The Researches on Cycle-Changeable Generation Settlement Method

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Abstract. Through the analysis of the business characteristics and problems of price adjustment, a cycle-changeable generation settlement method is proposed to support any time cycle settlement, and put forward a complete set of solutions, including the creation of settlement tasks, time power dismantle, generating fixed cycle of electricity, net energy split. At the same time, the overall design flow of cycle-changeable settlement is given. This method supports multiple price adjustments during the month, and also is an effective solution to the cost reduction of month-after price adjustment.

1. Introduction

Recently, the settlement cycle of power generation side in our country is fixed in month, that means power generation enterprises’ net energy starts at zero clock of this month’s first day and ends at zero clock of next month’s first day, in month settlement, split the net energy and calculate every contract’s energy and fee according to the priority of contracts. Price adjustment, which means the price adjustment of electricity contract, is a unique and common settlement business in China's long-term transaction contract model, usually the government departments issue a notice, including approved price, environmental protection price, contract price and so on in types, province and city Power Exchange Centers(PECs) execute in the monthly settlement.

This paper presents a cycle-changeable settlement method, which can solve the problem of month-forward price adjustment settlement and month-after price adjustment settlement by settlement task management, time energy process, etc., it also supports the random time price adjustment settlement. This method has clear thinking, and is operational, it can help to improve the level of price adjustment settlement.

2. Problems of Price Adjustment Settlement

In terms of price adjustment timeliness, there is a price adjustment in the month of the settlement, such as October 1 for September electricity settlement, the electricity measurement cycle is from September 1 to October 1, and September 12 to adjust the approved price, this type of price adjustment is usually called the month-forward price adjustment. The other type is adjust the history month contract which has completed settlement, such as the settlement on October 1, PEC receives a notice from the government that there is a power generation enterprises from May 12 began to adjust the price adjustment, the need for May 12 to September 1 has been the settlement of electricity to adjust the price, this type of price adjustment is usually called month-after price adjustment.

For month-forward price adjustment, PEC usually splits the net energy into sections from gathering to calculation, then deducts every contract’s energy (including price adjust contract) from the total net energy according to contract’s priority from high to low, at last splits the price changed contract’s
energy into sections according to the net energy segmentations’ proportion, this method dealing with the
price adjustment settlement is called “Settlement First, Split Second”. For month-after price
adjustment, because the history month settlement has been finished, and most history month energy
could not get segmented energy, so the common method is calculating the effected energy from price
adjustment time to this month, then calculating the compensation fee with effected energy and contract
price, and put the compensation fee in this month settlement.

PEC usually deals with the price adjustment settlement manually, calculates the energy and fee
offline, then uploads the results into system, this process has the following problems:
(1) Mostly calculate the effected energy of price adjustment manually or by Excel, this leads to
heavy work and easily lead to errors.
(2) Possibly there are several price adjustments among a month, and power consumption side also
has price adjustment, it leads to more complex operations.
(3) The compensation fee of month-after price adjustment is settled in current month, it cannot
reflect the real purchase cost of the history month, also the current month purchase cost is distorted in
analysis.

The existing researches mostly focus on the conventional settlement [1-3], the literature [4] and the
literature [5] describe the conventional monthly settlement operation method from the perspective of
power generation enterprises and regional grid, the literature [6] proposes a new method of settlement
for month-after energy compensation, the literature [7] proposes a new settlement method in regional
electricity markets, the literature [8] proposes a double settlement system to solve the problem of day
ahead trade settlement and long term trade settlement. The above studies all study on the fixed
monthly cycle of the settlement method, and some ones are not practical according to the actual
business, lack the price adjustment method introduction of one or more times within a month, and lack
the complete study and discussion on price adjustment settlement.

3. Cycle-Changeable Settlement
Cycle-changeable settlement means break the current settlement way which is fixed on monthly, by
delimiting the start time and end time customized, to achieve any period of time settlement, In cycle-
changeable settlement, the minimum time unit of all the metering energy is 15mins, and all the
contracts energy also are broken down into 15mins, this means all the energy time cycle is 15mins.
When there is a price adjustment, split the total month time into sections according to the price adjust
time points, then net energy, contract energy is processed according to the sections, the net energy and
contract in any section is calculated independently, and then get every section settlement result, at last
collect the results and release the energy and fee which have been merged.

3.1. Settlement Task Creation
Current monthly settlement starts from the first day of month, the energy gathering, net energy
calculation, contract energy confirms, net energy split and calculation all follow the settle day. In cycle-
changeable settlement, it starts the settlement with creating a settlement task and setting a task
management, and it runs following the task in all settlement parts. The settlement task defines all the
attributes and configurations of the settlement, including task name, creator, involved participants,
create time, start time of settlement data, end time of settlement data, through settlement task it
achieves the random time definition of cycle-changeable settlement.

3.2. 15mins Energy Split
Divide an hour into 15mins for a time segment, then every hour has 4 segments, every day has 24
segments. Split net energy and contract energy into 15mins, manage all the energy in 96 segments per
day.

Net energy calculation and split process: calculate every segment energy of the meters according to
the start code and end code of every segment, then calculate the settle unit’s every segment net energy
through the net energy calculation formula.

Meter’s segment energy calculation formulas:
\[ EP_n = (P_n - P_{n-1}) \times R \quad n = 1, 2, ..., 96 \]  (1)
In formula (1) and (2): $E_P_n$ is the positive active power of meter at the n time segment; $P_n$ and $P_{n-1}$ are the positive codes of meter at n and n-1 time; $E_Q_n$ is the reverse active power of meter at the n time segment; $Q_n$ and $Q_{n-1}$ are the reverse codes of meter at n and n-1 time; R is the meter ratio.

Contract energy calculation and split process:

If the schedule plan has provided actually executed power curve data per 15 minutes of every contract, so it can calculate every time segment energy from the power curve data; if there is no power curve data per 15 minutes, the contract total energy can be extracted according to contract start and end time, the split the total energy into 15mins time segment on the basis of settle unit’s 15mins net energy, as the following formula:

$$\text{ConEng}_n = \frac{\text{ConEng}_{total} \times \text{EngNet}_n}{\text{EngNet}_{total}} \quad n = 1, 2, ..., 96$$  \hspace{1cm} (3)

In formula (3): $\text{ConEng}_{total}$ is the total energy from contract start time to end time; $\text{EngNet}_n$ is the settle unit net energy at time segment n; $\text{EngNet}_{total}$ is the settle unit total net energy from contract start time to end time; $\text{ConEng}_n$ is the contract energy at time segment n.

3.3. Fixed Cycle Energy Processing

According to the last part of the calculation of each time section of the net energy, the contract energy, in accordance with the day, week, month, quarterly four time periods of integration. In the daily zero clock, every Sunday zero clock, energy month first day zero clock, quarterly the first day of zero clock to calculate the generation of the previous day, the previous week, the previous month, the previous quarter of the total net energy and the total energy of each contract, when there are four time periods involved in the settlement, it can by read data quickly, so it can reduce data read and processing time.

3.4. Net Energy Split

In the process of net energy split, all the contract energy needs to split from net energy according to each settlement priority, the lowest priority contract is the last one to get the rest energy. At last calculate all contracts’ actually settlement energy, price, fee. This step is implemented as follows:

Suppose that the settle unit net energy in specified time cycle is $\text{EngNet}_{net}$, and it has m contracts, each contract has the settlement priority $p_m$ ($p_m$ to $p_1$ is in descending order), and the contract energy in the settlement cycle is $EN_m$. Now settle every contract according to $p_m$ from high to low, the m-th contract has the highest priority, and the 1-st contract has lowest priority. Start from the m-th contract, so the i-th contract settlement energy as follows:

$$E_{S_i} = \max(\min(\text{EngNet} - \sum_{t=1}^{i-1} E_{S_t}, EN_i), 0)$$  \hspace{1cm} (4)

In formula (4): $\text{EngNet}$ is the settle unit net energy; $E_{S_t}$ is the t-th contract actually settlement energy; $EN_i$ is the contract original energy in cycle; $E_{S_i}$ is the i-th contract final settlement energy.

4. Process Design and Application Characteristics

4.1. Overall Process Design

The cycle-changeable settlement overall process design is defined in Figure 1.
Figure 1 Overall Process Design of Cycle-Changeable Settlement

Description of significant steps:

a. Settlement task creation. Configure parameters involved in cycle-changeable settlement, including participants, settlement data start time, settlement data end time.

b. Net energy calculation. Calculate the settle unit net energy according to 15min meter energy, 15min generation unit energy.

c. Contract energy calculation. Calculate all contract energy in cycle according to 15min contract energy and 15min non-contract energy.

d. Contract price extract. Extract contract price from contract information.

e. Net energy split. Split and calculate contract actually energy from net energy in basis of every contract priority.

f. Fee calculation. Calculate every contract final settlement fee with the settlement energy and price.

4.2. Application Characteristics

a. Time irrelevantly

This method can define the settlement time from any start time to end time through the settlement task, the minimum time granularity is 15 minutes, and the maximum time granularity theory has no upper limit. It can meet the PECs of the current conventional monthly settlement, non-fixed time forecast settlement, quarterly settlement and other business requirements, but also can meet the day ahead and real time settlement needs in the future.

Suppose that the generation participant has price adjustment at day 10 and day 18 in this month, it only needs to set the settlement task at the corresponding point in time to complete the custom cycle of settlement.
b. Multiple settlements in same cycle

Cycle-changeable settlement is driven by the settlement task, so the settlement can be repeated several times on same cycle. The results of the settlement can be saved independently and do not affect the other results. For multiple settlement results, you can choose any one of the settlement results to release.

c. Cost reduction of month-after price adjustment settlement

As the cycle-changeable settlement support for the historical data to re-settlement, and the data can be saved separately, so the energy influenced by month-after price adjustment can be re-settled, and the results can be compared with the historical data to generate deviation data. Statistical analysis of the deviation data will be accumulated in the historical data to restore, to solve the problem of the historical cost reduction and analysis.

The following is a case of the actual settlement of a power generation company, the case described as: the current time is October 1, PEC starts September settlement, and receives a notice from the government that the company in May approved price increase of 40 RMB/MWH. The traditional settlement results from January to September in Table 1:

| Month | Net Energy (MWH) | Price (RMB/MWH) | Purchase Fee(RMB) | Compensation Fee(RMB) | Sum Fee(10 Thousands RMB) | Average Price of Purchase(RMB/MWH) |
|-------|-----------------|----------------|-------------------|----------------------|--------------------------|----------------------------------|
| 5     | 254300          | 400            | 10172             | 10172                | 400                      | 400                              |
| 6     | 255800          | 400            | 10232             | 10232                | 400                      | 400                              |
| 7     | 263500          | 400            | 10540             | 10540                | 400                      | 400                              |
| 8     | 249800          | 400            | 9992              | 9992                 | 400                      | 400                              |
| 9     | 274200          | 440            | 12064.8           | 4093.6              | 16158.4                 | 589.29                           |

From columns Sum Fee and Average Price of Purchase, it can be found that if put the compensation fee from March to August in September, it will lead to a significant increase in the cost of purchase in September, the history of the settlement date and the current September purchase costs are seriously distorted.

Resettle the history month energy by cycle-changeable settlement method, compare the resettlement results with history month settlement results, the deviation data is saved separately, and restore the deviation when analyze. The results from resettled by cycle-changeable settlement method as Table 2:
### Table 2 Settlement Results of Cycle-Changeable Method

| Month | Net Energy (MWH) | Price (RMB/MWH) | Purchase Fee(RMB) | Compensation Fee(RMB) | Sum Fee(10 Thousands RMB) | Average Price of Purchase(RMB/MWH) |
|-------|------------------|-----------------|-------------------|----------------------|---------------------------|-----------------------------------|
| 5     | 254300           | 400             | 10172             | 1017.2               | 11189.2                   | 440                               |
| 6     | 255800           | 400             | 10232             | 1023.2               | 11255.2                   | 440                               |
| 7     | 263500           | 400             | 10540             | 1054                 | 11594                     | 440                               |
| 8     | 249800           | 400             | 9992              | 99.2                 | 10991.2                   | 440                               |
| 9     | 274200           | 440             | 12064.8           | 0                    | 12064.8                   | 440                               |

5. Conclusion

This paper presents a cycle-changeable settlement method to support any period of time in order to solve the problems existing in the month-forward price adjustment and month-after adjustment in the current business. The method starts with settlement task, through split any energy into 15mins time segment to meet the finest time granularity of 15 minutes’ settlement, in order to adapt to a variety of price adjustment of the system to achieve and after the price adjustment of the real cost of tracking to provide strong support.

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