Toolbased Cost-Benefit Analysis of Combined Heat and Power Driven Local Heating Networks

Bachelorarbeit

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1. Introduction

1.1 Relevance and Motivation

The topic of fuel shortage is very relevant in today's energy policies. Because of the diminishing of fossil fuels' reserves, the necessity of installing plants with high efficiency increases. The resolution of the energy revolution promotes many innovative techniques, including combined heat and power (CHP).

CHP plants can be very helpful regarding the issue of fuel shortage. Because of their high efficiency of up to 96 %, they are ideal for utilization with low wastage which is desirable in the current fuel situation. The 'Kraft-Wärme-Kopplungsgesetz' (KWKG; translated: combined heat and power law) subsidizes the generation of electricity through CHP systems increasing the interest in CHP.

Moreover, the support of CHP systems improves their economic feasibility making them a better investment opportunity. Small or medium sized CHP plants can be installed by companies, municipalities or other investors. An installation of a local heating network is necessary to provide whole residential or industrial areas with heat. A local heating network driven by a CHP plant, decreases the load of the public grid. The relief of the grid's load as well as the installation of the local heating network are supported through different programs.

Within the scope of this thesis, the following research question will be elaborated:

"Can combined heat and power driven local heating networks be economically feasible under current German market conditions?"

A cost benefit analysis of CHP driven local heating networks is made. The emissions of each alternative are calculated and presented, so that the environmental protection benefits are taken into account. For the purpose of the analysis, a calculation tool is designed in cooperation with Niedersächsische Landesgesellschaft mbH. The tool serves as a decision support for potential investors and can be the basis of increasing the interest in CHP and local heating.

1.2 Structure of the Work

At first, the theoretical basis is presented. It includes the methodology, which is used for the design and evaluation of the tool in chapter 2.1 as well as a literature research in chapter 2.2. The methodology 'Design Science Research' by Hevner is presented and adopted to the context of this thesis. It is followed by the procedure which is applied to the literature research. Then the CHP related literature is presented using a concept-centric analysis based on Webster's and Watson's main ideas.

In the third chapter the designed tool is introduced. The calculation basis of the tool contains the assumptions and the mathematical model which is presented in chapter 3.1. It is followed by the presentation of the graphical user interface with its input and output pages. Afterwards, the variety of financial support programs is pointed out.

After the presentation of the tool, the scenario analysis is done. In chapter 4.1 the methodology, which is used for the scenario analysis, is presented and applied to the context of this thesis. This is followed by the determination of the scenario field. The determination includes the introduction of three different cases which will be analyzed afterwards. The relevance of the influencing factors is evaluated and the key factors are identified. The outline data of each case is entered into the tool and the key factors are varied. Each combination of factors leads to a scenario, which is presented in chapter 4.4.

In chapter 5, the results of the scenario analysis are discussed finding similarities and differences between the three cases. A critical appraisal of the results is made and the limitations of the thesis is pointed out.

In chapter 6, a conclusion is made and further research gaps, which have been implied by the limitations, are pointed out.

6. Conclusion and Outlook

The economic performance of a CHP driven local heating network depends on many factors, especially fuel prices and heat and electricity sales prices. If these prices are given, the impact of the selected fuel as well as the the choice of a second CHP boiler is greater than the impact of the financial support.
The analysis shows, that woodchips fueled plants have a better economic outcome than natural gas fired plants. The installation of a CHP boiler as the redundancy boiler is not profitable and the consideration of financial support leads to a one to two cent lower cost-covering heat sales price[7] per kilowatt hour.

As is stated in chapter 1, the combination of CHP and local heating is helpful when solving the problems, that the world faces due to the fuel shortage. When using renewable fuels, such as woodchips, the emission of CO_2 equivalents decreases significantly compared to the use of natural gas.

The decision support provided by the tool 'Wirtschaftlichkeitsberechnung: KWK & Nahwärme', helps investors find the best combination of factors to make their specific project as profitable as possible. It can be used to support the planning phase of projects and can help to find the best alternative.

The heat demand has been the focus of this thesis and the electricity demand was excluded. In further research, the effects of the combination of heat and electricity demand on the economic outcome can be interesting. This way, other sales potentials for electricity can be used.

All in all, CHP is a promising technique, because of its high efficiency and possibility to be fueled with renewable fuels. CHP driven local heating networks have a great economic potential and can contribute to a solution for the fuel shortage. CHP driven local heating networks with an optimized design can be economically feasible under current German market conditions.

[7] The cost-covering heat sales price stands for the lowest possible heat sales price, that still generates a positive net present value.