## Details for dynamic energy hub model

1. Energy conservation equations at each energy bus:

For gas bus:



For electricity bus:



For heat bus:



For cooling bus:



1. Energy conversion constraints:

For combined heat and power plant (CHP):





For gas boiler (GB):



For electric heat pump (EHP):





For absorption chiller (AB):



1. Charging/discharging of energy storages:

For electric energy storage (EES):



For thermal energy storage (TES):



For ice storage (IS):



For temperature-controlled load (TCL) of the heat load:



For TCL of the cooling load:



where the energy flows between the node  and gas, electricity, heat, and cooling buses are denoted as , , , and , respectively.  is a binary variable;  and 0 represents winter and summer, respectively;  and  are the heat production and electricity generation efficiencies of CHP, respectively;  is the efficiency of GB;  is the efficiency of AB;  and  are the coefficient of performance of EHP for cooling and heating modes, respectively.

Then, we determine the control variables and output variables. It should be noted that there is more than one choice for state variables, control variables, and output variables. Here we choose the capacity of EES, TES, IS, and TCLs as the state variables , choose the energy flows in the DEH as the control variables, and choose the energy consumption of DEH as output variables . Other variables can be eliminated. Then, the above equations can be summarized into two groups of equations, i.e., system state equations, and output equations:

1. System state equation:



1. Output equation



Then, the two groups of equations can be written in the matrix form:

1. System state equation:



1. Output equation:

