Optimal diversification of large-scale district heating generation portfolios in Austria

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Overview

Diversification of heat sources and fuels for District Heating (DH) is fundamental for enabling long-term stable and competitive prices. Uncertainty of fuel prices can be identified as the key cause of DH plant investment risk. In Austria 28% of its citizens are supplied by DH, but economic viability has been challenged in the past years: several large systems rely on waste heat from natural gas power plants that turned unprofitable in the past years. The losses incurred by these plants directed the attention to finding diversification strategies for generation portfolio diversification. The application of Modern Portfolio Theory (MPT) in DH generation portfolio selection explicitly accounts for price risk in DH generation portfolio selection. For the three largest Austrian DH systems it suggest the integration of large-scale heat pumps and in some cases geothermal and solar DH in order to reduce the volatility of generation costs and retain economic viability.

Methods

Optimal adaptions for the DH generation portfolios of Vienna, Linz and Graz are computed based on the Modern Portfolio approach from financial mathematics. In this approach portfolio selection is based on minimizing expected levelized cost of heat adjusted by some level of risk, defined as variance or volatility Adapting this approach to the DH portfolio selection poses mathematical challenges as DH generation portfolios, in contrast to a simple financial portfolio, need to satisfy a time-varying load. This has been addressed in electricity generation portfolio selection by (Delarue, De Jonghe, Belmans, & D'haeseleer, 2011) and (Weber & Sunderkötter, 2011). The latter approach is adapted and further developed for DH systems within this paper.

Results

Based on the results of the mean-variance optimal portfolio adoption for Vienna, Linz and Graz several general characteristics of the transformation of large DH systems in Austria may be highlighted:

- Fossil fuel combustion plants: Fossil fuel CHP plants used to be the main source of DH generation in large and medium-size DH systems in Austria. Despite their current economic situation, natural-gas fired CHP plants will still play an important but less dominant role in DH generation
- Renewable fuel combustion plants: A desired regional supply of wood chips for biomass CHP and HOB plants sets a natural limit on their capacity. The investment for today's existing small-size steam turbine CHP plants required a considerable amount of subsidies in terms of feed-in tariffs. If the feed-in tariffs are not guaranteed any more, full load hours decline, but a continued operation is still preferable over a shut down. However for future new installation, small wood chips HOBs are preferred over a wood chips CHP plant for new installations.
- Heat Pumps: Heat pumps will be an important technology for generation portfolio diversification. With increasing risk aversion several heat sources for heat pumps are exploited in the all addressed DH system. Preferred heat sources are industrial waste heat, ground, sewage and river water.
- Non-combustible renewables: Geothermal DH is only available for Vienna. The analysis shows that due to its low generation costs exploiting geothermal DH sources is highly recommendable even in the presence of a considerable amount of exploration risk. In contrast, Solar DH with seasonal storages, has very high generation costs, but no price risk at all. This technology requires a very high number of full load hours for economic operation and is therefore only recommendable for DH systems with a too small available capacity of cheap waste heat sources for supply base load as in Graz.

Conclusions

The study of the mean-variance optimal portfolios of Vienna, Linz and Graz reveals that price risks can be decreased dramatically compared to the expected least-cost solution with only a small increase in expected annual costs. This allows for both stable ans competitive costumer prices and stresses the importance of diversification in generation portfolio. Furthermore the mean-variance optimal portfolios show that optimal diversification does not only correspond to a more balanced generation mix, but also in the consideration of technologies that would not be included in a least cost portfolio. For the portfolios of Vienna, Linz and Graz this was seen by several types of absorption and compressor heat pumps as well as for Solar DH with seasonal storage. The benefit for price stability of including these technologies may be overseen by a DH system operator that chooses purely expected least-cost portfolio.

References

Delarue, E., De Jonghe, C., Belmans, R., & D'haeseleer, W. (2011). Applying portfolio theory to the electricity sector: Energy versus power. *Energy Economics*.

Weber, C., & Sunderkötter, M. (2011). Mean-Variance Optimization of Power Generation Portfolios Under Uncertainty in the Merit Order. *EWL Working Paper*.