

# Day-ahead-real-time Market Transaction Rolling Optimization Mechanism based on System Security Operation Constraints

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**Abstract.** Under the "dual carbon" goal and background, as the scale of investment and construction of new energy projects and grid-connected transmission continue to increase, the safe operation of the power system and power market transactions will usher in new opportunities and challenges. Based on the micro-grid Day-ahead-real-time market two-stage transaction design theory, this paper proposes a micro-grid Day-ahead-real-time market two-stage rolling adjustment optimization transaction mechanism based on system security operation constraints, and briefly analyzes the income situation.

**Keywords:** New Energy Power Generation; Safe Operation; Day-ahead-real-time Market; Two-stage Rolling Optimization; Income Situation.

## 1. Introduction

In the context of carbon peak and carbon neutrality goals, the research of microgrid dispatching mainly focuses on the uncertainty processing of renewable energy, multiple time scales, and multiple energy forms. It mainly focuses on the internal resource output arrangement and optimal economy of microgrid. In the issue of market mechanism, electricity price is the basis and core factor of electricity market transactions. The electricity price determined by the market can ensure that the electricity price is rationalized and effective in the transaction link, and can ensure that the electricity price correctly reflects the actual value of electricity in the production and transaction. The current electricity price forecast can provide a basis for decision-making in the bidding of power generators and electricity sales companies in the spot market. Accurate day-ahead electricity price forecasts can greatly reduce the price risks faced by market participants and bring them stable returns. For this reason, it is necessary to study the dispatching problem of microgrid as the main power seller participating in the spot market. Based on the results of day-ahead and real-time microgrid internal wind/light/load forecasts, a two-stage revenue model for microgrid internal energy storage, diesel generation, demand response, day-ahead market and real-time market is established. In addition, considering the impact of the day-ahead quotation curve and the transfer of income from the deviation spread on the real-time market dispatch of the micro-grid, the optimal output plan for a variety of adjustable resources in the micro-grid is provided.

## 2. System Security Constraint Mechanism

This paper considers an optimized rolling mechanism based on system security constraints, considering system line loss and abandonment of wind and light, effectively maintaining the stability of the transmission power of the microgrid tie line, and meeting the strict deviation assessment requirements of the electricity market. In order to promote the consumption of new energy, this paper adds the tracking targets of line loss and abandoning wind and light to the traditional MPC. With the goal of minimizing the power adjustment of the tie line, while ensuring that the error between the actual controllable unit output value and the real-time adjusted power value is minimized, the MPC-based optimal power flow problem is converted into a quadratic nonlinear programming model.

$$\min x_j = \sum_{m=1}^M \| P_{j+m|j} - \hat{P}_{j+m|j} \|_Q^2 + \| P_{j+m|j}^{loss} + P_{j+m|j}^{waste} \|_w^2 \quad (1)$$

In the formula:

$$\begin{cases} P_{j+m|j} = P_{j0} + \sum_{t=1}^m \Delta u_{j+t|j} \\ P_{j+m|j} = [P_{j+m|j}^{grid}, P_{i,j+m|j}^T, P_{k,j+m|j}^T]^T \\ \Delta u_{j+m|j} = [\Delta P_{j+m|j}^{grid}, \Delta P_{i,j+m|j}^T, \Delta P_{k,j+m|j}^T]^T \end{cases} \quad (2)$$

The first term in the formula:  $M$  represents the predictive control step length.  $Q$  is the weight matrix of the error of the controllable unit's effort to track the reference value. In order to avoid the power deviation assessment and punishment in the power market, the weight coefficient of the set connection line is much larger than the controllable micro-source and battery energy storage, and it is related to the deviation penalty electricity price.  $P_{j+m|j}$  represents the active output value vector of each controllable unit planned for the future  $j+m$  period at time  $j$ .  $\hat{P}_{j+m|j}$  represents the reference value of active power output at time  $j+m$ .  $\Delta u_{j+t|j}$  is the time  $j$  to plan the change in the active output of each controllable unit in the future  $j+m$  period. Two terms in the formula: optimizing the actual line loss of the microgrid and abandoning the wind and abandoning the optical power, the purpose is to absorb the wind and wind power and reduce the line loss as much as possible.

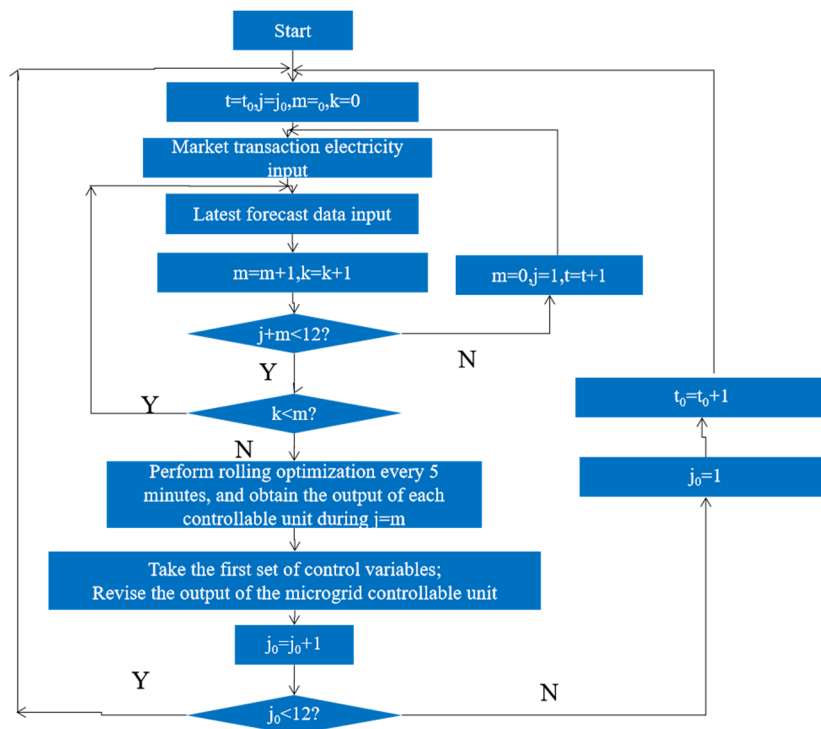


Figure 1. Optimized rolling solution process based on system security constraints

### 3. Day-ahead-real-time Two-stage Rolling Optimization Mechanism

(1) A day-ahead market clearing mechanism based on the microgrid aimed at the best operating efficiency. As a market entity, the microgrid participates in day-ahead energy trading, and formulates

the optimal economic arrangement for the next day based on the day-ahead market electricity price, user load, and forecasts of wind and solar power generation. Sell electricity to the market when its own power generation is surplus, and buy electricity when it is insufficient, and settle the settlement according to the electricity market clearing price before the day. In order to avoid the phenomenon of abandoning wind and light, this article regards the microgrid as the price receiver, and improves the system's absorption capacity through grid-connected operation. Sell electricity to the market when its own power generation is surplus, and buy electricity when it is insufficient, and settle the settlement according to the electricity market clearing price before the day. In order to avoid the phenomenon of abandoning wind and light, this article regards the microgrid as the price receiver, and improves the system's absorption capacity through grid-connected operation.

In the microgrid market operation that takes into account demand response, the goal of the microgrid daily dispatch plan is to maximize the daily operating revenue of the system. Among them, the daily operating income of the microgrid includes: trading income with the electricity market  $R_t^{MA}$  and electricity sales income to load users  $R_t^{LD}$ ; the daily operating costs of the microgrid include: operating costs and start-up costs of various distributed micro-power sources  $C_t^{CG}$ , wind power and photovoltaic operation and maintenance costs  $M_t^{DG}$ , battery energy storage depreciation costs  $C_t^{ES}$ , user demand-side response compensation costs  $P_t^{DR}$ .

$$\max R_{profit} = \sum_{t=1}^{NT} (R_t^{LD} + R_t^{MA} - M_t^{DG} - C_t^{ES} - P_t^{DR}) \quad (3)$$

In the formula:

$$R_t^{LD} = \pi_t^{ret} (D_t - P_t^{LC2}) \Delta T \quad (4)$$

$$R_t^{MA} = \pi_t^{DA} P_t^{DA} \Delta T \quad (5)$$

$$C_t^{CG} = \sum_{i=1}^{N_G} [C(P_{i,t}) + C_{i,t}^{UCD}] \quad (6)$$

(2) A real-time market clearing mechanism based on the microgrid aimed at optimal economic benefits.

Due to the influence of forecast errors, the microgrid needs to continuously update the forecast values of load and wind and wind power, and make real-time power adjustments to the daily dispatch plan. As a useful supplement to the day-ahead market, the real-time balance market is an effective way to improve the power balance of the system by using market adjustment methods to balance the deviation of power supply and demand in the operation of the power grid. Therefore, microgrid operators can reduce real-time adjustment costs and promote the consumption of intermittent energy by participating in the real-time market, predicting real-time electricity prices and formulating reasonable electricity transactions.

(3) After the day-ahead market is cleared, the microgrid's day-ahead revenue has been determined, and the real-time market dispatch is based on the day-ahead revenue and considers real-time market price fluctuations and deviated revenue return to the decision-making internal resources. The microgrid revenue after the market cleared a few days ago is:

$$R_{clear}^{DA} = \sum_{t=1}^{24} (P_{sell}^{DA}(t) E_{sell}^{grid} - P_{buy}^{DA}(t) E_{clear}^{DA}(t) + P_{load}^{DA}(t) P_{sell}^{load}) - C_{st}^{DA} - C_{die}^{DA} - C_{dem}^{DA} \quad (7)$$

Where:  $R_{clear}^{DA}$  is the day-ahead market revenue of the microgrid after the day-ahead market is cleared;  $E_{sell}^{grid}$  is the day-ahead market clearing price.

The return of deviation income and the constraints are:

$$C_{dev}(\varpi) = \sum_{t=1}^{24} abs(E_{\varpi}^{DA}(t) - E_{\varpi}^{RT}(t))l_{\varpi}(t) \tag{8}$$

$$g^{RT} = \frac{1}{N} \sum_{\varpi=1}^N (R^{RT}(\varpi) - C^{RT}(\varpi) - C_{dev}(\varpi)) + \mu^{RT} (\varepsilon - \frac{1}{N(1-\beta)} \sum_{\varpi=1}^N q_{\varpi}) - R_{clear}^{DA} \tag{9}$$

#### 4. Conclusion

Based on explaining the micro-network Day-ahead-real-time market two-stage transaction design theory, this paper proposes a micro-network Day-ahead-real-time market two-stage rolling adjustment optimization transaction mechanism based on the system's safe operation constraints. Establish a pricing mechanism that fully considers information asymmetry in the day-ahead market to provide a reference basis for new energy market bidding, operational decision-making, and economic feasibility assessment, and greatly reduce the cost of Day-ahead-real-time market transaction error adjustment. By constructing a Day-ahead-real-time market clearing model, new energy entities can actively declare real information, which can effectively encourage new energy units to actively participate in the market and significantly reduce the impact of market power. At the same time, increase the scalar quantity of new energy units in the market and reduce the loss caused by frequent changes in output of conventional units. At the same time, it guarantees system security, reduces the cost of generating electricity for new energy units, satisfies the interests of both supply and demand, further enhances the real-time liquidity of the power market, and promotes system power balance. It is helpful to improve the consumption capacity of microgrid distributed renewable energy, realize the maximum benefit of microgrid operators and the effective operation of internal and external trading markets.

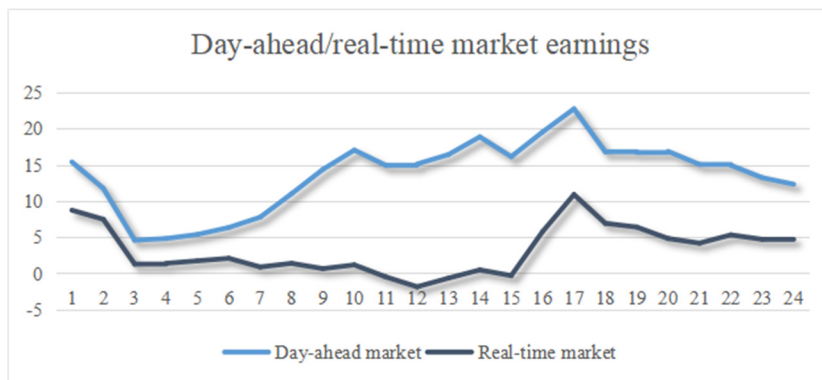


Figure 2. Day-ahead/real-time market earnings

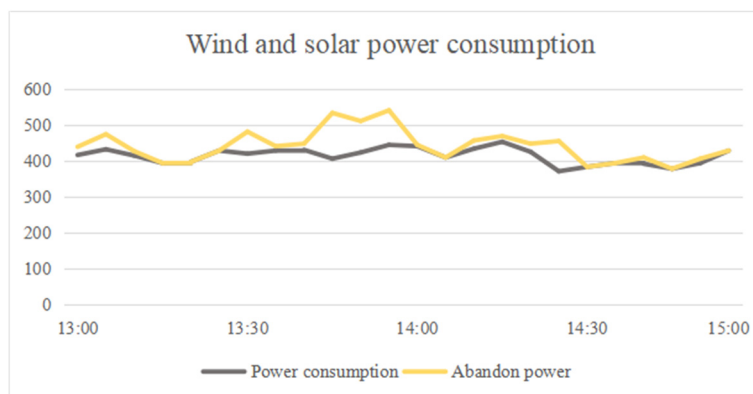


Figure 3. Wind and solar power consumption

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