

# ***HOW DO COMPANIES DIFFER IN THEIR INVESTMENT BEHAVIOUR FOR ENERGY EFFICIENCY? ANALYSING ENERGY INTENSIVE INDUSTRIES WITH SURVEY RESULTS AND CLUSTER ANALYSIS***

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## **Overview**

Industrial energy efficiency is a highly discussed topic, as it can lead to cost savings, competitive advantages, but also faces challenges concerning investment, regulation and other issues. Different studies identify a technical (Ranzani da Costa, Wagner et al. 2013) or techno-economical (Brunke and Blesl 2014) potential for possible saving options. Often, these potentials are not seen in practice due to barriers, which have been significantly researched (Cagno, Worrell et al. 2013, Brunke, Johansson et al. 2014). But few, if any studies account for them in analysing potentials and the likely uptake of energy efficiency measures (Fleiter, Schlomann et al. 2011). To gain a deeper understanding of the factors influencing investments in energy efficiency and the heterogeneity amongst companies within a single sector, as well as between sectors, it is important to capture the behavioural and decision-making characteristics of different companies (Trianni, Cagno et al. 2016). These aspects concern organization, production technology, strategy, decision processes about investments, attitude towards energy-related topics and many others.

The following industrial sectors are investigated due to their product homogeneity, their importance for the German and European economy in general and their high specific energy demand: aluminium, cement, foundries, glass, iron & steel and pulp and paper. For example, these sectors accounted for 46% of the final energy use and 31% of the electricity used in German industry in 2013 (Destatis 2015).

The paper is organised as follows: first, a short introduction is given. The second section gives an overview of recent research about energy efficiency in industry and the associated investment behaviour of companies. In the third section the methodology of the expert interviews, the quantitative survey and the cluster analysis is explained. Thereafter, the fourth section describes the results of the different explained methods, and connections between the results are shown. In the final section continuing steps of this research are derived.

## **Methods**

Expert interviews were conducted with company and sectoral trade association representatives to gain an insight into these sectors. In addition to these ten telephone based interviews, two production facilities were visited (cement and pulp and paper). Based on the answers of these preliminary interviews and the facility visits, a questionnaire was developed.

The questionnaire addresses the companies' attitudes towards energy efficiency technologies and investments, as well as demand side management and the current implementation status of energy efficiency measures in the specific company and the sector in general. With the questionnaire a 15 minutes telephone survey was realized with 300 companies and a weighted distribution of the different sectors was taken into account.

Subsequently different data analysing methods (regression and cluster analysis) based on the results of the telephone survey and on publicly available data (e.g. annual financial statements), identify different types of companies. The resulting dependencies and cluster groups are used to get a better overview of the differentiation in company typologies. Subsequently, these findings contribute to the modelling of company agents in a subsequent agent-based simulation which is not part of this paper.

## **Results**

First, expert interviews give a good overview about the problems and challenges in the examined sectors considering progress in energy efficiency. It is shown that those problems and challenges differ between the sectors. Therefore, a profound analysis of energy efficiency potentials requires a differentiation between sectors.

Second, the results of the quantitative survey illustrate the differences between companies within one sector. Hence, a profound analysis of energy efficiency potentials also requires a differentiation between companies.

Third, the data analysis shows how to group the companies in the different sectors. Thus, agents for a subsequent agent-based simulation can be modelled with their typical investment behaviour concerning energy efficiency technologies.

## Conclusions

Political goals for the reduction of energy use and carbon dioxide emissions in industry are challenging. Technical and economical potentials in reduction scenarios seem to be high. But the implementation of those potentials proves itself to be difficult. A better knowledge about the behaviour and expectations of different company types in different industrial sectors is important to think of new policy strategies to realize climate goals. A survey of current research about the potentials of energy efficiency measures in industry illustrates that a deeper insight of structural and behavioural aspects of companies is needed. It is shown that empirical data obtained by a telephone survey is suitable to fill this gap. This data is used to perform a regression analysis and a cluster analysis to contribute to the heterogeneity of different companies considering their investment behaviour. Furthermore, this detailed data provides a useful basis for novel modelling approaches in energy efficiency research, such as based on agent-based simulation. An agent-based simulation will be performed in a next step.

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