**Parameters and supplementary formulas in the simulation**

## Parameters in simulation

The parameters of the agreement with the TCL agent include:

(a) The TCL agent can participate in auxiliary declaration, wind curtailment mitigation, and clean power supply businesses throughout the day. (b) The maximum adjustable capacity of the TCL agent and segmentation points are shown in Fig. A1. (c) =1.25, =0.85, =0.



Fig. A1. Step curve segmentation points of the TCL agent

The parameters of the agreement with the MG include:

(a) The MG can participate in auxiliary declaration and wind curtailment mitigation businesses throughout the day. (b) , , . (c) =0.8, =0.7, =0.5, =1.4, =1.6, =1.8.

The other parameters in the simulation are as follows:

=0.05 yuan/kWh, ==1.5 yuan/kWh, ==0.15 yuan/kWh, *α*da=*β*da=10%, *α*id=*β*id=5%, *α*res=*β*res=1%, ==0.75 yuan/kWh, *α*tcl=0.1.

## Operation and maintenance costs of distribution lines and transformers

In the joint operation system, the wind farm and the flexible loads are generally connected through low or medium voltage distribution lines. The voltage of the wind farm collection system is generally 10kV or 35kV. The load side voltage levels are different according to different production or living needs. This paper takes TCLs and MG as an example. TCLs generally operate at 380V and the wind farm can be connected to the medium voltage distribution feeder (10kV) where the TCLs are located. The voltage level of MG may be 10kV or 35kV, and the wind farm can be connected to the grid connection point of MG. Whether a transformer is needed on the connecting line between the wind farm and the flexible loads depends on the voltage levels of both sides. No additional transformer is required if the voltage levels of the load and the wind farm collector system are the same.

In this paper, the wind farm is connected to the medium voltage distribution line where TCLs are located through a 35kV/10kV transformer with a capacity of 8MVA. The power factor of the transformers is 0.9137, and the maximum permissible active power is 7.31 MW. The MG is connected to the wind farm through a 35kV/10kV transformer with a capacity of 6.3 MVA. The power factor of the transformer is 0.85, and the maximum permissible active power is 5.355 MW.

The annual maintenance cost of transformer consists of overhaul cost, minor repair cost and routine inspection cost:



where *K*or is overhaul cost, is the probability of overhaul, *K*mr is minor repair cost, *K*pm is routine inspection cost, *S*eq is the equivalent age of transformer.

The annual maintenance cost of the distribution lines connecting the wind farm and flexible loads can be written as:



where the *K*lm is coefficient of equipment maintenance cost, *C*line,inv is the investment cost of the distribution line.

In this paper, *K*or is 6% of the equipment cost, *K*mr is 1.5% of the equipment cost, *S*eq=5. The unit capacity cost of 35kV transformer is about 160 thousand yuan/MVA. Assuming that the transformer is overhauled once every 8 years, so =0.125. *K*pm is taken as 50 thousand yuan for the transformer with the capacity of 8 MVA and the ratio of 35kV/10kV. *K*pm for the capacity of 6.3 MVA and the ratio of 35kV/10kV transformer is taken as 40 thousand yuan. *K*lm=3%, *C*line,inv=5280 thousand yuan. The annual operating cost of transformer between the wind farm and the TCL is 80.48 thousand yuan. The annual operating cost of the transformer between the wind farm and MG is 62.95 thousand yuan. *C*line,m is 158.40 thousand yuan. Therefore, the wind farm operator needs to pay about 301.83 thousand yuan per year for the maintenance of distribution lines and transformers.