Equilibrium on a heat market under network constraints

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The mathematical model of the electricity market and heat is defined as follows. As the basis the article [1] was used with the addition of the network structure of the market. Consider power system with I nodes $i = 1, \dots, I$ in which there are participants of market: various types of plants producing electric power P and plants producing heat Q, as well as the agents consuming electric power x and heat y (for details [1]).Each consumer has an utility function F_i^{CE} for agents consuming electricity and F_i^{CH} for heat.

$$F_i^{CE} = c_i^e x_i - r_i^e x_i^2; F_i^{CH} = c_i^h y_i - r_i^h y_i^2, \tag{1}$$

Consider the objective function which is a public welfare of this power system, so the consumers maximize their utility functions and the producers minimize their costs. Therefore we are maximizing the welfare:

$$F = \sum_{i=1}^{n} F_i^{CE} + \sum_{i=1}^{n} F_i^{CH} - F^{COST} \to max, \tag{2}$$

where:

$$F^{COST} = \sum_{i=1}^{n} a_i^{tec}(qP_i^{tec} + Q_i^{tec}) + \sum_{i=1}^{n} a_i^{kes} P_i^{kes} + \sum_{i=1}^{n} a_i^{kot} Q_i^{kot}, \tag{3}$$

We need to write the equations of network balance:

$$x_i = \sum_{i=1}^{n} P_i + \sum_{j=1}^{n} d_{ij}(1 - \delta_{ij})v_{ji} - \sum_{j=1}^{n} d_{ij} v_{ij}, \tag{4}$$

$$y_i = \sum_{i=1}^{n} Q_i + \sum_{j=1}^{n} d_{ij}(1 - \delta_{ij})w_{ji} - \sum_{j=1}^{n} d_{ij} w_{ij}, \tag{5}$$

$$\sum_{i=1}^{n} P_i^{tec} = b \sum_{i=1}^{n} Q_i^{tec}, \tag{6}$$

$$w_{ij} \leq wMax_{ij}; v_{ij} \leq vMax_{ij}. \tag{7}$$

where:
d_{ij} is a matrix showing the network structure;
v_{ij} is a flow of electric power between nodes ;w_{ij} is a flow of heat power;
δ_{ij} is s the percentage of losses ;
The results of numerical experiments are presented.

References

1. Molodyuk, V.,V.: A mathematical model of the power plant operation on the market of electricity and heat. Energy specialist, 12-16 (2014) (In russian)]