Applied Energy Symposium
MIT A+B
Co-organized with Harvard

Emergency control method of industrial park integrated energy system based on energy conversion

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Abstract

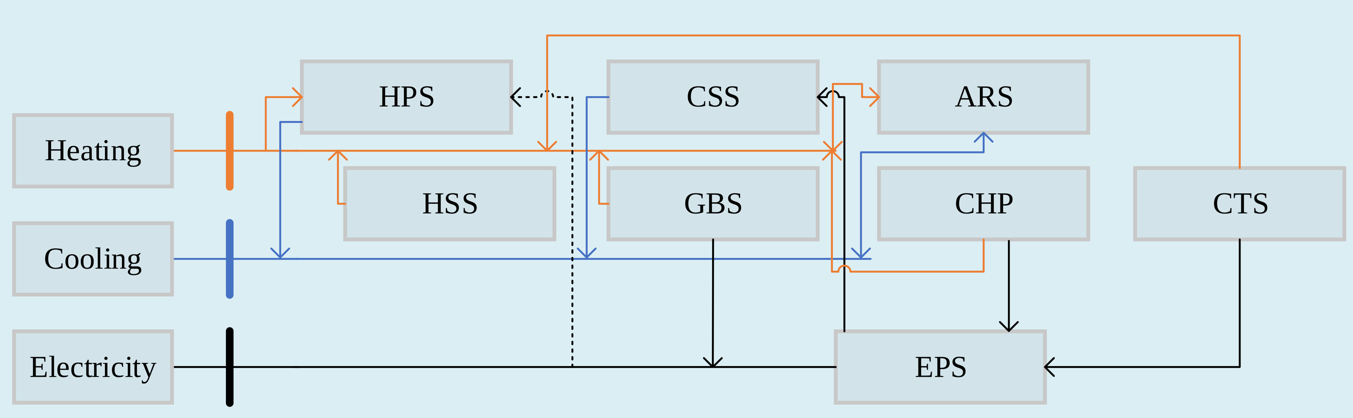
When failure occurs in the equipment layer of the integrated energy system and the energy supply system cannot meet the current energy requirements, the failure will rise from the equipment fault to the system fault. In order to solve this problem, a method in terms of emergency control based on energy conversion is proposed in this paper, which fully considers the characteristics of each energy supply system and its dynamical response. Firstly, the maximum power supply capacity of each energy system is evaluated based on the energy supply shortage. Then an optimal model with the aim of minimizing energy supply cost is built. Finally, based on the data of an industrial park, case studies are carried out to validate the effectiveness of the method.

Introduction

The integrated energy system (IES) will be the development direction of the energy field as an important part of the energy internet in the future. And IES has the advantages in energy conversion and utilization compared to the traditional power system, except for the electricity fault, there may be faults existing among the heating and cooling subsystem. Therefore, in order to ensure the reliability of energy supply of IES, it is necessary to conduct research on the emergency control with the consideration of different kinds of energy devices.

In the case of power system fault, the emergency control method can be divided into two categories: on the one hand the fault will be handled through the relay protection and emergency control method of the grid; on the other hand the emergency market is established to deal with the faults. Because of complicate relationship between the energy systems, it is difficult to establish the emergency market and the unified measurement of energy data. In summary, there are relatively few researches on emergency control for IES.

Maximum Energy Supply Capacity



HPS:Heat pump air conditioning power supply system
CSS:The cooling storage system
ARS:Absorption refrigeration system
GBS:Gas boiler system
HSS:Heat storage system
CHP:Combined heat and power
CTS:Condensing turbine system
EPS:Electrical power system

Fig. 1 .Schematic diagram of energy supply coupling of each energy supply system and equipment

A. The first type of heating and cooling energy supply system

$$P_{ES,\max} = \begin{cases} P_{ES0}, & (a) \\ \rho \cdot C \cdot f_v \cdot T_{am} - C \cdot m \cdot \dfrac{\Delta(T_{ac} - T_{am})}{\Delta t}, & (b) \end{cases}$$

B. The second type of heating and cooling energy supply system

$$\begin{cases} P_{ES,\max} = \begin{cases} P_{ES0}, & (a) \\ f_m \cdot h_{steam} \cdot T_{ac}, & (b) \end{cases} \\ \Delta P_B = f_m \cdot h_{steam} \cdot (T_{am} - T_{ac}) \end{cases}$$

C. Energy balance constraint

$$P_{HPS} + P_{CSS} \cdot \lambda_{CSS} + P_{ARS} = P_C$$

$$P_{GBS} \cdot \lambda_{GBS} + P_{HSS} \cdot \lambda_{HSS} - \frac{P_{ARS}}{\lambda_{ARS}} + P_{CHP} - P_{CTS} = P_H$$

$$\frac{-P_{HPS}}{\lambda_{HPS}} + \frac{P_{CHP}}{\lambda_{CHP}} + P_{GBS} \cdot \lambda_{GBS} + P_{ES} + P_{EPS} = P_E$$

Emergency Control Based on Energy Conversion

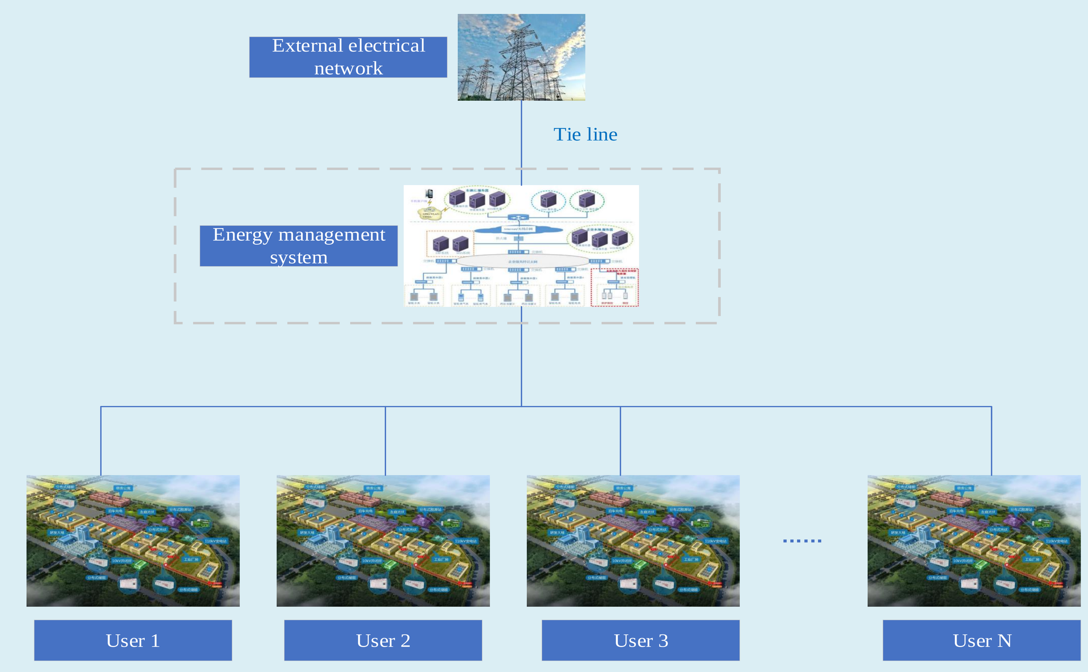


Fig. 2 . Schematic diagram of the industrial park

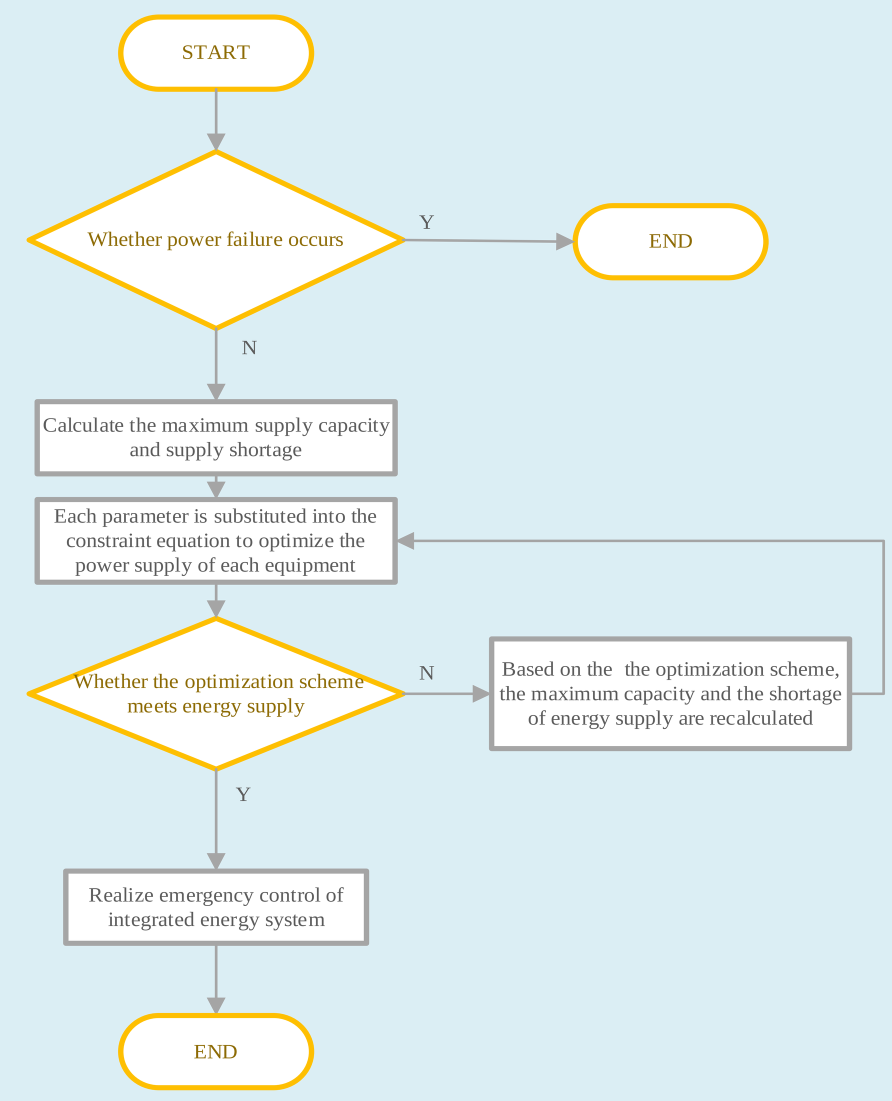


Fig. 3 . Emergency failure control flow chart

Normal Running Status

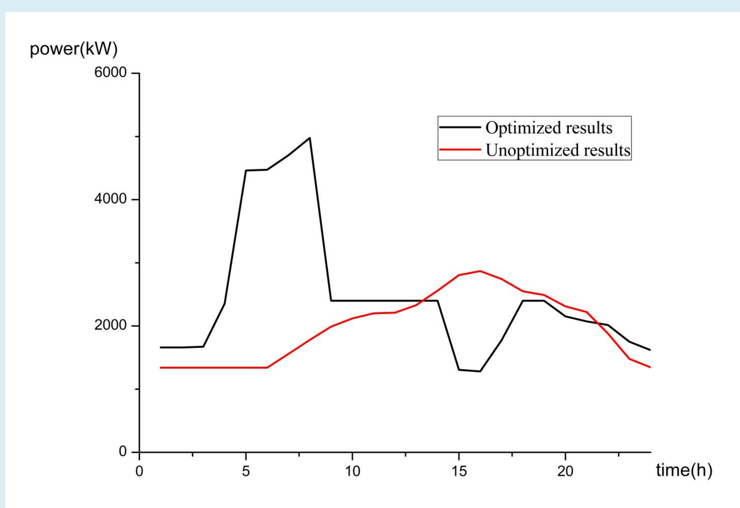


Fig. 4 . Tie line power

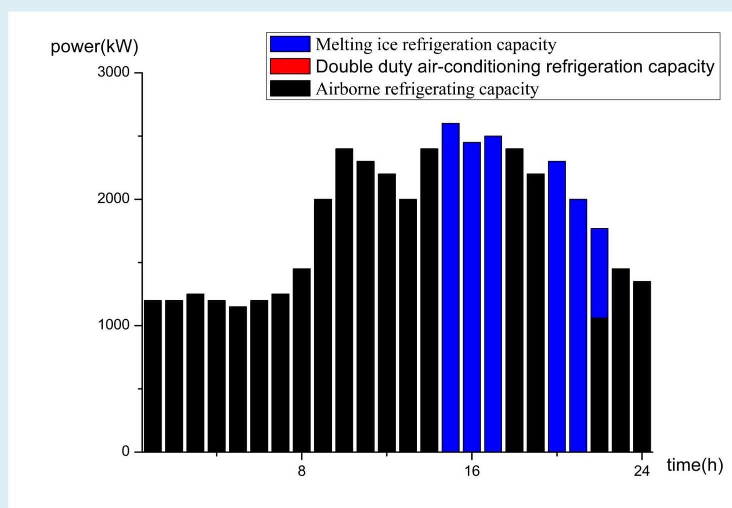


Fig. 5. The optimized results for normal state

Emergency Control for the Fault

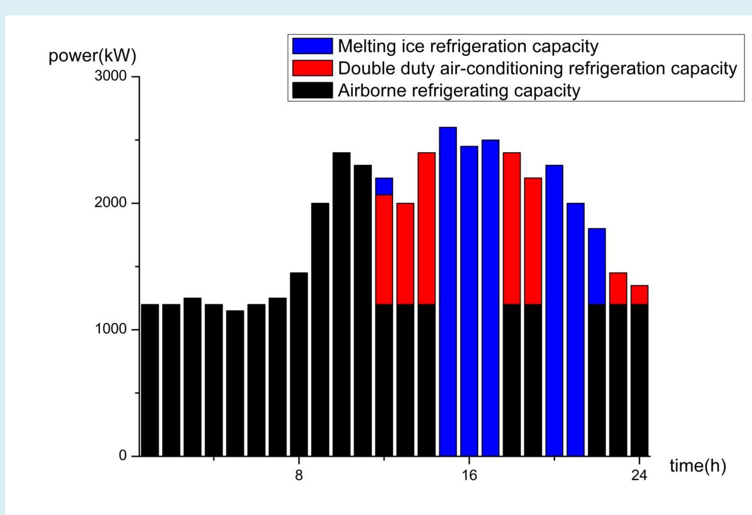


Fig. 6. The control results for the fault

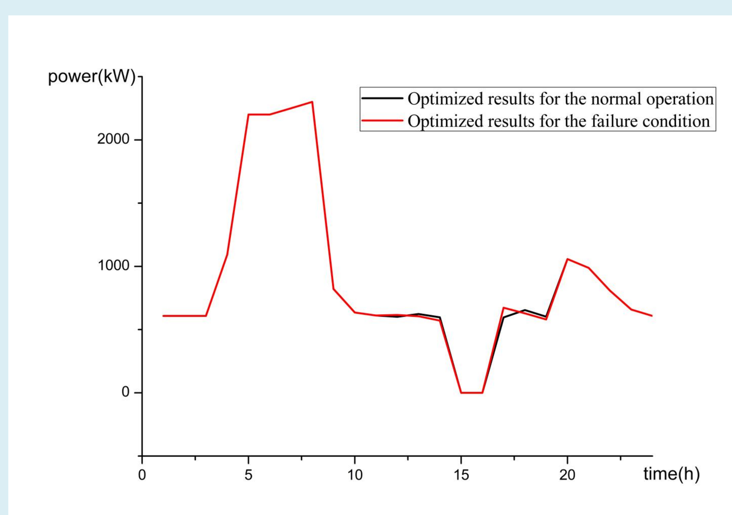


Fig. 7. Comparison of the electricity purchase

Conclusion

In this paper, the maximum supply capacity of each energy system is evaluated based on the energy supply shortage and a method in terms of emergency control and energy conversion is proposed. The emergency control regards economy as the optimal objective can come true the energy conversion and provide economic optimal operation strategy. By the emergency control, each energy system can adjust its own output in terms of its own energy supply shortage and constraints, ensure the stable supply and economic optimum.