Research on Energy Storage Capacity Allocation Technology of PV-Storage Microgrid for Balancing Source-Load Power

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Abstract

The low matching degree of photovoltaic output and load in the pv-storage microgrid will reduce the reliability of its power supply. Therefore, it is necessary to configure a certain capacity energy storage device to support source-load balance. This article first analyzes the impact of different load configurations and application scenarios on energy storage configuration, and then proposes an energy storage capacity configuration scheme with the minimum operating cost of the microgrid as the objective function and the constraints of the minimum power fluctuation in the network, and uses an improved particle swarm algorithm solve the solution. Finally, a numerical example is used to verify that the solution can stably support the source-load balance in the microgrid, reduce the power exchange at the common connection point of the microgrid, and improve the microgrid's own power supply capacity.

Objective function

$$C_{\text{total}} = C_{\text{tz}} + C_{\text{th}} + C_{\text{wh}} + C_{\text{grid}} - C_{\text{pv.sub}}$$

$$C_{\text{tz}} = (C_{\text{pv}}E_{\text{pv}} + C_{\text{bat}}E_{\text{bat}} + C_{\text{fuel}}E_{\text{fuel}}) \times \text{r}$$

$$C_{\text{th}} = \frac{C_{\text{thbat}}}{L_{\text{bat}}}$$

$$C_{\text{wh}} = C_{\text{tz}} \bullet \text{K}_{\text{wh}} + C_{\text{fuel}}$$

$$C_{\text{grid}} = \text{E}_{\text{grid.in}} C_{\text{grid.buy}}$$

$$C_{\text{pv,sub}} = E_{\text{pv}} C_{\text{pv.sub}}$$

Restrictions

$$P_{\text{pv1}}(t) + P_{\text{Nbat}} \bullet \eta + P_{\text{Nfuel}} \geq P_{\text{load}}(t)$$

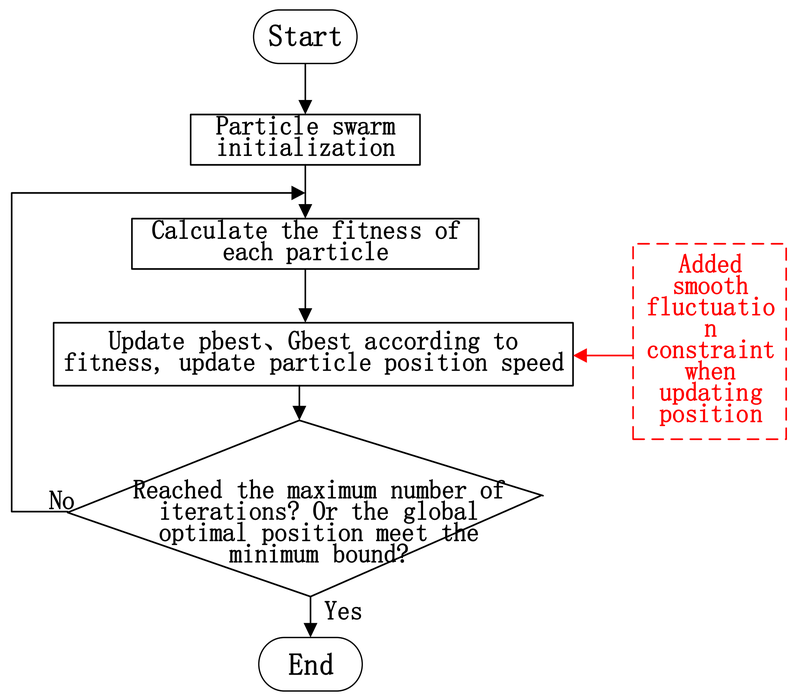
$$[P_{\text{pv1}}(t) + P_{\text{Nbat}} \bullet \eta + P_{\text{Nfuel}} - P_{\text{load}}(t)] \leq 0.01$$

$$P_{\text{bat}}(\text{t}) \geq 0 \quad E(t) = E(t-1) + \eta_{\text{c}} P_{\text{bat}}(t)\Delta\text{t}$$

$$P_{\text{bat}}(\text{t}) \leq 0 \quad E(t) = E(t-1) + \frac{P_{\text{bat}}(t)\Delta\text{t}}{\eta_{\text{d}}}$$

$$SOC_{\text{min}} \bullet E_{\text{bat}} \leq E(t) \leq SOC_{\text{max}} \bullet E_{\text{bat}}$$

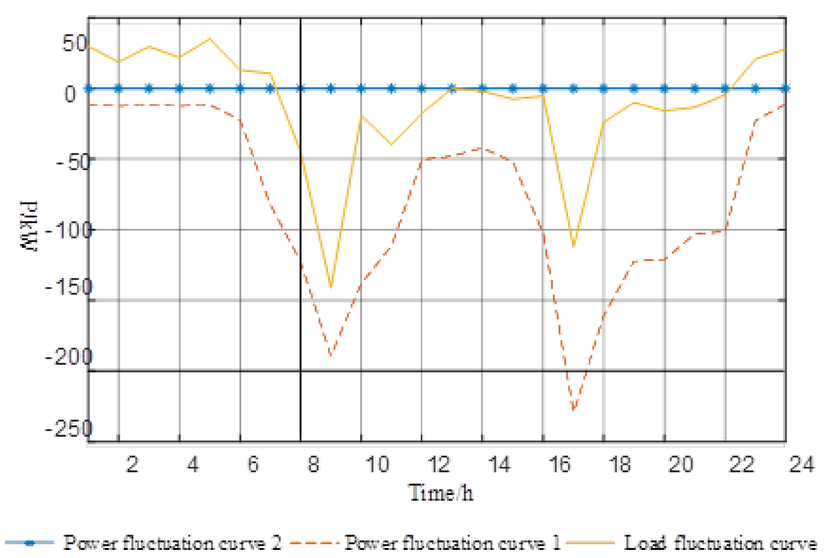
Solving Algorithm



Results

Method 1: Only the energy storage capacity allocation plan that aims at the lowest operating cost of the microgrid.
Method 2: With the lowest operating cost of the microgrid, limit the distribution network to transmit power to the microgrid. Case a of Method 2: The distribution network supplies a maximum power of 150kW to the microgrid, and the diesel power generation strategy is adopted first when the power of the microgrid is insufficient. Case b of Method 2: The distribution grid does not transmit power to the microgrid, leaving the microgrid off-grid.
Method 3: The energy storage capacity allocation plan with the lowest operating cost of the microgrid and smooth power load at the load point.

Configuration	Diesel generator average output (kW)	Distribution network average output (kW)	Energy storage capacity (kW)	Fluctuation average power (kW)	Daily operating expenses (million yuan)
Method 1	24.701	36.41	423	6.0489	3.832
Case a of Method 2	23.4517	64.0681	313.12	0.1898	7.770
Case b of Method 2	27.1323	-1.6353	1054.2385	14.2474	9.961
Method 3	24.2818	46.13601	227.254	0.004039	5.563



Conclusion

In this paper, through research on the energy storage capacity allocation technology of pv-storage microgrid, the following conclusions are drawn:
(1) The matching degree of source load output is high, and the required allocation capacity of energy storage is low; the matching degree of source load output is low, and the required allocation capacity is large.
(2) By limiting the output of the distribution network, the effect of using energy storage to balance the source load can be achieved, and using the energy storage to balance the source load can improve the microgrid's own power supply capacity, and the economy is better.
In summary, this paper comprehensively considers the load type, energy storage capacity, distribution network power supply situation, diesel generator operation situation, and power fluctuation situation, and proposes a configuration scheme that guarantees the system‘s economics and stability at the same.