Collaboration Mechanism for Equipment Instruction of Multiple Energy Systems

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Abstract. When multiple energy systems execute optimization instructions simultaneously, and the same equipment is shared, the instruction conflict may occur. Aiming at the above problems, taking into account the control objectives of each system, the characteristics of different systems, such as comprehensive clean energy, energy efficiency, and peak filling, etc., designed the instruction coordination mechanism for the daemon. This mechanism mainly acts on the main station of the system, and form a final optimization instruction. For some specific scenarios, the collaboration mechanism of unlocking the terminal is supplemented. The mechanism determines the specific execution instructions based on the arrival time of the instruction. Finally, the experiment in Tianjin eco-city shows that this algorithm can meet the instruction and collaboration requirements of multi-energy systems, and ensure the safe operation of the equipment.

1. Introduction

The main stakeholders of the smart park include owners, power grid enterprises, government and energy saving service providers [1]. As Wisdom Park and energy for the construction of the Internet, which in the light of the demand of the subject from their deployment, respectively, for the clean energy, energy-efficiency, cut peak valley as the control target of energy systems. Instead of being confined to the grid, these systems emphasize a combination of multi-class energy and multi-load control [2].

In smart grid parks, devices that are controlled by different systems often overlap. When one set of system executes the regulation instruction, it is bound to influence the load prediction and effect evaluation of other systems. In addition, when multiple systems give instructions to the same device, the instruction conflict can be caused, and even the device's repeated start-stop will eventually lead to equipment failure or scrap.

There are two main ways to realize the coordination of control instruction between multi-energy systems. One is to deploy daemons on the system (or platform) from the system (or platform) to implement the control instruction collaboration [3]. The other is to improve the terminal that is connected with the device, and to realize the coordinated of the control instruction through the terminal.
design and unlock mechanism. This paper puts forward the cooperation mechanism between the multi-energy system from the above daemons and terminals.

2. Three Types of Energy Systems

Common multi-energy systems include clean energy, energy efficiency, and peak filling. Different systems have different control strategies and regulatory objects, but the similarity of control methods determines that the instructions of the system can be handled uniformly. In the face of clean energy, energy efficiency, peak filling and other kinds of systems analysis.

(1) Clean use can mainly be favored by energy saving service providers and power grid enterprises. There are two common types of cleaning, one for improving clean energy and the other for electricity. Clean energy mainly includes wind, geothermal, solar, and hydraulic and other types. A lot of clean and energy equipment can both provide energy and use the function of two aspects. Taking solar air conditioning as an example, it absorbs solar energy and belongs to the energy supply side. And air conditioning provides cold load, belong to use energy side. In this paper, the equipment is abstracted for energy supply and energy use. Power replacement is to replace coal, gas, oil and other forms of energy consumption with electricity consumption.

(2) Energy efficiency promotion is the focus of energy saving service providers and governments. Energy efficiency promotion focuses on the improvement of the device itself, the promotion of user behavior. The strategy of energy efficiency promotion can be divided into two categories. One is the power adjustment instruction of the main station, the terminal receives the instruction, and the instruction is converted into a specific optimization strategy. The other kind is the main station directly issue specific control strategy.

(3) Cutting peak filling is to ensure grid stability and reduce infrastructure investment by reducing the use of electricity during peak hours. Most of the construction of peak filling system is power grid enterprises. The control methods of such systems are mainly used in the form of switching, the use of energy storage equipment and the load regulation of energy equipment.

In general, the equipment involved in clean energy, energy efficiency improvement, peak filling and valley systems have their own characteristics, but there are overlaps and similarities.

3. A collaborative algorithm for daemons

3.1. Collaboration with Instructions

Over time, multiple systems may give instructions to the same device. The first step is to analyze the direction of these instructions in the same direction, which is to reduce (or increase) the load (or power supply). The situation is divided into three main categories. The first is that the latter instruction happens to arrive at the end of the previous instruction execution. The second one is that the second instruction arrives after the execution of the previous instruction. The third category is that the two instructions overlap at the time of execution. The first kind of situation is not strictly conflict, and the two instructions can be executed separately. The second type of situation may cause failure due to the frequent failure of the equipment. This problem can be solved easily from the start-stop time interval of the device itself. The third category is more complex.

The following assumption is that the instruction of the clean energy system I on a device is $\Delta P_{clean_i}$. The instruction j from the system of energy efficiency enhancement system is $\Delta P_{effcy_j}$. The instruction k of the peak system is $\Delta P_{shift_k}$. Then, the instructions of each system to the device can be expressed in the form of the following collection:

$$\{PC = \{\Delta P_{clean_1}, \Delta P_{clean_2}, \ldots, \Delta P_{clean_l}\}\}$$
$$\{PE = \{\Delta P_{effcy_1}, \Delta P_{effcy_2}, \ldots, \Delta P_{effcy_n}\}\}$$
$$\{PS = \{\Delta P_{shift_1}, \Delta P_{shift_2}, \ldots, \Delta P_{shift_n}\}\}$$

(1)
The elements in the above set \((\Delta P_{\text{clean}}, \Delta P_{\text{effcy}}, \Delta P_{\text{shift}_k})\), increase load as positive and reduce load negative. From the intuitive point of view, it is a relatively simple strategy to select the minimum value of each instruction (i.e., to meet the maximum reduction of each system in terms of load reduction).

\[
\Delta P = \min \left( PC \cup PE \cup PS \right)
\]  

In formula (2), the control amount formed after the instructions of the equipment is integrated. However, cleaning can promote the use of electricity load instead of coal, oil and other forms of load; Energy efficiency promotes efficient use of energy, not just a reduced load. Therefore, the formula (2) is used to calculate the minimum value to generate the strategy, which is unfavorable to some systems. Further, the same device, in different sizes of cuts, its importance is different. For example, suppose there are two systems, the first system has to reduce the load of 10kW to all devices, and the second system will only reduce the load of 1kW. For a Shared device, they cut 0.5 kW. Therefore, the weights of each system should be considered in the formation of unified instructions.

\[
\text{Ratio} = \frac{\sum_{i=1}^{n} \Delta P_{\text{clean}_i}}{\sum_{j=1}^{l} \sum_{i=1}^{n} \Delta P_{\text{clean}_i}} + \frac{\sum_{j=1}^{k} \sum_{i=1}^{n} \Delta P_{\text{effcy}_j}}{\sum_{j=1}^{k} \sum_{j=1}^{k} \sum_{i=1}^{n} \Delta P_{\text{effcy}_j}} + \frac{\sum_{l=1}^{m} \Delta P_{\text{shift}_k}}{\sum_{l=1}^{m} \sum_{l=1}^{m} \sum_{l=1}^{m} \Delta P_{\text{shift}_k}}
\]  

The weights of each system can be specified, and even the priority of each system is specified. However, this one-size-fits-all approach can lead to the long term inresponse of certain system directives, and manually specified ways increase the difficulty of system maintenance. Therefore, the system weight should be generated by daemons. Assuming that the clean energy system I has the combined control instructions for all devices, the energy efficiency enhancement system j is, and the peak filling system k is. By formula (3), the total proportion of the equipment in various systems can be calculated, namely the Ratio of formula (3).

\[
\Delta P = \frac{\text{Max}(PC) \cdot \sum_{i=1}^{n} \Delta P_{\text{clean}_i}}{\text{Ratio} \cdot \sum_{j=1}^{l} \sum_{i=1}^{n} \Delta P_{\text{clean}_i}} + \frac{\text{Avg}(PE) \cdot \sum_{j=1}^{k} \Delta P_{\text{effcy}_j}}{\text{Ratio} \cdot \sum_{j=1}^{k} \sum_{j=1}^{k} \Delta P_{\text{effcy}_j}} + \frac{\text{Min}(PS) \cdot \sum_{l=1}^{m} \Delta P_{\text{shift}_k}}{\text{Ratio} \cdot \sum_{l=1}^{m} \sum_{l=1}^{m} \sum_{l=1}^{m} \Delta P_{\text{shift}_k}}
\]  

3.2. Collaboration of reverse instructions

When multiple systems control the same device, there are sometimes problems with reverse instructions. The reverse command consists of two scenarios, one of which is a system shutdown device, and another system starts the device. The second is that a set of systems demands increased load while the other requires less load. Situation a similar to the first two situations in section 3.1, which can lead to device corruption. Situation 2 is similar to the third condition of the same direction directive, which will make the device directive not be executed correctly.

4. The Instance in Tianjin Eco-City

The Tianjin eco-city includes the joint optimization of integrated management system of energy integrated management platform, the integrated management system of cold and heat and electric energy, and the three-part energy system. The joint optimization platform for integrated energy management
platform for end users is focused on the improvement of energy efficiency. The hybrid energy integrated management system for cold and heat energy is referred to as the hybrid energy system, which includes the joint optimization for the use of energy and the function of clean energy. At present, the user transformation to these systems is close to the end, which has the experimental environment for this article.

The joint optimization platform and the hybrid energy system are connected. The latter includes eight users managed by the former. The eight users have now completed the makeover. To avoid two sets of system instruction conflicts, daemons are set up in the joint optimization platform. According to the algorithm of this paper, the process of the equipment instruction collaboration has been done. As of May 2016, the daemon has processed four energy optimization instructions.

Table 1. The solution effect towards four times of command conflict.

| Number of conflicted users | The first time | The second time | The third time | The fourth time |
|----------------------------|----------------|----------------|---------------|----------------|
| Joint optimization platform | reduce 12kw    | reduce 15kw    | reduce 23kw   | reduce 32kw    |
| Hybrid energy system       | reduce 6kw     | reduce 21kw    | reduce 31kw   | reduce 80kw    |
| Guardian process           | reduce 9kw     | reduce 18kw    | reduce 27kw   | reduce 24kw    |
| In practice                | reduce 10kw    | reduce 18kw    | reduce 26kw   | no change      |

| Standard users | Joint optimization platform | 1 | 2 | 3 | 0 |
|----------------|----------------------------|---|---|---|---|
| Hybrid energy system | 1 | 2 | 2 | 0 |

5. Conclusion

If multiple energy systems share a portion of the same device, the instructions clash when these systems send instructions to the device simultaneously. Aiming at this problem, this paper proposes two kinds of cooperation methods of equipment instruction between two kinds of energy systems:

1. At the system level, the daemons are set up to generate effective control instructions according to the cooperative algorithm.

2. At the terminal level, set up the unlock mechanism to avoid the conflict of device instructions by means of unlocking.

According to the connection mode of terminal and system, one of these two modes can be flexibly chosen. The application of the cooperative mechanism in the real system shows that the method can solve the conflict problem of the equipment instruction in the precondition of meeting the target of every multi-energy system.

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