltage, different modes can be switched and the control methods of each unit converter can be changed.

### 3.2.1. Island balanced operation mode

When operating in isolated island mode, the load demand and the output power of wind power, photovoltaic power and wave power generation basically meet the balance of supply and demand, and small voltage fluctuations can be adjusted by energy storage. In order to avoid the service life of the electrochemical energy storage unit, small voltage fluctuations do not start the charge and discharge function of the electrochemical energy storage unit.

### 3.2.2. Excess energy operation mode

When the power of the system is greater than a certain value of the load power, the energy storage unit is first charged and absorbed, and then the power of the fan is limited to dynamically adjust the stability of the bus bar. If the energy storage system is in the charging state for a long time, and the charging power is greater than the set value, the system enters the energy excess operation mode.

### 3.2.3. Insufficient energy operation mode

When the system generation power is less than the load power set value, the electrochemical energy storage unit is first started to supplement, if the energy storage is in the discharge state for a long time, the system enters the power shortage operation mode. In this mode, if the fan and PV have power limits, the output power of the fan and PV is adjusted to match the system power generation and load demand, if the system power generation cannot meet the load demand, the fuel cell system is started to supplement until the system is balanced.

# 4. Simulation of Multi-energy Complementary Microgrid System

Based on the overall planning and design scheme, the electromagnetic transient simulation model of the system is built in PSCAD environment. The model includes the key subsystems of the system, such as wind electronic system, photovoltaic subsystem, hydrogen energy subsystem, etc. Based on the simulation model, the steady-state, dynamic and transient simulation of the system can be carried out.

## 4.1. System model building

The multi-energy complementary micro-grid system model is shown in Figure 5 [6-7]. The bus voltage of the system is 650VDC, the fan power is 200Kw double-fed wind generator, the photovoltaic array power is 200Kw, the energy storage system power is 80Kw/160kwh, the rated power of the hydrogen production system is 130Kw, and the hydrogen production capacity of the electrolytic cell is 20m³/h. The power of the fuel cell system is 80Kw, and the load is converted from direct current to 380V AC through an inverter, using resistors instead.

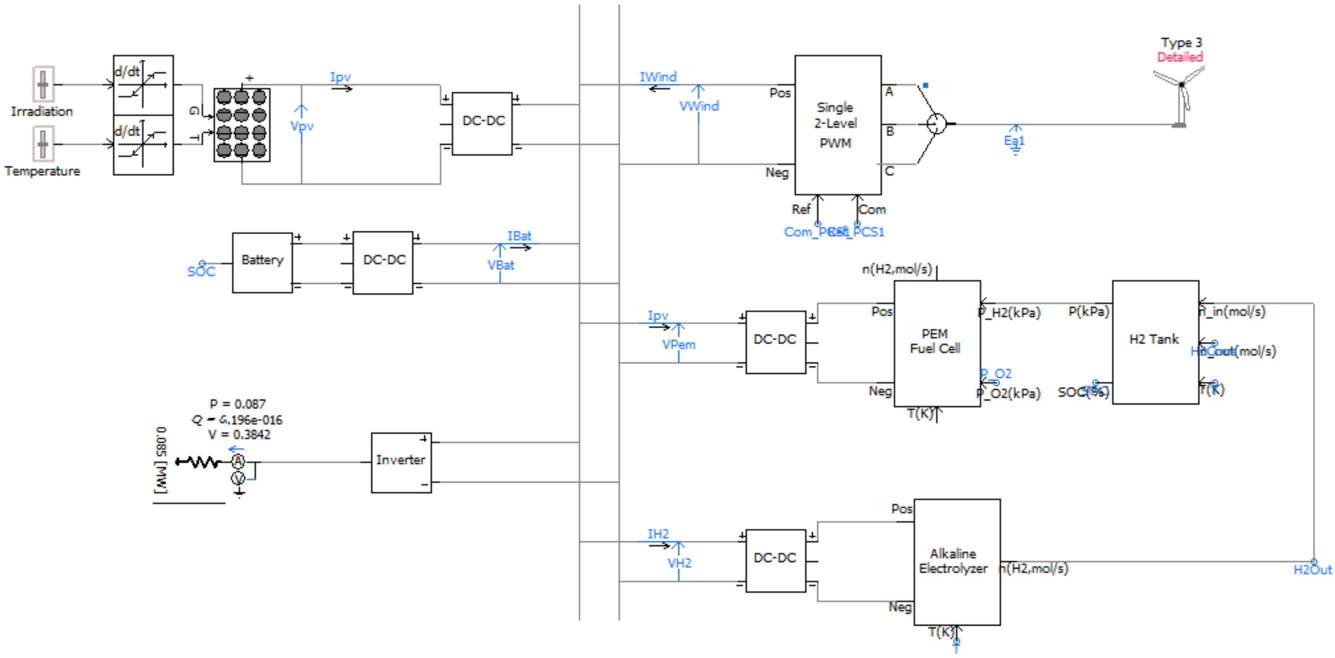


**Figure 5.** PSCAD simulation model of multi-energy complementary microgrid system

## 4.2. Example of system simulation

The steady-state operation characteristics of off-grid wind-solar hydrogen storage system are simulated. The energy storage capacity value in the simulation was set according to the approved energy storage capacity, and the initial value of the energy storage SOC was set to 100%. The applicability of the approved energy storage capacity was verified by the simulation. The simulation results are shown in Figure 6. According to the simulation results of the diagram, the photovoltaic subsystem and the wind power subsystem are not fully absorbed according to the output of lighting and wind resources within 24h. The energy storage subsystem controls a stable DC bus voltage, and its power varies with the power curve of wind power, photovoltaic power and load, with a maximum power of about 60kW; Dc bus voltage is stable. When the photovoltaic wind power output of the fuel cell system is greater than the load power, the hydrogen production system starts to produce hydrogen, when the photovoltaic wind power output is less than the load power, the hydrogen production system stops working, and the fuel cell system starts to generate power to maintain the power balance of the system. Based on the above analysis, the system and control strategy can meet the needs of stable operation of off-grid system.

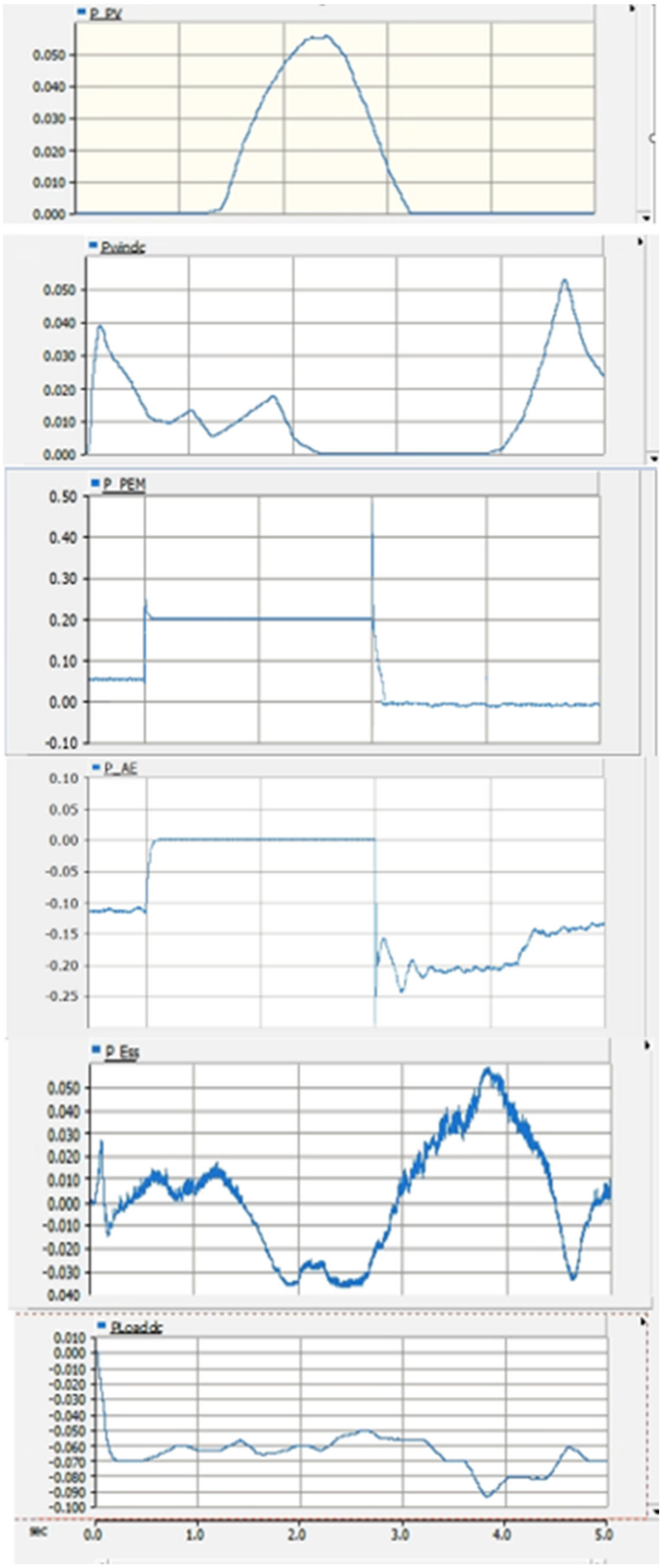


**Figure 5.** PSCAD simulation model of multi-energy complementary microgrid system

## 5. Conclusion

It can be seen from the simulation results that the multi-energy complementary microgrid system proposed in this paper can operate stably under the developed cooperative control strategy, and reasonably distribute the power of each unit according to the output and load power changes of wind power and photovoltaic systems, so as to maintain the power balance of the system and the stability of the bus voltage. To sum up, the multi-energy cooperative control strategy proposed in this paper is feasible.

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