# Data of the integrated electricity and gas system

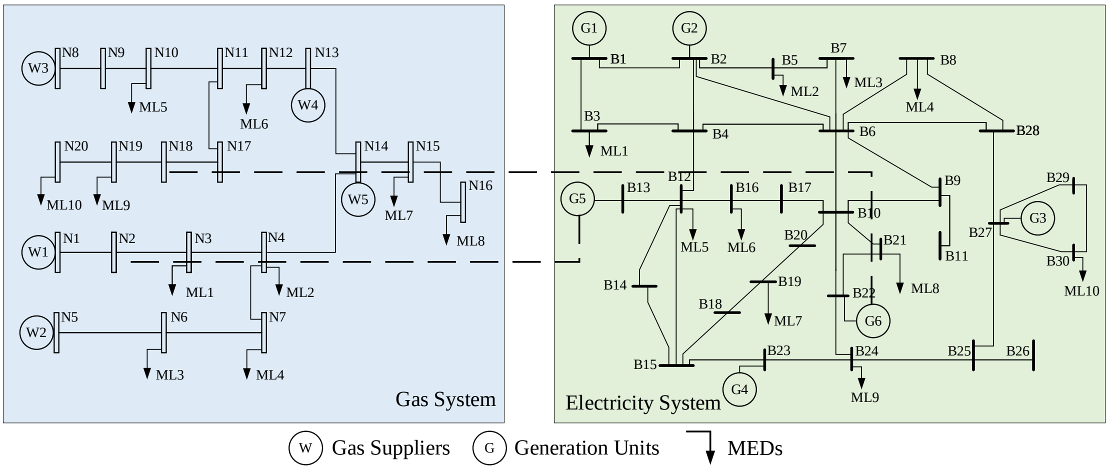


Figure 1 The topology of the test system

**Power system**

Table I Parameter of the generation units

| No | Type | Min (MW) | Max (MW) | Efficiency (Mm3/day/MW) | Ramping (%/min) |
|---|---|---|---|---|---|
| G1 | Coal | 20 | 250 | / | 2 |
| G2 | Coal | 20 | 250 | / | 2 |
| G3 | Coal | 20 | 180 | / | 2 |
| G4 | Coal | 20 | 240 | / | 2 |
| G5 | Gas | 20 | 250 | 0.004 | 10 |
| G6 | Gas | 20 | 250 | 0.004 | 10 |

Table II Bidding block of the generation units (MW)

| No | Block 1 | Block 2 | Block 3 | Block 4 | Block 5 |
|---|---|---|---|---|---|
| G1 | 100 | 45 | 45 | 45 | 45 |
| G2 | 70 | 35 | 35 | 35 | 35 |
| G3 | 60 | 30 | 30 | 30 | 30 |
| G4 | 80 | 40 | 40 | 40 | 40 |
| G5 | 80 | 40 | 40 | 40 | 40 |
| G6 | 80 | 40 | 40 | 40 | 40 |

Table III Bidding price of the generation units ($/MMBtu)

| No | Block 1 | Block 2 | Block 3 | Block 4 | Block 5 |
|---|---|---|---|---|---|
| G1 | 7.6 | 8.5 | 9.8 | 12.6 | 25.3 |
| G2 | 7.9 | 8.7 | 9.4 | 19.6 | 24.1 |
| G3 | 7.5 | 9.4 | 10.6 | 19.7 | 23.1 |
| G4 | 7.6 | 8.6 | 10.5 | 15.6 | 19.1 |
| G5 | 6.6 | 8.6 | 10.6 | 15.5 | 18.6 |
| G6 | 8.1 | 9.5 | 11.2 | 15.5 | 18.8 |

Table IV Parameter of the branch

| Reactance | Capacity |
| --- | --- |
| Ref [1] | Inf. |

**Gas system**

Table V Parameter of the gas suppliers

| No | Min (Mm3) | Max (Mm3) |
| --- | --- | --- |
| W1 | 0 | 0.031 |
| W2 | 0 | 0.037 |
| W3 | 0 | 0.032 |
| W4 | 0 | 0.025 |
| W5 | 0 | 0.040 |

Table VI Bidding block of the gas suppliers (Mm3)

| No | Block 1 | Block 2 | Block 3 | Block 4 | Block 5 |
| --- | --- | --- | --- | --- | --- |
| W1 | 0.007 | 0.006 | 0.006 | 0.006 | 0.006 |
| W2 | 0.009 | 0.009 | 0.007 | 0.007 | 0.005 |
| W3 | 0.008 | 0.006 | 0.006 | 0.006 | 0.006 |
| W4 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 |
| W5 | 0.010 | 0.007 | 0.007 | 0.007 | 0.007 |

Table VII Bidding price of the generation units ($/MMBtu)

| No | Block 1 | Block 2 | Block 3 | Block 4 | Block 5 |
| --- | --- | --- | --- | --- | --- |
| W1 | 5.2 | 6.2 | 8.5 | 10.6 | 13.6 |
| W2 | 5.2 | 7.2 | 9.5 | 11.5 | 14.6 |
| W3 | 5.4 | 6.5 | 8.8 | 11.8 | 14.2 |
| W4 | 5.1 | 6.5 | 8.2 | 9.8 | 14.4 |
| W5 | 6.9 | 8.7 | 9.4 | 11.4 | 14.5 |

Table VIII Parameter of the pipeline

| C | Bar | Capacity |
| --- | --- | --- |
| Ref [2] | | Inf. |

# Data of the MEDs

**The electricity, gas, and heat demand of terminal load**

The electricity and gas load can refer to the [3].

Table IX Heat demand (MW)

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 175 | 168 | 195 | 184 | 165 | 166 | 174 | 181 | 175 | 165 | 156 | 177 |
| 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| 187 | 177 | 190 | 172 | 170 | 194 | 201 | 187 | 177 | 170 | 165 | 175 |

Table X Load portion of the MEDs

| No | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Portion | 0.092 | 0.12 | 0.095 | 0.087 | 0.096 | 0.089 | 0.101 | 0.109 | 0.103 | 0.0961 |

**The piecewise function of the MEDs in different** $k_3$

1. $k_3 > k_1 > k_2$

$$\Delta L_E = \begin{cases} -P_{G2E}^{\max} + \max\left(0, L_{H0} - P_{G2H}^{\max}\right) & : \rho_E > k_3\rho_G \\ -P_{G2E}^{\max} + P_{P2H} & : \rho_E = k_3\rho_G \\ -P_{G2E}^{\max} + \min\left(L_{H0}, P_{P2H}^{\max}\right) & : k_1\rho_G < \rho_E < k_3\rho_G \\ -P_{G2E} + \min\left(L_{H0}, P_{P2H}^{\max}\right) & : \rho_E = k_1\rho_G \\ \min\left(L_{H0}, P_{P2H}^{\max}\right) & : k_2\rho_G < \rho_E < k_1\rho_G \\ \min\left(L_{H0}, P_{P2H}^{\max}\right) + P_{P2G} & : \rho_E = k_2\rho_G \\ \min\left(L_{H0}, P_{P2H}^{\max}\right) + P_{P2G}^{\max} & : \rho_E < k_2\rho_G \end{cases} \quad \Delta L_G = \begin{cases} k_1 P_{G2E}^{\max} + \min\left(L_{H0}, P_{G2H}^{\max}\right) & : \rho_E > k_3\rho_G \\ k_1 P_{G2E}^{\max} + P_{G2H} & : \rho_E = k_3\rho_G \\ k_1 P_{G2E}^{\max} + \max\left(0, L_{H0} - P_{P2H}^{\max}\right) & : k_1\rho_G < \rho_E < k_3\rho_G \\ k_1 P_{G2E} + \max\left(0, L_{H0} - P_{P2H}^{\max}\right) & : \rho_E = k_1\rho_G \\ \max\left(0, L_{H0} - P_{P2H}^{\max}\right) & : k_2\rho_G < \rho_E < k_1\rho_G \\ \max\left(0, L_{H0} - P_{P2H}^{\max}\right) - k_2 P_{P2G} & : \rho_E = k_2\rho_G \\ \max\left(0, L_{H0} - P_{P2H}^{\max}\right) - k_2 P_{P2G}^{\max} & : \rho_E < k_2\rho_G \end{cases}$$

2. $k_1 > k_3 > k_2$

$$\Delta L_E = \begin{cases} -P_{G2E}^{\max} + \max\left(0, L_{H0} - P_{G2H}^{\max}\right) & : \rho_E > k_1\rho_G \\ -P_{G2E} + \max\left(0, L_{H0} - P_{G2H}^{\max}\right) & : \rho_E = k_1\rho_G \\ \max\left(0, L_{H0} - P_{G2H}^{\max}\right) & : k_3\rho_G < \rho_E < k_1\rho_G \\ P_{P2H} & : \rho_E = k_3\rho_G \\ \min\left(L_{H0}, P_{P2H}^{\max}\right) & : k_2\rho_G < \rho_E < k_3\rho_G \\ \min\left(L_{H0}, P_{P2H}^{\max}\right) + P_{P2G} & : \rho_E = k_2\rho_G \\ \min\left(L_{H0}, P_{P2H}^{\max}\right) + P_{P2G}^{\max} & : \rho_E < k_2\rho_G \end{cases} \quad \Delta L_G = \begin{cases} k_1 P_{G2E}^{\max} + \min\left(L_{H0}, P_{G2H}^{\max}\right) & : \rho_E > k_1\rho_G \\ k_1 P_{G2E} + \min\left(L_{H0}, P_{G2H}^{\max}\right) & : \rho_E = k_1\rho_G \\ \min\left(L_{H0}, P_{G2H}^{\max}\right) & : k_3\rho_G < \rho_E < k_1\rho_G \\ P_{G2H} & : \rho_E = k_3\rho_G \\ \max\left(0, L_{H0} - P_{P2H}^{\max}\right) & : k_2\rho_G < \rho_E < k_3\rho_G \\ \max\left(0, L_{H0} - P_{P2H}^{\max}\right) - k_2 P_{P2G} & : \rho_E = k_2\rho_G \\ \max\left(0, L_{H0} - P_{P2H}^{\max}\right) - k_2 P_{P2G}^{\max} & : \rho_E < k_2\rho_G \end{cases}$$

3. $k_1 > k_2 > k_3$

$$\Delta L_E = \begin{cases} -P_{G2E}^{\max} + \max\left(0, L_{H0} - P_{G2H}^{\max}\right) & : \rho_E > k_1\rho_G \\ -P_{G2E} + \max\left(0, L_{H0} - P_{G2H}^{\max}\right) & : \rho_E = k_1\rho_G \\ \max\left(0, L_{H0} - P_{G2H}^{\max}\right) & : k_2\rho_G < \rho_E < k_1\rho_G \\ \max\left(0, L_{H0} - P_{G2H}^{\max}\right) + P_{P2G} & : \rho_E = k_2\rho_G \\ \max\left(0, L_{H0} - P_{G2H}^{\max}\right) + P_{P2G}^{\max} & : k_3\rho_G < \rho_E < k_2\rho_G \\ P_{P2H} + P_{P2G}^{\max} & : \rho_E = k_3\rho_G \\ \min\left(L_{H0}, P_{P2H}^{\max}\right) + P_{P2G}^{\max} & : \rho_E < k_3\rho_G \end{cases} \quad \Delta L_G = \begin{cases} k_1 P_{G2E}^{\max} + \min\left(L_{H0}, P_{G2H}^{\max}\right) & : \rho_E > k_1\rho_G \\ k_1 P_{G2E} + \min\left(L_{H0}, P_{G2H}^{\max}\right) & : \rho_E = k_1\rho_G \\ \min\left(L_{H0}, P_{G2H}^{\max}\right) & : k_2\rho_G < \rho_E < k_1\rho_G \\ \min\left(L_{H0}, P_{G2H}^{\max}\right) - k_2 P_{P2G} & : \rho_E = k_2\rho_G \\ \min\left(L_{H0}, P_{G2H}^{\max}\right) - k_2 P_{P2G}^{\max} & : k_3\rho_G < \rho_E < k_2\rho_G \\ P_{G2H} - k_2 P_{P2G}^{\max} & : \rho_E = k_3\rho_G \\ \max\left(0, L_{H0} - P_{P2H}^{\max}\right) - k_2 P_{P2G}^{\max} & : \rho_E < k_3\rho_G \end{cases}$$

**Parameter of the ECE in the MEDs**

Table XI Capacity of ECE in the MEDs (MW)

| No | P2G | G2E 1 | G2E 2 | P2H | G2H |
|---|---|---|---|---|---|
| MED 1 | 15 | 10 | 10 | 20 | 10 |
| MED 2 | 15 | 10 | 10 | 20 | 20 |

| | | | | | |
|---|---|---|---|---|---|
| MED 3 | 15 | 10 | 10 | 20 | 20 |
| MED 4 | 15 | 10 | 10 | 10 | 10 |
| MED 5 | 15 | 10 | 10 | 20 | 15 |
| MED 6 | 15 | 10 | 10 | 20 | 20 |
| MED 7 | 15 | 10 | 10 | 25 | 10 |
| MED 8 | 15 | 10 | 10 | 10 | 25 |
| MED 9 | 15 | 10 | 10 | 10 | 25 |
| MED 10 | 15 | 10 | 10 | 20 | 20 |

**Bidding example of the MEDs**

Table XII Bidding price of the MEDs' self-elasticity curve ($/MMBtu)

| Price | Block 1 | Block 2 | Block 3 | Block 4 | Block 5 |
|---|---|---|---|---|---|
| Electricity Price | 13.5 | 11 | 9 | 8 | 7 |
| Gas Price | 11 | 10 | 9.5 | 8 | 6.5 |

The bidding price of a MED's complementary-elasticity curve is listed in Table XIII.

Table XIII Bidding price of the MEDs' complementary-elasticity curve ($/MMBtu)

| No | Price | Block 1 | Block 2 | Block 3 | Block 4 | Block 5 |
|---|---|---|---|---|---|---|
| MED 1 | Electricity Price | 16 | 16.7 | 11.76 | 10 | 5.6 |
| | Gas Price | 12 | 7 | 8 | 9 | 10 |

# Data of the clearing algorithm

Table XIV The initial values for clearing algorithm

| Lagrange multipliers $\alpha^0,\beta^0$ | Shared variables $\overline{P}_{i,t}^0,\overline{Q}_{i,t}^0,\overline{P}_{d,t}^0,\overline{Q}_{d,t}^0$ | Penalty factor $\rho_g^0,\rho_d^0$ |
|---|---|---|
| 1 | 0 | 0.1 |


[1] https://matpower.org/docs/ref/matpower5.0/case_ieee30.html

[2] D. De Wolf and Y. Smeers, "The gas transmission problem solved by an extension of the simplex algorithm," Management Science, vol. 46, no. 11, pp. 1454–1465, 2000.

[3] C. Wang, W. Wei, J. Wang, F. Liu, and S. Mei, "Strategic Offering and Equilibrium in Coupled Gas and Electricity Markets," IEEE Transactions on Power Systems, vol. 33, no. 1, pp. 290–306, Jan. 2018.