Paper Review

Collaborative Optimization of PV Greenhouses and Clean Energy Systems in Rural Areas

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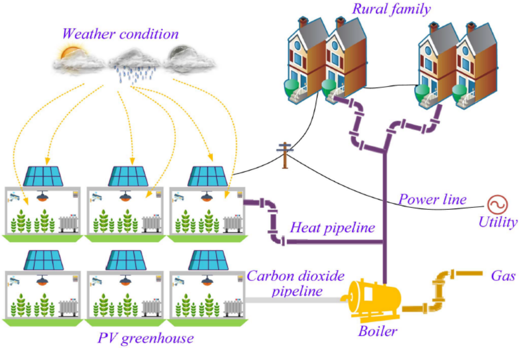
Abstract

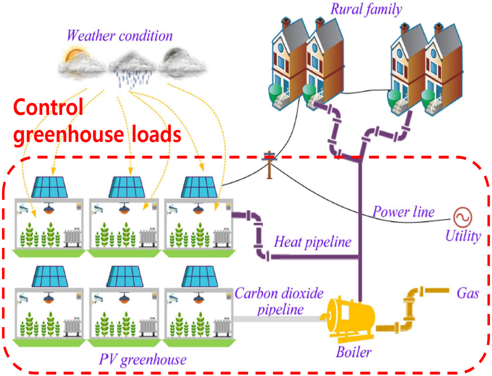


- optimize green house energy consumption
- considering photosynthesis, carbon emissions, economic costs
- can save 15% on total costs

Motivation

- considerable research has been devoted to industrial integrated energy systems (IESs), less attention has been given to rural IESs
- PV greenhouse can absorb carbon dioxide, when energy supply ensures crop photosynthesis
- light, temperature, and carbon dioxide can be regulated to supply energy for crop photosynthesis

Problem distribution



- meets the needs of crop growth in different weather
- improves the economy and low-carbon performance

optimal control of greenhouse loads

$$\min f_{\text{obj}}(I_{\text{set}}, T_{\text{crop}}, C_{\text{crop}}) = \sum_{i=1}^{24} (P_{\text{grid}}(t) \cdot E_{\text{gird}} + P_{\text{loss}}(t) \cdot E_{\text{gird}}$$
$$+ V_{\text{gas}}(t) \cdot E_{\text{gas}} - P_{\text{pvup}}(t) \cdot E_{\text{PV}}$$
$$- M_{\text{CO}_2}(t) \cdot E_{CO_2}), \qquad (40)$$

[Eq 1. objective function of the rural energy system]

- light intensity(I_{set}), temperature (T_{crop}), and carbon-dioxide concentration (C_{crop}) are the decision variables

- I_{set} can be regulated by supplemental light
- T_{crop} can be regulated by a radiator
- C_{crop} can be regulated by gas boiler

- Particle swarm optimization (PSO) is applied
  - PSO algorithm is a method for finding the optimal solution in the search space

optimal control of greenhouse loads

$$I_{\min} \le I_{\text{set}} \le I_{\max},$$

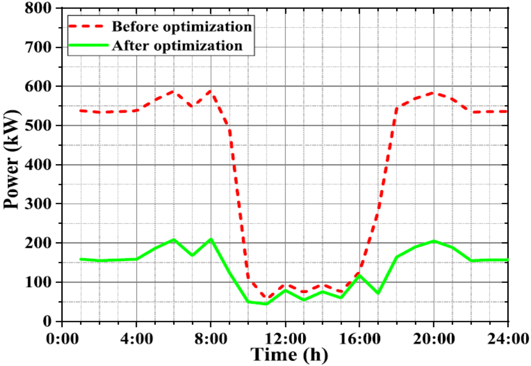
$$T_{\min} \le T_{\text{crop}} \le T_{\max},$$

$$C_{\min} \le C_{\text{crop}} \le C_{\max};$$

[Eq 2. constraints of the greenhouse]

- constraints on the decision variables define the search space
- constraints for each decision variable are conditions that can optimize the greenhouse load
- makes decisions considering the constraints
  - If the solar irradiance decreases, and the use of supplemental lighting is determined

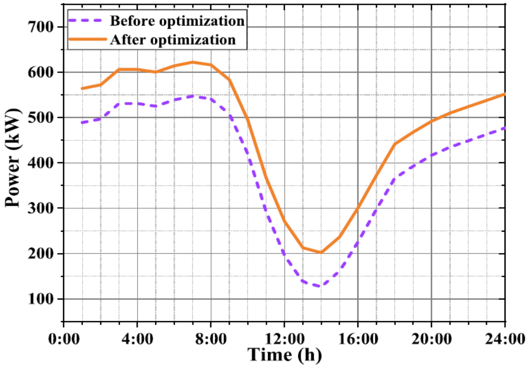
Results



[Fig 1. Comparison of power-load]

- daily power consumption saved by optimization is 6416kWh

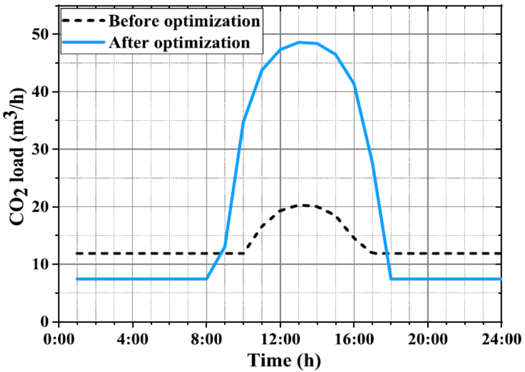
Results



[Fig 2. Comparison of heat-load]

- daily gas purchase cost slightly increased

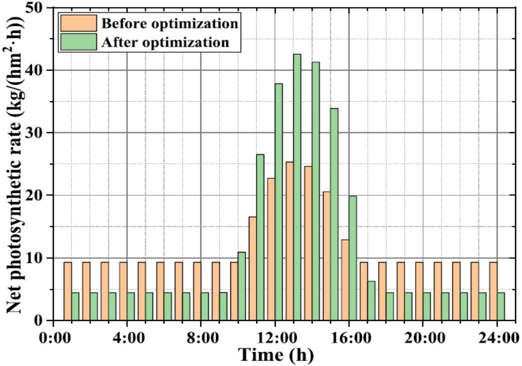
Results



[Fig 3. Comparison of carbon-dioxide consumption]

- total consumption of carbon dioxide after optimization is greater than before
- carbon consumption has been enhanced

Results



[Fig 4. Net photosynthetic rates of greenhouse]

- if the net photosynthetic rate is higher than before, operation cost will increase
- maintains the photosynthetic rate while reducing energy costs

Results

TABLE VIII
ENVIRONMENTAL AND ECONOMIC PERFORMANCE BEFORE AND AFTER OPTIMIZATION

Microclimate	Before optimization (Traditional)	After optimization (Proposed)
Carbon reduction with photosynthesis	639.57 kg	900.45 kg
Carbon reduction with PV generation	307.02 kg	307.02 kg
Daily power purchase cost	43840 CNY	34059 CNY
Daily gas purchase cost	16450 CNY	17724 CNY
Daily energy loss	1732 CNY	945 CNY
Sales revenues of PV	-137.47 CNY	-154 CNY
Carbon benefit	-26.5 CNY	-34 CNY
Total cost	61858 CNY	52540 CNY

[Table. Comparison of Economic Performance]

- proposed method saves total energy costs

Conclusion

- optimizes energy management strategies in PV greenhouses, maintaining the crop photosynthesis rate while reducing costs
- contributes to reducing greenhouse gas emissions

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"Thank you for listening"
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