Electricity Market Reform Support Through Enhanced Power Transaction Model: In Relation to Optimization in Applied Mathematics

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Abstract-- Given that the electricity trading market has been specified, some of the growing demands include the establishment of long-term mechanisms, the improvement of electric power emergency mechanisms, and the strengthening of electric power demand side. Therefore, this study proposed a model for optimizing the planning of the monthly power generation. Specifically, the grey model algorithm was examined to discern some of the improvements that could be implemented. With the energy conservation development direction and the market considered, the research setting involved a regional power grid dispatch management system. A key parameter that was examined involved the monthly free energy conservation strategy and how the rate of short-term energy saving establishment could be improved. From the findings, it was evident that the proposed model for optimizing energy-saving power generation establishments poses beneficial effects in terms of power generation scheduling and improved resource allocation, hence meeting the electric power market reform needs.

1. Introduction

As the power grids’ emission-reduction and energy-saving deepen, one of the major demands in the power industry involves improvements in the grid power generation planning [1]. The energy-saving scheduling algorithm has gained increasing application relative to domestic energy-saving power generation dispatch [2, 3]. This algorithm has been observed to optimize short-term power generation plans [4, 5]. Despite this promising role of the algorithm, it remains notable that the practical operation and laws of energy-saving power generation dispatching, it is only after combining new energy utilization and development trends that better scheduling outcomes could be obtained [6-8], having established a monthly energy-saving power generation dispatch framework [9, 10].

Imperative to note is that the energy-saving power generation dispatch reflects a unit combination problem. Currently, foreign and domestic research outcomes targeting the long-term annual energy planning and short-term daily power generation planning have been documented [6-9]. In particular, most of the previous scholarly investigations have focused on various power generation frameworks that inform the scheduling of the power generation process. To ensure that the limitations and short-term nature of the previous energy-saving power generation dispatching models are solved, this study proposed a monthly dispatching framework that could guide and optimize the outcomes of energy-saving power generation. The proposed framework was that which would assure safe power grid operations and also support the realization of the two optimization goals of emission reduction and energy saving – by considering and accounting for the parameter of coal-fired power consumption measurement technologies. The motivation was to establish a model that would allocate power resources optimally, given a monthly span. Also, the study strived to develop an optimization
framework through which the emission-reduction and energy-saving effects might be improved in the target power generation plans.

2. Methodology
For the monthly plan, major variables that were considered included the achievement of clean, economical, safe power grid dispatch operation, coordinate the resources of power generation in relation to the power grid’s future operation control, develop the overhaul plan for the transmission and generation of power, and investigate the cost of purchasing electricity outside and within a given region; besides predicting the monthly demand for electricity. For each functional module in the selected plan for power dispatching generation, functions were optimized to discern the degree to which they could yield stability, safety, and orderliness for the whole plan involving short-term and long-term power grid dispatching in the entirety. To ensure that the entire operation and dispatching process of the power grid was optimized, the study combined different incoming water plans, maintenance plans, and fuel plans. Upon combing and considering these factors, the proposed framework sought to improve the entire grid's economic efficiency.

The study combined a grey model checking algorithm GM (1, 1) after considering a sliding average algorithm, an exponential soothing algorithm, and the grey model prediction algorithm. The algorithmic process was summarized in the form:

\[
\chi^{(n)} = [\chi^{(n-1)} | k = 1, 2, ..., n] \quad (n=0, 1)
\]

\[
\chi^{(n)}(k) = \sum_{i=1}^{k} [\chi^{(n-1)}(i)]
\]

\[
A = \begin{bmatrix}
-\frac{1}{2} [\chi^{(1)}(1) + \chi^{(1)}(2)] & 1 \\
-\frac{1}{2} [\chi^{(1)}(2) + \chi^{(1)}(3)] & 1 \\
\vdots & \ddots \\
-\frac{1}{2} [\chi^{(1)}(n-1) + \chi^{(1)}(n)] & 1
\end{bmatrix}
\]

For each month, a power balance situation was determined before establishing the system power supply surplus by developing a monthly unit combination scheme. The parameter that was considered at this stage entailed the system reserve capacity.

3. Results and Discussion
The simulation and analysis of the monthly scheduled optimization was achieved by considering the coal-fired units’ average coal consumption, the unit load rate, and the start-stop status of the unit. The two sets of major generating units that were considered had their capacities set at 100MW and 600MW. From the data simulation procedure, the case of the 1000MW unit saw a slightly higher average load factor obtained compared to the case of the equalized dispatch model. In a case where small capacity
units were maintained, the system’s peak pressure was achieved. For the case of the 600MW unit, there was low average load rate every day and the outcomes were similar to the values for the 1000MW unit’s average load rate. When the actual scheduling mode was considered, there was slightly higher average load factor compared to the equalized dispatch framework.

Another context that was considered involved the case of the optimal scheduling mode. In this scenario, the 600MW class unit had its load factor improve greatly. However, certain peak pressure in the system caused the 1000 MW unit’s average load rate to be slightly lower.

| model                | Total coal consumption (10kt) | Average coal consumption (g/kWh) | Total coal saving (10kt) | Coal savings per unit (g/kWh) | Coal saving rate |
|----------------------|-------------------------------|---------------------------------|--------------------------|-------------------------------|-----------------|
| Balanced scheduling  | 545.2                         | 311.09                          | --                       | --                            | --              |
| Actual scheduling    | 538.9                         | 307.51                          | 6.3                      | 3.58                          | 1.15%           |
| Improved scheduling  | 521.0                         | 297.25                          | 24.2                     | 13.84                         | 4.45%           |

Table 1: Summary of the research outcomes relative to improved scheduling and coal-savings per unit

It is also worth noting that the study investigated the performance of the proposed model from the perspective of the balanced dispatch model. Whereas there was similarity regarding the use of the individual unit levels, the grid’s energy saving reduced. A factor that accounted for this trend involved power generation balance. It is also worth noting that in this mode, the grid’s average coal consumption was the highest. The specific value that was attained was 311.0900 g/kWh. When the actual dispatch mode was examined, there was no optimization of the start-stop condition. However, there was adjustment of the start-up unit’s load factor. Compared to small units, large units’ load rate was higher. In the model, the rate of coal saving reached 1.1500% while 307.5100 g/kWh was recorded as the power grid’s average consumption of coal. When the optimal dispatching mode was considered, small units were associated with the system’s peak load pressure. When the system’s outage was utilized in the form of small capacity units, there was a significant reduction in the utilization rate. In the model, the grid’s average consumption of coal was recorded at 297.2500 g/kWh. Compared to the balanced rate of coal consumption, the results stood at 4.4500%. Hence, there was full utilization of the power grid’s energy-saving potential.

4. Conclusion

From the analytical outcomes that were obtained after applying the proposed framework to monthly energy-saving generation scheduling, the model on the focus strived to deviate from the grey model prediction algorithm. The motivation of the study was to optimize decision-making in relation to unit plans for monthly shutdown. Also, the investigation considered various parameters. These parameters included the grid critical section constraints, future grid operation risks, system standby, and the balance of power demand and supply. The target plan to which the proposed model was applied was that which constituted transmission equipment maintenance and monthly load forecasting. Also, the motivation of the study was to establish a framework that would help to realize mutual cooperation among same-type, large-scale units, improve the energy-saving power generation dispatch’s effectiveness, avoid frequent start-stop, optimize the energy-saving power generation dispatch’s effectiveness, and improve the energy-saving power generation dispatch’s orderliness.

From the findings, it was evident that the proposed framework steered improvements in the orderly mediation experienced between the units. In turn, the model paved the way for increased rate of operating rate of the unit while ensuring reductions in the total power generation coal consumption. Hence, the proposed framework proved beneficial in such a way that it provided room for coal
consumption reduction and also ensured that energy conservation is promoted through the use of actual coal consumption, rather than rely on coal consumption designs that operate out of line with real situations. In summary, the model proved promising and worth applying or incorporation into industrial processes because of several beneficial effects. These effects include the promotion of energy conservation and the reduction of coal consumption, upon which fairness and positive significance would be felt relative to conditions involving energy-saving power generation dispatching.

5. References

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