ENERGY SAVINGS OF INTERCOMPANY HEAT INTEGRATION – A METHODOLOGICAL FRAMEWORK (PART I)

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Background and literature review

Heat or process integration is a technical concept to minimize cooling and heating requirements of industrial plants. The basic idea of heat integration is to interconnect processes requiring cold with processes requiring heat via heat exchanger, thus reducing overall energy demand (Kemp, 2007). The more processes can be interconnected within a heat exchanger network (HEN), the more savings can be achieved with heat integration. Thus, production sites with more than one factory/production hall set up HENs with borders beyond production halls. A further concept is to interconnect production sites not belonging to the same company. This concept is called intercompany process or heat integration (Hiete et al., 2012). Here two or more companies use the same HEN with the aim to reduce their overall energy demand with respect to heating and cooling.

Several case studies exist, analyzing large production sites or industrial estates assessing potential energy savings which might be caused by HENs. The papers focus mainly on methodologies about how to analyze total sites. Depending on the case, intercompany heat integration is sometimes addressed indirectly. For example Hackl et al. (2011) apply total site analysis (TSA) on an industrial estate consisting of five chemical companies. They show that by using a HEN the current utility demand could be eliminated completely. Few publications are explicitly dedicated to the field of “intercompany energy integration”. For instance Hiete et al. (2012) examine a case study where a set of companies is located around a chemical pulp manufacturer.

For Germany the potential energy savings which might be achieved by intercompany heat integration have not been estimated up to now. This is mainly based due to the lack of data. However, a structured way to estimate energy saving potentials by intercompany heat integration beyond case study approaches is interesting, especially with regard to policy design to increase the uptake of heat integration and industrial energy demand projections. In this contribution we present a methodological framework to estimate these potentials for regions systematically. Within the framework methodologies from spatial analysis and heat integration are combined. The focus in this paper lies on the methodologies from heat integration and sets the foundation for a further contribution dealing with the methodologies from spatial analysis.

Methodology to assess HENs and validation on a case study

To quantify energy saving potentials of intercompany heat integration it is necessary to have information on the heating and cooling requirements of the affected companies and their location towards each other. Furthermore a methodology is needed to assess a possible HEN based on this information. Within this paper we present and apply a methodology on how to assess intercompany HENs, representing one major pillar from the methodological framework.

First, we present the formulation of the methodology applied. We formulate the task to generate intercompany HENs as linear transport problem based on Cerda et al. (1983). Special attention is payd to aspects relevant for intercompany heat integration such as investments for pipes and heat losses. This is done by extending the model presented in Ludwig (2012). We furthermore extend the formulation of the transport algorithm presented by Cerda et al. (1983) in order to address time dependent load variations of the affected companies to a certain extent.

Second, we apply the model to evaluate a hypothetical case study which considers two plants with regard to the model extensions. Within that context we first validate our model based on thermodynamic considerations.

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We then execute sensitivity calculations in order to show how the model responds to factors relevant for intercompany heat integration. An extract of the analysis' results is given in Figure 1. Beginning from the top optimized HENs has been generated; first for a site consisting of one plant and then for a site consisting of two plants.

- **Cases 1 to 4**
  Cases one and two represent an optimized HEN for a site with one plant and cases three and four for a site with two plants. First HENs only based on energetic considerations are generated for both sites in cases one and three. Then investments for heat exchangers are included additionally in cases two and four. Taking investments into account makes some configurations economic unfeasible and consequently in cases one and three more waste heat is utilized than in two and four.
- **Cases 5 to 7**
  In cases five to seven also HENs for the same site with two plants are generated. Besides investments for heat exchangers additionally investments depending on distances are taken into account (e.g. for pipes). As a result less waste heat is utilized comparing the equivalent cases four and five. We then scale thermal loads of plant P1 up, so that again more waste heat is utilized (cf. case six). Finally we assume that the up scaled plant P1 also operates at part load and consider this in generating an optimized HEN. This consequently results in less waste heat utilized by the optimal HEN in case seven.

The results of the sensitivity analysis show that factors relevant for intercompany energy integration are addressed plausible.

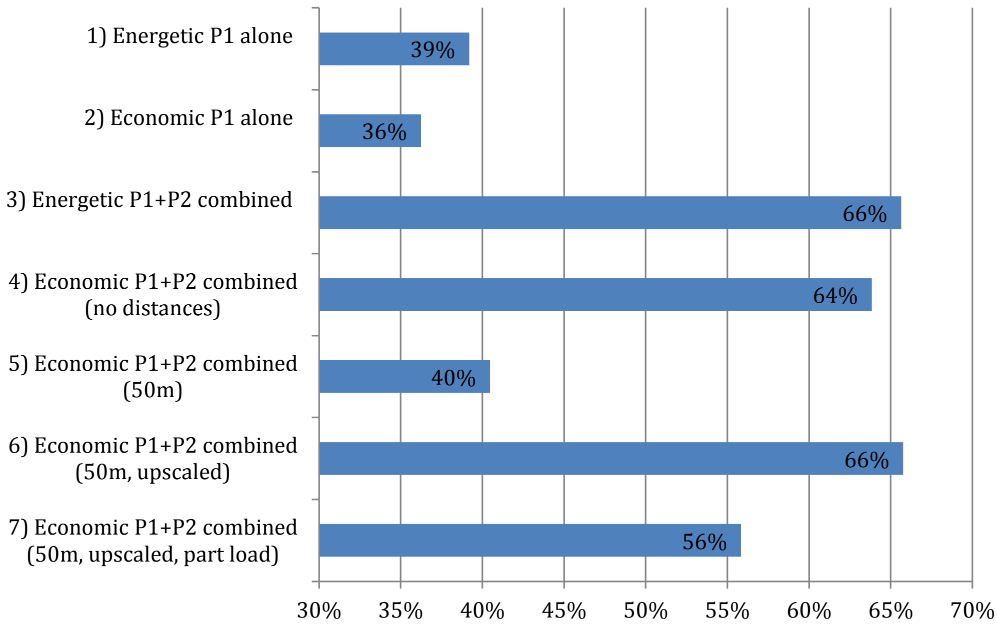

Figure 1: Sensitivity calculations: percentage of waste heat utilized in the HEN per case.

Outlook: Methodological framework to estimate energy saving potentials by heat integration

Finally, we present the methodological framework where the model presented before shall interact within. In the outlook it is presented how data gaps might be closed by a combination of top-down and bottom-up approaches and spatial analysis.