APPENDIX

The independent optimal operation model is shown as follows:

1）Optimal scheduling model of transmission power systems

$$\min\left\{\sum_{t=1}^{T}\left(\sum_{g\in S_g^{nng}} K_g P_{g,t} + \sum_{w\in S_{w,TS}} K_w^{cut} P_{w,t}^{cut}\right)\right\}$$

s.t. (2)-(6)

2）Optimal scheduling model of distribution power systems

$$\min\sum_{t=1}^{T}\sum_{w\in S_{w,DS}} K_w^{cut} P_{w,t}^{cut}$$

s.t. (8)-(9), (11)-(16), (23)-(24)

3）Optimal scheduling model of natural gas systems

$$\min\sum_{t=1}^{T}\sum_{gw\in S_{gw}} K_{gw} G_{gw,t}$$

s.t. (19)-(22), (26)

Table 1. Parameters of ESS

	$SOC_{\min}$(MWh)	$SOC_{\max}$(MWh)	$P_{\mathrm{ch,max}}$(MW)	$P_{\mathrm{dch,max}}$(MW)	η^{ch} / η^{dch}
ESS1	4	20	5	5	0.9
ESS2	4	20	5	5	0.9

Table 2. Parameters of CHP and EB

	Minimum output (MW)	Maximum output (MW)	Energy efficiency	
CHP	4	20	0.41(Electricity)	0.44(heat)
EB	4	20	0.75	

Table 3. Branch parameters of gas network

From node	To node	Weymouth constant	Maximum gas flow (kcf)
2	1	10.12	300
4	2	10.02	300
5	2	7.5	100
5	3	8.7	300
6	5	9.06	300

Table 4. Node parameters of gas network

Node	Minimum gas pressure/psi	Maximum gas pressure/psi
1	26.25	30

2	29	33.75
3	28.25	34
4	31.75	36.75
5	31	35.75
6	35	39.75

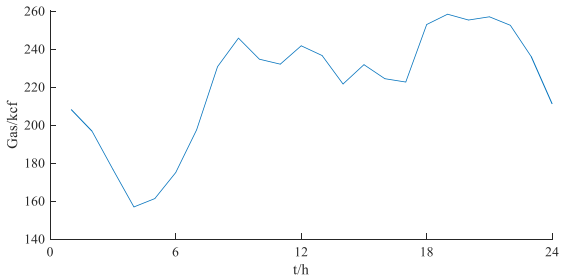

Fig. 3 Load of natural gas network