DISTRICT HEATING TRANSMISSION LINE PLANNING WITH REDUNDANCY CONSTRAINTS

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Abstract

Due to high investment and long payback time, district heating (DH) grid should be planned precisely. DH grid consists of transmission pipes with distribution pipes branching out [1]. This study presents a mathematical optimization model for determination of economic DH areas and planning routes, sizes and costs of a district heating transmission network. In the formulation of the model, conditions for satisfying redundancy criteria against unavailability of heat sources are defined. The approach will be integrated as a separate module in the DH-Plan model [2]. DH-Plan model maximizes the profit with respect to spatial and economical aspects of implementing district heating system. The model is applied to the case study Brasov, Romania.

The workflow is as follows:

- Determine the potential DH areas based on method introduced by Persson et al. [3]under following conditions:
    - Distribution grid cost ceiling (EUR/MWh),
    - Available capital for investment in grid (Million EUR).
- Breaking potential DH areas into smaller areas using clustering module of DH-Plan,
    - Seeds for clustering are obtained from the skeleton of the potential DH areas (step 1).
    - For clustering, a minimum and maximum heat demand in each cluster is defined.
    - Clustering is performed based on minimization of distance of cluster members to the selected seeds by an optimization model.
- Calculate shortest path routes between all pairs of cluster centroids and heat sources based on street routes and constitute a distance matrix.
- Adding redundancy constraints to the DH-Plan model.
- Feed the input data and distance matrix to the optimization model.
- Get among all, cost optimal transmission lines' routes, costs and sizes.

Fig. 1 shows the results of the model **without** consideration of redundancy constraints. The impact of the redundancy constraints on transmission line routes and costs are compared with this base case.

Determination of DH transmission line routes, dimensions and costs is a complex task. The first step in determining potential DH areas and the use of clustering model reduce the overall complexity of the problem substantially. Furthermore, the approach allows for a step-wised planning of extension of grid. For example, the construction of transmission lines can be started from clusters with higher profit. The obtained transmission line plan under redundancy constraints guarantees the heat supply under conditions that a heat supply unit is unavailable and contributes in the security of supply.

This method provides a generic approach. Therefore, the outputs should be regarded as pre-feasibility results that can facilitate detailed heating planning in study areas.

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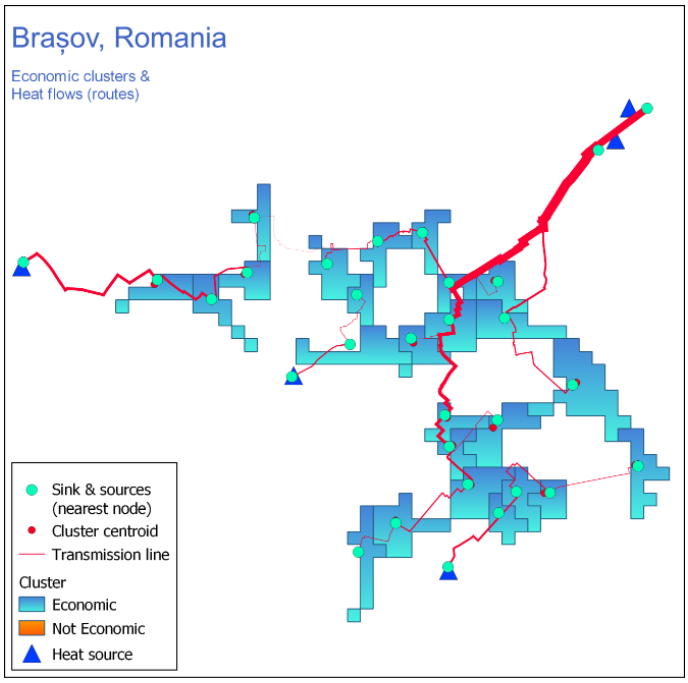

Figure 1: Transmission lines without consideration of redundancy constraint under certain input parameters

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